The IPv4 Address Exhaustion Issue and Guidelines for Response

On April 15, 2011, the regular pool of IPv4 addresses for the Asia-Pacific region was exhausted.
In order to continue using the Internet in the future as we have done up to this point,
we must respond appropriately to the IPv4 address exhaustion issue.
Here we examine the methods that should be used to deal with this issue.

4.1 Introduction

The growth of the Internet to date gives a sense of how wonderful it is to be connected via a network. It is now possible to keep in touch with different people all over the world from Japan, and we can send email and browse the Web as usual even when traveling as long as we have Internet access. Last year I had the opportunity to visit a number of regions around the world, and the hotels in each region provided wireless LAN and Ethernet ports for accessing the Internet, allowing me to carry out my work in the same manner as usual. The Internet is now used to optimize business activities and provide quick access to information.

It is also important to recognize that the Internet makes it easy to develop new services. There are many examples of emerging companies accomplishing rapid growth after developing new services such as those for voice calls or video distribution. I believe it is likely that the number of people and regions with access to the Internet will continue to increase worldwide, and new services will continue to be provided via the Internet. The issue this wonderful tool that is the Internet now faces is that international availability of the IPv4 addresses required to connect to the Internet is drying up. This is known as the IPv4 address exhaustion issue.

4.2 Asia-Pacific Region Status

The IP addresses used for Internet communications are currently allocated through Internet registries*1, which have a hierarchical structure. Under this hierarchical structure the global free pool of available IPv4 addresses is managed by IANA*2 (Internet Assigned Numbers Authority), which is operated by ICANN. IANA allocates IP addresses to RIR (Regional Internet Registry) established in each region. LIR (Local Internet Registry) such as ISPs that actually assign IP addresses to users receive IP address allocations via an RIR such as APNIC or an NIR (National Internet Registry) such as JPNIC. In the middle of the night on February 3, 2011 Japan time the central pool of IPv4 addresses was exhausted at IANA, which manages the global free pool of addresses. This was triggered by the allocation of two /8 blocks to APNIC, leaving five /8 blocks in the central pool at IANA, at which point the remaining IP addresses were allocated to the five RIR in accordance with a previously established policy.

Because the central pool of IPv4 addresses has been exhausted, availability at each RIR will dwindle as addresses are allocated. APNIC, which allocates IP addresses as RIR for the Asia-Pacific region, will cease regular allocation of remaining IPv4 addresses when down to its last /8 block, and will subsequently adopt a policy of allocating only one /22 block to each member organization. It was thought that regular allocation would end sometime during the summer of 2011. However, the free pool of IPv4 addresses at APNIC was actually reduced to one /8 block early than expected, on April 15, 2011. For this reason, APNIC has now transitioned to a policy for IPv4 allocation from the last /8 block. Because JPNIC, which handles IP address allocation for Japan, shares its pool of IPv4 addresses with APNIC, the allocation of IPv4 addresses in Japan has also finished. This means we are facing the exhaustion of IPv4 addresses ahead of other regions, so the eyes of the world are focused on what is happening in the Asia-Pacific region.

*1 Organizations that allocate and manage Internet resources such as IP addresses.
*2 A faculty for managing and regulating the Internet resources operated by ICANN.

The regular pool of IPv4 addresses have been exhausted in the Asia-Pacific region. Currently, the pool of addresses at organizations actually operating networks such as ISPs that receive IPv4 address allocations from APNIC or JPNIC are being consumed. The number of IPv4 addresses remaining and the speed of their consumption will vary for each ISP. However, at ISPs continuing to gain users and expand their services, remaining IPv4 addresses will be exhausted in the near future. If this issue is neglected there could be repercussions, such as ISPs not being able to accept new users or provide IPv4 addresses when they are required temporarily for the redesign of systems.

4.3 Responding to the IPv4 Address Exhaustion Issue

The Internet still has a wealth of untapped potential, and many people desire to maintain an environment that can be used by people in more regions of the world. The following three solutions could be considered in response to the IPv4 address exhaustion issue that we currently face.

- Raising the utilization rate of IPv4 addresses
- Sharing IPv4 addresses
- Migrating to IPv6

Currently the only effective way of dealing with the issue permanently is the third solution, migrating to IPv6. However, it is likely that while deploying IPv6 a combination of multiple solutions will be implemented depending on the status of the ISP and network.

4.3.1 Improving IPv4 Address Utilization

Improving IPv4 address utilization in response to this issue involves targeting IPv4 addresses that are no longer used due to changes in business and network configurations. This solution aims to extend the life of IPv4 by recovering IPv4 addresses that are no longer in use and redistributing them to other organizations that require them. However, recovering IPv4 addresses in small batches is not an effective solution. It may be possible to implement this in some form within organizations, but to properly maintain reachability over the Internet a block of sequential IPv4 addresses is required. At this point in time a size of approximately one /24 block is necessary. Additionally, although there have already been cases of IPv4 addresses being recovered, there are issues such as the difficulty of persuading the providing party, the length of time required for recovery, and high demand resulting in recovered addresses being used up immediately.

