ICIL 2011

RIPE NCC - Internet governance and registration of IP addresses

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Abstract

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1. Introduction

1.1. Internet Protocol and IP addresses

The Internet started as an experimental project in the early 1960s by US government-funded researchers. These researchers saw great potential value in allowing computers located in different geographic locations to remotely communicate with each other. In the early days the Internet was named ARPANET and connected research networks located in Universities and Research Institutes, mainly in the United States.[i]

The architecture of the Internet is based on a system named the Internet Protocol (IP) that was formally documented in 1981. The Internet Protocol is designed to allow communication between interconnected networks. This communication is achieved by transmitting packets of data between devices in these interconnected networks.

For the purposes of routing the data to be transmitted from device to device, the location of each device must be uniquely identified within these networks. Therefore each device is given a unique address, known as Internet Protocol (IP) address.[ii]

The Internet Protocol documented1981 is called Internet Protocol version 4 and the IP addresses within this protocol are named IP version 4 (IPv4) addresses. IPv4 addresses consist of 32 bits and they appear as 4 numbers (from 0 to 255) separated by dots (for example 192.0.2.76). This combination generates over four billion IPv4 addresses, which in 1981 appeared to be enough for the needs of the limited networks participating in the Internet.

The unexpected success of the Internet though, made the number of the possible IPv4 addresses insufficient for the needs of the continuously increasing number of networks globally. In the 1990s a new version of the Internet Protocol was designed as a successor to the IPv4 protocol.

IP addresses based on the Internet Protocol version 6 (IPv6 addresses) are 128-bit numerical identifiers instead of the 32-bit addresses provided by the IPv4 protocol.[iii] That means that the number of IP addresses produced by the IPv6 protocol are 2^{128} individual addresses available, which is approximately 3.4×1038, and exactly: 340,282,366,920,938,463,463,374,607,431,768,211,456 IP addresses.[iv]

1.2. Need for cooperation and coordination among network operators

As the use of the Internet expanded beyond geographic limits and its applications expended beyond research or governmental needs, network operators realised the need to coordinate with each other and to create policies and procedures for the proper function of the Internet.

This paper explains Internet governance with regards to the registration of IP addresses as deployed over the years by the network operators from across the world. It analyses the reasoning behind the creation of the Regional Internet Registry system, the structure and the function of the Regional Internet Registries in general and of the RIPE NCC in particular as the Regional Internet Registry in Europe, Middle East and Central Asia. Furthermore the paper presents the policy-making procedure that generates the policies according to which Regional Internet Registries operate. Finally it will examine the principles according to which IP addresses are distributed and registered to networks, the function and the importance of the publicly available registry (also known as the RIPE database) and future challenges for this system.

2. Internet governance

2.1. Development of the Internet Registries concept

Communication between devices using the Internet Protocol relies on identifying the appropriate devices; IP addresses serve the purpose of identifying devices in a network. Therefore IP addresses have to be unique. To ensure that a unique IP address is attached to each device, IP addresses must be distributed and registered in an organised manner. This requirement was identified from the early years of the Internet.

Initially it was one person, named Jon Postel, that registered in a notebook the IP addresses distributed to networks that wanted to become connected to the Internet. Later, at the beginning of the 1990s, this function was formally transferred to the Internet Assigned Numbers Authority (IANA). [v]

As the Internet in the early years was a research project, organisations that requested IP addresses for their networks were generally those participating in the research effort, such as military, government and government-sponsored research organisations. Moreover, due to the fact that the Internet was a project originally funded by the US government, the criteria for assigning IP addresses were based on US federal laws.

As the Internet became more stable though, it started being used by a broad range of academic and research institutions as well as by the industry. Additionally the use of the Internet was increasing and being developed in a wide geographical area. Organisations from different countries were requesting the assignment of IP addresses in order for their networks to be interconnected. Applying the same criteria to all network operators without taking into account the individual needs of different networks in the various geographic regions was considered inappropriate.

Network operators concluded that allocation and registration criteria could not be harmonised globally by one single organisation and therefore IANA was regarded as unable to handle the distribution of IP addresses for diverse stakeholders in different geographic regions. The need for a new system of allocation and registration of IP addresses was defined, which would meet the demands of network operators in different regions.

In 1990, a new system was proposed.[vi] This new system suggested the creation of an Internet Registry that would be responsible for the allocation and the registration of IP addresses. The function of this Internet Registry would be distributed among multiple centers on different geographic regions.

