# POSITION PAPER
# IPV6 ADDRESS STRATEGY / RIPE MEMBERSHIP

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| Author(s): | Enno Rey |
| Project Lead in Charge: | Christopher Werny<br>cwerny@ernw.de<br>+49 173 6745905 |

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# 1 Handling

The present document is classified as CONFIDENTIAL. Any distribution or disclosure of this document REQUIRES the permission of the document owner as referred in Section "Document Status and Owner".
The present document provides an overview of the relevant entities, processes and terms involved with getting global IPv6 address space for an organization of $COMPANY's size.

## 1.1 Document Status and Owner

As the owner of this report, the document owner has exclusive authority to decide on the dissemination of this document and responsibility for the distribution of the applicable version in each case to the places defined in the respective section.

The possible entries for the status of the document are "Initial Draft", "Draft", "Effective" (currently applicable) and "Obsolete".

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| **Author(s):** | Enno Rey |
| **Project Lead in Charge:** | Christopher Werny<br>mluft@ernw.de<br>+49 151 16227574 |

## 1.2 Classification Levels

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| **Public:** | Everyone |
| **Internal:** | All employees and business partners |
| **Confidential:** | Only employees |
| **Secret:** | Only selected employees |

## 2 Management Summary

In the course of the IPv6 deployment planning efforts at $COMPANY so far certain steps have been undertaken to get global address space from the organization responsible for the administration of IPv6 addresses in Europe, that is the Amsterdam-based *RIPE NCC*. More specifically the RIPE NCC has provided two so-called assignments of network address ranges of a specific size (these are called "/48 prefixes") to $COMPANY.

As this approach differs from the strategy other organizations of a similar size have opted for – they have become a member of RIPE which then subsequently leads to a so-called allocation of a much larger address block (a "/29 prefix") with a higher degree of flexibility when it comes to handling the addresses for different scenarios – a 3rd party organization with vast expertise as for IPv6 deployments in complex organizations (ERNW GmbH) was tasked to evaluate the strategy options and to provide a recommendation.

For this purpose several requirements relevant for the future use of IPv6 within $COMPANY have been identified. It was then assessed to what extent the potential strategies are suited to fulfill these requirements in the mid– and long-term. Here it should be kept in mind that, for reasons within the overall IPv6 design and due to the variety of use cases, it can be expected that most enterprise organizations incl. $COMPANY will use *global* addresses for large parts of their networks (as opposed to today's IPv4 networks which use *private* address space).

Based on this assessment the authors strongly recommend that $COMPANY becomes a RIPE member/LIR as only this approach will allow to scale in a sustainable way and will hence support proper IPv6 deployment and $COMPANY's future business cases.

Doing so would require an initial effort of up to one man-day of consulting plus an initial fee of EUR 2.000. In addition a yearly fee of about EUR 1.400 will be charged by RIPE, and $COMPANY administrators involved with the relevant tasks should undergo a training (4–8 hours) once a year. It should be noted that a decision about a strategy should be taken before the actual IPv6 deployment starts on a significant scale as otherwise so-called renumbering will be needed later which usually has an impact on networks operations.

While this paper was authored from an IPv6 deployment perspective we'd like to highlight that becoming a RIPE LIR will greatly facilitate implementing a proper *geolocation* strategy for IPv4 networks, too.

# 3 Requirements

The following requirements were identified for $COMPANY in the context of an IPv6 address strategy:

- {REQ1] Scalability: sufficient space (addresses, segments) for the next at least 20 years. Also: new (unidentified as of today) use cases/network entities in unknown – potentially high – quantity must be supported.
- [REQ3] Flexibility: be able to move/re-route segments, to assign address ranges to sites/business partners/subsidiaries et.al. Support communication with cloud based services.
- [REQ4] Routability: support routing & route propagation over/towards Internet, cloud links, business partner links, from"local Internet breakout" scenarios etc. Allow this based on the assumption of an address strategy which relies mostly on *global* addresses.
- [REQ5] Support of mergers & acquisitions, incl. ability to transfer routing (responsibility), to change routing paths for segments/subsidiaries, to assign (or retract) address ranges.
- [REQ6] Support geolocation to the best possible degree.
- [REQ2] Support new classes of devices (telematics modules like the telematics units, fitness trackers, "smart home" sensors/monitoring/alarm systems etc.) which may act in highly volatile environments and unclear administrative responsibilities => be able "to act as provider".

