Issue 2: Consultation on international public policy issues concerning IPv4 addresses.
The Council Working Group on International Internet-Related Public Policy Issues invites all stakeholders to provide input on international public policy issues related to

(a) unused legacy IPv4 addresses, and
(b) inter-region transfers of IPv4 addresses

Joint Response from the Regional Internet Registries

31 July 2013

The five Regional Internet Registries (RIRs), coordinated via the Number Resource Organization (NRO), welcome the opportunity to provide colleagues in the International Telecommunication Union (ITU) with information on the current global situation regarding IPv4 address space. The Tunis Agenda paragraph 55 states, "We recognize that the existing arrangements for Internet governance have worked effectively to make the Internet the highly robust, dynamic and geographically diverse medium that it is today, with the private sector taking the lead in day-to-day operations, and with innovation and value creation at the edges." The RIRs are responsible for the technical coordination and management of Internet number resources.

As the recognized stewards responsible for the distribution and registration of IP address space, and facilitators of the open, community-driven processes that define policy regarding these activities, the RIRs are the authoritative organisations for policies in this operational area. As such, the RIRs ensure that all stakeholders can have their voices heard and have access to the necessary information, statistics, analysis and venues for their active participation.

Unused "Legacy" IPv4 Address Space

IPv4 address space distributed prior to establishment of the RIRs is referred to as "legacy" address space, and it accounts for approximately 35% of the total IPv4 address space. Legacy space is administered by the RIR for the region in which it is assigned.

It is important to recognize that all address resources, legacy or not, have the following characteristics:

- IP address blocks are assignments of unique address resources that originated from a single coordinated registry.
- The Internet numbers registry is cooperatively operated by the five RIRs in collaboration with ICANN/IANA, as documented by a Memorandum of Understanding (MoU) between these parties.

- Each Regional Internet Registry has its own policies, set via an inclusive community-based, bottom-up processes, which apply to Internet number resources registered in that region.

During the recent WTPF-13 conference, the RIRs made several points regarding legacy address space that we would like to again highlight:

- **The term "unused legacy address space" can be problematic.** It is impossible to accurately gauge if any given address block is in use, let alone the rate of utilization of this address space. Even if the addresses are not visible on the public Internet, holders of this space may be using them on private networks. Governments, for example, often use number resources without making them visible. Address resources issued by the RIRs may also be invisible on the public Internet, but nonetheless in use - this does not violate current address usage policies or any IP addressing standard.

- **It is critical to the security and stability of the Internet that all address space be accurately registered.** The Internet registry system contains a significant incentive for legacy space holders to maintain accurate registration of their resources in a public, RIR-maintained database. Registration data for all address blocks is held in the RIR databases (transferred from the original records when the RIRs were established), and this data is used by Internet Service Providers to validate requests for routing of specific blocks. Stale or unmaintained registrations can render the addresses unusable on the public Internet, as operators decide not to propagate or accept routing announcements for such blocks.

- It is worth noting that even if 20% of the entire IPv4 global unicast address space were to become available for redistribution, this would provide for slightly less than three years' worth of allocations, based on the global 2010 address consumption rate. For this reason alone, the global adoption of IPv6 is imperative for the Internet's continued growth and operation.

  Further to the above, some stakeholders have argued that these legacy resources should be made available to developing countries to help them deal with the shortage of the IPv4 address space. We note that in Africa where there is huge growth in networks and an obvious need for IP addresses, AFRINIC, the RIR serving that region, has the largest reserve of IPv4 of all the RIRs. This reserve is expected to serve the region's connectivity needs for at least the next four years of growth. Even with this in mind though, AFRINIC continues to promote the transition to IPv6. It is clear that Africa and other developing areas will not be well served by becoming islands of IPv4 while the rest of the world moves to IPv6.

- A global policy governing the return of legacy IPv4 space to the IANA has been in place since May 2012. Under this policy, returned addresses are to be allocated between the five RIRs, based on each RIR's demonstrated need, for distribution to their members.

  Global Policy for Post Exhaustion IPv4 Allocation Mechanisms by the IANA (Ratified 6 May 2012):
  https://www.icann.org/en/news/in-focus/global-addressing/allocation-ipv4-post-exhaustion

  Since the policy's ratification, the following legacy address space has been returned to IANA:

  APNIC: 2.31 million
  RIPE NCC: 1.31 million
  ARIN: 16.8 million (slightly more than a /8)

  This returned address space is subject to future reallocation by the IANA to Regional Internet Registries in accordance with agreed global policy, and future regional needs.

Additional Information

Prior to establishment of the RIR system, IP addresses were allocated from a central registry to users on every continent, based on those users' networking needs. The unprecedented growth and adoption of the IPv4-based Internet was not initially foreseen.

