Allocation of Remaining IPv4 Addresses: What is a Fair and Equitable Model to the Internet users?

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Internet Protocol (IP)

The Internet Protocol (IP) provides the functions necessary to deliver a package of data from a source to a destination over the Internet, where sources and destinations are devices identified by fixed length addresses (IP addresses).

IP Address

Internet Protocol (IP) addresses are the numbers that uniquely identify and enable the connection of all the devices on the Internet. These devices can be an originating point, an intermediate point, or the destination point. IP addresses are used by a process called routing to move parcels of data called packets from an originating point through any intermediate points to a destination point. An allocation or assignment of an IP address entitles an organization or person to the exclusive use of, and therefore to derive benefit from the use of, the IP address. IP addresses are not property. They cannot be bought, sold, leased or rented, traded, transferred, attached, or otherwise provided to an organization or person other than by policy.

The Global Equitable Distribution of IP Addresses

IP addresses are provided to those who can demonstrate a need for them in accordance with policies developed by the community that uses them. It is these community-based, bottom up policies that are designed to provide an equitable distribution of IP addresses. IP addresses are either allocated or assigned. Definitions of terms relevant to IP address provisioning are:

- Provision – Allocate or assign a number resource
- Allocate – Provide number resources to a Registry or Service Provider
- Assign – Provide a number resource to a consumer

Internet number resources are provided to organizations and persons by a hierarchical chain of organizations. ICANN through its IANA function manages the global IP address pool. It allocates large blocks of IP address space to the Regional Internet Registries (RIRs) in accordance with global policy. The Regional Internet Registries, in turn, allocate IP addresses to organizations in their respective regions. These organizations can include National Internet Registries (NIR), Local Internet Registries (LIR), or Internet Service Providers. These organizations can further allocate IP addresses to other LIRs or ISPs. Allocations to these organizations are done in accordance with community-developed regional policy. Enterprises (sometimes called end user organizations) can be assigned IP addresses by an RIR, NIR, LIR, or ISP. The assignment of IP addresses to enterprises is also done in accordance with community-developed regional policy.

The responsibility of each IP address provisioning organization is summarized in Table 1.

ORGANIZATION	PROVISIONING RESPONSIBILITY
ICANN IANA [Internet Assigned Numbers Authority]	**Manage Global IP Address Pool** [Allocate Internet Number Resources to the RIRs]
RIRs [AfriNIC, APNIC, ARIN, LACNIC, RIPE NCC]	**Manage Regional IP Address Pool** [Allocate Internet Number Resources to LIRs/ISPs] [Assign Internet Number Resources to Enterprises]
NIRs/LIRs/ISPs/Enterprises	**Manage Local IP Address Pool** [Allocate Internet Number Resources to LIRs/ISPs] [Assign Internet Number Resources to Enterprises and Infrastructure]

Table 1: Provisioning Organization Responsibility

The Depletion of the IPv4 Free Address Pool

IPv6 was put into operational use in 1999. It is at this point that IPv4 and IPv6 began to co-exist side by side. It was recognized that these protocols would continue to operate in this co-existence environment for many years to come. In 1999, it was estimated that there was enough IPv4 address space in the pool managed by IANA to satisfy the then rate of growth for about 10 to 15 years. From the perspective of changing the dominant IP addressing protocol from IPv4 to IPv6, this was deemed to be a sufficient amount of time for this transition to occur.

However, there was not a strong move then to undertake the shift of services from IPv4 networks to IPv6 networks. One way to measure whether IPv4 or IPv6 is dominant is to look at the number of entries in the global routing table. Each entry indicates a separate network entity, such as a router, that is connected to the global Internet. This single entity may be providing services to hundreds or thousands of other entities such as servers or individual users using that single route. By 2007, the IPv6 global routing table had grown to about 1000 such entries while, in comparison, the IPv4 routing table contained nearly 250,000. Clearly IPv6 is nowhere near the dominant version of IP addressing.

