Study Group on Advanced Use of Internet with IPv6

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Chapter 1 Details on the Past and Current Situations

Section 1 Background of Discussions

1. Role of IP addresses with the internet

The internet uses a method of communication known as IP (Internet Protocol) and which takes place by data divided into packets being relayed using a number of devices known as “routers”. Each of the devices that are connected to the internet is assigned a unique “IP address”, which is a number used to identify the device and which enables communication from the source to destination. (Figure 1-1-1)

There are multiple IP versions. At present the main version being utilized over the internet is IPv4 (Internet Protocol version 4). An IP address with IPv4 is expressed as a 32-digit binary number, thus allowing a total of 2^{32} (4,294,967,296 or approximately 4.3 billion) unique addresses. This then means that approximately 4.3 billion devices can be connected at the same time to the internet via the use of IPv4[1].

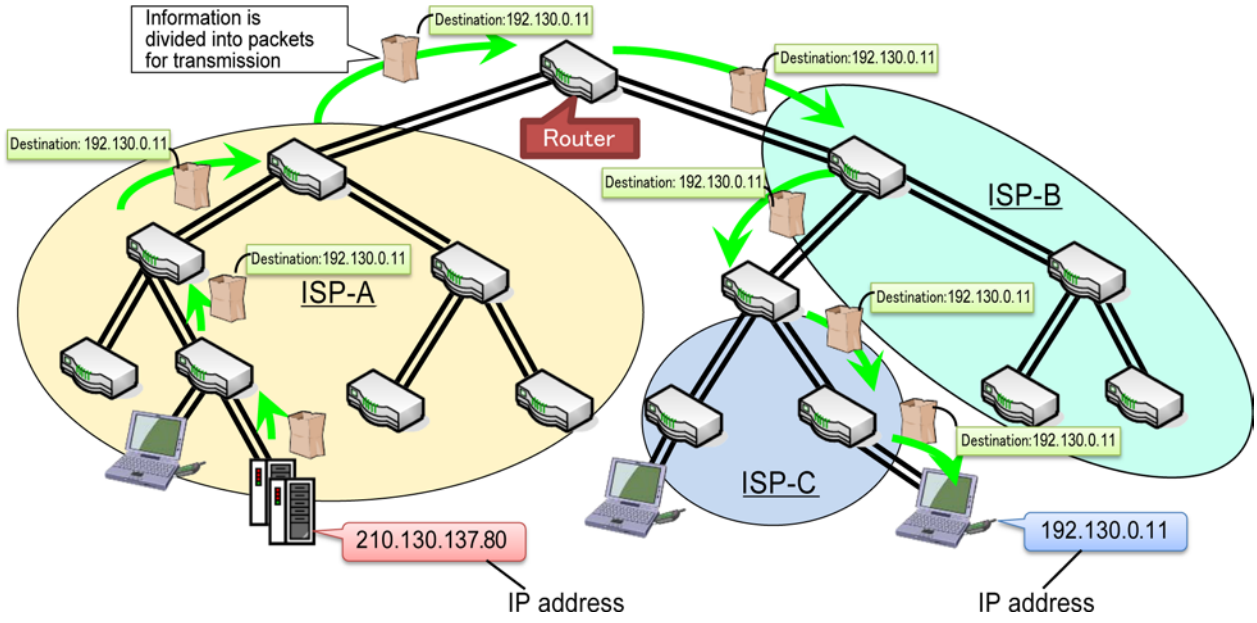

Figure 1-1-1 IP addresses

An IP address with IPv6 (Internet Protocol version 6), the successor standard to IPv4, is expressed as a 128-digit binary number, thus allowing a total of 2^{128} (approximately 340 undecillion, or 340 trillion x trillion x trillion) unique addresses. This then means that approximately 340 undecillion

[1] IPv4 addresses include special addresses called private IP addresses that are only used within private networks (networks that cannot be accessed externally, including corporate and home networks). The same private IP address can be used within different private networks. The number of devices that can actually be connected to the internet thus in fact exceeds 4.3 billion.

devices can be connected at the same time to the internet via use of IPv6.

2. Changes in environment surrounding the internet

The use of IP addresses is considered to be closely related to changes in the type of internet use. Past changes that have taken place in the environment surrounding the internet are therefore presented below.

(1) Until the first half of the 1990s

The internet originated from ARPANET (Advanced Research Project Agency NET), which was first established in 1969 by the United States Department of Defense, but which was then made available for public use in the latter half of 1980s.

At that time the internet was mainly used in academic research by universities and enterprises, etc., although some commercial use had commenced upon. Devices that connected to the internet were deployed by enterprises rather than individuals and universities or sections of them. Communications had therefore been taken place at an “organization” level.

(2) Latter half of the 1990s

In the latter half of the 1990s Internet Service Providers (ISPs), etc. started providing internet connection services for individual users and use of the internet then expanded to general households. Usage such as viewing websites (net surfing) and sending/receiving e-mail, etc. prevailed, and communications had by then were not only taking place at an “organization” level but also “individual” level.

(3) First half of the 2000s

In the first half of the 2000s the use of ADSL services expanded through high-speed, large volume, but lower price internet services being made available. This led to full-time internet use at homes then expanding, with the number of broadband service subscriptions exceeding 10 million in 2003.

Diverse use of the internet had progressed to including the viewing of websites and sending/receiving e-mail that involved large volume content, including video pictures, etc., internet shopping, and interactive communications, etc. Communications were also taking place at both an “organization” and “individual” level.

Rapid increase in internet use due to the dissemination of full-time internet use and so-called “IT bubble” or “internet bubble” accelerated the consumption of IPv4 addresses, resulting in the

estimation[2] that the unallocated address pool would be exhausted within few years being made. The IT bubble burst, however, slowed down the speed at which IPv4 addresses were being utilized, with the expected time of IPv4 address exhaustion now being estimated to be around 2020[3].

(4) Latter half of the 2000s

High-speed and large volume communications have further advanced. Broadband access using optical fiber called FTTH has penetrated the market in place ADSL. The number of FTTH subscriptions exceeded that of ADSL in 2008.

In addition, diverse use of the internet has further progressed and the internet has become an essential infrastructure for social/economic activities as devices other than PCs, including televisions, recording devices, and game devices, have become capable of being connected to the internet and through the emergence and dissemination of such concepts as “Application Service Providers (ASPs)”, “Software as a service (SaaS)”, and “cloud services”, which enable the use of a variety of different services. Furthermore mobile internet use has started to prevail and an environment developed for individuals to have multiple internet access methods through the emergence of hot spot services via wireless LANs and internet access via mobile phones, etc.

In addition to communications made at an “organization” and “individual” level they are also being made at “equipment (device)” level.

The speed at which IPv4 addresses were being used, that had slowed down also accelerated again as internet use expanded in Asian countries, including China and India, etc., with the estimation then being made that the unallocated IP address pool would be exhausted by 2011 at the earliest[4].

(5) 2010 on

In addition to PCs and home appliances, etc., all sorts of “equipment (devices)”, including sensors represented by smart grids[5], etc., are expected to be connected to networks and autonomously communicate with each other in the future. Because of this communications are expected to be to be made at an “organization", “individual”, and “equipment” level.

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[2] “Ideal Internet Policies in 21st Century” (August 2002, Information and Communications Council): “Estimating exactly when IPv4 addresses will be exhausted is in fact rather difficult, but according to ICANN data it is expected to take place between 2004 and 2007. Assuming that the same address allocation methods and address usage schemes continue to be used but taking into account the recent IT recession, although mainly in North America, a conservative estimate indicates that they will be exhausted by around 2009.”

[3] “IPv4 - How long have we got?” (July 2003, Geoff Huston): “RIR exhaustion of the unallocated address pool will occur in 2022.”

[4] “Report of Study Group on Internet's Smooth Transition to IPv6” (June 2008): “The addresses used in Japan will not be capable of being replenished from the beginning of 2011 to the middle of 2013.”

[5] A next generation electric power network that can be used to adjust demand and supply which thus enables more efficient supply of electrical power through utilization of information and communications technologies.

3. Issue of IPv4 address exhaustion

IP addresses are managed by ICANN (Internet Corporation for Assigned Names and Numbers), an international internet resource adjustment/management organization, and are allocated to business operators, including ISPs, etc., according to demand.

At present IPv4 is mainly used with the internet and the number of IPv4 addresses is approximately 4.3 billion. IPv4 addresses are allocated in units of blocks called "/8" (the number of IP addresses in a block being 2^{24} (16,777,216 or approximately 16.80 million)) by ICANN. As of the end of December 2009 the number of unallocated IP addresses was 26 blocks (approximately 440 million).

Until around 2003 the annual consumption was around five blocks but which then doubled around 2004 due to a recent increase in demand mainly from the Asia-Pacific, South American, and European regions. The estimation with the unallocated IPv4 address pool is therefore that it will be exhausted within a few years.

IP addresses are allocated fairly to each region according to demand, and thus IP address exhaustion is not an issue specific to Japan and instead a global issue.

4. Issues expected to arise due to IPv4 address exhaustion

If the unallocated IPv4 address pool is exhausted the internet will still be useable but responding to new user applications or provision for servicers will become difficult, thus affecting people's lives and business activities, etc. affected in various ways.

Without an IPv4 address, for example, new service providers will not be able to enter the market and existing service providers will be incapable of establishing new or additional devices for connection to networks. In addition, users will not be able to subscribe to new internet connection services while existing users will not be able to use newly emerging future services (Figure 1-1-2).

The occurrence of these problems will thus impede the development of the internet, which has been making such a contribution to the development of society.