IP addresses would be allocated and registered according to criteria determined by the specific needs and the particularities of the relevant stakeholders in each geographic region. These criteria would be defined by the administrators of the networks located in each particular region. In other words, network operators themselves would be able to determine the particular criteria according to which IP addresses would be assigned to them.

Finally the Internet Registry would also collect and administer information that would be publicly available for the purposes of permitting network administrators to make decisions as to the acceptability of traffic destined to or from each and every legitimate IP address.

Over the next 2 years the need for the distribution of the registration function became urgent as the demand for IP addresses grew significantly. In 1992 a plan was developed for the implementation of the 1990 proposal regarding the management of the distribution and registration of IP addresses. [vii]

According to this plan the distribution and registration of IP addresses for different geographic regions would be managed by different Regional Internet Registries (RIRs). It was crucial, according to the plan, that allocation and registration of IP addresses in each geographic region would be managed by a single RIR. The basic criterion for the qualification of an organisation as an RIR would be the relevant recognition and support expressed by the networks operator within the geographic area the RIR was meant to be responsible for. In other words it was crucial that this organisation would be unbiased and widely recognised as an RIR by network providers within the respective geographic region.

2.2 The developments in Europe - RIPE and the RIPE NCC

Parallel to this development, in Europe a group of Internet pioneers acknowledged the necessity of creating a forum where all network operators in Europe and beyond would be able to cooperate technically in order to promote and coordinate interconnection of IP networks within Europe as well as with networks on other continents and to exchange relevant information. This forum was created in 1989, and named Réseaux IP Européens (RIPE)[viii]. It began a series of regular meetings to share experiences and carry out technical coordination work. Additionally the group started exchanging information for coordinating purposes and established a publicly available database for storing operational data. This database was initially referred to as a "whois database" because it consisted information about the networks that have been distributed IP addresses to.

The RIPE community was following closely and participating in the discussions about the creation of an Internet Registry and the distribution of its function to Regional Internet Registries for different geographic regions. In 1990, the RIPE community proposed the creation of a Network Coordination Center for the support and coordination of the management of a pan European IP network. This Network Coordination Center would act as the Regional Internet Registry for IP addresses in Europe and in this way it would contribute to the global administrative framework of the Internet.

This Network Coordination Center was founded in 1992 and was named the RIPE Network Coordination Center (RIPE NCC) and since then it has kept the registry of IP addresses allocated in Europe, Middle East and Central Asia.[ix]

2.3. The Regional Internet Registry system

In 1996 a Best Current Practice document was approved, which provided general rules and guidelines governing the distribution and registration of IP addresses. [x] This document defined the RIR system by describing its structure, the hierarchy of the stakeholders in this system and their relationships with each other.

On the top of this hierarchy IANA was established as the authority over all IP addresses used in the Internet. IANA would allocate blocks of these IP addresses to Regional Internet Registries.

At a second level the Regional Internet Registries would be established under the authority of IANA and would operate in large geopolitical regions such as continents. The RIPE NCC was recognised in this document as the Regional Internet Registry for Europe and other areas. [xi]

At a lower level Local Internet Registries would be established under the authority of the Regional Internet Registry in their respective region and IANA. Local Internet Registries would be responsible for the distribution and registration of IP addresses to network operators. However Local Internet Registries would be coordinated and represented by their relevant Regional Internet Registry.

The Best Current Practices of 1996 also stipulated the establishment of a public registry documenting address space allocation and assignment. This would be necessary to ensure uniqueness and to provide information for Internet trouble shooting at all levels. The RIPE NCC was already adhering to this condition by maintaining the "whois database", which was called RIPE Network Management Database and later on RIPE Database.

2.4. Establishment of RIRs and the Number Resources Organization (NRO)

Initially the criteria for an organisation to become an RIR were not specifically defined. It was however crucial that the Internet community of a specific region support the establishment of a certain organisation as the Regional Internet Registry for their region. [xii] This was the case for example with the RIPE NCC, which was established with the support of the RIPE community that represents the Internet community in that region.