Lack of public education, use of technical workarounds, and uncertainty about implementation costs have all been identified as factors in the slower than expected universal adoption of IPv6. Meanwhile, the available IPv4 address pool has shrunk to the point that there is now about three years of address space left. Because of this slow adoption, the transition to IPv6 can be considered to have not succeeded because the dominant IP protocol will still be IPv4 when the IANA managed free pool is depleted. There will not be a supply of IPv4 address blocks to sustain the growth of the Internet using IPv4.

Growth of the Internet will only occur with the use of IPv6. This means that for the foreseeable future the dominant protocol of the Internet will continue to be IPv4 and not IPv6 which will cause an Interregnum Period until such time as the dominant IP protocol is IPv6. It is this environment in which the Internet must continue to operate. It is important to look at what will happen during this transition period from when the central pool depletes to when IPv6 becomes the predominant protocol of the Internet infrastructure. There is a need for a proper coordination in this regard among all stakeholders in the community, be they public, private, or civil society sectors. This coordination includes:

- Ensuring the stability of the Internet by smoothing the shift from the Internet infrastructure where IPv4 is predominant to one where IPv6 is predominant

- Shortening the transition period by providing mechanisms and incentives for the rapid adoption of IPv6

Review of the Current Policy Debate in the RIRs

There are several policy topics in the RIRs to address the impending Interregnum Period.

- *Extend the life of IPv4 so that Internet growth can continue to be sustained using IPv4 address space.*

  There have been several proposals in this area. They have all been dismissed by various RIR communities as being impractical or unfair. It is not expected that there will be much more effort in this area. It could be argued that the discussion of the change in the RIR's transfer policies will help sustain growth of the IPv4 Internet. However, this would have a limited effect on the growth.

- *Identify and reserve IPv4 address space so that infrastructure requirements for the coexistence environment of IPv4 and IPv6 can be met. This includes providing IPv4 address space to new entrants to the IP business who are intending to use IPv6.*

  This is where most of the current policy work is being done. Included in this is the global policy to distribute the last portion of the IANA free pool of IPv4 address space amongst the RIRs. Also included are discussions for a given RIR to set aside IPv4 address space to support the IPv4-IPv6 infrastructure interface to include provision of IPv4 address space to new IPv6 entrants. The transfer policies that are being discussed in several regions can also be included here as well as the limited growth support identified in the previous paragraph. Several RIRs have specific proposals in this area that are unique to their individual region.

- *Provide incentives and means for qualified entities to obtain IPv6.*

  Much work has been done in this area over the past several years. IPv6 allocation and assignment policies have been continuously liberalized so as to lower barriers to entry for those desiring to use IPv6. It can be expected that there will continue to be some work in this area.

Issues or Questions to be Addressed

There are several issues and questions that can be addressed regarding the Interregnum Period.

1. Are developing countries with huge potential for growth and/or large populations being pushed into a disadvantageous situation (Africa, India, China, Indonesia, and Brazil, for example)?

The issue of developing countries is an interesting one, for it is not only the development of the Internet in these countries, but also the development of the Internet in the isolated and rural areas of developed countries that is of the same type of concern. The difference is the means and resources that can be brought to bear on the problem. The policies that are under discussion in the various regions that pertain to the IPv4-IPv6 infrastructure and new IPv6 entrants are probably the most significant in this

area. While there are factors that would favor the growth of an IPv4 Internet in these areas, such as cost of equipment, there must be consideration given to the fact that this entire infrastructure will have to be transitioned to IPv6 at some time in the future, thus incurring an additional cost. To a certain extent, it makes more sense for the backbone networks and the consumers at the edges of these backbones of these developing areas to begin as IPv6, with more consideration given to developing the infrastructure necessary to work in the near future with the IPv4 network during the Interregnum Period.

2. Why is it not enough to "recover" unused legacy address blocks given to some early players, mostly in the United States?

In the early days of the Internet, organizations received /8 (Class A) allocations, many to organizations inside North America. ARIN and the IANA have been successful in recovering some of these allocations that are now unused. The /8s that have been recovered were placed back into the IANA free pool for future use across the five Regional Internet Registries.

