IPv6 Address Allocation and Assignment Policy

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Abstract

This document defines registry policies for the assignment and allocation of globally unique IPv6 addresses to Internet Service Providers (ISPs) and other organisations. It was developed through joint discussions among the APNIC, ARIN and RIPE communities.

Contents

1. Introduction

1.1. Overview

This document describes policies for the allocation and assignment of globally unique Internet Protocol version 6 (IPv6) address space.

[RFC 4291] designates 2000::/3 to be global unicast address space that the Internet Assigned Numbers Authority (IANA) may allocate to the RIRs. In accordance with [RFC 4291], IANA allocated initial ranges of global unicast IPv6 address space from the 2000::/3 address block to the RIRs. This document concerns the initial and subsequent allocations of the 2000::/3 unicast address space, for which RIRs formulate allocation and assignment policies. All bits to the left of /64 are in scope.

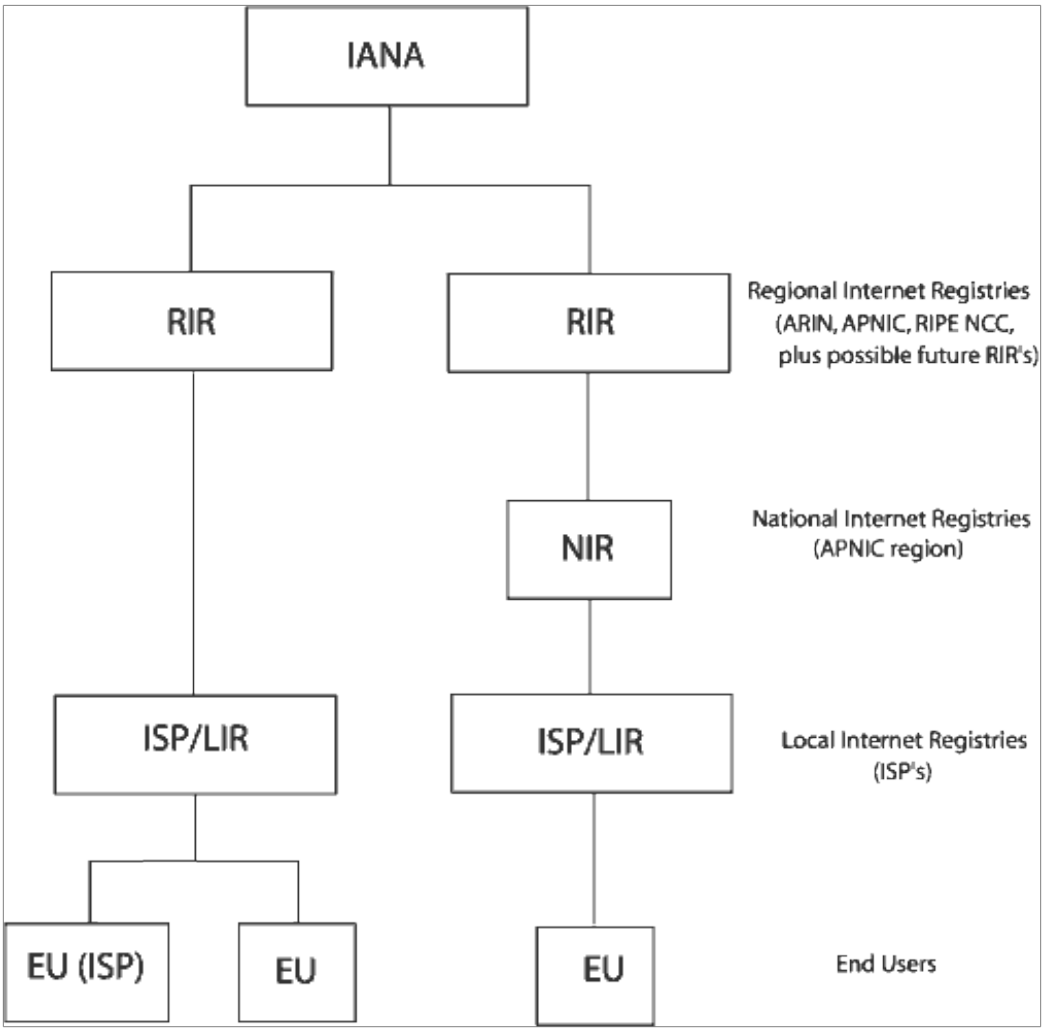
This policy is subject to future review and potential revision, subject to continuing experience in the administration of IPv6.