## 3.1 References

[RIPE655] "IPv6 Address Allocation and Assignment Policy" (currently valid)
https://www.ripe.net/publications/docs/ripe-655

# 4 (Technical) Overview of Approaches and Associated RIPE Policies

This section presents a short overview of processes, roles & responsibilities and types of addresses to be handled by various parties.

## 4.1 Overview as of RIPE NCC Policies

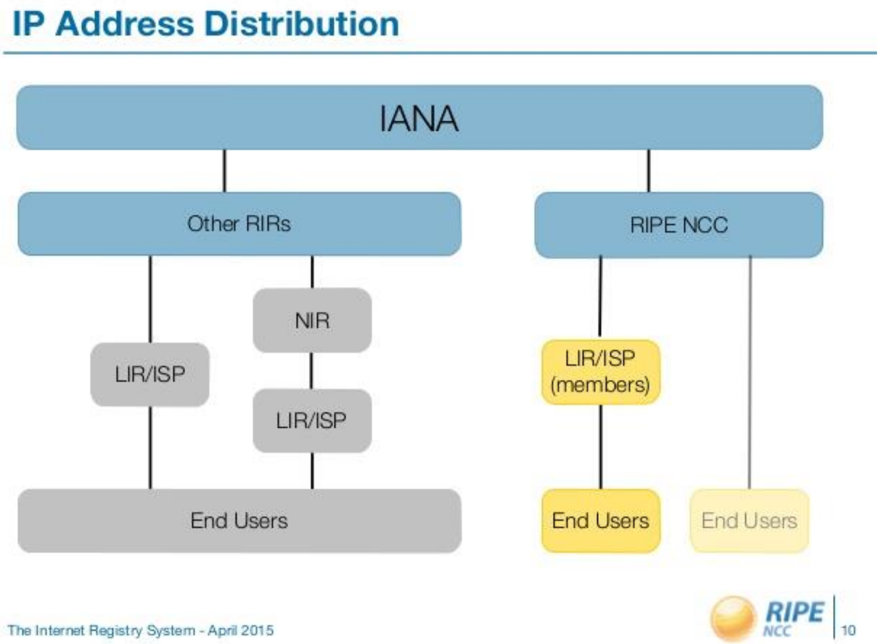


*Figure 1 Overview Internet Address Management*[1]

In the past, that is until about 2013, the involved entities and their roles & associated address handling strategies have been fairly clearly identified:

- Internet Service Providers (ISP), that means "organizations providing services in the context of Internet connectivity, hosting and the like as their [main] business service" acted as (according to

[1] *Source: http://image.slidesharecdn.com/rir-system-hlig-150421-150506065611-conversion-gate01/95/introduction-to-ip-addressing-and-regional-internet-registries-10-638.jpg*

RIPE terminology) *Local Internet Registries* (LIRs) – which in turn required becoming a RIPE member – and hence received an address space *allocation* (see below).

- Organizations whose [main] business is not in the field of "Internet services" (but, say, in manufacturing, automotive, finance, insurance etc.) are supposed to- be "end users" (as of the above terminology)[2]. As such they were mostly supposed to receive their address ranges from an LIR (an ISP). Under specific circumstances and following certain procedural rules (see below on all this) they could also get IP address space directly from the RIPE NCC[3] (usually through intermediation of an LIR) which then was/is an *assignment*, also commonly called "PI space". The latter approach was mainly used by large organizations (not least due to the associated requirements like multihoming).

This (picture) has changed significantly in the interim. As of today (mid 2016) there's many more LIRs than before[4] and many of those are so-called "Enterprise LIRs", that is former "end user" type organizations who have opted to become an LIR. Some did this already for IPv4, for quite some this happened in the course of their IPv6 deployment efforts (mainly for reasons which will become apparent from the discussion below).

## 4.2 Allocations / "PA Space"

For our discussion the main property of an allocation is that is meant to be used for further distribution (usually of parts of it, not as a whole). [RIPE655] states:
"To 'allocate' means to distribute address space to IRs for the purpose of subsequent distribution by them."