Later on, ICANN [xiii] published a document that defined concrete criteria for the establishment of new Regional Internet Registries based on the following principles [xiv]:

1) The region of coverage by the proposed Regional Internet Registry should meet a concrete scale to be defined by ICANN, in order to avoid fragmentation of IP address blocks
2) The proposed Regional Internet Registry must be broadly supported by Local Internet Registries in the proposed region
3) There must be an established bottom-up self-governance structure for setting local policies (see below for RIPE policies)

4) The proposed Regional Internet Registry must be neutral and impartial in relation to all interested parties, and particularly the Local Internet Registries in the relevant region

5) The proposed Regional Internet Registry must have a staff of technical experts

6) The proposed Regional Internet Registry must adhere to global policies regarding address space conservation, aggregation and registration[xv]

7) The proposed Regional Internet Registry must have a clear activity plan

8) The proposed Regional Internet Registry must have a funding model

9) The proposed Regional Internet Registry must have a system for keeping records so it operates as a registry

10) All business information it receives from Local Internet Registries must be treated as confidential.

Until now five organisations fulfill the criteria as set up in the above document:
- AfriNIC, for the African region
- APNIC, for the Asian Pacific region
- ARIN, for North America and some Caribbean Islands
- LACNIC, for Latin America and some Caribbean Islands, and
- RIPE NCC for Europe, Middle East and Central Asia (former U.S.S.R.)

RIRs are independent from each other and represent different service regions. They are not competing each other, rather they cooperate with each other because they are all parts of the global Internet registration system. In 2003 they formed the Number Resource Organization (NRO), the purpose of which is to serve as the coordinating mechanism of the RIRs for acting collectively on matters relating to the interests of the RIRs, such as the promotion and protection of the bottom-up policy development process. Additionally the NRO is meant to be the point of reference for input from the multistakeholder Internet community regarding the RIR system.

The NRO is not incorporated to a legal entity. According to the Memorandum of Understanding of all RIRs for the creation of the NRO, "[a]ny legal obligations incurred or undertakings made by the NRO either in its unincorporated status, or once incorporated, shall require the prior written commitment of all RIRs through the signature of all RIR CEOs."

2.5. Legal framework of the RIPE NCC

2.5.1. Structure of the RIPE NCC

The RIPE NCC, like all Regional Internet Registries, is a non-for-profit organisation. In particular the RIPE NCC is an association under Dutch law. It consists of the following bodies:
- The individual Members: Members of the RIPE NCC can be natural or legal persons.
- The General Meeting: This is the core of the RIPE NCC. The General Meeting of the Members takes the most important decisions such as the adoption of the activity plan and recommendation on the budget.

- The Executive Board: The Executive Board is elected by the General Meeting and consists of five individuals.
- The Management Team: The technical team to which is delegated the day to day activity of the RIPE NCC.

2.5.2. Contractual relationships with LIRs and End Users

Every network operator that receives IP addresses in the RIPE NCC service region is bound by a contract. This section presents the different kinds of contractual relationships within the RIPE NCC service region.

As described above, Regional Internet Registries delegate the distribution of IP addresses on a local level to Local Internet Registries (LIRs). LIRs within the RIPE NCC structure are natural or legal persons that receive IP addresses and related services based on a contract with the RIPE NCC. LIRs are in principle Members of the RIPE NCC and they must pay an annual fee as contribution to the RIPE NCC activities. It must be highlighted however that this fee does not specially refer to the allocation of IP addresses, but to the provision of RIPE NCC services in general. [xvi]

LIRs sub-allocate IP addresses to their customers. Within the RIR system these customers are known as End Users. This sub-allocation is usually subject to a contract between the LIR and the End User. The End Users are not necessarily the individual users of a device connected to the Internet through an IP address. In fact End Users are generally organisations that request IP addresses in order to connect their network to the Internet without having any interest in acting as a local Internet registry by sub-allocating parts of their allocation to any other organisations further on.

For technical reasons, End Users that receive IP addresses sub-allocated from an LIR's allocation are not able to manage the network attached to these IP addresses independently from the LIR. End Users that want to manage their network independently from an LIR, can request IP addresses from the RIPE NCC directly or indirectly through an LIR, in which case the LIR will only forward the request to the RIPE NCC without sub-allocating IP addresses from their own allocation. This way End Users are able to manage their network independently from an LIR. The End Users that want this independent management of IP addresses have to conclude a contract with either the RIPE NCC or the LIR accordingly. [xvii]

2.6 RIPE policy-making process – a self-regulatory system

The system according to which the RIPE NCC distributes IP addresses is determined by policies adopted by the RIPE community, which are named RIPE policies. There is a clear functional distinction between the RIPE NCC and the RIPE community. The RIPE NCC does not make the RIPE policies; the RIPE community makes them. The RIPE NCC is responsible for the implementation of the RIPE policies.

