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Things To Be Considered for RFC 3484 Revision
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Abstract

RFC 3484 has several known issues to be fixed. Deprecation of IPv6 site-local unicast address and the coming of ULA brought some preferable changes to the rules. Additionally, the rule 9 of the destination address selection rules, namely the longest matching rule, is known for its adverse effect on the round robin DNS technique. This document covers these points to be fixed and proposes possible useful changes to be included in the revision of RFC 3484.

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1. Introduction

RFC 3484 [RFC3484] defines default address selection rules for IPv6 and IPv4. Because of the deprecation of IPv6 site-local unicast address[RFC3879] and the coming of ULA, [RFC4193] these rules in RFC 3484 are known to cause communication failures depending on the network environment.

Additionally, there was a discussion at v6ops and ietf mailing lists that the rule 9 of the destination address selection has a serious adverse effect on the round robin DNS technique. [RFC1794] RFC 3484 defines that the destination address selection rule 9 should be applied to both IPv4 and IPv6, which spoils the DNS based load balancing technique that is widely used in the IPv4 Internet today.

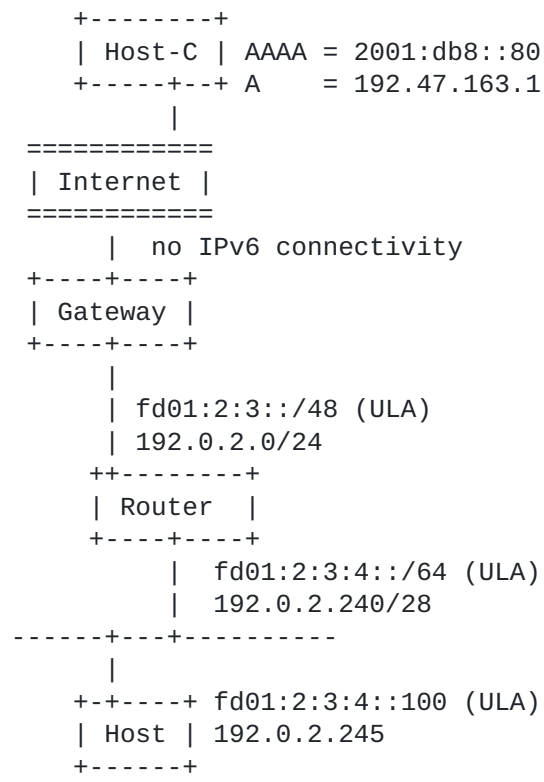
Remi Denis-Courmont summarized NAT related address selection problems and possible solutions in [I-D.denis-v6ops-nat-addrsel].

Problems related to IPv6 and IPv4 address selection are described in RFC 5220 [RFC5220]. Some of them can be fixed by updating RFC 3484, and some of the others are solved by address selection design team's proposal [I-D.chown-addr-select-considerations].

This document covers these points to be fixed and proposes possible useful changes to be included in the revision of RFC 3484.

1.1. Problem Example

When an enterprise has IPv4 Internet connectivity but does not yet have IPv6 Internet connectivity, and the enterprise wants to provide site-local IPv6 connectivity, ULA is the best choice for site-local IPv6 connectivity. Each employee host will have both an IPv4 global or private address [RFC1918] and a ULA. Here, when this host tries to connect to Host-C that has registered both A and AAAA records in the DNS, the host will choose AAAA as the destination address and ULA for the source address. This will clearly result in a connection failure.



[Fig. 1]

This problem can be solved by changing the scope of ULA to site-local, or by adding one entry to the default policy table that sets lower priority for ULA than IPv4 address.

This problem was mentioned at ipv6 mailing lists by Pekka Savola.

2. Proposed Changes to RFC 3484

2.1. Changes related to the default policy table

The default policy table is defined in RFC 3484 Section 2.1 as follows:

Prefix	Precedence	Label
::1/128	50	0
::/0	40	1
2002::/16	30	2
::/96	20	3
::ffff:0:0/96	10	4

The changes that should be included into the default policy table are those rules that are universally useful and do no harm in every reasonable network envionment. The changes we should consider for the default policy table are listed in this sub-section.

The policy table is defined to be configurable. The changes that are useful not universally but locally can be put into the policy table manually or by using the auto-configuration mechanism proposed as a DHCP option [I-D.fujisaki-dhc-addr-select-opt].

2.1.1. Arrival of ULA

RFC 5220 Section 2.1.4, 2.2.2, and 2.2.3 describes address selection problems related to ULA. These problems can be solved by changing the scope of ULA to site-local, or by adding an entry for default policy table entry that has its own label for ULA.

