IPv6 Address Allocation and Assignment Policy

APNIC, ARIN, RIPE NCC

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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. This document obsoletes the "Provisional IPv6 assignment and allocation policy document". It was developed through joint discussions among the APNIC, ARIN and RIPE communities.

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1. Introduction

1.1. Overview

This document describes policies for the allocation and assignment of globally-unique Internet Protocol Version 6 (IPv6) address space. It updates and obsoletes the existing Provisional IPv6 Policies in effect since 1999 [RIRv6-Policies]. Policies described in this document are are intended to be adopted by each registry. However, adoption of this document does not preclude local variations in each region or area.

[RFC 2373, RFC 2373bis] designate 2000::/3 to be global unicast address space that IANA may allocate to the RIRs. In accordance with [RFC 2928, RFC 2373bis, IAB-Request], IANA has allocated initial ranges of global unicast IPv6 address space from the 2001::/16 address block to the existing RIRs. This document concerns the initial and subsequent allocations of the 2000::/3 unicast address space, for which RIRs formulate allocation and assignment policies. Because End Sites will generally be given /48 assignments [RFC 3177, RIRs- on-48s], the particular emphasis of this document is on policies relating the bits within 2000::/3 to the left of the /48 boundary.
However, since some End Sites will receive /64 and /128 assignments, all bits to the left of /64 are in scope.

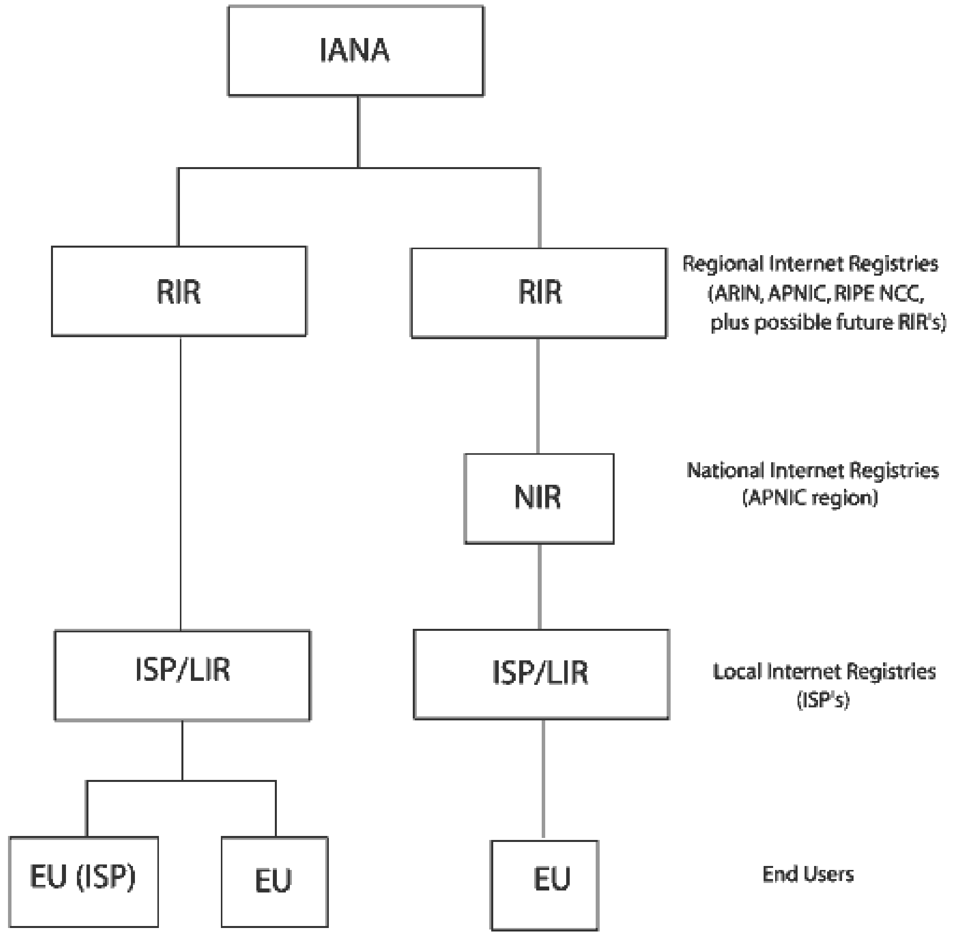
This policy is considered to be an interim policy. It will be reviewed in the future, subject to greater experience in the administration of IPv6.

