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IPv6 Router Advertisement Options for DNS Configuration
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Abstract

This document specifies IPv6 Router Advertisement options to allow IPv6 routers to advertise a list of DNS recursive server addresses and a DNS Search List to IPv6 hosts.

This document obsoletes [RFC 6106](#) and allows a higher default value of the lifetime of the RA DNS options to avoid the frequent expiry of the options on links with a relatively high rate of packet loss.

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1. Introduction

The purpose of this document is to standardize an IPv6 Router Advertisement (RA) option for DNS Recursive Server Addresses used for the DNS name resolution in IPv6 hosts. This RA option was originally specified in an earlier Experimental specification [[RFC5006](#)] and was later published as a Standards Track in [[RFC6106](#)]. This document obsoletes [[RFC6106](#)], allowing a higher default value of the lifetime of the RA DNS options to avoid the frequent expiry of the options on links with a relatively high rate of packet loss, and also making additional clarifications, see [Appendix A](#) for details.

Neighbor Discovery (ND) for IP version 6 and IPv6 Stateless Address Autoconfiguration (SLAAC) provide ways to configure either fixed or mobile nodes with one or more IPv6 addresses, default routers, and some other parameters [[RFC4861](#)][[RFC4862](#)]. Most Internet names are identified by using a DNS name. The two RA options defined in this document provide the DNS information needed for an IPv6 host to reach Internet names.

It is infeasible to manually configure nomadic hosts each time they connect to a different network. While a one-time static configuration is possible, it is generally not desirable on general-purpose hosts such as laptops. For instance, locally defined name spaces would not be available to the host if it were to run its own recursive name server directly connected to the global DNS.

The DNS information can also be provided through DHCPv6 [[RFC3315](#)][[RFC3736](#)][[RFC3646](#)]. However, the access to DNS is a fundamental requirement for almost all hosts, so IPv6 stateless autoconfiguration cannot stand on its own as an alternative deployment model in any practical network without any support for DNS configuration.

These issues are not pressing in dual-stack networks as long as a DNS server is available on the IPv4 side, but they become more critical with the deployment of IPv6-only networks. As a result, this document defines a mechanism based on IPv6 RA options to allow IPv6 hosts to perform the automatic DNS configuration.

1.1. Applicability Statements

RA-based DNS configuration is a useful alternative in networks where an IPv6 host's address is autoconfigured through IPv6 stateless address autoconfiguration and where there is either no DHCPv6 infrastructure at all or some hosts do not have a DHCPv6 client. The intention is to enable the full configuration of basic networking information for hosts without requiring DHCPv6. However, for networks that need to distribute additional information, DHCPv6 is

likely to be employed. In these networks, RA-based DNS configuration may not be needed.

RA-based DNS configuration allows an IPv6 host to acquire the DNS configuration (i.e., DNS recursive server addresses and DNS Search List) for the link(s) to which the host is connected. Furthermore, the host learns this DNS configuration from the same RA message that provides configuration information for the link.

The advantages and disadvantages of the RA-based approach are discussed in [\[RFC4339\]](#) along with other approaches, such as the DHCP and well-known anycast address approaches.

1.2. Coexistence of RA Options and DHCP Options for DNS Configuration

Two protocols exist to configure the DNS information on a host, the Router Advertisement options specified in this document and the DHCPv6 options specified in [\[RFC3646\]](#). They can be used together. The rules governing the decision to use stateful configuration mechanisms are specified in [\[RFC4861\]](#). Hosts conforming to this specification MUST extract DNS information from Router Advertisement messages, unless static DNS configuration has been specified by the user. If there is DNS information available from multiple Router Advertisements and/or from DHCP, the host MUST maintain an ordered list of this information as specified in [Section 5.3.1](#).

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [\[RFC2119\]](#).

3. Terminology

This document uses the terminology defined in [\[RFC4861\]](#) and [\[RFC4862\]](#). In addition, four new terms are defined below:

- o Recursive DNS Server (RDNSS): Server that provides a recursive DNS resolution service for translating domain names into IP addresses or resolving PTR records, as defined in [\[RFC1034\]](#) and [\[RFC1035\]](#).
- o RDNSS Option: IPv6 RA option to deliver the RDNSS information to IPv6 hosts [\[RFC4861\]](#).
- o DNS Search List (DNSSL): The list of DNS suffix domain names used by IPv6 hosts when they perform DNS query searches for short, unqualified domain names.