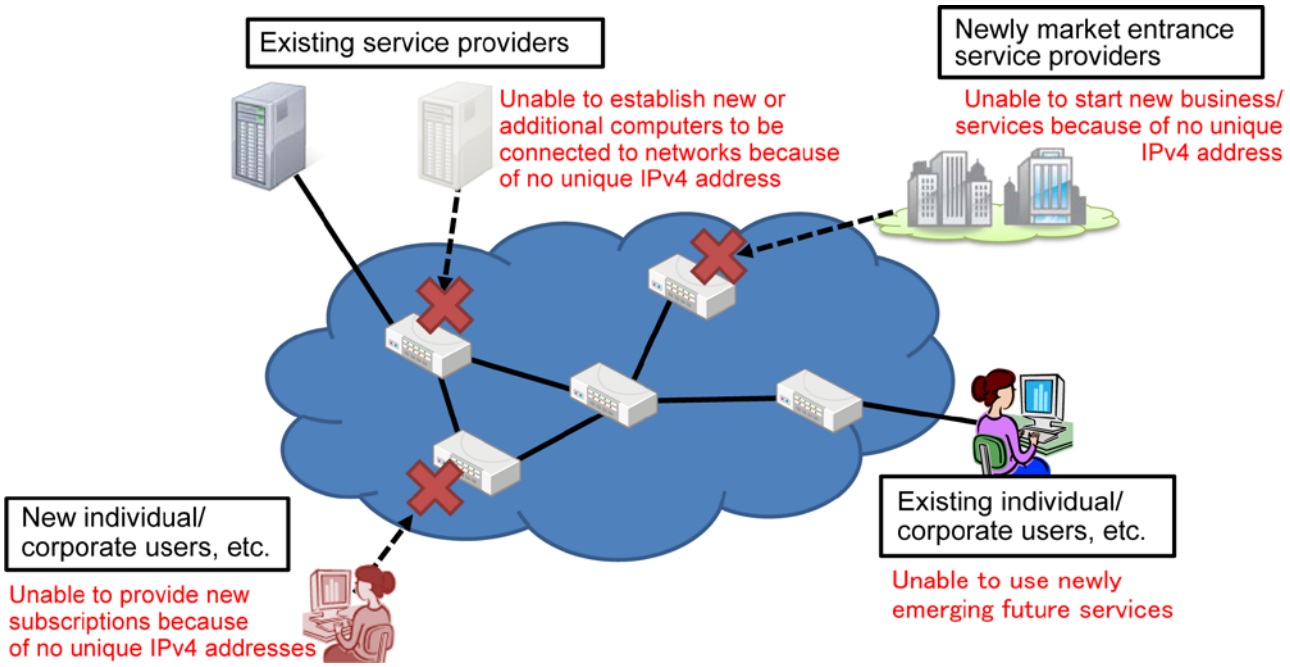

Figure 1-1-2 Issues expected to arise in case of IPv4 address exhaustion

5. Past measures with IPv4 address exhaustion

The following measures have been taken in the past in response to the above problems.

(1) Formulation of measures for IPv4 address exhaustion

[1] Discussion by "Study Group on Internet's Smooth Transition to IPv6"

This Study Group was held at the Ministry of Internal Affairs and Communications between August 2007 and June 2008 to discuss measures to take in counteracting IPv4 address exhaustion. A report put together by the Study Group provided action plans on what and by when respective relevant business operators should do in response and also recommended the following roles for the government:

- Provision of support for improved IPv6 educational programs in facilitating the acquisition of the necessary skills by engineers, including development of test beds, etc.
- Discussions in cooperation with relevant organizations on support measures, including initial cost bearing with respect to responding to IPv4 addresses being exhausted

[2] Establishment of a system to respond to IPv4 address exhaustion for the private and public sectors

A "Task Force on IPv4 Address Exhaustion" was established in September 2008 by the relevant agencies and organizations, mainly the Ministry of Internal Affairs and Communications and the IPv6 Promotion Council, as a nationwide action plan promotion system in cooperation between the

government and the private sector in responding to the issue of IPv4 address exhaustion. The Task Force has been making various efforts through [1] discussing the relevant issues (technological, operational, and managerial), [2] publicity and enlightenment, [3] human resource development, and [4] progress management for smoothly overcoming the expected IPv4 address exhaustion. As of the end of December 2009 19 agencies/organizations[6] were participating in the Task Force.

(2) Promotion of concrete measures

[1] Detailed action plans

The action plans formulated by the Study Group were taken into account in more detailed action plans being formulated for use in the respective internet service domains in February 2009 by the Task Force on IPv4 Address Exhaustion. They were revised in October the same year with consideration given to their follow-up. (Reference Document-1)

[2] Promotion of IPv6 related engineer development in cooperation between the government and private sector

The Ministry of Internal Affairs and Communications has been implementing a two-year plan "Test Bed Development for Acquiring IPv6 Operation Skills" with the aim of developing IPv6 operation engineers since FY 2009.

More concretely, two test beds with an environment equivalent to that of the actual network have been established nationwide (Kawasaki City and Osaka City) in developing engineers who will be capable of operating/establishing complex large-scale internet usage via IPv6 by enabling network engineers of ISPs, System Integrators (SIers), network device vendors, and content service business operators, etc. to acquire the skills needed to establish/operate IPv6 networks, etc. via test beds[7]. (Figure 1-1-3, Reference Document-2)

[6] Ministry of Internal Affairs and Communications, IPv6 Promotion Council, Internet Association Japan, Next Generation IX Consortium, Communications and Information network Association of Japan, Association for Promotion of Public Local Information and Communication, Telecom Services Association, Telecommunications Carriers Association, Japan Approvals Institute for Telecommunications Equipment, Japan Internet Providers Association, Japan Cable Laboratories, Japan Data Communications Association, Japan Network Information Center, Japan Network Operators' Group, NPO Japan Network Security Association, Japan UNIX Society, Japan Registry Services, Institute for HyperNetwork Society, and WIDE.
[7] Amount of FY 2009 budget: 360 million yen, FY 2010 government budget proposal: 360 million yen.

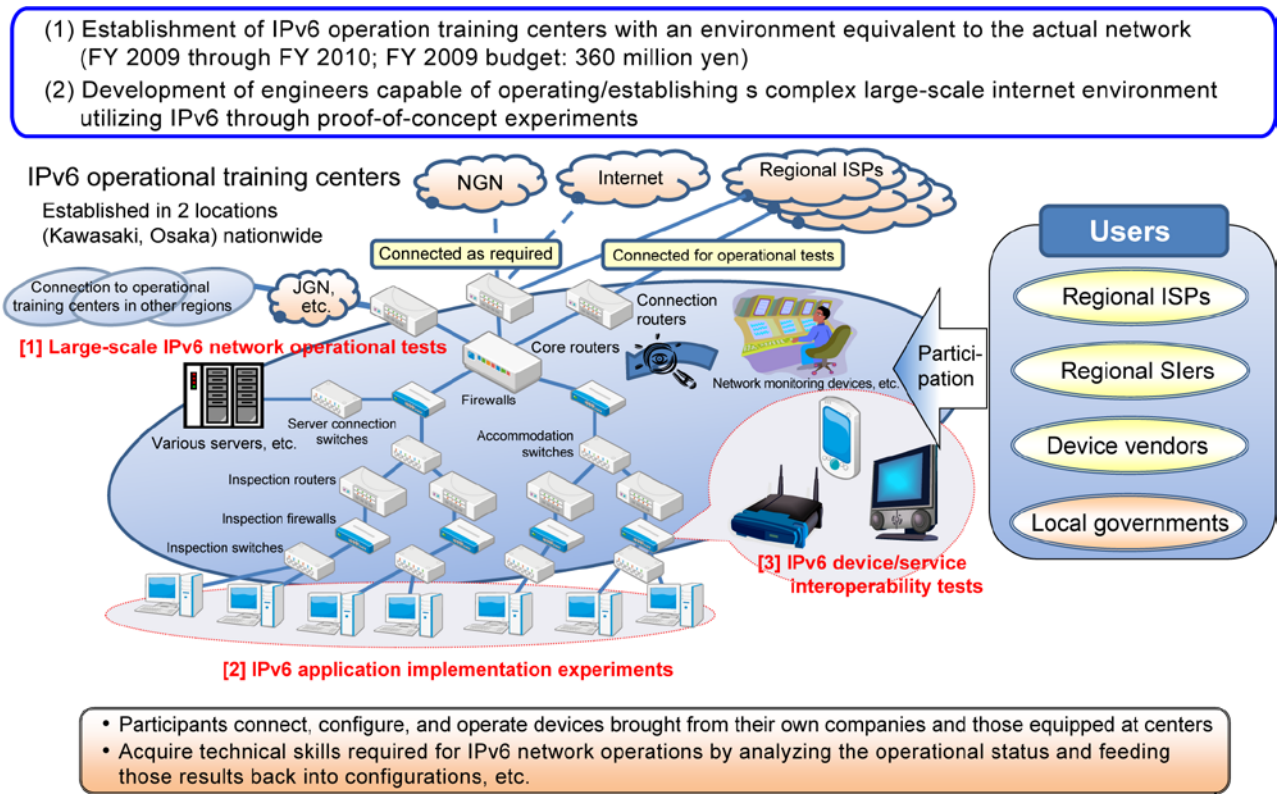

Figure 1-1-3 Development of test beds for use in acquiring IPv6 operational skills

[3] Promotion of publicity activities on IPv4 address exhaustion

The issue of IPv4 address exhaustion has been rapidly manifesting since around 2007. The fact that IPv4 addresses will be exhausted and that it could then impact existing services, etc. and impede the continued development of the internet in various ways therefore needs to be made available to internet related business operators, etc. Publicity activities on IPv4 address exhaustion has therefore been promoted through lectures at various seminars, etc. and journal articles, etc., mainly by the Task Force on IPv4 Address Exhaustion and organizations participating in the Task Force, including the Ministry of Internal Affairs and Communications[8].

[4] Determination of IPv6 connection methods between NGN of NTT East and West and ISPs

Enabling individual users to access the internet via IPv6 requires support from both ISPs and access network providers[9]. Discussions on connection methods between the NGN access network

[8] According to a questionnaire survey provided to enterprises that are members of respective industry organizations conducted by the Task Force on IPv4 Address Exhaustion during the period of late February to early May 2009, 98% were aware that “IPv4 addresses would be exhausted” (of which over 80% were also aware of the expected timing of that exhaustion). In addition, the Ministry of Internal Affairs and Communications has consistently been providing relevant information to all telecommunications carriers.
[9] According to a “Survey on the Status with Provision of IPv6 Connection Services (March 2009, Ministry of Internal Affairs and Communications)” IPv6 internet connection services for individual users are provided by

provided by NTT East and West and ISPs in enabling IPv6 internet connections have therefore taken place between NTT East and West and the Japan Internet Providers Association.