2. Definitions

[Note: some of these definitions will be replaced by definitions from other RIR documents in order to be more consistent.]

The following terms and their definitions are of particular importance to the understanding of the goals, environment and policies described in this document.

Responsibility for management of IPv6 address spaces is distributed globally in accordance with the hierarchical structure shown below.



2.1. Internet Registry (IR)

An Internet Registry is an organisation that is responsible for distributing IP address space to its members or customers and for registering those distributions. IRs are classified according to their primary function and territorial scope within the hierarchical structure depicted in the figure above.

2.2. Regional Internet Registry (RIR)

Regional Internet Registries are established and authorised by respective regional communities and recognised by the IANA to serve and represent large geographical regions. The primary role of RIRs

is to manage and distribute public Internet address space within their respective regions.

2.3. National Internet Registry (NIR)

A National Internet Registry primarily allocates address space to its members or constituents, which are generally LIRs organised at a national level. NIRs exist mostly in the Asia Pacific region.

2.4. Local Internet Registry (LIR)

A Local Internet Registry is an IR that primarily assigns address space to the users of the network services that it provides. LIRs are generally ISPs whose customers are primarily End Users and possibly other ISPs.

2.5. Allocate

To “allocate” means to distribute address space to IRs for the purpose of subsequent distribution by them.

2.6. Assign

To “assign” means to delegate address space to an ISP or End User for specific use within the Internet infrastructure they operate. Assignments must only be made for specific purposes documented by specific organisations and are not to be sub-assigned to other parties.

Providing another entity with separate addresses (not prefixes) from a subnet used on a link operated by the assignment holder is not considered a sub-assignment. This includes for example letting visitors connect to the assignment holder's network, connecting a server or appliance to an assignment holder's network and setting up point-to-point links with 3rd parties.

2.7. Utilisation

The actual usage of addresses within each assignment may be low when compared to IPv4 assignments. In IPv6, "utilisation" is only measured in terms of the bits to the left of the efficiency measurement unit (/56). In other words, "utilisation" effectively refers to the assignment of network prefixes to End Sites and not the number of addresses assigned within individual End Site assignments.

Throughout this document, the term "utilisation" refers to the assignment of network prefixes to End Sites and not the number of addresses assigned within individual subnets within those End Sites.

2.8. HD-Ratio

The HD-Ratio is a way of measuring the efficiency of address assignment [RFC 3194]. It is an adaptation of the H-Ratio originally defined in [RFC 1715] and is expressed as follows:

$$HD = \frac{\log(\text{number of allocated objects})}{\log(\text{maximum number of allocatable objects})}$$

where (in the case of this document) the objects are IPv6 site addresses assigned from an IPv6 prefix of a given size.

2.9. End Site

An End Site is defined as an End User (subscriber) who has a business or legal relationship (same or associated entities) with a service provider that involves:

- that service provider assigning address space to the End User
- that service provider providing transit service for the End User to other sites
- that service provider carrying the End User's traffic
- that service provider advertising an aggregate prefix route that contains the End User's assignment

3. Goals of IPv6 address space management

3.1. Goals

IPv6 address space is a public resource that must be managed in a prudent manner with regards to the long-term interests of the Internet. Responsible address space management involves balancing a set of sometimes competing goals. The following are the goals relevant to IPv6 address policy.

3.2. Uniqueness

Every assignment and/or allocation of address space must guarantee uniqueness worldwide. This is an absolute requirement for ensuring that every public host on the Internet can be uniquely identified.

3.3. Registration

Internet address space must be registered in a registry database accessible to appropriate members of the Internet community. This is necessary to ensure the uniqueness of each Internet address and to provide reference information for Internet troubleshooting at all levels, ranging from all RIRs and IRs to End Users.