As the Internet grew, the management of this allocation and registration function passed through several organisations. During this period, IP addresses were allocated in blocks referred to as "classes". Many larger organisations received a "Class A", which is the equivalent of a /8 (around 16 million individual addresses), while the operators of smaller networks received either a "Class B" (/16 or 65,536 addresses) or "Class C" (/24 or 256 addresses).

This system of distribution (now referred to as "classful" addressing) was intended to facilitate efficient hierarchical Internet routing, thereby reducing the amount of computing power required to move data around the world. It was also based on an assumption that the 32-bit IPv4 address space, with its four billion individual addresses, was large enough that such practices would not quickly exhaust the supply of addresses. The explosive growth of the Internet proved this generally-held assumption mistaken.

Two decades ago, the Internet community did come to the realization that "classful" addressing would quickly exhaust the IPv4 address space. The response, developed through open, bottom-up processes like those practiced in the RIR communities, allowed the Internet, no longer simply a research and development project, to continue its dramatic growth unimpeded. Meanwhile,

engineers and operators worked on the development of long-term technical solutions to Internet growth:

- The coordinated implementation of Classless Inter-Domain Routing (CIDR) allowed for a far higher ratio of IP addresses to be both administered and routed on the Internet;
- The development of the Regional Internet Registry (RIR) system enabled the adoption of distinct regional IP address management policies that could better accommodate the specific needs of each region;
- The standardization of IPv6 in the Internet Engineering Task Force (IETF) identified and standardized, through global cooperation, a successor to IPv4, which provided a massively expanded pool of unique IP addresses.

Inter-region Transfer of IPv4 Address Blocks

The exhaustion of RIR IPv4 address pools means that some network operators are seeking to obtain IPv4 address blocks from other operators with IPv4 address holdings. With pending IPv4 exhaustion in their regions, individual RIR communities have established policies that allow for such transfers of address blocks between parties based within their regions, and with parties in other regions where transfer policies exist.

Complementary policy frameworks in the ARIN and APNIC communities now permit the transfer of address blocks and registration records between parties in those service regions. A policy proposal is currently under discussion in the RIPE community that would allow transfers between parties in the RIPE NCC service region and parties in the APNIC or ARIN regions. While regional address exhaustion is still some years off in their regions, discussions have also begun in the AFRINIC and LACNIC communities on appropriate policy mechanisms to facilitate inter-region transfers for parties in those service regions.

Policy discussions about inter-region transfers must address a range of issues, technical (e.g. minimum size of transfer block), administrative (e.g. the transfer of registration data between registries), economic (e.g. minimizing the risk of IP address hoarding or market distortion), and socio-political (e.g. ensuring that developing Internet communities have access to IPv4 addresses). Questions about whether such transfers should be subject to a demonstrated need requirement touch on several of these areas.

Government stakeholders have a legitimate interest in this subject, as it has the potential to significantly affect their citizens and economies. There are effective solutions that can be found by working together and we welcome governments' input in policies that can help shape those solutions. It is through a multi-stakeholder, bottom-up policy development process, as facilitated by the RIRs in their respective communities, that the concerns identified above can be addressed. Bottom-up, multi-stakeholder development of policy is the best means of responding to the swiftly evolving technical and economic needs of

network operators and thereby ensuring that all citizens benefit from the Internet.

The backbone of a multi-stakeholder environment is to share and discuss information, and the RIRs appreciate this opportunity to further discuss these very important issues. We understand the importance of policy makers having all of the facts available when making decisions and we are happy to provide information as needed.

In Conclusion
We are now in the final phases of IPv4 address allocation; and transfer mechanisms, while helping to satisfy remaining demand, can only provide temporary relief.

The adoption of IPv6 is the only option for future growth and interoperability of the Internet. Addressing the challenges of IPv6 deployment will require engagement of all stakeholders, including governmental and inter-governmental. It is clear is that the most successful IPv6 adoption initiatives seen to date have been multi-stakeholder in nature, harnessing the strengths of various sectors (public, private, academic, civil society) to encourage deployment of IPv6 or to build the capacity necessary to do so.

The NRO and RIRs welcome the opportunity to work with all stakeholders to develop strategies that will ensure the smooth, efficient and widespread adoption of IPv6 around the globe.

Additional Information

About the Regional Internet Registries
The five RIRs were established via open, community-driven, bottom-up policy-making processes to manage, distribute, and register Internet number resources (IPv4 and IPv6 addresses and Autonomous System Numbers) in their respective service regions. This process has been documented as the ICANN "Internet Consensus Policy 2: Criteria for Establishment of New Regional Internet Registries" [ICP-2]. The earliest RIR, the RIPE NCC, was established in 1992, while the most recent, AFRINIC, was accredited as the fifth RIR in 2005. Three RIRs, the RIPE NCC, APNIC and ARIN were established before ICANN; LACNIC and AFRINIC were established subsequent to ICANN's formation. Each of the RIRs is an independent, not-for-profit, membership-based entity, adhering closely to open, transparent, participatory policy decision-making processes, and each is guided by a locally-elected executive board.