[5] Promotion of IPv6 adoption for use with electronic government systems

The government and local governments also need to adopt IPv6 for use with electronic government systems in ensuring services can be consistently provided to the public via the internet. The "New IT Reform Strategy (January 2006)" provided for an IPv6 introduction plan by the government in which "IPv6 adoption will be implemented by FY 2008 in principle with a renewal of information and communications devices within the respective ministries and agencies". Concrete implementation plans were formulated in the "Priority Plan 2008 (August 2008)" and concrete promotion measures for IPv6 support in electronic government systems in the "First Information Security Basic Plan (February 2006)", "Guidelines for IPv6 Support in Electronic Government Systems (March 2007)", and "i-Japan Strategy 2015 (July 2009)", etc. In consideration of that measures for IPv6 adoption for use in electronic government systems are about to be implemented within the respective ministries and agencies. (Reference Document-3)

[6] Taxation support measures for IPv4 address exhaustion

At present IPv6 enabled routers are specified within the "Next Generation Broadband Infrastructure Promotion Tax System" as equipment subject to a special exemption for fixed property tax[10] granted to business operators and cable television business operators through an implementation plan that was approved in accordance with the Act on Temporary Measures concerning Telecommunication Infrastructure Improvement. IP address translation equipment, IPv4/IPv6 translators, IPv6 enabled management equipment, and IPv6 enabled VoIP servers for telecommunications businesses will be new subjects in FY 2010 in promoting a response to the IPv4 address exhaustion issue (limited, however, to business operators with a capital or contribution of less than 5 billion yen). (Reference Document-4)

[7] Provision of "criteria" for "IPv6 enabled devices", "IPv6 enabled services", and "technologies required for IPv6 adoption" (Reference Document-5)

At present the IPv6 Ready Logo Program is being implemented as an international certification mechanism for the IPv6 interoperability of network devices, etc. by the IPv6 Ready Logo Committee via the IPv6 Forum, an international NPO established with the aim of promoting use of IPv6. The

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Internet Initiative Japan, NTT Communications, and NIFTY, etc. using tunnel connections, etc. (http://www.soumu.go.jp/menu_seisaku/ictseisaku/ipv6/index.html)

[10] Tax base of property tax will be 4/5 and the amount of tax due reduced by 20%.
As a result IPv6 services will be provided via two methods, namely the tunnel method and native method, and the provision of the respective services commenced upon from April 2011 as soon as they are ready.

said Program has been issuing certification logos for communication devices such as routers, PCs, communication terminals such as IP telephones, embedded software and OSs, etc. in thus avoiding any confusion for users.

The Japan Approvals Institute for Telecommunications Equipment concluded a memorandum with the IPv6 Forum in implementing certification work in Japan for issuing the logos as an IPv6 Ready Logo Program certification organization in April 2008, with a number of products since having been granted with the certification logos. As of the end of September 2009 167 devices had been granted a Phase-1 logo, which confirms basic communication functions, and 72 devices with a Phase-2 logo, which confirms IPv6 specific functions, including encrypted communication, in addition to basic communication functions. The number of devices granted Phase-1 logos was 405 and that of Phase-2 logos 286 worldwide, thus indicating that the acquisition of certification logos is making progress in Japan.

In addition, the Ministry of Internal Affairs and Communications has been providing **criteria** on whether services currently being provided on the internet support IPv6 or not, with "Basic Policies for IPv6 Adoption in Internet Services, etc. / Basic Policies for Acquisition of IPv6 Related Skills Required for Network Engineers[11]" having been formulated in June 2009 with the aim of facilitating the acquisition of IPv6 related skills by network engineers, etc.

The following two systems have commenced being used in the private sector in consideration of those policies.

(a) IPv6 Enabled Program[12]

A system implemented by the IPv6 Forum for registering and issuing logos for IPv6 enabled websites and internet connection services that meet certain requirements. The translation information is being provided by the Japan Approvals Institute for Telecommunications Equipment in Japan.

(b) Certification program for acquisition of IPv6 related skills required by network engineers[13]

A system implemented by the IPv6 Promotion Council and Japan Approvals Institute for Telecommunications Equipment to use in certifying qualification tests and curriculums for the acquisition of IPv6 related skills needed by network engineers that meet certain requirements.

[11] http://www.soumu.go.jp/menu_news/s-news/15272.html
[12] http://www.ipv6forum.com/ipv6_enabled/ipv6_enable.php
[13] http://www.v6pc.jp/jp/entry/wg/2009/11/v6qualification.phtml

Section 2 Trends with IP addresses

1. Consumption status and future outlook with IPv4 addresses

(1) Preconditions for estimating period of IPv4 address exhaustion

Various methods can be used to estimate when IPv4 exhaustion will take place but the methods used here include the following two that were used in the "Report of Study Group on Internet's Smooth Transition to IPv6 (June 2008)".

[1] Internationally used common estimation model provided by Geoff Huston (Chief Scientist of APNIC[14]) (Geoff Model)

[2] Linear model (Moderate Model)

Both methods estimate the exhaustion period via regression analysis and based on the allocation of IP addresses over the last 1,200 days and the actual status with IP address usage, etc.[15]. The Geoff Model assumes that "changes in the allocation rate" with IP addresses over the last 1,200 days will continue to be relevant[16] whereas the Moderate Model assumes that the actual "allocation rate" with IP addresses over the last 1,200 days will continue to be relevant.

In addition, both methods assume no changes will be made to international rules on address allocation and no selfish allocation of surplus addresses will take place, and do not reflect the economic conditions that are considered to be closely related to trends in the consumption of IP addresses.

Furthermore, the policy of allocating one block to each Regional Internet Registry (RIR)[17] when the number of blocks in the unallocated address pool (IANA[18] pool) reaches 5 is utilized. In addition, the final address blocks are assumed to be used for special use rather than ordinary use in responding to IPv4 address exhaustion.

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[14] Asia Pacific Network Information Centre; An organization that manages internet resources, including IP addresses, etc., in the Asia-Pacific region.
[15] The actual status is of November 24, 2009.
[16] The allocation rate is assumed to continue to be further accelerating if the allocation rate over the last 1,200 days was accelerating but assumed to continue to be further slowing down if the allocation rate over the last 1,200 days was slowing down.
[17] Organizations that manage internet resources, including IP addresses, etc., respectively for the five global regions, which include ARIN (American Registry for Internet Numbers), that has jurisdiction over the North American region, RIPE NCC (Réseaux IP Européens Network Coordination Centre), over European, Middle Eastern, and Central Asian regions, LACNIC (Latin American and Caribbean Internet Addresses Registry; actual name and the abbreviation do not match) over South American regions, AfriNIC (African Network Information Centre) over the African region, and APNIC (Asia-Pacific Network Information Centre) over the Asia-Pacific region.
[18] Internet Assigned Numbers Authority; Resource management and adjustment functions of ICANN.

(2) Estimation using Geoff Model

Figure 1-2-1 indicates the IPv4 address consumption according to the Geoff Model. The timing at which worldwide IPv4 address exhaustion is estimated to occur is in the latter half of 2011 and that of IPv4 address exhaustion in the Asia-Pacific region (APNIC) the middle of 2012[19].

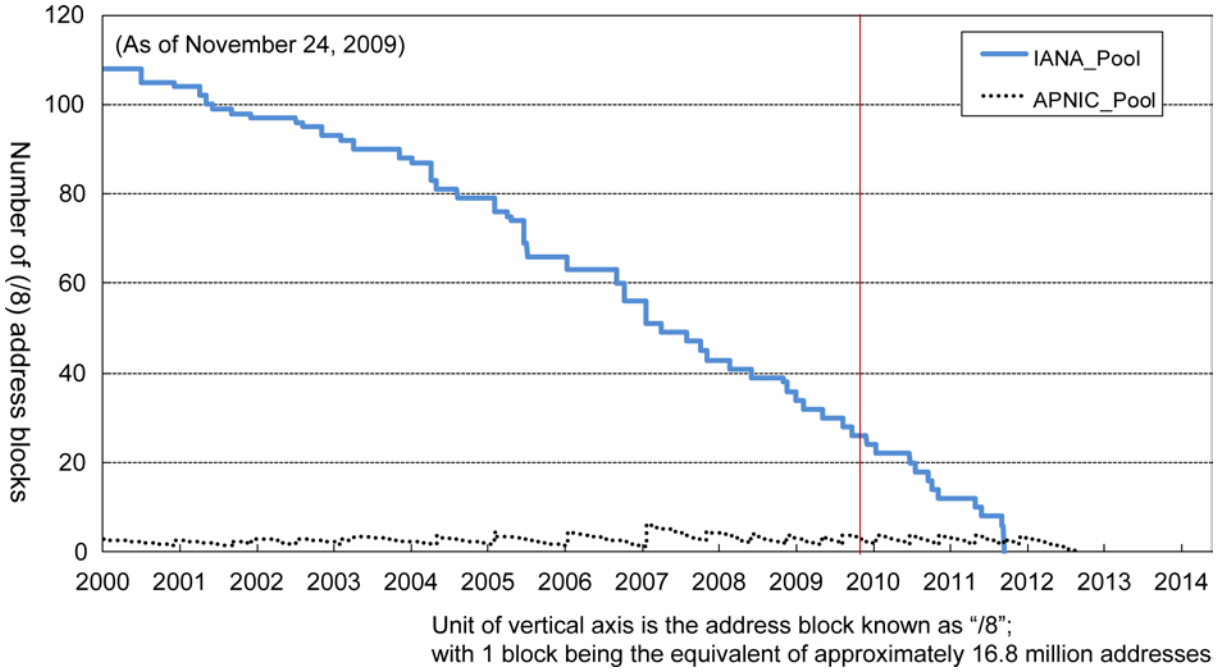

Figure 1-2-1 Estimation using Geoff Model

(3) Estimation using Moderate Model

Figure 1-2-2 indicates the IPv4 address consumption according to the Moderate Model. The timing at which worldwide IPv4 address exhaustion is estimated to occur is in the middle of 2011 and that of IPv4 address exhaustion in the Asia-Pacific region (APNIC) the middle of 2012. (Reference Document-6)

[19] Details of the estimation method using the Geoff Model are available on the website of Geoff Huston (http://www.potaroo.net/tools/ipv4), etc.