In its nature, ULA has global scope. This is because ULA's scope is defined to be defined in routing mechanism. It may be the case that ULA and global IPv6 address are used for source and destination addresses of communication.

On the other hand, to prioritize ULA to ULA communication is basically reasonable. ULA should not be exposed to outside of its routable routing domain, so if ULA is given from the application as a candidate destination address, it can be generally expected that the ULA is within or at least close to the source host.

Therefore, the scope of ULA should be global, and prioritization of ULA to ULA communication should be implemented in policy table, by assigning its own label for ULA fc00::/7.

Discussion: Centrally assigned ULA [I-D.ietf-ipv6-ula-central] is proposed, and assigned fc00::/8. Using the different labels for fc00::/8 and fd00::/8 makes sense if we can assume the same kind of address block is assigned in the same or adjacent network. However, the way of assignment and network adjancency may not have any relationships.

2.1.2. Arrival of Teredo and harm of transitional mechanisms

Teredo [RFC4380] is defined and has been assigned 2001::/32. Teredo's priority should be less or equal to 6to4, considering its characteristic of tunnel mechanism. About Windows, this is already in the implementation.

Discussion: Regarding the prioritization between IPv4 and these transitional mechanisms, the connectivity of them are recently known to be worse than IPv4. These mechiansms are said to be the last resort access to IPv6 resources. While 6to4 should have higher precedence over Teredo, in that 6to4 host to 6to4 host communication can be over IPv4, which can result in more optimal path, and 6to4 does not need NAT traversal.

2.1.3. Deprecated addresses

IPv4-compatible IPv6 address is deprecated. [RFC4291] IPv6 site-local unicast address is deprecated. [RFC3879] Moreover, 6bone testing address was [RFC3701] The issue is how we treat these outdated addresses.

Discussion: These addresses was removed from the current specification. So, it should not be treated differently, especially if we think about future re-use of these address blocks.

Considering the inappropriate use of these address blocks especially in outdated implementations and bad effects brought by them, however, it should be labeled differently from the legitimate address blocks.

2.1.4. Renewed default policy table

When we apply these changes, the default policy table will be:

Prefix	Precedence	Label
::1/128	60	0
fc00::/7	50	1
::/0	40	2
::ffff:0:0/96	30	3
2002::/16	20	4
2001::/32	10	5
::/96	1	10
fec::/16	1	11
3ffe::/16	1	12

2.2. Source address selection for multicast packet

Source address selection for a multicast packet easily fails. It is suggested to add some notes describing this issue of multicast address selection.

As described in RFC 5220 Section 2.1.6, by default, ULA will be chosen for a multicast packet of any scope.

This issue cannot be solved by changing a RFC 3484 rule. This is because, multicast and unicast have different sets of scope and it is site-dependent which unicast address scope is appropriate for the site's multicast scope. Therefore, this issue can be solved, for example, by configuring the policy table per-site.

2.3. RFC 3484 Section 6 Rule 9 and DNS round robin

There was a discussion at v6ops and ietf@ietf.org mailing lists that the rule 9 of the destination address selection has a serious adverse effect on the round robin DNS technique. RFC 3484 defines that the destination address selection rule 9 should be applied to both IPv4 and IPv6, which spoils the DNS based load balancing technique that is widely used in the IPv4 Internet today.

When the destination address acquired from one FQDN are two or more, the Rule 9 defines that the longest matching destination and source address pair should be chosen. As in RFC 1794, the DNS based load balancing technique is achived by not re-ordering the destination addresses returned from the DNS server. The Rule 9 defines deterministic rule for re-ordering at hosts, hence the technique of RFC 1794 is not available anymore.

Regarding this problem, there was discussion in IETF and other places like below.

http://drplokta.livejournal.com/109267.html
http://www.ietf.org/mail-archive/web/ietf/current/msg51874.html
http://www.ietf.org/mail-archive/web/discuss/current/msg01035.html
http://www.ietf.org/mail-archive/web/dnsop/current/msg05847.html
http://lists.debian.org/debian-ctte/2007/11/msg00029.html
http://www.ietf.org/mail-archive/web/ietf/current/msg55991.html

Discussion: The possible changes to RFC 3484 are as follows:

1. To delete Rule 9 completely.
2. To apply Rule 9 only for IPv6 and not for IPv4. In IPv6, hiearchical address assignment is general principle, hence the longest matchin rule is beneficial in many cases. In IPv4, as stated above, the DNS based load balancing technique is widely used.
3. To apply Rule 9 for IPv6 conditionally and not for IPv4. When the length of matching bits of the destination address and the source address is longer than N, the rule 9 is applied. Otherwise, the order of the destination addresses do not change. The N should be configurable and it should be 32 by default. This is simply because the two sites whose matching bit length is

longer than 32 are probably adjacent.