The establishment of the RIRs reflected the Internet community's acknowledgement that distribution and registration of Internet number resources (including IP addresses) was a vital role for the rapidly expanding regionally-based Internet, and that a centralized model would not scale. Reasons for this included:

- Sheer volume of administrative tasks;
- Reducing the distance between address space consumers and their registry;
- Need to more effectively obtain and process local community support and guidance;
- Need to more effectively respond to regional needs.

There are five RIRs:
AFRINIC, serving Africa – http://www.afrinic.net
APNIC, serving the Asia Pacific region – http://www.apnic.net
ARIN, serving Canada, many Caribbean and North Atlantic islands, and the United States – http://www.arin.net
LACNIC, serving Latin America and the Caribbean – http://www.lacnic.net
RIPE NCC, serving Europe, the Middle East and parts of Central Asia – http://www.ripe.net

A document produced in 2001 (prior to the establishment of LACNIC or AFRINIC) details the history and reasoning that led to regional management of IP addressing:
http://www.nro.net/about-the-nro/regional-registries-system

The NRO and RIRs are collectively committed to the fair and efficient use of the IP address pool, while providing accurate and publicly accessible registration data. This is often distilled to three guiding principles in relation to IP address management:

- **Conservation**
- **Aggregation** (sometimes referred to as "routability")
- **Registration**

Over the past 20 years, the RIR system has ensured stable, transparent and effective management of the IP address space. The system has allowed the Internet community to navigate successfully through major events including the implementation of Classless Inter-Domain Routing (CIDR) in the early 1990s *[see document above for more information]* and the final allocations of unregistered IPv4 addresses from the Internet Assigned Numbers Authority (IANA) to the RIRs. The RIR communities have successfully addressed these challenges, via their respective (and where appropriate, globally coordinated) policy processes, producing measured responses that take account of all stakeholders' concerns at both the regional and global levels.

References
ICP-2: Criteria for Establishment of New Regional Internet Registries
http://www.icann.org/icp/icp-2.htm
Up-to-date information on each of the RIRs:
https://www.nro.net/about-the-nro/regional-internet-registries

Final Allocation of IPv4 Address Space
On 3 February 2011, IANA allocated the final five IPv4 address blocks from the "free pool" of IPv4 address space to the five RIRs, in accordance with a globally agreed-upon policy for distribution of these final blocks. Following this, each RIR could continue to distribute IPv4 address space to their regional constituents, but no additional space would be available once their local pool of addresses was allocated.

The RIR communities had foreseen these events well in advance, and the global policy regarding distribution of the IANA's final five blocks of IPv4 was one response to this, ensuring an orderly IANA exhaustion that all stakeholders could effectively prepare for, respecting the needs of all in the global community. The policy provided a "soft landing" to the exhaustion of the IANA IPv4 address pool.

In addition to this global policy, each of the RIR communities considered appropriate regional policy strategies to mitigate the consequences of IPv4 exhaustion. The "final /8" policies implemented independently by several RIR communities are one such response. These policies restrict the number of addresses that any single organisation can be allocated from the RIR's final /8 block of IPv4 space. The maximum is generally set at /22 (or 1,024 individual addresses).

Such restrictions enable new network operators to request a small "transitional" block of IPv4 address space, ensuring that those operators have the means to connect their new IPv6 networks to the IPv4 Internet. A single /8 contains 16,384 /22 blocks meaning that these small allocations of IPv4 address space will be available to new operators for a long time to come, providing for the future growth and interoperability of the Internet.

Since IANA made its final allocations in 2011, two RIRs have reached their final /8s of IPv4 address space:

- On 15 April 2011, the APNIC pool reached its last /8 of available IPv4 addresses, triggering that registry's "final /8 policy". As of July 2013, APNIC has made roughly 2,800 allocations small allocations (/22 or smaller) from its last /8.

- On 14 September 2012, the RIPE NCC began to allocate IPv4 address space from its last /8 of IPv4 address space, which is also distributed according to a "final /8 policy". As of July 2013, the RIPE NCC has allocated roughly 1,800 /22 blocks from this final /8.

As of July 2013, AFRINIC, ARIN and LACNIC are continuing to allocate IPv4 addresses from their respective pools, in line with their specific allocation policies.

About the Number Resource Organization
The Number Resource Organization (NRO) is the coordinating and representative body for the five Regional Internet Registries. It serves to coordinate a range of technical, administrative and communications activities among the RIRs, including liaison with international and intergovernmental organizations. The NRO also serves as the Address Supporting Organization (ASO) within the framework of the Internet Corporation for Assigned Names and Numbers (ICANN).

References
http://www.nro.net
http://aso.icann.org
http://www.icann.org

Contact
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