There is also a distinction between Members of the RIPE NCC and participants of the RIPE community. Members of the RIPE NCC have to pay a fee to contribute to the activities of the RIPE NCC. Participants of the RIPE community do not have to pay any fees in order to participate in the discussions and in the policy-making process of

the RIPE community. Being a Member of the RIPE NCC is not incompatible with being a participant of the RIPE community. In fact Members of the RIPE NCC often participate in the discussions and the policy-making process of the RIPE community. However participants of the RIPE community do not have to be Members of the RIPE NCC.

The policies adopted by the RIPE community define the criteria according to which the RIPE NCC distributes and registers IP addresses. To make sure that these criteria represent the particular needs of all relevant stakeholders in the region RIPE NCC is responsible for, the RIPE policy-making process has the following aspects:
- It is open for everyone to participate. It represents anyone having an interest in participating in the policy-making procedure
- It is transparent
- It follows a bottom-up process
- The decision making process is based on consensus.[xviii]

The following section will analyse these aspects.

Openness

The RIPE community is a forum without legal personality, formal membership, or any participation fees. RIPE community is open to anyone that wants to participate in the policy-making procedure and the relevant discussions. This way policies made by the RIPE Community are representative of the actual needs and requests of those they are applicable to.

To participate in the discussions and the policy-making process of the RIPE community, people can subscribe to the mailing lists created for these purposes.[xix] Subscription to these mailing lists is open to everyone and free. Discussions are also taking place in meetings of the RIPE community (RIPE Meetings). These meetings are also open for everyone to participate physically or remotely. Decisions, however, on RIPE policies are not made during the RIPE meetings. Policy-making decisions are made only through the mailing lists. Therefore the least precondition for participation in the discussions and policy-making process of the RIPE community is access to an email account, so one can subscribe to the mailing lists. No further requirements or obligations exist. This way the RIPE community allows all interested parties of the Internet community in this area to participate.

Furthermore, because the Internet has no geographic limits and because interconnection with networks in other geographic areas is a precondition for the proper functioning of the Internet, the participation of people from other regions is also encouraged in the policy development process. All in all, anyone with an interest in the development of RIPE policies is allowed and encouraged to participate so that RIPE policies are representative of all relevant stakeholders and reflect their actual needs and interests.

Consequently the RIPE community has active participants from all geographic areas and all relevant sectors, both from the private and the public sector (industry, academia, government etc). In other words, policy development within the RIPE community is done on a multistakeholder and multilateral basis and international co-operation.

Transparency

In order for the RIPE community to make sure that the policy making process is not taking place "behind closed doors" and that all interested parties have sufficient information about the relevant discussions, it has been decided that all developments are transparent to everyone. Transparency is accomplished in the following ways:
- All developments are announced through the mailing lists.
- All discussions taking place through the mailing lists are archived in a comprehensive way and are publicly available.
- All discussions and developments that take place at the RIPE Meetings are webcast, recorded, archived and publicly available. In addition a transcript and the minutes of the discussions is archived and publicly available.
- All RIPE policies and announcements are archived and publicly available.

Bottom-up process

The RIPE policy making process is designed so that anyone with an interest in participating knows how to participate and is able to do so. Anyone can propose a policy or an amendment of a current policy. Once a participant submits a policy proposal, other participants can submit their comments, support or objection to the proposal. This process adheres to established timeframes within which anyone can submit their feedback to the proposal but if the community needs more time to consider a particular proposal, these timeframes can be expanded.

The policies are created by the participants of the RIPE community. The individual participants of the RIPE community submit, comment on, and accept or reject a policy proposal. Should a proposal be accepted, the RIPE NCC has to implement it.

Consensus

For a policy proposal to become a RIPE policy, consensus must be reached. All parties participating in the discussion must agree upon the proposal. There is no voting process since it is difficult to declare any kind of majority in an open forum with no defined membership such as the RIPE community. As a result if there are arguments or objection about a proposal, this proposal is not adopted.

3. Policies regulating the distribution of IP addresses

3.1 Principles for the distribution of IP addresses

The RIPE community defines the criteria according to which IP addresses are distributed to networks in the RIPE NCC service region. These criteria are based on certain principles that were identified in 1996 [xx] and are acknowledged by the whole Internet community. These principles as articulated by the RIPE community are the following:
- Uniqueness

- Aggregation
- Conservation
- Registration

These principles are explained in the following paragraphs.