The goal of registration should be applied within the context of reasonable privacy considerations and applicable laws.

3.4. Aggregation

Wherever possible, address space should be distributed in a hierarchical manner, according to the topology of network infrastructure. This is necessary to permit the aggregation of routing information by ISPs and to limit the expansion of Internet routing tables.

This goal is particularly important in IPv6 addressing, where the size of the total address pool creates significant implications for both internal and external routing.

IPv6 address policies should seek to avoid fragmentation of address ranges.

Further, RIRs should apply practices that maximise the potential for subsequent allocations to be made contiguous with past allocations currently held. However, there can be no guarantee of contiguous allocation.

3.5. Conservation

Although IPv6 provides an extremely large pool of address space, address policies should avoid unnecessarily wasteful practices. Requests for address space should be supported by appropriate documentation and stockpiling of unused addresses should be avoided.

3.6. Fairness

All policies and practices relating to the use of public address space should apply fairly and

equitably to all existing and potential members of the Internet community, regardless of their location, nationality, size, or any other factor.

3.7. Minimised overhead

It is desirable to minimise the overhead associated with obtaining address space. Overhead includes the need to go back to RIRs for additional space too frequently, the overhead associated with managing address space that grows through a number of small successive incremental expansions rather than through fewer, but larger, expansions.

3.8. Conflict of goals

The goals described above will often conflict with each other, or with the needs of individual IRs or End Users. All IRs evaluating requests for allocations and assignments must make judgments, seeking to balance the needs of the applicant with the needs of the Internet community as a whole.

In IPv6 address policy, the goal of aggregation is considered to be the most important.

4. IPv6 Policy Principles

To address the goals described in the previous section, the policies in this document discuss and follow the basic principles described below.

4.1. Address space not to be considered property

It is contrary to the goals of this document and is not in the interests of the Internet community as a whole for address space to be considered freehold property.

The policies in this document are based upon the understanding that globally unique IPv6 unicast address space is licensed for use rather than owned. Specifically, IP addresses will be allocated and assigned on a license basis, with licenses subject to renewal on a periodic basis. The granting of a license is subject to specific conditions applied at the start or renewal of the license.

RIRs will generally renew licenses automatically, provided requesting organisations are making a "good faith" effort at meeting the criteria under which they qualified for or were granted an allocation or assignment. However, in those cases where a requesting organisation is not using the address space as intended, or is showing bad faith in following through on the associated obligation, RIRs reserve the right to not renew the license. Note that when a license is renewed, the new license will be evaluated under and governed by the applicable IPv6 address policies in place at the time of renewal, which may differ from the policy in place at the time of the original allocation or assignment.

4.2. Routability not guaranteed

There is no guarantee that any address allocation or assignment will be globally routable.

However, RIRs must apply procedures that reduce the possibility of fragmented address space which may lead to a loss of routability.

4.3. Minimum allocation

The minimum allocation size for IPv6 address space is /32.

4.4. Consideration of IPv4 infrastructure

Where an existing IPv4 service provider requests IPv6 space for eventual transition of existing services to IPv6, the number of present IPv4 customers may be used to justify a larger request than

would be justified if based solely on the IPv6 infrastructure.

5. Policies for Allocations and Assignments

5.1. Initial allocation

5.1.1. Initial allocation criteria for LIRs

To qualify for an initial allocation of IPv6 address space, an LIR must have a plan for making sub-allocations to other organisations and/or End Site assignments within two years.

5.1.2. Initial allocation size
LIRs that meet the initial allocation criteria are eligible to receive an initial allocation of /32 up to /29 without needing to supply any additional information.

LIRs may qualify for an initial allocation greater than /29 by submitting documentation that reasonably justifies the request. If so, the allocation size will be based on the number of users, the extent of the LIR infrastructure, the hierarchical and geographical structuring of the LIR, the segmentation of infrastructure for security and the planned longevity of the allocation.

5.2. Subsequent allocation

LIRs that have received an IPv6 allocation may receive a subsequent allocation in accordance with the following policies.