Now that IPv6 PI address is admitted in some RIRs, hierachical address assignment is not maintained anymore. It seems that the longest matching algorithm may not worth the adverse effect of disalbing the DNS based load balance technique.

2.4. RFC 3484 Section 6 Rule 9 and local DNS round robin

There is another issue related to the longest matching rule, which was found by Dave Thaler. It is also malfunction of DNS round robin technique. It is common for both IPv4 and IPv6.

When a destination address DA, DB, and the source address of DA Source(DA) are on the same subnet and Source(DA) == Source(DB), DNS round robin load-balancing cannot function. By considering prefix lengths that are longer than the subnet prefix, this rule establishes preference between addresses that have no substantive differences between them. The rule functions as an arbitrary tie-breaker between the hosts in a round robin, causing a given host to always prefer a given member of the round robin.

By limiting the calculation of common prefixes to a maximum length equal to the length of the subnet prefix of the source address, rule 9 can continue to favor hosts that are nearby in the network hierarchy without arbitrarily sorting addresses within a given network. This modification could be written as follows:

Rule 9: Use longest matching prefix.

When DA and DB belong to the same address family (both are IPv6 or both are IPv4): If CommonPrefixLen(DA & Netmask(Source(DA)), Source(DA)) > CommonPrefixLen(DB & Netmask(Source(DB)), Source(DB)), then prefer DA. Similarly, if CommonPrefixLen(DA & Netmask(Source(DA)), Source(DA)) < CommonPrefixLen(DB & Netmask(Source(DB)), Source(DB)), then prefer DB.

2.5. Deprecation of site-local unicast address

RFC3484 contains a few "site-local unicast" and "fec::" description. It's better to remove examples related to site-local unicast address, or change examples to use ULA. Possible points to be re-written are below.

- 2nd paragraph in RFC 3484 Section 3.1 describes scope comparison mechanism.
- RFC 3484 Section 10 contains examples for site-local address.

2.6. Private IPv4 address scope

As detailed in Remi's draft [I-D.denis-v6ops-nat-addrsel], when a host is in NATed site, and has a private IPv4 address and transitional addresses like 6to4 and Teredo, the host chooses transitional IPv6 address to access most of the dual-stack servers.

This is because private IPv4 address is defined to be site-local scope, and as in RFC 3484, the scope matching rules (Rule 2) set lower priority for private IPv4 address.

By changing the address scope of private IPv4 address to global, this problem can be solved. Considering the widely deployed NAT with IPv4 private address model, this change works in most of the cases. If not, this behavior can be overridden by configuring policy table, or by configuring routing table on a host.

Moreover, some modern OSs have already implemented this change.

3. Conclusion

This document lists several issues that should be included in the revision of RFC 3484, which are useful universally and do no harm in reasonable network environments.

As the deployment of IPv6 progresses, the role of the address selection mechanism is getting more important. This situation revealed several important issues about the current address selection rules.

It is much anticipated to provide the solutions for these issues. Part of them, which are common issues for most of the reasonable environment, should be done by updating the default address selection rules as stated in this document, and the lest of them should be done on per site basis by configuring the policy table manually, or using the proposed policy updating mechanism.

4. Security Considerations

No security risk is found that degrades RFC 3484.

5. IANA Considerations

Address type number for the policy table may have to be assigned by

IANA.

6. References

6.1. Normative References

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[RFC5220] Matsumoto, A., Fujisaki, T., Hiromi, R., and K. Kanayama, "Problem Statement for Default Address Selection in Multi-Prefix Environments: Operational Issues of RFC 3484 Default Rules", RFC 5220, July 2008.

6.2. Informative References

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[I-D.fujisaki-dhc-addr-select-opt]
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Appendix A. Acknowledgements

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Appendix B. Revision History

03:
- Added acknowledgements.
- Added longest matching algorithm malfunction regarding local DNS round robin.
- The proposed changes section was re-structured.
- The issue of 6to4/Teredo and IPv4 prioritization was included.
- The issue of deprecated addresses was added.
- The renewed default policy table was changed accordingly.

02:
- Added the reference to address selection design team's proposal.

01:
- The issue of private IPv4 address scope was added.
- The issue of ULA address scope was added.
- Discussion of longest matching rule was expanded.

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