Uniqueness

As mentioned already, for the proper functioning of the Internet Protocol, the IP addresses in an interconnected network must be unique, ensuring that devices on this network can be uniquely identified.

Aggregation

For technical reasons, routing a block of IP addresses that consist of numbers next to each other is more efficient and therefore preferable by the network administrators. For example a network would more efficiently route 256 IP addresses consisting of the numbers 195.0.0.0 to 195.0.0.255 than 256 IP addresses consisting of numbers that are not contiguous.

Therefore, to ensure the proper operation of Internet routing, IP addresses must be distributed to networks in blocks of contiguous IPv4 addresses. Networks must be able to route the IP addresses allocated to them in a collective way.

Conservation

As the Internet grew and its application moved beyond research purposes, operators of Internet networks realized that the need of IP addresses would exceed the number of possible IPv4 addresses. Therefore IP addresses had to be allocated with "thoughtful care".[xxi]

In 1996 the need for careful allocation of IP addresses was reflected in the principle of conservation of IP addresses. In order for the Internet registries to comply with this principle they had to distribute IP addresses fairly and according to the operational needs of the network the IP addresses would be allocated to. The prevention of stockpiling in order to maximize the lifetime of the IP addresses was highlighted.[xxii]

Accordingly, the RIPE community identified "conservation" as a goal of the Internet registry system. In particular, according to the IPv4 Address Allocation and Assignment Policies for the RIPE NCC Service Region "Public IPv4 address space must be fairly distributed to the End Users operating networks. To maximise the lifetime of the public IPv4 address space, addresses must be distributed according to need and stockpiling must be prevented".[xxiii]

Registration

The need to record in a public registry the IP addresses allocated to networks was identified from the early years of the Internet and became a principle for the RIPE community's policies. This goal has two aspects: the insurance of uniqueness of the IP addresses distributed and the provision of contact information of networks for Internet troubleshooting at all levels.[xxiv]

3.2. Can IP addresses be owned?

In the everyday language network operators use a wording that creates the impression that IP addresses are "owned" by them. The question is consequently whether IP addresses could be considered as a property that can be owned or sold by the organisations they are registered to.

To reply to this question, one should consider the principles and goals according to which IP addresses are allocated. According to the conservation principle all IP address allocations and registrations are based on need. This principle is reflected in the procedures that are followed before and after IP addresses are allocated.

Before the allocation of the IP addresses, the requiring organisation must demonstrate a justified need for the allocation of IP addresses. If an organisation does not operate a network that is meant to interact with other networks in the Internet, the RIPE NCC will not allocate IP addresses to them. Apart from that the organisation must justify the number of IP addresses it requests. The RIPE NCC will allocate as many IP addresses as are needed by the set up of the relevant network, the number of the devices within the network etc, regardless of the number of IP addresses an organisation is requesting.

After the allocation, the IP addresses remain under the control of the Regional Internet Registries. Local Internet Registries must adhere to the policies of the Regional Internet Registries and it is the responsibility of the Local Internet Registries to make sure that their customers follow the same policies. Additionally all IP address allocations are subject to audits and verification controls as specified by the assigning Regional Internet Registry. If the network no longer meets the original allocation criteria or the allocation was based on false information, the registry will deregister the IP addresses and will make them available for a new, valid allocation.

Further, organisations are not entitled to transfer allocated IP addresses to a different organisation unless such a transfer is approved by the Regional Internet Registry. For such a transfer to be approved by the Regional Internet Registry, the acquiring party must meet the same criteria that would apply to them if they were requesting IP addresses from the Regional Internet Registry.

Finally, organisations that do not comply with these policies, lose their rights to the registration of the IP addresses. [xxv]

In conclusion, the allocated IP addresses are not property of the organisation they are allocated to.

3.3. Public registry – the RIPE Database (whois)

3.3.1. The purpose of the RIPE Database

As already mentioned, along with the need to keep records of the distributed IP addresses in an organised manner, network operators realised also the need to "know each other", to determine the use of particular ranges of IP addresses by particular networks and to communicate with operators of other networks. Based on this information they would also be able to peer with each other for routing purposes and enhance the efficiency of Internet traffic.