- o DNSSL Option: IPv6 RA option to deliver the DNSSL information to IPv6 hosts.
- o DNS Repository: Two data structures for managing DNS Configuration Information in the IPv6 protocol stack in addition to Neighbor Cache and Destination Cache for Neighbor Discovery [[RFC4861](#)]. The first data structure is the DNS Server List for RDNSS addresses and the second is the DNS Search List for DNS search domain names.
- o Resolver Repository: Configuration repository with RDNSS addresses and a DNS Search List that a DNS resolver on the host uses for DNS name resolution; for example, the Unix resolver file (i.e., /etc/resolv.conf) and Windows registry.

4. Overview

This document standardizes the ND option called the RDNSS option defined in [[RFC6106](#)] that contains the addresses of recursive DNS servers. This document also standardizes the ND option called the DNSSL option defined in [[RFC6106](#)] that contains the Domain Search List. This is to maintain parity with the DHCPv6 options and to ensure that there is necessary functionality to determine the search domains.

The existing ND message (i.e., Router Advertisement) is used to carry this information. An IPv6 host can configure the IPv6 addresses of one or more RDNSSes via RA messages. Through the RDNSS and DNSSL options, along with the prefix information option based on the ND protocol ([[RFC4861](#)] and [[RFC4862](#)]), an IPv6 host can perform the network configuration of its IPv6 address and the DNS information simultaneously without needing DHCPv6 for the DNS configuration. The RA options for RDNSS and DNSSL can be used on the network that supports the use of ND.

This approach requires the manual configuration or other automatic mechanisms (e.g., DHCPv6 or vendor proprietary configuration mechanisms) to configure the DNS information in routers sending the advertisements. The automatic configuration of RDNSS addresses and a DNS Search List in routers is out of scope for this document.

5. Neighbor Discovery Extension

The IPv6 DNS configuration mechanism in this document needs two ND options in Neighbor Discovery: (i) the Recursive DNS Server (RDNSS) option and (ii) the DNS Search List (DNSSL) option.

5.1. Recursive DNS Server Option

The RDNSS option contains one or more IPv6 addresses of recursive DNS servers. All of the addresses share the same Lifetime value. If it is desirable to have different Lifetime values, multiple RDNSS options can be used. Figure 1 shows the format of the RDNSS option.

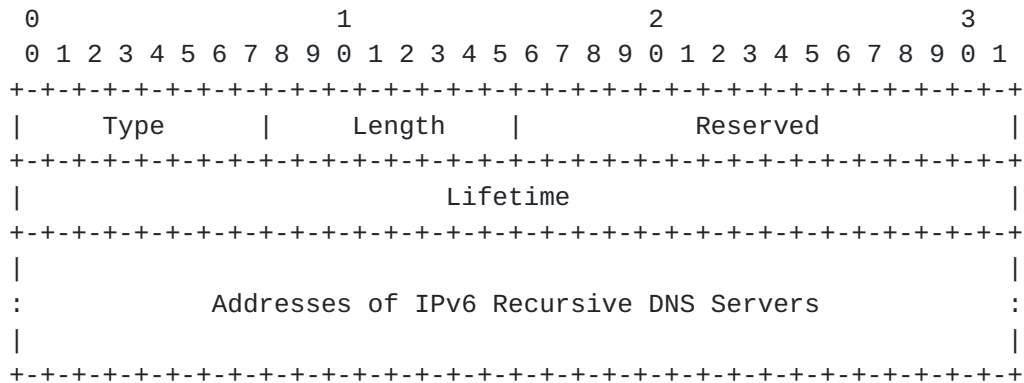


Figure 1: Recursive DNS Server (RDNSS) Option Format

Fields:

- Type 8-bit identifier of the RDNSS option type as assigned by the IANA: 25

- Length 8-bit unsigned integer. The length of the option (including the Type and Length fields) is in units of 8 octets. The minimum value is 3 if one IPv6 address is contained in the option. Every additional RDNSS address increases the length by 2. The Length field is used by the receiver to determine the number of IPv6 addresses in the option.

- Lifetime 32-bit unsigned integer. The maximum time in seconds (relative to the time the packet is received) over which these RDNSS addresses MAY be used for name resolution. The value of Lifetime SHOULD by default be at least 3 * MaxRtrAdvInterval where MaxRtrAdvInterval is the Maximum RA Interval defined in [\[RFC4861\]](#). A value of all one bits (0xffffffff) represents infinity. A value of zero means that the RDNSS addresses MUST no longer be used.

- Addresses of IPv6 Recursive DNS Servers
 One or more 128-bit IPv6 addresses of the recursive DNS servers. The number of addresses is determined by the Length field. That is, the number of

addresses is equal to $(Length - 1) / 2$.