5.2.1. Subsequent allocation criteria

Subsequent allocation will be provided when an LIR:

> a) Satisfies the evaluation threshold of past address utilisation in terms of the number of sites in units of /56. To this end, the HD-Ratio [RFC 3194] is used to determine the utilisation thresholds.
>
> or
>
> b) Can justify new needs (which can't be satisfied within the previous allocation), according to the initial allocation size criteria as described in section 5.1.2.

5.2.2. Applied HD-Ratio

The HD-Ratio value of 0.94 is adopted as indicating an acceptable address utilisation for justifying the allocation of additional address space. Appendix A provides a table showing the number of assignments that are necessary to achieve an acceptable utilisation value for a given address block size.

5.2.3. Subsequent allocation size

When an LIR meets the subsequent allocation criteria, it is immediately eligible to obtain an additional allocation that results in a doubling of the address space allocated to it. Where possible, the allocation will be made from an adjacent address block, meaning that its existing allocation is extended by one bit to the left.

If an LIR needs more address space, it must provide documentation justifying its new requirements, as described in section 5.1.2. The allocation made will be based on the relevant documentation.

5.3. LIR-to-ISP allocation

There is no specific policy for an LIR to allocate address space to subordinate ISPs. Each LIR organisation may develop its own policy for subordinate ISPs to encourage optimum utilisation of the total address block allocated to the LIR. However, all /48 assignments to End Sites are required to be registered either by the LIR or its subordinate ISPs in such a way that the RIR/NIR can properly evaluate the HD-Ratio when a subsequent allocation becomes necessary.

5.4. Assignment

LIRs must make IPv6 assignments in accordance with the following provisions.

5.4.1. Assignment address space size

End Users are assigned an End Site assignment from their LIR or ISP. The size of the assignment is a local decision for the LIR or ISP to make, using a minimum value of a /64 (only one subnet is anticipated for the End Site).

5.4.2. Assignments shorter than a /48 to a single End Site

When a single End Site requires an assignment shorter than a /48, it must request the assignment with documentation or materials that justify the request. Requests for multiple or additional prefixes exceeding a /48 assignment for a single End Site will be processed and reviewed (i.e., evaluation of justification) at the RIR/NIR level.

Note: There is no experience at the present time with the assignment of multiple network prefixes to the same End Site. Having the RIR review all such assignments is intended to be a temporary measure until some experience has been gained and some common policies can be developed. In addition, additional work at defining policies in this space will likely be carried out in the near future.

5.4.3. Assignment to operator's infrastructure

An LIR may assign a network prefix per PoP as the service infrastructure of an IPv6 service operator. Each assignment to a PoP is regarded as one assignment regardless of the number of users using the PoP. A separate assignment can be obtained for the in-house operations of the operator.

5.5 Registration

When an LIR holding an IPv6 address allocation makes IPv6 address assignments, it must register these assignments in the appropriate RIR database.

These registrations can either be made as individual assignments or by inserting an object with a status value of 'AGGREGATED-BY-LIR' where the assignment-size attribute contains the size of

the individual assignments made to End Users. When more than a /48 is assigned to an organisation, it must be registered in the database as a separate object with status 'ASSIGNED'.

In case of an audit or when making a request for a subsequent allocation, the LIR must be able to present statistics showing the number of individual assignments made in all objects with a status of 'AGGREGATED-BY-LIR' in such a way the RIR is able to calculate and verify the actual HD-ratio.

5.6. Reverse lookup

When an RIR/NIR delegates IPv6 address space to an LIR, it also delegates the responsibility to manage the reverse lookup zone that corresponds to the allocated IPv6 address space. Each LIR should properly manage its reverse lookup zone. When making an address assignment, the LIR must delegate to an assignee organisation, upon request, the responsibility to manage the reverse lookup zone that corresponds to the assigned address.

5.7. Existing IPv6 address space holders

LIRs that hold one or more IPv6 allocations are able to request extension of each of these allocations up to a /29 without providing further documentation.

The RIPE NCC should allocate the new address space contiguously with the LIRs' existing allocations and avoid allocating non-contiguous space under this policy section.