This information should be collected in one database and remain publicly available in an organised manner. This task was delegated to the Regional Internet Registries. The RIPE NCC implemented this mandate by creating the RIPE Database, which is also known as a "whois database".

Information publicly available in the RIPE Database can be divided into the following categories:
- Information about organisations (usually LIRs), to which IP addresses are allocated by the RIPE NCC. This includes the name of the organisation as well as some technical contact details of natural persons responsible for managing technical problems with regards to the allocation that can be reported by third parties. The RIPE NCC is responsible for collecting this information and making it publicly available.[xxvi]
- Information about networks or customers to which IP addresses have been assigned by LIRs. This is necessary for two reasons: first, to provide operational information about the use of the network and contact details in case of operational/security problems; and second to ensure that LIRs have indeed exhausted a majority of their allocation and therefore can justify receiving an additional allocation.[xxvii]
- Routing information: The RIPE Database has information necessary to permit network administrators to make decisions as to the acceptability of traffic coming from and going to different legitimately allocated IP addresses.[xxviii]

3.3.2. Quality of the RIPE database

It is very important that the data collected in the RIPE database is accurate, correct and up-to-date. It is the responsibility of LIRs to provide the registry with correct and updated information. LIRs are also obliged to comply with audit controls performed by the RIPE NCC, for the purposes of assessing the data quality of this information.[xxix] The RIPE NCC also ensures the quality of this data everytime the LIR asks for an additional allocation.[xxx]

3.3.3. Data protection aspects

The registration of personal contact details in the RIPE Database does not refer to the registration of the actual user of a specific device connected to the Internet. It refers to the registration of the organisation (for example, the ISP) that is responsible for the maintenance of the network that corresponds to a block of IP addresses.

To facilitate communication among persons responsible for networks in case of a technical disorder, every registered organisation is obliged to provide and to keep updated the professional contact details of persons that, because of their profession, are responsible for the administration and the technical maintenance of each network.

These contact details are very important for the smooth and uninterrupted operation of Internet connectivity. It should be stressed once again that these persons have nothing to do with the actual users of devices.[xxxi]

To avoid this misunderstanding the RIPE NCC does not use the term "whois" when referring to their public database, but refers to the RIPE Database.

4. Challenges

4.1 The run out of IPv4 addresses

Although IPv4 addresses were numerous enough for the needs of the 1980s, later on the unpredicted success of the Internet later on meant that they were insufficient. The careful allocation of the IPv4 addresses based on demonstrated need for the purposes of the conservation of the IP addresses or other "tricks", such as the use of "dynamic" IP addresses by Internet Service Providers could only postpone the inevitable run out of IPv4 addresses.

In the beginning of 2011 more than 95% of the IPv4 addresses have been allocated, assigned or otherwise reserved. The IANA free pool of IPv4 address was exhausted in February 2011. Many of the addresses are with the five Regional Internet Registries or have been allocated by them.

The RIPE community, realising the need for a fair distribution of the last IP addresses and taking into account the need of future/not-yet-existing LIRs to have access to IPv4 addresses to manage the transition to IPv6, has come up with a policy according to which only small blocks of the last IPv4 addresses would be distributed to LIRs that have already been allocated IPv6 addresses[xxxii]. Taking into account that IPv6 addresses are allocated only if there is a plan for IPv6 infrastructure, the RIPE community also tried with this policy to give LIRs an incentive to deploy IPv6; either an LIR has to plan to deploy IPv6 or it does not receive a share of the last IPv4 addresses.

4.2 Maintaining a good registry

After the depletion of the IPv4 addresses, distribution of IP addresses will no longer be the main function of the Regional Internet Registries. IPv6 addresses are not allocated in the same way as IPv4. For technical reasons IPv6 addresses cannot be allocated individually to End Users but as subnets. A single user of a computer is generally entitled to be assigned 2^{64} addresses.

Therefore Regional Internet Registries are focusing on maintaining the registration of IP addresses, which is still a very important activity for the operation of the Internet. Maintaining an up-to-date registry will be the primary goal of the Regional Internet Registries. Information about the networks to which IP addresses have been distributed is and will continue to be controlled. However, this goal faces the following challenges:

- A request for an additional IPv4 address allocation by the RIPE NCC was an opportunity for the performance of an audit by the RIPE NCC regarding the quality of their registration data of the LIR. Now with the large blocks of IPv6 addresses that are distributed to LIRs, requesting an additional allocation is not foreseeable. The obligation to keep the records in the publicly available database correct and up-to-date is no longer easy to enforce.