As stated above getting an allocation requires being member of a RIR (here: RIPE NCC) incl. the payment of a one-time fee (currently in the range of EUR 2,000 EUR/) and a yearly fee (as of today 1,400 EUR)[5]. The most common IPv6 allocation size by the RIRs is a /32; in RIPE NCC space currently the kind-of default is a /29 out of 2a00::/12.

## 4.3 Assignments / "PI Space"

Here the main property is that an assignment is *not* supposed to be

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[2] *Here the term "end user" must not be confused with/taken for "end user" as a human person acting as a subscriber of some ISP's services.*
[3] *There is the specific corner case of "ALLOCATED UNSPECIFIED" netblocks which were assigned, in the 90s, from* LIRs *directly to* end users *(see also https://ripe72.ripe.net/presentations/112-FeedbackRS-RIPE72_final.pdf), but those are not relevant for the present discussion/document.*
[4] *See https://labs.ripe.net/Members/nathalie_nathalie/10-000-lirs-with-ipv6-resources.*
[5] *See also https://www.ripe.net/participate/member-support/info/billing/billing-procedure-and-fee-schedule-2016.*

- split into pieces.
- transferred to other entities (neither within the own organization nor "external"/3rd party entities).

[RIPE655] states:
"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."

An assignment is usually done through a so-called *sponsoring LIR*[6], that means from a procedural perspective the end user organization does not interact with RIPE NCC in a direct manner. The default size of an assignment is a /48, out of 2001:678::/29, but an end user organization can (in a mostly easy way, paperwork-wise) apply for several /48s. Currently the yearly fee for *each* assignment is EUR 50 and it may happen that the sponsoring LIR charge for their (paperwork or "consulting") effort on top of that[7].

## 4.4 Routability of IPv6 Prefixes

The routability of IPv6 prefixes and its relationship with the length of prefixes has been a recurring topic in the IPv6 community. In general a prefix length of /48 is considered to be the "minimum network size" (=> maximum prefix length, bit-wise) which can appear as an individual entry/individual BGP route in the *default-free zone* (DFZ). In other words it is considered unlikely that a smaller netblock (having a prefix length longer than 48 bits) can be routed properly, without being filtered by transit providers[8].

The perception that a /48 "usually represents a (single, physical) site" goes back, amongst others to RFC 3177[9] *IAB/IESG Recommendations on IPv6 Address Allocations to Sites* which, while updated in the interim by RFC 6177 which explicitly suggests a more flexible approach[10], has shaped the idea of "give a site a /48 and treat this as smallest possible entity when it comes to Internet routing" for quite some time.

[6] *For $COMPANY this* sponsoring LIR *is abc.*
[7] *For example see slide #6 of http://www.ipv6conference.ch/wp-content/uploads/2015/06/B09-Rey_IPv6_Business_Conference_Address_Space_Approaches.pdf.*
[8] *In a study performed in 2012 (https://labs.ripe.net/Members/emileaben/ripe-atlas-a-case-study-of-ipv6-48-filtering) by RIPE Labs /48 is assumed to be the kind-of baseline of a prefix which can be expected to be properly routed.*
[9] *https://www.ietf.org/rfc/rfc3177.txt*
[10] *RFC 6177, from the abstract: "this document clarifies that a one-size-fits-all recommendation of /48 is not nuanced enough for the broad range of end sites and is no longer recommended as a single default."*

To summarize (and this is the main conclusion relevant for the discussion here): for IPv6 netblocks smaller than /48 there's a *high chance* that they will *not* be visible in the global Internet, *regardless* of the potential impact of *strict prefix filtering* (see below).

## 4.5 Strict (IPv6) Prefix Filtering

Due to concerns that a high number of IPv6 routes might have a negative impact on the TCAM memory of their routers some "traditional ISP" (as opposed to "Enterprise LIRs", see above) type organizations perform a specific approach of route/prefix filtering called *strict prefix filtering*[11]. The main idea is: "once an organization has received an *allocation* [read: it's an LIR], it can be assumed there's multiple paths to their network and they have a consistent backbone network spanning the full organization, so they can easily announce one single route propagating the so-called *covering aggregate* [route] and there's no need they announce longer prefixes such as /48s. Which is why we filter (=> discard) such routes".