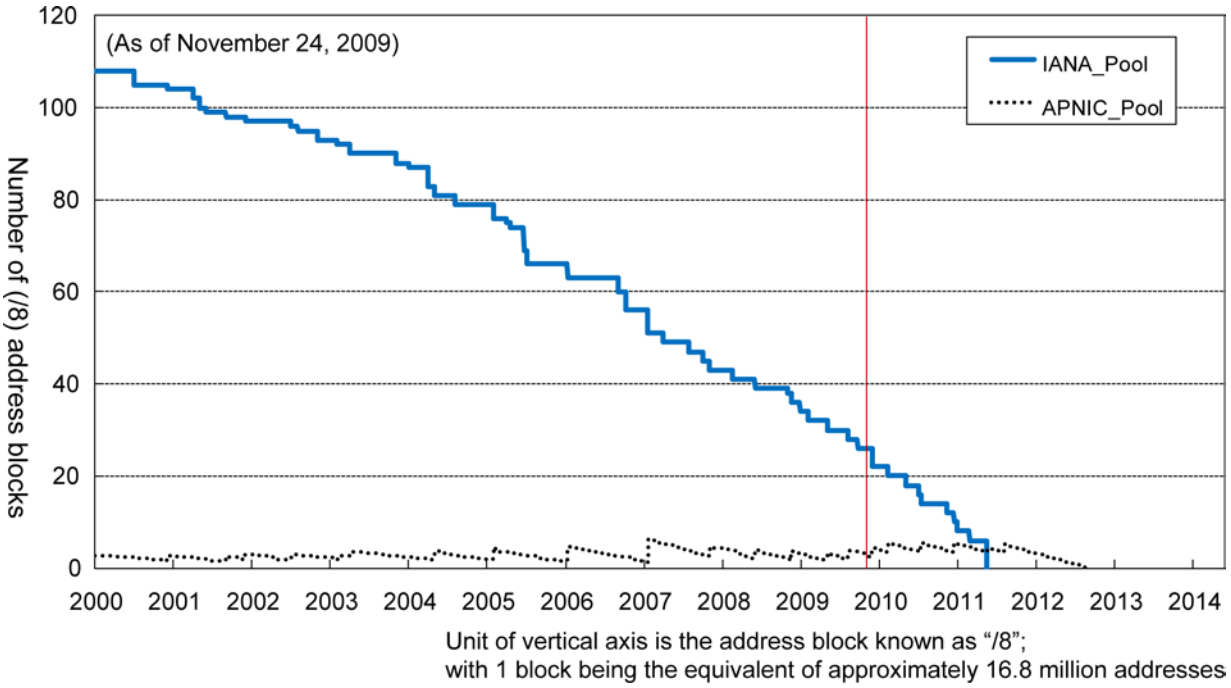

Figure 1-2-2 Estimation using Moderate Model

2. Estimation of number of IPv6 enabled users

Estimating the number of IPv6 enabled users is important for business operators providing internet services with the adoption of IPv6. The number of IPv6 enabled users was estimated using the assumption of multiple scenarios in facilitating IPv6 adoption by internet related business operators.

(1) Estimation methods

Scenarios to use in estimating the number of IPv6 enabled users include cases in which existing internet users using IPv4 do not enthusiastically migrate to IPv6 and only new internet users become IPv6 enabled (scenarios 1 and 2) and those in which existing users become IPv6 enabled without actually being aware of it (scenario 3). The internet can still be used in the case of IPv4 address exhaustion, thus making it unlikely that all existing internet connection users will immediately migrate to IPv6 connections. Scenarios 1 and 2 are therefore considered capable of being used to indicate a number that is closest to the actual number of IPv6 enabled users when compared to scenario 3, whereas scenario 3 is considered to indicate the number of potential IPv6 enabled users.

[1] Scenario 1: Of new broadband users from April 2000 on optical connection users are estimated to be IPv6 enabled

At present NTT East and West plan to provide IPv6 enabled services only to optical NGN connections. Because of this new optical connection users (including users of business operators

other than NTT East and West) count as being IPv6 enabled users. Provision of IPv6 enabled services via CATV is also being planned but the expected number of these services is not included.

Some new users may not be using IPv6 enabled OSs but the number of those users is not taken into consideration because most OSs being sold or used as of 2011 are considered to be IPv6 enabled.

[2] Scenario 2: New optical connection users from April 2000 on, including migrated contracts due to moving house, etc., are estimated to be IPv6 enabled users.

Similar to Scenario 1 new optical connection users count as being IPv6 enabled users. The number of migration contracts is estimated based on population migration and the percentage of households using broadband, which is then added to the number of new users. Similar to Scenario 1 the number of IPv6 enabled users via CATV is at present not included.

[3] Scenario 3: PC users with IPv6 enabled OSs are estimated as being IPv6 enabled users

OSs for PCs (both client and server) are the subjects. The number of shipments of OSs of the following versions and later count as being IPv6 enabled products[20].

- Windows Vista and later versions
- Linux kernel 2.6 and later versions
- BSD 4.0 and later versions
- Mac OS X (10.2) and later versions

(2) Results of estimation

The estimated number of IPv6 enabled users with the respective scenarios is as indicated in Table 1-2-3.

With each scenario users that are capable of using IPv6 under certain conditions count as IPv6 enabled users but they may in fact not be IPv6 enabled due to other conditions. The estimated number of users therefore may be larger than the actual number.

Table 1-2-3 Estimated number of IPv6 enabled users

Scenario	FY	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	Number of subscriptions (million households)	0	3.1	6.2	9.3	12.4	15.5	18.5	21.5	24.6	27.6
2	Number of	0	4.0	7.9	11.8	15.6	19.4	23.1	26.8	30.4	34.0

[20] Statistics on the number of shipments do not specify the OS version in many cases while Linux and BSD include many variants, and hence the number of shipment was totalled using the assumption that all users would have migrated to the new OS after shipment of any IPv6 enabled versions.

	subscriptions (million households)										
3	Number of IPv6 enabled PCs (million PCs)	58.64	60.54	61.44	62.35	63.09	63.87	-	-	-	-

(3) Other estimation scenarios

In addition to the above scenarios the following can also be used to estimate the number of IPv6 enabled users using data obtained by monitoring actual IPv4 and IPv6 communications over the internet. All these scenarios, however, have issues and estimation methods that need to be discussed.

[1] Estimation based on data on DNS requests from IPv6 addresses

At present many users with an IPv6 enabled OS may not actually be able to use IPv6 due to a limited connection environment. The number of users actually using IPv6 is estimated using the percentage of DNS requests from IPv4 addresses (A queries) and IPv6 addresses (AAAA queries), and the percentage of IPv4 and IPv6 use within those requests, etc. However, issues remain that include the inability to identify cases in which the actual communications use IPv6 but DNS requests are made using IPv4 communications and determining domestic requests from all DNS requests being difficult, etc.

[2] Estimation based on data on pass through IPv6 packets in Internet Exchange (IX), etc.

The number of IPv6 enabled users is estimated from the number of IPv6 packets observed at concentrated communication locations, including IX, etc. This does enable an assessment specific to the domestic situation but includes such issues as the possible inability of insignificant estimation being made due to a weak correlation between the number of packets and number of users and the inability to identify communications that do not go through IX (direct communications between service providers) and communications using IPv4 tunnels, etc.

Section 3 Situation with Internet Related Business Operators

1. Measures possibly taken by internet related business operators

The following main three measures are considered to be possibly being used by internet related business operators.

(1) Reduction of IPv4 addresses (NAT) and utilization of translators

[1] Reduction of IPv4 addresses through utilization of Network Address Translation (NAT)

Network Address Translation (NAT)[21] is technology for use in an IP address being shared by multiple devices. It separates networks within work places and homes as LANs (Local Area Network) and then uses private addresses[22] to communicate within LANs and global addresses within the overall LAN setup to communicate with external networks[23].

Introduction of NAT by ISPs enables an IP address to be shared by multiple users, thereby reducing the number of necessary IP addresses. Large scale NATs introduced by ISPs are called LSNs (Large Scale NATs).

[2] Utilization of translators

Upon IPv4 addresses being exhausted newly established networks in the future will communicate using IPv6. The communication methods differ between IPv4 and IPv6 and the communication cannot take place directly. Interconnection between IPv4 networks and IPv6 networks therefore requires the communication methods to be translated. At present available translators use the Proxy method[24], NAT-PT method[25], and TRT method[26], etc.

Each of the above measures has been established to a certain degree in terms of technology and products that support the methods are available in the market, and thus early IPv6 support is considered possible[27]. Issues do remain, however, that include some of the applications not appropriately operating[28] or some functions being limited due to the communication having to be

[21] NAPT (Network Address Port Translation) used to translate port numbers in addition to IP addresses included here. (Port number: a number ranging from 0 to 65,535 used for mutually distinguishing between programs when multiple programs on the same network devices communicate using IP addresses)
[22] Also called local addresses.
[23] Called a WAN (Wide Area Network) in contrast to a LAN.
[24] A translation method within the application layer.
[25] Network Address Translation-Protocol Translation method: a method of translating IPv4 and IPv6 addresses in collaboration with DNS.
[26] Transport Relay Translator method: a translation method within the transport layer.
[27] Implementation of this measure does not dispense with the necessity of IPv4 global addresses. Service providers will therefore need to secure any IPv4 global addresses required in providing services in the future.
[28] With NAT, for example, parts of some websites may not display due to a limitation on the number of sessions (the number of communications that can be made at the same time).

translated along the way. In addition, the acquisition and storage of log information is costly because the large amount of log information that needs to be stored, with some business operators possibly having to forgo the acquisition and storage of log information. This could then make identifying the source of attacks difficult in the case of cyber attacks over the internet, for example. There are some concerns over the safe and secure operation/development of the internet therefore being impeded.

(2) Reallocation of IPv4 addresses

[1] Current status with migration of IPv4 address

Reallocation of IPv4 addresses involves the cases in which IPv4 addresses are voluntarily returned to RIR and in which a migration of IPv4 addresses are transferred between business operators, including ISPs, etc.

The transfer of IP addresses is already being implemented or is at the stage of being prepared for in some RIR. (Table 1-3-1)

Table 1-3-1 Trends with implementation of procedures for IPv4 address transfer in respective regions

RIR	Status	Implementation period (plan)
APNIC (Asia-Pacific)	At the stage of preparing for implementation and a consensus being reached	Around February 2010
RIPE NCC (Europe and Middle East)	Already implemented	December 2008
ARIN (North America)	Already implemented	June 2009
LACNIC (Middle and South America)	Discussion being made at Communities	Unknown
AfriNIC (Africa)	Not proposed	Unknown

Discussions have also commenced by JPNIC in response to efforts made in implementing the transfer of IPv4 addresses within APNIC. The IPv4 address transfer may be implemented in 2010 if things go as planned, although the details, including the implementation period, are yet to be determined. (Reference Document-7)

[2] Estimation of distribution amount of IPv4 addresses resulting from implementation of IP address transfer

Although making an accurate estimation is difficult the following rough estimates suggest that reallocation of the number of IPv4 addresses approximately equivalent to an annual demand over 0.9 of a year is considered possible.

- The number of IPv4 addresses allocated as former class A addresses: 38
- Of which the number of IPv4 addresses for routing tables: 20 (these addresses are assumed to be already in use on the internet)

- The remaining IPv4 addresses that are not for routing tables: 18 (these addresses are assumed to be in use in internal networks, including intranets, etc.)
- Of which approximately half of the IP addresses can be replaced and assumed for distribution in the market: 9 (approximately equivalent to the annual demand over 0.9 of a year)

(Unit of the number of addresses is "/8" (equivalent to approximately 1,680 IPv4 addresses))

The advantage of adopting this measure is that network modification costs are not required because the introduction of new devices and communication methods is not necessary. At present, however, how it will be operated remains unclear and the number of IPv4 addresses that can be reallocated considered quite small. It is therefore not considered to be a permanent solution.