- Although after the creation of the RIR system the allocation of IP addresses adhered to a concrete system that was defined by certain principles, policies and contractual obligations, quite a few addresses were given out before the formation of the RIR system. As much as IP addresses distributed by the RIPE NCC are registered and maintained in the RIPE Database, IP addresses distributed in the early years of the Internet (known as "legacy space") constitute a large number of addresses that are neither properly registered nor clearly adhere to the RIPE policies. The RIPE NCC and other RIRs are now trying to collect all possible information about these IP addresses and update their records in their registries because after the depletion of IPv4 addresses, the possibilities of hijacking unregistered and unconfirmed addresses is very high. However the RIRs depend on the holders of these IP addresses to cooperate with these efforts and to comply in the future to Internet community policies.

4.3 Commercialisation of IPv4 addresses

Although the need for more IP addresses was identified in the 1990s, implementation of this new protocol has not yet been achieved. Currently 66% of the LIRs in the RIPE NCC service region have not requested IPv6 addresses.

The exhaustion of IPv4 addresses in combination with the unwillingness of the industry to implement IPv6 addresses will lead to a situation where IPv4 addresses become extremely valuable and their use extremely complex. ISPs or other LIRs or users attach value to IP addresses by applying property features to them, e.g. by commercialising (selling) them or by treating them as assets.

Discussions are currently taking place around the designation of IPv4 addresses as "public resources" and the proper and fair allocation of unused IPv4 addresses in light of this.[xxxiii] However while IPv4 addresses are indeed scarce resources and their distribution must be fair, the question is whether it is appropriate to investigate methods of reallocating when IPv4 addresses cannot meet the demands of the Internet in the long run.

This issue would be solved with the deployment of the IPv6 protocol. But the high investment that this deployment requires and the lack of incentives by the public and the private sector create obstacles to the solution of the problem.

[i] For more information see Leiner B. M., Cerf V. G., Clark D. D., Kahn R. E., Kleinrock L., Lynch D. C.,　Postel J., Roberts L. G., Wolff S., A brief history of the Internet, online at http://www.isoc.org/internet/history/brief.shtml/accessed 18.04.2011

[ii] Postel J., (1981) Internet Protocol DAPRA Internet Program Protocol Specification, RFC 791, online at http://www.ietf.org/rfc/rfc791.txt/ accessed 18.04.2011

[iii] Deering S., Hinden R., (1998), Internet Protocol, Version 6 (IPv6) Specification, RFC 2460, online at http://www.ietf.org/rfc/rfc2460.txt/ accessed 18.04.2011

[iv] RIPE NCC, What is IPv6?, online at http://www.ipv6actnow.org/info/what-is-ipv6/ accessed 18.0402011

[v] More information about Jon Postel can be found online at http://www.isoc.org/awards/postel/memory.shtml /accessed 18.04.2011

[vi] Cerf V., (1990), IAB Recommended Policy on Distributing Internet Identifier Assignment and IAB Recommended Policy Change to Internet "Connected", RFC 1174, online at http://www.rfc-editor.org/rfc/rfc1174.txt/accessed 18.04.2011

[vii] Gerich E., (1992), Guidelines for Management of IP Address Space, RFC 1366, online at http://www.rfc-editor.org/rfc/rfc1366.txt/accessed 18.04.2011

[viii] Blokzijl R., Brunel M., Fluckiger F., Karrenberg D., Martin O., Valente E., (1992), RIPE Terms of Reference, ripe-001, online at http://www.ripe.net/ripe/docs/ripe-001/accessed 18.04.2011

[ix] Blokzijl R., Devillers Y., Karrenberg D., Volk R., (1990), RIPE Network Coordination Center (RIPE NCC), ripe-19, online at ftp://ftp.ripe.net/ripe/docs/ripe-019.txt/accessed 18.04.2011

[x] Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050, online at http://www.ietf.org/rfc/rfc2050.txt,/accessed 18.04.2011

[xi] Later the RIPE NCC was recognised by the European Union. For more information see http://ec.europa.eu/information_society/policy/internet_gov/index_en.htm/ accessed 18.04.2011

[xii] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050

[xiii] Internet Corporation for Assigned Names and Numbers (ICANN) is the organisation that in undertook the IANA function in 1998. For more information see http://www.icann.org/en/participate/what-icann-do.html /accessed 18.04.2011