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 (IR) 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 (RIRs) 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 (NIR) 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 (LIR) 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.

2.7. Utilisation

Unlike IPv4, IPv6 is generally assigned to End Sites in fixed amounts (/48). The actual usage of addresses within each assignment will be quite low, when compared to IPv4 assignments. In IPv6, "utilisation" is only measured in terms of the bits to the left of the /48 boundary. In other words, utilisation refers to the assignment of /48s to End Sites, and not the number of addresses assigned within individual /48s at those End Sites.

Throughout this document, the term utilisation refers to the allocation of /48s to End Sites, and not the number of addresses assigned within individual /48s 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 [RFC1715] and is expressed as follows:

```
          Log (number of allocated objects)
     HD = ------------------------------------------------
          Log (maximum number of allocatable objects)
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where (in the case of this document) the objects are IPv6 site addresses (/48s) 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 relationship 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

RIRs will apply a minimum size for IPv6 allocations, to facilitate prefix-based filtering.

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

To qualify for an initial allocation of IPv6 address space, an organisation must:

a) be an LIR;

b) not be an end site;

c) plan to provide IPv6 connectivity to organisations to which it will assign /48s, by advertising that connectivity through its single aggregated address allocation; and

d) have a plan for making at least 200 /48 assignments to other organisations within two years.

5.1.2. Initial allocation size

Organisations that meet the initial allocation criteria are eligible to receive a minimum allocation of /32.

Organisations may qualify for an initial allocation greater than /32 by submitting documentation that reasonably justifies the request. If so, the allocation size will be based on the number of existing users and the extent of the organisation's infrastructure.

5.2. Subsequent allocation

Organisations that hold an existing 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 organisation (ISP/LIR) satisfies the evaluation threshold of past address utilisation in terms of the number of sites in units of /48 assignments. The HD- Ratio [RFC 3194] is used to determine the utilisation thresholds that justify the allocation of additional address as described below.

5.2.2. Applied HD-Ratio

The HD-Ratio value of 0.8 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 organisation has achieved an acceptable utilisation for its allocated address space, 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 organisation needs more address space, it must provide documentation justifying its requirements for a two-year period. The allocation made will be based on this requirement.

5.3. LIR-to-ISP allocation

There is no specific policy for an organisation (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

Assignments are to be made in accordance with the existing guidelines [RFC3177,RIRs-on-48], which are summarized here as:

- /48 in the general case, except for very large subscribers
- /64 when it is known that one and only one subnet is needed by design
- /128 when it is absolutely known that one and only one device is connecting.

RIRs/NIRs are not concerned about which address size an LIR/ISP actually assigns. Accordingly, RIRs/NIRs will not request the detailed information on IPv6 user networks as they did in IPv4, except for the cases described in Section 4.4 and for the purposes of measuring utilisation as defined in this document.

5.4.2. Assignment of multiple /48s to a single end site

When a single end site requires an additional /48 address block, it must request the assignment with documentation or materials that justify the request. Requests for multiple or additional /48s 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 /48s 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 organisation (ISP/LIR) may assign a /48 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 organisation holding an IPv6 address allocation makes IPv6 address assignments, it must register assignment information in a database, accessible by RIRs as appropriate (information registered by an RIR/NIR may be replaced by a distributed database for registering address management information in future). Information is registered in units of assigned /48 networks. When more than a /48 is assigned to an organisation, the assigning organisation is responsible for ensuring that the address space is registered in an RIR/NIR database.

RIR/NIRs will use registered data to calculate the HD-Ratio at the time of application for subsequent allocation and to check for changes in assignments over time.