(3) Introduction of IPv6

Introduction of IPv6, the successor standard to IPv4, for existing networks that currently use IPv4 communications could solve the basic problem of the availability of only approximately 4.3 billion IPv4 addresses.

Ceasing use of IPv4 addresses and only using IPv6 addresses, however, is impractical and thus maintaining an environment that enables mutual communication between IPv4 and IPv6 (dual stack environment) will be required for a certain period. Completing IPv6 support is therefore considered to require a large amount of both time and money.

(4) Comparison of respective measures

The characteristics of the respective measures are as compiled in Table 1-3-2, and from this facilitating a reduction in IPv4 address (NAT) use and utilization of translators as a short-term solution but introducing IPv6 as the essential solution is considered appropriate. The transfer of IPv4 addresses remains unclear and at present adopting this measure is considered quite risky.

Table 1-3-2 Characteristics of measures for IPv4 address exhaustion

Measure	Utilization of NAT/translators	Reallocation of IPv4 addresses	Introduction of IPv6
Early implementation	○	▲ (at present unclear)	x
Impact on existing services	x	○	○
Possibility of being essential solution	x	x	○

2. Status with progress of response measures taken by internet related business operators

The level of progress of response measures taken by internet related business operators can be

indicated to be in the follow order:

- 1st stage: The stage at which business operators grow aware of IPv4 address being exhausted
- 2nd stage: The stage at which business operators recognize and understand the impact of that exhaustion
- 3rd stage: The stage at which issues start being analyzed and identified by business operators
- 4th stage: The stage at which response measures start being discussed
- 5th stage: The stage at which response measures are determined upon
- 6th stage: The stage at which implementation plans for response measures get formulated
- 7th stage: The stage at which response measures get implemented

The Task Force on IPv4 Address Exhaustion conducted a survey which revealed the status with progress of responses in various industries to be follows.

(1) ISPs, ASPs, and content service providers (CSPs)

Approximately 70% to 80% of business operators recognize and understand the impact of the exhaustion (2nd stage) and only the leading groups implement response measures (4th stage).

(2) Communications device vendors

Less than half of business operators recognize the impact (2nd stage). Concrete information on the level of the impact of IPv4 address exhaustion and the necessity for a response can be considered inadequate.

(3) Software developers

Same as communications device vendors.

(4) System Integrators (SIers)

Same as communications device vendors.

3. Current situation with information provision to Internet related business operators

Information needs to be appropriately provided to internet related business operators according to the stage they are at. At present the Task Force on IPv4 Address Exhaustion has been providing them with the following information after having identified the status of the progress of responses taken by respective industries. (Reference Document-8)

(1) ISPs, ASPs, and CSPs

Improved recognition of the issue is considered to have taken place but updates on any relevant

information will continue to be made in the future. Information on concrete measures (How-To information), in particular, will continue to be provided.

Regular events held to provide updated information, practical training on IPv6 network operation (hands-on seminars) through member organizations of the Task Force, and improving the test beds, etc. will continue to take place. In addition, the provision of support for the formulation of action plans by business operators will also be promoted.

(2) Communications device vendors

The level of progress and issues vary with the type of device concerned. Strategies will therefore need to be discussed separately for each type of device in the future. Questionnaire surveys will also be conducted on participants at events such as CEATEC, etc.

(3) Software developers

Discussions will be held on the content of information provided to facilitate improved recognition and identification of the impact (information on the necessity of response measures via applications and response plans by communications business operators, etc.). Channels for providing information to software developers/enterprises will also be developed.

Presentations, documents, and questionnaire surveys will be actively provided at conferences, including Open Source Conferences (OSC), etc., in which software developers participate.

(4) System Integrators (SIers)

The status of the IPv4 address exhaustion will first be disseminated and SIers notified of business opportunities. The systems handled by SIers vary, and hence discussion of areas and periods of response and solutions required by them will be supported.

Seminars and questionnaire surveys on member organizations, etc. will be conducted in cooperation with the relevant organizations, including the Japan Information Technology Services Industry Association (JISA) and Japan Users Association of Information Systems (JUSA), etc.

4. Example of concrete response measures by internet related business operators

Some internet related business operators have already commenced using concrete measures in response to IPv4 address exhaustion, with reference cases of concrete measures being as follows.

(1) Response measures by ISPs and CATV business operators

According to a questionnaire survey provided to ISPs and the "Results of a Survey on the Status with Provision of IPv6 Connection Services" (March 2009, Ministry of Internal Affairs and Communications)[29] approximately 27% of ISPs were discussing response measures for use with IPv4 address exhaustion (including those that have already formulated or are implementing response measures) as of the end of March 2009.

In addition, hearings held by the Study Group revealed that some ISPs, including Internet Initiative Japan, NEC BIGLOBE, NTT Communications, So-net Entertainment, and NIFTY, etc., ISPs with own access networks, including SoftBank Group, KDDI, and K-Opticom, etc., and CATV business operators, including Jupiter Telecommunications, etc., have already commenced discussing the introduction of LSN and/or IPV6 adoption, etc. These business operators accounted for approximately 75%[30] of the share of all subscriptions. Some business operators plan to start providing IPv6 enabled services in around 2011. (Reference Documents-9, 10, 11)

The period and methods of response measures taken by ISPs depend on the period and method of response taken with access networks. At present, therefore, discussions are mainly taking place on IPv6 internet connection services via the NGN of NTT East and West for which methods of adopting IPv6 have already been determined.

In addition, the types of services provided to individual users by ISPs have been classified, as in Figure 1-3-3. The characteristics of the respective types are as indicated in Table 1-3-4.

[29] http://www.soumu.go.jp/menu_seisaku/ictseisaku/ipv6/pdf/090327_1_i1.pdf
[30] This does not indicate the percentage of subscribers subject to response measures for IPv4 address exhaustion by ISPs. (At present whether response measures for IPv4 exhaustion will be taken for all the service menus provided by the above ISPs is yet to have been decided)

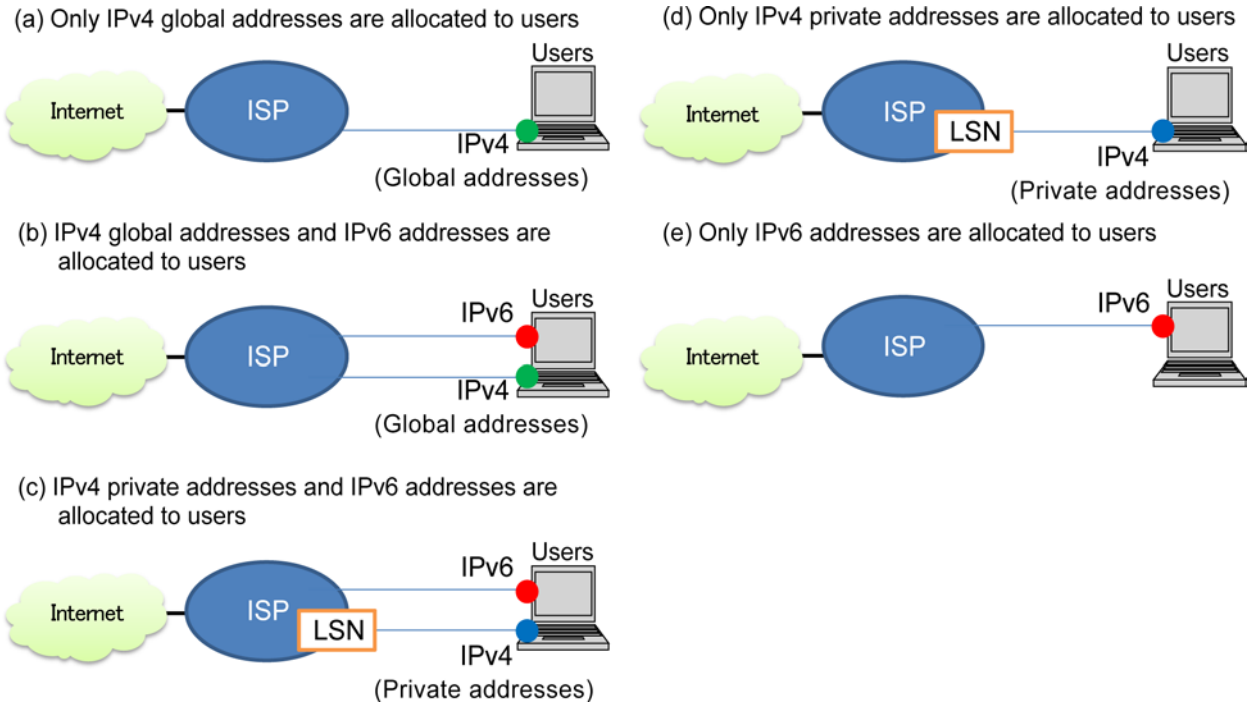

Figure 1-3-3 Examples of types of services provided to individual users by ISPs

Table 1-3-4 Characteristics of respective services

	(a)	(b)	(c)	(d)	(e)
IPv4 addresses allocated	Global	Global	Private	Private	Not allocated
Allocation of IPv6 addresses	×	○	○	×	○
Networks operated by ISPs	IPv4 only	IPv4 and IPv6	IPv4 and IPv6	IPv4 only	IPv6 only
Acceptance of new subscribers	Unable to accept if IPv4 addresses exhausted	Unable to accept if of IPv4 addresses exhausted	○	○	○
Introduction of LSN	Not required	Not required	Required	Required	Not required
Impact on users of existing services	None	None	Small	May be partially limited	Services cannot be used without IPv6 being adopted by service providers

(2) Response measures by business operators of access networks

Discussions on IPv6 being adopted for use in access networks have been commenced upon by some business operators and implementation of response measures, including support for devices and establishment of operating systems, etc. are being arranged. With the NGN of NTT East and West, for example, connection methods for ISPs have been determined; with the commencement of

service provision being planned for April 2011 (refer to Section 1). Discussions on response measures mainly with FTTH are also underway by KDDI, SoftBank Group, and K-Opticom, etc.

(3) Response measures by mobile business operators

Internet access using mobile phones and data communication terminals is increasing from the networks of mobile business operators. Similar to fixed internet access, therefore, discussions on response measures for IPv4 address exhaustion also need to take place with regard to mobile internet access. A US business operator Verison, for example, requests that the allocation of IPv6 addresses be enabled within the specifications of LTE[31] terminals. At present mobile phone business operators in Japan have not announced any concrete measures that include current and future services such as LTE, etc.

Some MVNO[32] business operators are however discussing IPv6 adoption measures. Japan Communications, for example, are providing services in the form of allocating IP addresses to user terminals itself (layer-2 connections) and is discussing a method of allocating IPv6 addresses to user terminals by enabling devices used within its own networks to utilize IPv6.