6. Anycasting TLD and Tier 0/1 ENUM Nameservers

The organisations applicable under this policy are TLD managers, as recorded in the IANA's Root Zone Database and ENUM administrators, as assigned by the ITU. The organisation may receive up to four /48 prefixes per TLD and four /48 prefixes per ENUM. These prefixes must be used for the sole purpose of anycasting authoritative DNS servers for the stated TLD/ENUM, as described in BCP126/RFC 4786.

Assignments for authoritative TLD or ENUM Tier 0/1 DNS lookup services are subject to the policies described in the RIPE Document entitled "Contractual Requirements for Provider Independent Resource Holders in the RIPE NCC Service Region".

Anycasting assignments are registered with a status of 'ASSIGNED ANYCAST' in the RIPE Database and must be returned to the RIPE NCC if not in use for infrastructure providing authoritative TLD or ENUM Tier 0/1 DNS lookup services any longer.

7. IPv6 Provider Independent (PI) Assignments

To qualify for IPv6 PI address space, an organisation must meet the requirements of the policies described in the RIPE NCC document entitled "Contractual Requirements for Provider Independent Resources Holders in the RIPE NCC Service Region".

The RIPE NCC will assign the prefix directly to the End User organisations upon a request properly submitted to the RIPE NCC, either directly or through a sponsoring LIR.

The minimum size of the assignment is a /48. Organisations requesting a larger assignment (shorter prefix) must provide documentation justifying the need for additional subnets.

Additional assignments may also be made when the need is demonstrated and documented based on address usage, or because different routing requirements exist for additional assignments. When possible, these further assignments will be made from an adjacent address block.

Assignments will be made from a separate 'designated block' to facilitate filtering practices.

The PI assignment cannot be further sub-assigned to other organisations.

7.1 IPv6 Provider Independent (PI) Assignments for LIRs

LIRs can qualify for an IPv6 PI assignment for parts of their own infrastructure that are not used for customer end sites. Where an LIR has an IPv6 allocation, the LIR must demonstrate the unique routing requirements for the PI assignment.

The LIR should return the IPv6 PI assignment within a period of six months if the original criteria on which the assignment was based are no longer valid.

8.0 Transfer of IPv6 resources

The transfer of Internet number resources is governed by the RIPE Document, "RIPE Resource Transfer Policies".

9. References

[RFC 1715] "The H Ratio for Address Assignment Efficiency", C. Huitema. November 1994, ftp://ftp.ripe.net/rfc/rfc1715.txt.
[RFC 2026] "The Internet Standards Process -- Revision 3 IETF Experimental RFC ftp://ftp.ripe.net/rfc/rfc2026.txt see Sec. 4.2.1
[RFC 2462] "IPv6 Stateless Address Autoconfiguration", S. Thomson, T. Narten, 1998, ftp://ftp.ripe.net/rfc/rfc2462.txt
[RFC 4291] "IP Version 6 Addressing Architecture", R. Hinden, S. Deering. February 2006, ftp://ftp.ripe.net/rfc/rfc4291.txt
[RFC 2928] "Initial IPv6 Sub-TLA ID Assignments", R. Hinden, S. Deering, R. Fink, T. Hain. September 2000 ftp://ftp.ripe.net/rfc/rfc2928.txt
[RFC 3194] "The H-Density Ratio for Address Assignment Efficiency An Update on the H ratio", A. Durand, C. Huitema. November 2001, ftp://ftp.ripe.net/rfc/rfc3194.txt
[RFC 4291] "IP Version 6 Addressing Architecture", R. Hinden, S. Deering. February 2006, ftp://ftp.ripe.net/rfc/rfc4291.txt
[RFC 4786] "Operation of Anycast Services", J. Abley, K. Lindqvist. December 2006, ftp://ftp.ripe.net/rfc/rfc4786.txt

10. Appendix A: HD-Ratio

The utilisation threshold T, expressed as a number of individual /56 prefixes to be allocated from IPv6 prefix P, can be calculated as:

$$T = 2^{((56-P)*HD)}$$

Thus, the utilisation threshold for an LIR requesting subsequent allocation of IPv6 address block is specified as a function of the prefix size and target HD ratio. This utilisation refers to the use of /56s as an efficiency measurement unit, and does not refer to the utilisation of addresses within those End Sites. It is an address allocation utilisation ratio and not an address assignment utilisation ratio.