A policy for promoting the utilization of unused IPv4 addresses has also been discussed. This is called the IPv4 Address Transfer Policy. When following standard procedures, addresses that are no longer required are first returned to JPNIC or APNIC, and then redistributed to the organization that requires them. However, under this policy IPv4 addresses can be transferred between organizations provided that both parties reach agreement. JPNIC plans to implement a transfer system by around summer 2011. Also, because this policy was already implemented at APNIC last year, it is now possible to transfer IPv4 addresses within the range managed by APNIC. Because the policy for the transfer of IPv4 addresses only deals with confirming agreement between the providing and receiving parties, APNIC or JPNIC are not involved even when money changes hands. It is said that IPv4 address transfers amount to the buying and selling of IPv4 addresses. Because money is involved, it is more likely that IPv4 addresses will go to the organizations that need them. Transfer procedures have actually already been carried out in the United States.

4.3.2 Sharing IPv4 Addresses

The sharing of IPv4 addresses involves moving forward using the NAT technology that is already in use. Many homes currently have a NAPT router installed. Users are generally allocated a single IPv4 address from their ISP, with the number of addresses required reduced by sharing this address between internal hosts using NAPT. This solution involves taking this concept one step further, and having ISPs run a large-scale NAPT on their side to further reduce the number of addresses required. This would allow ISPs to provide connection services to more users using the IPv4 addresses they already have. However, this could lead to degradation in service. For example, because the IPv4 address allocated to a user would not be directly reachable via the Internet, there is a chance that games and

other applications could no longer be used from home, and that public Web servers would no longer be operable. Additionally, depending on the NAPT implementation features such as VPN may be limited.

4.3.3 Migration to IPv6

It is likely that responses to the IPv4 address exhaustion issue will involve using the solutions detailed above to extend the life of IPv4 while migrating to IPv6, which will dramatically increase the number of IP addresses available. To achieve this IPv6 connectivity must first be secured. In Japan the implementation of IPv6 was initiated comparatively quickly, and a number of ISPs already provide IPv6 connectivity. Companies can use these services to proceed with support for IPv6. Home use is currently stalled until access network support is in place. However, a number of providers have already indicated they will support IPv6, and an environment for providing access to IPv6 connection services is scheduled to be in place by the end of the year. It appears that for the foreseeable future those requiring IPv6 connectivity will need to apply for it, but in the future it should be possible to secure IPv6 connectivity as standard when signing up for a Internet connection that uses an access network compatible with IPv6.

Migrating from an IPv4-only environment to one that combines both IPv6 and IPv4 inevitably increases complexity. Moreover, accessing an IPv6 service from a device that only supports IPv4 or accessing an IPv4 service from an IPv6 device requires the implementation of a device for suitably mediating between these communications. In this case the mediating device handles the complexity resulting from combining IPv6 and IPv4, which should simplify processing on the terminal side. However, when a communications error of some kind occurs, isolating the problem becomes extremely difficult. This means this method can only be used at times when support is too difficult or when usage will be limited. The preferred method at this point in time is to move forward with support for IPv6 while IPv4 addresses can still be used, and then prepare an environment that can be accessed via both IPv6 and IPv4. In most implementations IPv6 connectivity will be used as priority, so the key will be to secure high quality IPv6 connectivity from day one.

4.3.4 Other Issues of Concern

There are other matters of concern with regard to IPv4 address exhaustion. If IPv4 addresses are transferred between organizations, information about who is managing those IPv4 resources will become even more important. In the past there have been problems with route hijacking where another party's IP address is advertised without permission. In most cases these issues were caused by incorrect settings. However, because at some point in the future available IPv4 address will run out, providing the opportunity to profit from IPv4 address transfers, it is conceivable that there may be cases in which another party's IPv4 addresses are used or transferred without permission by hijacking registered information. Organizations that manage networks such as ISPs must update the information registered to the Internet Registry correctly, and confirm than no unintended changes have been made to the registered information.

4.4 Conclusion

IPv4 address exhaustion is not a new problem, as it has been discussed for many years. It was initially thought that the implementation of IPv6 would take place more swiftly. However, in reality implementation is proceeding at a sluggish pace, and the exhaustion of available IPv4 addresses appears likely to come first. For this reason, it has become necessary to move ahead with implementing IPv6 while maintaining IPv4 connectivity, which is a higher cost solution. From this point forward, the longer migration to IPv6 takes, the greater the cost of development and device installation will be for maintaining IPv4 connectivity. We hope to see IPv6 implemented in the smoothest possible way, so the Internet becomes an environment where everyone can share their wisdom on more entertaining topics.

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