IRs shall maintain systems and practices that protect the security of personal and commercial information that is used in request evaluation, but which is not required for public registration.

5.6. Reverse lookup

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

organisations that received /35 IPv6 allocations under the previous IPv6 address policy [RIRv6-Policies] are immediately entitled to have their allocation expanded to a /32 address block, without providing justification, so long as they satisfy the criteria in Section 5.1.1. The /32 address block will contain the already allocated smaller address block (one or multiple /35 address blocks in many cases) that was already reserved by the RIR for a subsequent allocation to the organisation. Requests for additional space beyond the minimum /32 size will be evaluated as discussed elsewhere in the document.

6. References

[RFC1715] "The H Ratio for Address Assignment Efficiency", C. Huitema. November 1994, ftp://ftp.ripe.net/rfc/rfc1715.txt.

[IAB-Request] "Email from IAB to IANA",

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[RFC2373] "IP Version 6 Addressing Architecture", R. Hinden, S. Deering. July 1998, ftp://ftp.ripe.net/rfc/rfc2373.txt.

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[RFC2928] "Initial IPv6 Sub-TLA ID Assignments", R. Hinden, S. Deering, R. Fink, T. Hain. September 2000
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[RFC3194] "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.

[RIRs-on-48]
http://www.arin.net/library/guidelines/ipv6_initial.html.

[RIRv6-Policies]
http://www.arin.net/registration/ipv6/l,
http://www.ripe.net/ripe/docs/ipv6-policy.html,
http://www.apnic.net/docs/drafts/ipv6/ipv6-policy-280599.html.

7. Appendix A: HD-Ratio

The HD-Ratio is not intended to replace the traditional utilisation measurement that ISPs perform with IPv4 today. Indeed, the HD-Ratio still requires counting the number of assigned objects. The primary value of the HD-Ratio is its usefulness at determining reasonable target utilisation threshold values for an address space of a given size. This document uses the HD-Ratio to determine the thresholds at which a given allocation has achieved an acceptable level of utilisation and the assignment of additional address space becomes justified.

The utilisation threshold T, expressed as a number of individual /48 prefixes to be allocated from IPv6 prefix P, can be calculated as:

$$T = 2^{((48-P)*HD)}$$

Thus, the utilisation threshold for an organisation 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 allocation of /48s to End Sites, and not the

utilisation of those /48s 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 0.8 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 0.8

P	48-P	Total /48s	Threshold	Util%
48	0	1	1	100.0%
47	1	2	2	87.1%
46	2	4	3	75.8%
45	3	8	5	66.0%
44	4	16	9	57.4%

43	5	32	16	50.0%
42	6	64	28	43.5%
41	7	128	49	37.9%
40	8	256	84	33.0%
39	9	512	147	28.7%
38	10	1024	256	25.0%
37	11	2048	446	21.8%
36	12	4096	776	18.9%
35	13	8192	1351	16.5%
34	14	16384	2353	14.4%
33	15	32768	4096	12.5%
32	16	65536	7132	10.9%
31	17	131072	12417	9.5%
30	18	262144	21619	8.2%
29	19	524288	37641	7.2%
28	20	1048576	65536	6.3%
27	21	2097152	114105	5.4%
26	22	4194304	198668	4.7%
25	23	8388608	345901	4.1%
24	24	16777216	602249	3.6%
23	25	33554432	1048576	3.1%
22	26	67108864	1825677	2.7%
21	27	134217728	3178688	2.4%
20	28	268435456	5534417	2.1%
19	29	536870912	9635980	1.8%
18	30	1073741824	16777216	1.6%
17	31	2147483648	29210830	1.4%
16	32	4294967296	50859008	1.2%
15	33	8589934592	88550677	1.0%
14	34	17179869184	154175683	0.9%
13	35	34359738368	268435456	0.8%
12	36	68719476736	467373275	0.7%
11	37	137438953472	813744135	0.6%
10	38	274877906944	1416810831	0.5%
9	39	549755813888	2466810934	0.4%
8	40	1099511627776	4294967296	0.4%
7	41	2199023255552	7477972398	0.3%
6	42	4398046511104	13019906166	0.3%
5	43	8796093022208	22668973294	0.3%
4	44	17592186044416	39468974941	0.2%

8. Appendix B: Background information

8.1. 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.

8.2. 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.

8.3. 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 [RFC2373], 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 [RFC2462].

The middle 16 bits of an address indicate the subnet ID. Per [RFC 3177, RIRs-on-48s], this field will often be inefficiently utilized, but the operational benefits of a consistent width subnet field were deemed to be outweigh the drawbacks.

The decisions to inefficiently utilize the bits to the right of /48 were made under the knowledge and assumption that the bits to the left of /48 would be managed prudently and that if done so, will be adequate for the expected lifetime of IPv6 [RFC3177].

8.4. Acknowledgment

The initial version of this document was produced by The JPNIC IPv6 policy drafting team consisting of Akihiro Inomata, Akinori Maemura, Kosuke Ito, Kuniaki Kondo, Takashi Arano, Tomohiro Fujisaki, and Toshiyuki Yamasaki. Special thanks goes out to this team, who worked over a holiday in order to produce an initial document quickly.

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 this document was done by Thomas Narten.