In accordance with the recommendations of [RFC 3194], this document adopts an HD-Ratio of 0.94 as the utilisation threshold for IPv6 address space allocations.

The following table provides equivalent absolute and percentage address utilisation figures for IPv6 prefixes, corresponding to an HD-Ratio of 0.94.

Prefix	Total /56s	/56s HD 0.94	Util %
10	70368744177664	10388121308479	14.76
11	35184372088832	5414630391777	15.39
12	17592186044416	2822283395519	16.04
13	8796093022208	1471066903609	16.72
14	4398046511104	766768439460	17.43
15	2199023255552	399664922315	18.17
16	1099511627776	208318498661	18.95
17	549755813888	108582451102	19.75
18	274877906944	56596743751	20.59
19	137438953472	29500083768	21.46
20	68719476736	15376413635	22.38
21	34359738368	8014692369	23.33
22	17179869184	4177521189	24.32
23	8589934592	2177461403	25.35
24	4294967296	1134964479	26.43
25	2147483648	591580804	27.55
26	1073741824	308351367	28.72
27	536870912	160722871	29.94
28	268435456	83774045	31.21

29	134217728	43665787	32.53
30	67108864	22760044	33.92
31	33554432	11863283	35.36
32	16777216	6183533	36.86

11. Appendix B: Background information

11.1. Background

The impetus for revising the 1999 provisional IPv6 policy started with the APNIC meeting held in Taiwan in August 2001. Follow-on discussions were held at the October 2001 RIPE and ARIN meetings. During these meetings, the participants recognised an urgent need for more detailed, complete policies. One result of the meetings was the establishment of a single mailing list to discuss a revised policy together with a desire to develop a general policy that all RIRs could use. This document does not provide details of individual discussions that lead to policies described in this document; detailed information can be found in the individual meeting minutes at the www.apnic.net, www.arin.net, and www.ripe.net web sites.

In September 2002 at the RIPE 43 Meeting in Rhodes, Greece, the RIPE community approved the policy allowing Internet experiments to receive temporary assignments. As a result, Section 6 was added to this document in January 2003.

11.2. Why a joint policy?

IPv6 addresses are a public resource that must be managed with consideration to the long-term interests of the Internet community. Although regional registries adopt allocation policies according to their own internal processes, address policies should largely be uniform across registries. Having significantly varying policies in different regions is undesirable because it can lead to situations where "registry shopping" can occur as requesting organisations request addresses from the registry that has the most favorable policy for their particular desires. This can lead to the policies in one region undermining the efforts of registries in other regions with regards to prudent stewardship of the address space. In cases where regional variations from the policy are deemed necessary, the preferred approach is to raise the issue in the other regional registries in order to develop a consensus approach that all registries can support.

11.3. The size of IPv6's address space

Compared to IPv4, IPv6 has a seemingly endless amount of address space. While superficially true, short-sighted and wasteful allocation policies could also result in the adoption of practices that lead to premature exhaustion of the address space.

It should be noted that the 128-bit address space is divided into three logical parts, with the usage of each component managed differently. The rightmost 64 bits, the Interface Identifier [RFC 4291], will often be a globally unique IEEE identifier (e.g., mac address). Although an "inefficient" way to use the Interface Identifier field from the perspective of maximizing the number of addressable nodes, the numbering scheme was explicitly chosen to simplify Stateless Address Autoconfiguration [RFC 2462].

The middle bits of an address indicate the subnet ID. This field may often be inefficiently utilised, but the operational benefits of a consistent width subnet field were deemed to be outweigh the drawbacks. This is a variable length field, determined by each LIR's local assignment policy.

11.4. Acknowledgment

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An editing team was then organised by representatives from each of the three RIRs (Takashi Arano, Chair of APNIC's Policy SIG, Thomas Narten, Chair of ARIN's IPv6 WG, and David Kessens, Chair of the RIPE IPv6 Working Group).

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The final editing of the initial version of this document was done by Thomas Narten.