[31] Long Term Evolution: A new mobile phone standard called the 3.9th generation mobile phones in contrast to the 3rd generation mobile phones that are widely in use at present.
[32] Mobile Virtual Network Operators.

Section 4 Trends in Foreign Countries

Various measures for IPv6 promotion are also being taken in foreign countries. (Reference Document-12)

(1) Formulation of action plans, etc. by governments

Measures taken by governments, for example, include the federal government providing a common roadmap toward IPv6 adoption in the U.S.A. In the EU a report titled “Advancing the Internet: Action Plan for the deployment of Internet Protocol version 6 (IPv6) in Europe” was adopted in May 2008. In France one of 154 measures within “Digital France 2012”, published in October 2008, provides for “compatibility with IPv6 being required within government procurements in a stepwise manner from 2009 on”. The model project of China Next Generation Internet (CNGI) has been promoted since December 2003 in China and a “Basic Plan for Management of Internet Address Resources, etc.” formulated in December 2008 in Korea. In Australia the Australian Government Information Management Office formulated strategies for migrating from IPv4 software and hardware owned by all Australian Government agencies to IPv6 enabled software and hardware in 2007. As seen above government level IPv6 promotion plans have been formulated in several countries.

(2) Measures in cooperation between the government and public sector

In the U.K., for example, migration to IPv6 has been promoted in cooperation between the government, industry, and private experts, etc. under the “UK IPv6 Task Force”. In Korea a “IPv6 Migration Promotion Council” was organized with the involvement of the government and private industry experts, etc. and an “IPv6 Migration Support Center” established within the National Internet Development Agency of Korea (governmental agency) to promote IPv6 from various points of views.

(3) Measures for development of engineers

Various measures to develop IPv6 engineers have been taken in France, Korea, and Australia, etc. The Victorian State Government in Australia, for example, has been providing funds for IPv6 test bed networks with participation from the communications sector and other sectors related to IPv6 migration, including the construction, medical, financial, and vehicle sectors, etc. Various measures to deal with a shortage of engineers have also been taken in several countries.

(4) Other measures

In addition to government measures the importance of taking measures in cooperation with other countries through international frameworks that include ICANN and Organization for Economic

Cooperation Development (OECD), etc., and international activities by industry organizations has been recognized.

For example, ICANN intends to put efforts into educational and promotional activities in cooperation between the ICANN Board and regional internet registries, etc. using the assumption of that IPv4 addresses will be exhausted within a few years and in view of future internet developments depending on the timely introduction of IPv6.

In addition, OECD has also been taking measures to respond to IPv4 address exhaustion. The report “Internet Address Space: Economic Considerations with the Management of IPv4 and in the Deployment of IPv6” compiled by OECD in 2007 emphasized with respect to the issue of IPv4 address exhaustion that, similar to service continuity, the maintenance of security and stability of services requires the creation of policy environments for implementing a “migration to IPv6” in a timely manner being necessary. In consideration of IPv4 address exhaustion and contributing to the development of the internet economy the adoption of the new version of the internet protocol (IPv6) was encouraged through IPv6 being adopted in a timely manner by major IPv4 address users and the government, in particular, at the OECD Seoul Ministerial Meeting on the future internet economy held in June 2008.

International activities by industry organizations include, for example, promotion of the “IPv6 Ready Logo Program”, which certifies IPv6 enabled websites and ISPs implemented by the IPv6 Forum, an international IPv6 promotion organization that has as participation global communications business operators and research organizations, etc. In addition, the North American IPv6 Task Force (NAv6TF) has been providing specialized knowledge required in promoting use of IPv6 in cooperation with industry organizations and the government. As indicated above, various IPv6 promotion activities have been implemented from the international level down to the regional level.

Chapter 2 Present Issues and Responses

Considering the above facts any responses to the issue of IPv4 address exhaustion need to minimize the impact and confusion caused by that exhaustion and promote the use of IPv6. From this point of view the Study Group provides the following summary.

Section 1 Promotion of Strategic Publicity

1. Necessity for Publicity

The internet is used in various ways in people's lives as a basis for social and economic activities, and hence the IPv4 address exhaustion could have an impact on and confuse both individual users and corporate users. Disseminating the appropriate information on IPv4 address exhaustion and any issues it could rise to, etc. and calling for the appropriate responses, or that is, publicity, is thus considered extremely important.

Various parties are involved with the internet, including communications business operators, ISPs, ASPs, Content Service Providers (CSPs), communication device vendors, software developers, and SIers, etc., thus making appropriate publicity to all relevant parties by the pertinent parties important in effective responding to the IPv4 address exhaustion issue. In addition, the environment through which users access the internet could change and the burden imposed on users (not limited to just the financial burden), and thus making publicity on the issue for both internet related business operators and users being considered very important.

2. Content and period of publicity

The following content will need to be appropriately publicized:

- IPv4 addresses will be exhausted and not available for new allocation within a few years
- This will make serving new users and the provision of new services difficult and could thus impede development of the internet, which has been such a support to social developments
- In addition, the introduction of IPv6, the successor standard to IPv4, will enable continued development of the internet

In addition, the realization of environments in which all internet related business operators can appropriately disclose information considered necessary in enabling easy acquisition of the required information will be necessary.

Furthermore, the data needed in completing response measures for IPv4 exhaustion is also important. Application of the two models of the Geoff Model and Moderate Model result in IPv4 addresses estimating to be unavailable for new allocation from around the middle of 2012 (Section 2 of Chapter 1). That estimation was based on actual figures of past IP address allocations and the actual status with IP address use, etc. In actuality, however, economic conditions, etc. will also have

an impact, thus making a precise estimation extremely difficult. The unallocated IPv4 address pool is down to less than 10% of the total, however, and thus changes in the estimated exhaustion period due to uncertainties are considered fairly small. Response measures using the assumption that IPv4 addresses will be exhausted within the next two years or thereabouts are therefore considered necessary.

Furthermore, the stable provision of services using IPv6 technologies can be considered to take some time. In view of avoiding any confusion to users, etc. setting the target period for response measures to be taken by internet related business operators of rather than being immediately after a little earlier than the IPv4 address exhaustion is considered appropriate.

Internet related business operators are therefore being requested to respond to the IPv4 address exhaustion issue by early 2011.

The respective business operators will, however, need to make optimal schedules in consideration of their own status. Business operators that cannot respond by early 2011, for example, will need to realist that a risk is involved that the services they provide and users of those services could be impaired.

3. Subjects of publicity

(1) Publicity to internet related business operators

Publicity being provided to internet related business operators has been promoted by the Task Force on IPv4 Address Exhaustion after identifying the status of progress of responses by respective industries and formulating the required publicity strategies and concrete methods. It is expected to continue to be appropriately implemented. (Section 3 of Chapter 1)

As indicated above responding to the IPv4 address exhaustion issue in cooperation with all internet related business operators is very important. However, responses from other business operators tend to have been rather slow and without sufficient progress being made with responses from ISPs that provide internet connection functions in particular. Considering that at present some ISPs have already commenced implementing concrete measures initially promoting response measures from ISPs and then conducting publicity activities in maintaining pace with other internet related business operators is thus considered effective.

(2) Publicity to users by internet related business operators

Regardless of being an individual or corporate user ISPs are typically the direct point of contact to the internet. The concrete impact of IPv4 address exhaustion on users will thus depend on how ISPs respond. Or in other words responses by users will completely differ depending on the ISPs that users are receiving services from.

Basically providing publicity to users through the ISPs that serve as the “window to the internet” is therefore considered appropriate. IPv6 adoption by corporate users, however, is mainly being discussed by SIers, etc. in most cases. In such cases SIers, etc. will be expected to analyze the impact on customers, including corporate users, etc., in cooperation with ISPs and appropriately publicize the results for corporate users, etc. In addition the content and period of publicity to individual users will also need to be made according to the following types of users:

- Users of the internet who are unaware of the particular IP version
- Users with relatively high information literacy that understand the issue posed by the IPv4 address exhaustion
- Advanced users

In addition, many inquiries from individual users can be expected, for example, whether online games they are currently using will continue to be available or not, or what types of televisions should be selected when purchasing new televisions that can connect to the internet, etc. Other internet related business operators will therefore need to provide the appropriate publicity in line with publicity provided by ISPs.

4. Appropriate publicity by ISPs

With publicity being provided to internet related business operators as well as individual users ISPs playing the leading/main part in response measures will be important. Improved response measures for IPv4 address exhaustion by ISPs are therefore being expected.

Response measures for IPv4 address exhaustion by ISPs will be related to the business operations of respective business operators. The period and methods, etc., therefore, will basically need to be determined individually but with user trends and the management environments, etc. of the respective business operators taken into account.

The assumption is that the above idea will be used but ISPs maintaining the pace of the period of response to IPv4 address exhaustion could also be effective. If no systematic issues existing were to be assumed, for example, ISPs could voluntarily set a common cooperative target period using action plans formulated by the Task Force on IPv4 Address Exhaustion as reference material.

(1) Formulation of “Guidelines for Information Disclosure on IPv4 Address Exhaustion by ISPs (tentative name)”

ISPs will be expected to specify whether they have responded to IPv4 address exhaustion or not and concrete methods and the period, etc. used when implementing response measures in minimizing any impact, etc. from the IPv4 address exhaustion on their individual/corporate users, etc.

Ensuring ISPs can provide the appropriate information to users leads to the rapid formulation of

“Guidelines for Information Disclosure on IPv4 Address Exhaustion by ISPs (tentative name)” by the government with consideration given to the opinions of the relevant business operators, etc. therefore being expected

The establishment of a system for providing information on the status of responses to IPv4 address exhaustion by ISPs to users and other internet related business operators, etc. in an understandable manner can be considered to occur from business operator organizations, etc. utilizing the guidelines as required.

For example, the following items can be considered to be included when disclosing information provided for in the guidelines:

[1] Response to IPv4 address exhaustion

Whether measures against the IPv4 address exhaustion will be used with services provided by them or not. And if measures against IPv4 address exhaustion will be taken which services measures will be taken and which services measures not taken with the multiple service menus provided by them.

[2] Concrete measures/period of measures to be taken

If measures for IPv4 address exhaustion will be taken, and of the service types indicated in Figure 1-3-3, for example, which type of services will be adopted, when they will be adopted, and whether other types of services will be adopted or not.

[3] Methods and cost of using IPv6 enabled services by users

If NGN of NTT East and West will be used to provide IPv6 internet connection services, for example, whether users will be able to continue using home gateways or whether new devices will be required, and the cost, which will depend on the method, i.e. tunnel method or native method, adopted by ISPs.