More /8 allocations remain active, but there are significant challenges to returning them to the free pool. Large allocation holders claim they are using the address space and are not willing to return it. ARIN and IANA have attempted to convince these holders to return their large blocks in exchange for smaller blocks that better fit their needs.

Even the successful return of more of these /8s would not significantly increase the free pool availability lifetime for IPv4. The five RIRs currently allocate over twelve /8s per year, meaning the return of two /8 blocks would extend the IPv4 free pool by less than two months according to current trends.

3. Isn't there a fear of remaining precious IPv4 addresses becoming very expensive with speculation and/or unauthorized trading outside RIR policy framework?

Issues of speculation and unregulated trading are essential in regions where transfer policies are being discussed. Aside from discussion on the proposed policies' details, there is a separate discussion on the role of the RIR publisher of the authoritative directory of entities entitled to benefit from specific IP address blocks. This goes to one of the basic functions of an RIR as the entity that guarantees uniqueness through registration activities. The RIRs' adoption of RPKI, a mechanism that helps authenticate that a certain block belongs to a certain organization, will strengthen that ability to ensure uniqueness. However, this ability does not create or increase the power and authority that the RIRs have maintained for several years. In the end it will be the socio-economic aspects of the business of the Internet that will reinforce that authority.

4. What is the effort for making the secondary market across five regions?

One cannot say that there is a concerted effort being made to develop a secondary market in any region. There has existed in the past and can be expected in the future that such markets are there. The effectiveness of these markets depends on how useful the blocks of addresses that are moving between parties are. If they cannot be routed, then they are useless. Routing depends on many things, but the most important is that of other parties to interconnect with a particular network. If one party doubts whether the other is the rightful user of the address space, then that party may decide not to interconnect with the network in question. It is this aspect of Internet operations that makes discussion around transfer policies so important and why participation in the RIR fora is important as these policies are being discussed.

5. Are ISPs responding to the challenge of IPv4 address pool depletion?

Yes, ISPs are responding to IPv4 depletion issues, but not as soon or as thoroughly as desired. There are some success cases where ISPs registered IPv6 early and began integrating it into their networks, to include creating future IPv6 provisioning plans for their customers. Many ISPs have registered IPv6 address space, but have only experimented with it. Still, far too many have not yet taken an active interest in preparing for IPv6.

Each RIR is engaged in an awareness campaign inside its region to ensure the community knows of the coming IPv4 free pool depletion and the need to begin adopting IPv6. Inside the ARIN region this includes publishing Board of Trustees resolutions, interacting with the media, disseminating educational literature, aggressively gaining agenda time at conferences, exhibiting at large conferences, and much more.

It is encouraging to see that the response to the issue has grown much larger in the last year.

6. If not, why not, and what can be done to encourage them?

It is vitally important for ISPs to be aware of the situation and to have accurate information that helps them prepare for IPv6 in a way that is most convenient and beneficial to their business.

ARIN staff members are constantly exhibiting, presenting, interviewing, and publishing documents in relation to this topic. ARIN provides information showing the amount of IPv4 address space remaining and how much space is allocated yearly. Using that information, ARIN explains that future Internet growth will be done using IPv6 and how that has an impact on everyone on the Internet.

ARIN asks organizations to consider “dual-stacking” IPv4 and IPv6 so they can continue to communicate with IPv4 portions of the Internet, yet be able to communicate with the new and soon fast-to-grow IPv6 portions. ARIN advises organizations to begin by deciding what makes their routers, DNS, web servers, and mail servers compatible with IPv6. Various resources help them become more educated and prepared to take action, including the ARIN IPv6 wiki (http://www.getipv6.info). This resource allows the entire community to share IPv6 deployment experiences, and read information about IPv6 readiness in products, implementation strategies, and many other useful pieces of information to help plan an IPv6 adoption scheme.

Messages from the various administration and governance bodies of the Internet must share a common theme when speaking to the community about IPv4 depletion and IPv6 adoption issues. Receiving conflicting information from various sources is confusing to organizations, who cannot afford to make mistakes in allotting their valuable time and resources. They expect to have a consistent message and a clear path for deployment success before they are willing to spend significant amounts of time and money. Their businesses depend on it.