[xiv] ICANN, (2001), ICP-2: Criteria for Establishment of New Regional Internet Registries, online at http://www.icann.org/en/icp/icp-2.htm / accessed 18.04.2011

[xv] The concepts of address space conservation, aggregation and registration are explained in section 3.1. of this paper

[xvi] RIPE NCC Standard Service Agreement, (2008), online at https://www.ripe.net/ripe/docs/ripe-435 / accessed 18.04.2011, RIPE NCC Standard Terms and Conditions, (2008), online at https://www.ripe.net/ripe/docs/ripe-418 / accessed 18.04.2011, RIPE NCC Charging Scheme, (2011), online at http://www.ripe.net/ripe/docs/ripe-499 / accessed 18.04.2011

[xvii] Hilliard N., (2009), Contractual Requirements for Provider Independent Resource Holders in the RIPE NCC Service Region, online at http://www.ripe.net/ripe/docs/ripe-452 / accessed 18.04.2011

[xviii] Blokzijl R., Lindqvist K., Yilmaz F., (2010), Policy development Process in RIPE, ripe-500, online at http://www.ripe.net/ripe/docs/ripe-500, accessed 18.04.2011

[xix] More information about the RIPE Working Group mailing lists can be found online at http://www.ripe.net/ripe/mail/wg-lists / accessed 18.04.2011

[xx] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050

[xxi] See above Cerf V., (1990), IAB Recommended Policy on Distributing Internet Identifier Assignment and IAB Recommended Policy Change to Internet "Connected", RFC 1174

[xxii] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050

[xxiii] Bush R., Carr B., Karrenberg D., O'Reilly N., Sury O., Titley N., Yilmaz F., Wijte I., (2011), IPv4 Address Allocation and Assignment Policies for the RIPE NCC Service Region, ripe-509, online at http://www.ripe.net/ripe/docs/ripe-509 / accessed 18.04.2011

[xxiv] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050

[xxv] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050, Bush R., Carr B., Karrenberg D., O'Reilly N., Sury O., Titley N., Yilmaz F., Wijte I., (2011), IPv4 Address Allocation and Assignment Policies for the RIPE NCC Service Region, ripe-509 and RIPE NCC, Closure of LIRs and Deregistration of Internet Number Resources, ripe-517, online at http://www.ripe.net/ripe/docs/ripe-517 / accessed 18.04.2011

[xxvi] See above Blokzijl R., Devillers Y., Karrenberg D., Volk R., (1990), RIPE Network Coordination Center (RIPE NCC), ripe-19

[xxvii] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050

[xxviii] See above Cerf V., (1990), IAB Recommended Policy on Distributing Internet Identifier Assignment and IAB Recommended Policy Change to Internet "Connected", RFC 1174

[xxix] RIPE Database Terms and Conditions, online at http://www.ripe.net/data-tools/support/documentation/terms / accessed 18.04.2011

[xxx] See above Hubbard K., Kosters M., Conrad D., Karrenberg D., Postel J., (1996), Internet registry IP allocation guidelines, RFC 2050, Blokzijl R., Devillers Y., Karrenberg D., Volk R., (1990), RIPE Network Coordination Center (RIPE NCC), Bush R., Carr B., Karrenberg D., O'Reilly N., Sury O., Titley N., Yilmaz F., Wijte I., (2011), IPv4 Address Allocation and Assignment Policies for the RIPE NCC Service Region, ripe-509

[xxxi] RIPE NCC Privacy Statement, online at http://www.ripe.net/lir-services/ncc/legal/ripe-ncc-privacy-statement / accessed 18.04.2011

[xxxii] Smith P., Bidron A., (2011), Allocations from the last /8, 2010-02, online at http://www.ripe.net/ripe/policies/proposals/2010-02 , accessed 18.04.2011, see above Bush R., Carr B., Karrenberg D., O'Reilly N., Sury O., Titley N., Yilmaz F., Wijte I., (2011), IPv4 Address Allocation and Assignment Policies for the RIPE NCC Service Region, ripe-509

[xxxiii] Weber R. H., Heinrich U. I., IP Address Allocation through the Lenses of Public Goods and Scarce Resources Theories (2011), online at http://www.law.ed.ac.uk/ahrc/script-ed/vol8-1/weber.asp / accessed 18.04.2011