[4] Services and their content that will be limited due to IPv6 adoption or measures for IPv4 address exhaustion by ISPs

What limitations measures against IPv4 address exhaustion adopted by ISPs will have on existing services. Disclosing this information in cooperation with service providers after examining as many services as possible is considered desirable.

[5] Schedule for response to IPv4 address exhaustion[33]

[33] This information will also be required when internet related business operators other than ISPs take

Schedule via which ISPs will actually implement response measures.

These items are expected to be updated in a timely manner as required, but with early disclosure being the most desirable. Any items that are difficult to disclose will necessitate indicating the expected time when the information can be disclosed being considered.

(2) Implementation of "preliminary experiment on introduction of IPv6" and development of "response manuals for inquiries from users"

Usage environments are expected to significantly change once new types of services, including IPv6 enabled services, etc., start being provided. Attention will therefore need to be paid to the following points in avoiding any confusion to users.

- Appropriately explanations being made in advance when providing new types of services, including IPv6 enabled services, etc.
- Thoroughly responding to inquiries from users after commencing provision of new types of services

Thoroughly responding to inquiries from users, in particular, will require support systems to be set up in advance. More concretely, trial implementations (rehearsals) of the provision of IPv6 internet connection services and establishment of common user support centers for a specific period can be considered necessary. Clarifying the social/economic impact of and required response to assumed situations both before and after the IPv4 address exhaustion, collecting reference cases of issues caused by IPv4 address exhaustion, and creating response manuals for inquiries from users through these measures will also be required.

Response measures taken by individual ISPs at the time of exhaustion will be limited. Unified implementation within the industry is therefore considered necessary while government cooperation can also be expected to cooperate as necessary from the point of view of avoiding any confusion to users, etc.

5. Appropriate publicity by internet related business operators other than ISPs

The necessity for the appropriate information to be disclosed by ISPs, as indicated above, also applies to internet related business operators other than ISPs. Unified content, a set period, and a general framework for publicity are considered desirable.

(1) Business operators of access networks

Similarly to ISPs business operators of access networks (fixed and wireless) are a direct point of

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measures against IPv4 address exhaustion with the services or devices, etc. they provide.

contact for users. Early and appropriate disclosure of information on their response to IPv4 address exhaustion is therefore also necessary.

More concretely, discussions on IPv6 adoption are being held by some business operators, mainly FTTH and CATV operators, but including the NGN of NTT East and West. With other networks, including ADSL and dial-up, etc., discussions on the status, period, and methods, etc. of IPv4 address exhaustion and early and appropriate information disclosure can be expected to take place.

(2) Mobile business operators

Internet access via the networks of mobile phone business operators is increasing in popularity. Similar to fixed networks discussions on the status, period, and methods, etc. of IPv4 address exhaustion and early and appropriate information disclosure can therefore also be expected to be held by mobile phone business operators.

(3) Communications device vendors, etc.

Communications device vendors are expected to acquire IPv6 Ready Logos for "IPv6 enabled products" and to disclose information in an early and appropriate manner on which functions will be IPv6 enabled and which will not.

When SIers, etc. explain the necessity of IPv6 adoption to customers, including corporate users, etc., using objective documents prepared by third parties, including the government or industry organizations, etc., the most effective would be clarifying that it is not solely based on the commercial activities by SIers, etc.

6. Other points requiring consideration

In addition to the above the following points will also require consideration.

(1) Publicity to internet related business operators that will not adopt IPv6

Some user terminals are already IPv6 enabled[34] and IPv6 communications are taking place over the internet. IPv6 communications may therefore take place over the networks of Internet related business operators even if they have not adopted IPv6. From the point of view of security, therefore, appropriate publicity will need to be provided to internet related business operators that have not adopted IPv6 that they will be expected to discuss IPv6 adoption[35].

[34] For example, a lot of basic software for computers is already being designed on the assumption of IPv6 enabled environments (or environments in which IPv4 and IPv6 coexist).
[35] Appropriate control, including disconnection of IPv6 communications, etc., will be necessary in avoiding any security problems caused by unanticipated problems with servers and routers, etc. that are not IPv6 enabled.

(2) Quantitative identification of IPv6 penetration

Quantitatively identifying the current level of IPv6 penetration on the internet is effective in promoting the adoption of IPv6. Continued measurement of the following items with regard to internet traffic, for example, is therefore required. (Reference Document-13)

- Status with IPv6 address allocation
- Comparison of IPv4 and IPv6 requests to DNS servers
- Status with IPv6 adoption with the major services (websites, DNS, e-mail) in domains
- Comparison of IPv6/IPv6 access to dual stack web servers
- Comparison of IPv4 and IPv6 in routing information using BGP

At present IPv6 is in the process of being introduced and the fact is that the quality of communication using IPv6 is relatively low (large delays) when compared to that using IPv4[36]. That difference in quality is considered to be mainly caused by insufficient progress in IPv6 being adopted[37] over the internet and can be assumed decrease as IPv6 adoption progresses.

Appropriate publicity is therefore required to avoid promotion of IPv6 use being impeded through dissemination of incorrect knowledge such as “IPv6 results in a slower communication speed than IPv4”. There are opinions, however, that the subjects of publicity will need to be appropriately selected because it could result in confusion to any users that are unaware of a difference in latency.

[36] According to the survey conducted by Intec NetCore a measurement of access to web servers from IPv6 enabled users indicated at present a delay of tens of milliseconds per communication. The impact of that delay on the typical speed of sending/receiving e-mail or viewing simple websites is therefore considered insignificantly small. In cases requiring multiple communications, such as viewing very rich content websites, however, the tens of milliseconds of latencies could add up, thus resulting in a more significant impact on typical speeds.

[37] If sections that only support IPv4 exist on the communication route, for example, IPv6 communication requires them to be bypassed, etc., thus resulting in a larger delay when compared to IPv4 communication.

Section 2 Realization of “Internet Society of Equipment”

Diverse use of the internet is progressing as communications are taking place at the “equipment” level in addition to at the “organization” and “individual” levels. Active utilization of IPv6, including realization of an “Internet Society of Equipment” via use of IPv6 is therefore considered to be a great driving force for new growth strategies in Japan.

1. Role of IPv6 in realization of “Internet Society of Equipment”

(1) “Internet Society of Equipment”

Changes in the environment surrounding the internet have resulted in communications not only being made at the “organization” and “individual” levels but also the “equipment” level. A society in which the convenience of ICT can be enjoyed in various ways in people’s lives, or an “Internet Society of Equipment[38]”, is thus considered realizable through communication (exchange of information) between “individuals” and “equipment” and “equipment” and other “equipment”.

More concretely, the realization of an “Internet Society of Equipment” will enable the convenience of ICT to be taken advantage of in medical, disaster prevention, and educational situations, etc. that are base of social lives as well as in the environmental sector, in which particular importance is being recognized in recent years.

(2) “IPv6” and “Internet Society of Equipment”

An “Internet Society of Equipment” has the following characteristics, and consideration of them lead to the utilization of IPv6 needing to be further promoted as a core technology in support of an Internet Society of Equipment”.

- **Development of an environment in which many devices can be connected to open networks**

An “Internet Society of Equipment will involve” establishing individual networks not only as private networks but also as open networks that are connected to the internet, etc. which will then enable the provision of more flexible and convenient services, for example the provision of services by combining multiple sensor networks or utilization of a sensor network in multiple services, etc. With an “Internet Society of Equipment”, therefore, networks can be considered in many cases to be implemented using IP addresses that are used on the internet, with a very large number of devices then resulting in being connected to the network. It will therefore be considered practical to use IPv6

[38] Sometimes used to refer to RFID networks such as electronic tags, etc., although only in a narrow sense, but actually also to networks to which devices other than PCs connect, including networks of information home appliances and sensor networks, etc. here.

addresses as Ipv4 addresses[39] have limited availability.

- **Utilization of "cloud networks"**

Utilization of IPv6 will enable the establishment of complex large-scale networks more efficiently than IPv4 because of the address design being easier[40]. IPv6 will also enable easier management and expandable IP address usage with server virtualization and allocation of IP addresses to network devices according to the network structure via use of spare addresses, etc. whereas IPv4 has limited ease of management and expandability because the number of available addresses is inadequate and thus they need to be carefully used without being wasted.

In addition, servers can be allocated with multiple IP addresses for networks using virtualization technologies, including cloud technologies, etc., thus making it more practical to implement such networks using IPv6 addresses rather than IPv4 addresses, which have limited availability.

- **Utilization of "direct communication"**

Low-latency high-quality communications through direct communications without (or minimized) server intervention, etc. are assumed to be necessary in the "Internet Society of Equipment". The number of IP addresses is limited with IPv4 and furthermore NAT is generally used to share global IP addresses between multiple devices, thus making direct communications even more difficult. IPv6 addresses in contrast are practically unlimited in number and global IP addresses can be allocated to respective devices. With IPv6 NAT is not required and direct communications can easily be implemented.

It should be noted, however, that the following issues were pointed out to exist with direct communications:

- Direct communications with devices will increase security risks[41] as they lead to greater susceptibility to external attacks, thus requiring address conversion mechanisms (NAT) as firewalls.
- If devices are allocated with fixed IP addresses the IP address itself will be private information, thus requiring NAT.

[39] NAT will enable more devices to be handled using IPv4 addresses but two-way communications will then be more difficult.
[40] IPv6 will enable easier management and expandable IP address usage with allocation of IP addresses to network devices according to the network structure via use of spare addresses, etc. For example, "hotel room numbers" are assigned according to the "structure of the building", for example rooms on the fifth floor being assigned with numbers between 500 and 599, which results in "room numbers" being not used but the convenience (floors can easily be identified using the room number) and expandability (new rooms can be added with the same numbering scheme) improved.
[41] It has also been pointed out, however, that identifying the source of attacks will be relatively easy in such cases.

Direct communications using IPv6 are therefore not always the most appropriate.

2. Active utilization of IPv6 in various sectors

The emergence of new services can be assumed to occur in the future with the realization of an "Internet Society of Equipment" via use of IPv6. Active development of these new services both domestically and overseas can be considered to make a contribution to strengthening the international competitiveness of Japan. More concretely, active utilization of IPv6 toward realization of an "Internet Society of Equipment" in the following sectors is being considered.

(1) Active utilization in environmental sector

Measures to reduce the impact of economic activities on the global environment via improved efficiency and reduced movement provided through ICT utilization have been making progress in recent years. Measures known as smart grids and smart meters[42] in particular are being promoted in reducing electricity consumption and CO_2 emissions via improved more efficient energy usage through active ICT utilization. In addition, measures that enable more effective acquisition/analysis of environmental information through utilization of sensor networks, including estimation of short-term and regional climate changes and reduction of the heat island phenomenon, etc., are also being used.