The main problem of such an approach (performed by *other* entities) is that enterprise organizations (incl. $COMPANY) might have very valid reasons to announce, say, /48 prefixes, including:

- For network topology reasons like regional network hubs/data centers.
- For organizational reasons like different administrative domains.
- For security reasons, e.g. in the case of a "selective announcements" strategy[12].

It should be noted that usually such filtering only takes place for routes from PA space (= allocations to LIRs), but not for routes/prefixes from PI space (assignments to *end users*, from [RIPE NCC context] 2001:678::/29).

While it can be observed nowadays that the overall amount of strict prefix filtering is decreasing[13] its existence should be kept in mind and potential route announcements of /48 prefixes without a *covering aggregate* must

- have appropriate so-called *route6* objects[14] in the RIPE database.

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[11] *Initially described here: http://www.space.net/~gert/RIPE/ipv6-filters.html.*
[12] *See also https://www.insinuator.net/2015/12/developing-an-enterprise-ipv6-security-strategy-part-2-network-isolation-on-the-routing-layer/ and http://www.insinuator.net/2014/12/security-implications-of-using-ipv6-guas-only/.*
[13] *See the data sets in https://www.ernw.de/wp-content/uploads/ERNW_Newsletter_44_Dynamics_IPv6_Prefixes_en_v.1.0.pdf and https://ripe69.ripe.net/wp-content/uploads/presentations/137-RIPE69_Langner_Rey_Schaetzle_Slash48_Considered_Harmful.pdf. Furthermore it should be noted that, as of July 2016, about 46% of IPv6 routes in the DFZ are /48 prefixes.*
[14] *These are specific objects which can (in an easy way, from the "LIR Portal" web interface) be created to designate a netblock (usually a subset of an allocation) to be handled in a specific way (e.g. to appear as an individual route in the DFZ/Internet BGP table).*

- be closely observed once initially propagated (e.g. by means of *Looking Glass* servers)[15]

## 4.6 General Aspects of Geolocation

*Geolocation* information is usually provided from several sources and databases[16]. The RIPE NCC themselves suggests using an approach which involves certain additional attributes for specific objects (usually identifying allocations/assignments a whole, the inet6num[17] objects in the RIPE database). This is described in a document published by RIPE NCC[18].

While it is not entirely clear which impact those attributes actually have in real-life scenarios, it should be noted that they can only be used for *inet6num objects* which in case of an assignment ("PI space") constitutes the full individual assignment (as this one cannot be split further, see above).

## 4.7 Geolocation for IPv4 Networks

While the present report has its origins in determining the *IPv6* address strategy best suited to fulfill $COMPANY's needs, we include some notes on the feasibility of geolocation in IPv4 networks in the following. As mentioned above it should be kept in mind that geolocation services usually work on the basis of two main sources of information:

- Databases maintained by 3rd party organizations[19]. These databases may fully or partially, or may not at all, rely on information provided from the RIPE database.
- Geolocation information provided by means of specific attributes of the *inet[6]num* objects in the RIPE database.

In any case tagging geolocation information to a set of IP addresses/a netblock makes most sense once this netblock can be routed in the Internet as an individual entity which currently means that it has to be at least an IPv4 /24 prefix[20]. Thinking of RIPE database objects (and taking into account the applicability of the related

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*[15] A list can be found here: http://www.bgp4.as/looking-glasses.*
*[16] To get an idea see https://www.ripe.net/manage-ips-and-asns/db/tools/geolocation-in-the-ripe-database.*
*[17] https://www.ripe.net/manage-ips-and-asns/db/support/documentation/ripe-database-documentation/rpsl-object-types/4-2-descriptions-of-primary-objects/4-2-3-description-of-the-inet6num-object.*
*[18] https://labs.ripe.net/Members/denis/geolocation-prototype-for-ripe-database and https://labs.ripe.net/Members/denis/example-usage-of-ripe-database-geolocation-prototype.*
*[19] Amongst others, the following organizations provide such services: maxmind.com, ip2location.com, ipligence.com, neustar.com (formely Quova), akamai.com, hostip.info, db-ip.com, dnsstuff.com, panacode.com, geobytes.com, digitalenvoy.net.*
*[20] There's some discussions ongoing to "allow" smaller prefixes (/25s or even /26s) in the Internet routing table, but as of today /24 is considered the minimum size for proper routability.*

attributes discussed above) this further means that an organization should have the ability to create different inet[6]num and/or route[6] objects which in turn – to be performed in a feasible way – requires full RIPE membership.