The realization of an "Internet Society of Equipment" using IPv6 is also considered effective in measures to reduce the environmental impact. Dealing with the various issues via proof-of-concept experiments, etc. is therefore necessary.

As a method of facilitating measures to improve energy usage efficiency at homes and in office buildings, for example, reducing the cost of smart meters is being considered. This will require simplifying smart meter functions as much as possible while also implementing the necessary processes on the network side. In doing so the following issues will need to be resolved:

- How smart meters are controlled from the network side through utilizing IPv6 technologies
- Which functions should be implemented on the smart meter side and which on the network side
- What are the technological requirements of processes on the network side that utilize cloud technologies, for example, the information security that clouds will need to provide

Promotion of these measures is considered effective in facilitating ICT utilization in an "Internet Society of Equipment".

(2) Active utilization in mobile sector

[42] Advanced electric power meters with communication functions that manage/control home appliances, etc. via networks.

Utilization of mobile phone networks, etc. is essential in realizing an environment in which everything can be connected to the internet as an “Internet Society of Equipment”. Active utilization of IPv6 in the mobile sector is therefore expected.

For example, service provision of LTE will commence in 2010 and IPv6 (or both IPv4 and IPv6) is expected to be used for the internet access from user terminals.

Section 3 Further Promotion of Conventional Measures

1. Development of results of measures

Various measures for IPv4 address exhaustion have to date been implemented (Section 1 of Chapter 1) but domestic/overseas development of the results of those measures is still necessary.

“Development of test beds for acquiring IPv6 operation skills” implemented by the Ministry of Internal Affairs and Communications, in particular, is taking place, although mainly aimed at the development of engineers who will be capable of operating/establishing a complex large-scale internet system using IPv6. In addition to the development of engineers various other skills and knowledge on the introduction of IPv6 over IPv4 networks and the management/operation of IPv6 networks are being amassed.

The development of engineers for network business operators via test beds is making steady progress. Expanding the equipment as required and further facilitating use by ASPs and CSPs, etc. will, however, be required in the future. Furthermore, in addition to facilitating a smooth response to IPv4 address exhaustion over the internet the expansion of the network based industry through dissemination/utilization of IPv6 as part of a growth strategy in Japan can be expected with the government consistently providing environments for verifying IPv6 from an “independent position” without having to depend on any specific enterprises or technologies.

Utilization of accumulated knowledge both domestically and overseas, including proposing standardization at IETF, etc. and enabling overseas engineers to utilize the test beds, will also be important in the development of a network based industry in Japan.

2. Strengthening international cooperation

The course of promoting IPv6 adoption over the internet due to IPv4 address exhaustion is internationally inevitable. When implementing IPv6 adoption as a measure against IPv4 address exhaustion international collaboration is therefore desirable in determining the necessary period and methods because an abrupt change in the internet usage environment can be expected. The following measures may be considered, for example, in realizing this.

(1) Provision of Information to foreign countries

Promoting measures for IPv4 address exhaustion while also securing international consistency through actively providing information on advanced measures in Japan to foreign countries can be expected.

(2) Overseas development of IPv6 related technologies and know-how

Needs with the provision of acquired knowledge and technical information regarding advanced technologies and know-how on measures for IPv4 address exhaustion and IPv6 adoption are considered to be quite large.

More concretely, the promotion of cooperation with IPv6 adoption within the APEC-TEL and Japan-ASEAN framework can be considered effective in strengthening collaborations in the Asia region. Comprehensive promotion of cooperation with IPv6, including supporting IPv6 engineer developments, etc., was agreed upon with ASEAN In the “ASEAN-Japan ICT Work Plan for 2008-2009” adopted between Japan and ASEAN in 2008. In accordance Japan has been dispatching engineers, mainly from the IPv6 Promotion Council, to Malaysia to provide technical training on the interoperability of IPv6 devices. These measures will need to continue to be promoted.

(3) Domestically provision of information on status of measures in foreign countries

Securing international consistency and strengthening international competitiveness necessitate information being obtained on measures implemented by the government and private business operators in foreign countries, with the appropriate provision of that information domestically in cooperation between the government and private sector then being important in promoting measures against IPv4 address exhaustion.

3. Promotion of IPv6 adoption for use in electronic government

The government and local governments also need to promote IPv6 adoption for use in electronic government systems in ensuring fair provision of services to the people via the internet. Appropriate cooperation between the government, which will manage the system, and private sector, which will establish and provide the system, is thus important with IPv6 being adopted for use in electronic government systems, with the roles of the Task Force on IPv4 Address Exhaustion, and the Local Authorities Systems Development Center and Association for Promotion of Public Local Information and Communication, which support promotion of information technology usage by local governments and regions, therefore being considered to be quite large.

Discussions on establishment of a new electronic government system and local governments using cloud networks, for example, will need to be held with consideration also given to IPv6 adoption.

In addition, taking the initiative in IPv6 being adopted for use in electronic government and electronic local government systems is also expected to facilitate IPv6 adoption in the private sector.

Section 4 Future Issues

Future issues with promoting response measures for IPv4 address exhaustion and an “Internet Society of Equipment” using IPv6 are as follows. These issues need to be solved via an appropriate division of roles between the government and the private sector.

1. Systematic issues

The following issues, for example, are included as being systematic.

(1) Issues with privacy and data protection

With IPv4 user devices are not allocated a fixed IP address and instead a dynamically allocated IP address, in general. With IPv6 IP addresses are assumed to be of fixed allocation in many cases[43], thereby necessitating that sufficient consideration be paid to the fact that IP addresses linked to users could therefore be private information.

(2) Issues with emergence of new services, etc.

Rapid changes in technologies and services can be assumed with the emergence of an “Internet Society of Equipment” but the systems to deal with those changes may be slow to be established. In addition, a number of business operators are involved in providing on internet services, thus making their relationship complex and solving issues resulting from problems difficult. Systems to use in clarifying a division of responsibility and identifying the cause of any problems and systems for effectively solving any issues are therefore necessary.

In addition, the provision of new services by combining multiple sensor networks could result in new types of use that have not been taken into account by the establishers of devices, including sensors, etc. (information providers). The relationship of rights between establishers of devices, providers of new services, and users of new services may therefore need to be further clarified through establishing new systems, etc.

(3) Issues with international collaborations resulting from globalization

Japan taking the lead in promoting IPv6 being adopted over the internet is very important when considering the first mover advantage in terms of business. However, that promotion will need to take place through international collaborations in avoiding any Japanese originals only.

[43] Similar to IPv4 a method that does not allocate fixed IP addresses to users also exists with IPv6. In addition, privacy protection needs to be sufficiently considered when using sensor networks, including surveillance cameras, etc., and electronic tags, etc. Doing so will necessitate a broad range of discussions by relevant parties, including governments, taking place and broad dissemination of the results.

(4) Issues with security of internet as a basis for social and economic activities

The importance of the internet is expected to increase even further in the future as a basis for social and economic activities. Measures will therefore also need to be concurrently taken to guard against any system failures or problems with respect to the disaster prevention, medical, and energy sectors, etc. because the impact on society could be rather significant.

2. Usage/business issues

The following, for example, are included as usage/business issues.

(1) Collaboration between relevant parties in providing highly convenient services

Realizing flexible and highly convenient services such as providing services through combining multiple networks or using a network with multiple services at low cost will require the relevant parties to maintain the pace of providing open networks using IPv6.

In addition, formulating conditions, including common specifications and interfaces, etc., and then applying them in ensuring the interoperability of devices, applications, and services, etc. in the future will be the most effective in providing those services.

(2) Appropriate cost bearing and division of roles between relevant parties

At present estimating the overall image of the characteristics of the communications used in the new services that will result from the realization of an “Internet Society of Equipment” is difficult. In addition, many devices will be connected to networks, with devices with limited security functions also being connected due to cost reasons. This will make maintaining security over all the networks difficult and could have an impact on ensuring the quality of other services.

Relevant parties, including network business operators, application providers, and device providers, etc., are therefore expected to appropriately cooperate in ensuring the quality of their services and clarifying the division of responsibility before actually providing the services.

(3) Securing information security and promotion of measures

Direct communications without NAT that use of IPv6 will enable may increase the risk with the security of information and therefore more consideration should be paid to ensuring the security of information. In addition, the know-how required to ensure the security of information through actually implementing measures against violations of it will be important.

When communications are made between equipment via the internet concern over any leakage of information that should be protected can arise due to the communications taking place in a way not

assumed/controlled by users. Methods/measures to use in controlling communications between equipment and verifying whose decision/permission those communications are based on (including decisions on encryption) can therefore be expected.

(4) Promotion of innovations

Similar to the current situation with the internet maintaining an open environment in which everyone can participate is expected to take place in promoting innovations with regard to the "Internet Society of Equipment".

(5) Provision of communication services that connect a large number of devices to the internet at low cost

Connecting a large number of devices, including sensors, etc., to the internet leads to the expectation that the use of networks and cost of allocating IP addresses, etc. will increase according to the number of devices, thereby raising connection charges. The provision of services that enable a large number of devices to be connected to the internet at low cost by limiting communication speed and available the services, for example, can therefore be expected.

3. Technical issues

The following, for example, are included as technical issues.

(1) Facilitating research and development and promoting standardization

Facilitating research and development and promoting standardization with regard to the following issues is expected.

- Ensuring the security of information and protecting privacy
- Securing interoperability between different types of devices
- Measures for dealing with the load resulting from for routing and maintaining networks when a large number of devices are connected to networks
- Measures for changes in the characteristics of traffic[44]

(2) Promotion of international collaborations and developments

Promotion of international collaborations and developments through participation in and support for activities that take place in formulating international de facto standards, the and creation of

[44] With conventional web access, etc., for example, download (communication from servers to user terminals) traffic is generally greater than upload (communication from user terminals to servers) traffic. With sensor networks, however, upload (communication from sensor terminals to servers) traffic can be expected to be greater than download (communication from servers to sensor terminals) traffic.

common frameworks and human resource development between different industries can be expected.

4. Other cross-sectional issues

In addition to the above the following are included as cross-sectional issues.

- **Discussion on issues when a transfer from IPv4 addresses becomes possible, etc.**

Formulation of rules for transferring IPv4 addresses is expected to take place using a fair and transparent procedure.

In addition, enabling a transfer from IPv4 addresses that was impossible in the past could bring significant changes to the use of IP addresses over the internet. At present the resulting issues cannot be specified, and hence the situation will need to be continued to be closely observed by the government and the private sector in thus enabling a rapid response if any issue does arise.