Becoming a RIPE member includes (as of today) an allocation of an IPv4 /22 netblock which could easily be split into several /24 assignments used for geolocation-oriented network segmentation.

## 4.9 Advantages / Disadvantages of the Approaches

### 4.9.1 Become LIR and Receive Allocation

Advantages:

- (Probably) provides enough space for future purposes hence satisfies requirements [REQ1] and [REQ2]. Here it should be kept in mind that commonly prefixes are used in a way that is aligned with *nibble boundaries* which then significantly reduces the number of "available" prefixes[21].
- Allows for assignments of smaller parts to individual sites, organizations (e.g. subsidiaries) hence supports [REQ3], [REQ4] and [REQ5].
- Allows for flexible assignments to sites or subsidiaries and hence supports geolocation based on attributes of the inet6num objects, [REQ6].

Disadvantages:

- Requires RIPE membership (small amount of paper work, initial fee EUR 2,000 + yearly fee).
- Strict filtering must be kept in mind.
- Requires that responsible administrators are a bit familiar with RIPE NCC procedures & policies.

### 4.9.2 Go with (Potentially Multiple) PI Space Assignments

Advantages:

- No RIPE membership and associated costs.
- Less risk of IPv6 strict prefix filtering.

Disadvantages:

- Paperwork can be more extensive than RIPE membership application. Initial costs may be similar.
- Does not scale well, hence does not satisfy [REQ1].
- Does not allow for further splitting/sub-assignments, hence does not satisfy [REQ5].
- Not flexible as for sub-assignments or working with administrative entities of different (prefix) sizes, hence potentially violates [REQ3], [REQ4], [REQ5].
- Geolocation approach supported by RIPE database might be harder to implement (would require multiple assignments with own inet6num object each).

[21] *In practice this means that a /48 prefix is not used for 65536 (but much less) /64 networks.*

ERNW Enno Rey Netzwerke GmbH
Carl-Bosch-Str. 4
69115 Heidelberg
BIC: GENODE61HD3

Tel. +49 – 6221 – 48 03 90
Fax +49 – 6221 – 41 90 08
VAT-ID DE813376919
IBAN: DE43672901000059789104

# 5 Conclusions and Recommendation for $COMPANY

In this chapter we present a recommendation, together with some additional information how to proceed.

## 5.1 Recommendation

The authors strongly recommend that $COMPANY becomes a RIPE member/LIR as (only this approach) will allow to scale in a sustainable way and will hence support IPv6 deployment and $COMPANY's future business cases.

## 5.2 What to Keep in Mind / Caveats

Strict filtering must be kept in mind in the course of route propagation. Also a LIR-based strategy requires that responsible administrators at $COMPANY are somewhat familiar with RIPE NCC procedures & policies.

## 5.3 Necessary Steps / Checklist

Steps involved encompass, amongst others:

- ❑ Apply to become RIPE member/LIR. Usually this can be completed within approx. four weeks.
- ❑ Subsequent initial design of an IPv6 address plan at $COMPANY.
- ❑ Discuss route propagation approach with uplink providers.[22]
- ❑ Create route6 objects where necessary.
- ❑ Closely monitor route propagation for first announced prefixes and work with providers to solve potential issues.

## 5.4 Expenses & Efforts

Application for membership (4–8 hours paper work). *Certificate of registration* ("Handelsregisterauszug") must be provided in the course of the procedure and "signature of contract by an officer" will be needed.

Initial fee: EUR 2,000. + yearly fees in the EUR 1.500 range.

Half-day training of most important concepts & procedures for responsible persons at $COMPANY.

[22] *See also https://www.insinuator.net/2015/01/ipv6-related-requirements-for-the-internet-uplink-or-mpls-networks/.*