Note: The addresses for recursive DNS servers in the RDNSS option MAY be link-local addresses. Such link-local addresses SHOULD be registered into the resolver repository along with the corresponding link zone indices of the links that receive the RDNSS option(s) for them. The link-local addresses MAY be represented with their link zone indices in the textual format for scoped addresses as described in [RFC4007]. When a resolver sends a DNS query message to an RDNSS with a link-local address, it MUST use the corresponding link.

5.2. DNS Search List Option

The DNSSL option contains one or more domain names of DNS suffixes. All of the domain names share the same Lifetime value. If it is desirable to have different Lifetime values, multiple DNSSL options can be used. Figure 2 shows the format of the DNSSL option.

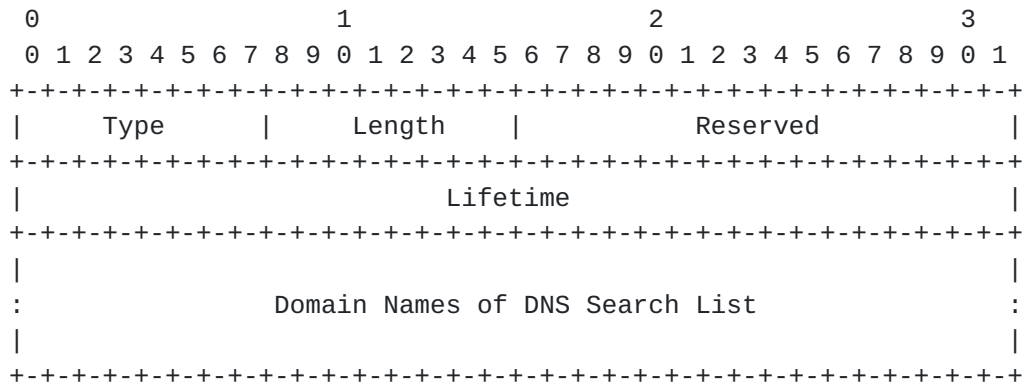


Figure 2: DNS Search List (DNSSL) Option Format

Fields:

- Type 8-bit identifier of the DNSSL option type as assigned by the IANA: 31

- Length 8-bit unsigned integer. The length of the option (including the Type and Length fields) is in units of 8 octets. The minimum value is 2 if at least one domain name is contained in the option. The Length field is set to a multiple of 8 octets to accommodate all the domain names in the field of Domain Names of DNS Search List.

- Lifetime 32-bit unsigned integer. The maximum time in seconds (relative to the time the packet is received)

over which these DNSSL domain names MAY be used for name resolution. The Lifetime value has the same semantics as with the RDNSS option. That is, Lifetime SHOULD by default be at least $3 * \text{MaxRtrAdvInterval}$. A value of all one bits (0xffffffff) represents infinity. A value of zero means that the DNSSL domain names MUST no longer be used.

Domain Names of DNS Search List

One or more domain names of DNS Search List that MUST be encoded as described in [Section 3.1 of \[RFC1035\]](#). By this technique, each domain name is represented as a sequence of labels ending in a zero octet, defined as domain name representation. For more than one domain name, the corresponding domain name representations are concatenated as they are. Note that for the simple decoding, the domain names MUST NOT be encoded in a compressed form, as described in [Section 4.1.4 of \[RFC1035\]](#). Because the size of this field MUST be a multiple of 8 octets, for the minimum multiple including the domain name representations, the remaining octets other than the encoding parts of the domain name representations MUST be padded with zeros.

5.3. Procedure of DNS Configuration

The procedure of DNS configuration through the RDNSS and DNSSL options is the same as with any other ND option [\[RFC4861\]](#).

5.3.1. Procedure in IPv6 Host

When an IPv6 host receives DNS options (i.e., RDNSS option and DNSSL option) through RA messages, it processes the options as follows:

- o The validity of DNS options is checked with the Length field; that is, the value of the Length field in the RDNSS option is greater than or equal to the minimum value (3), and satisfies that $(\text{Length} - 1) \% 2 == 0$. The value of the Length field in the DNSSL option is greater than or equal to the minimum value (2). Also, the validity of the RDNSS option is checked with the "Addresses of IPv6 Recursive DNS Servers" field; that is, the addresses should be unicast addresses.
- o If the DNS options are valid, the host SHOULD copy the values of the options into the DNS Repository and the Resolver Repository in order. Otherwise, the host MUST discard the options.

In the case where the DNS options of RDNSS and DNSSSL can be obtained from multiple sources, such as RA and DHCP, the IPv6 host SHOULD keep some DNS options from all sources. Unless explicitly specified for the discovery mechanism, the exact number of addresses and domain names to keep is a matter of local policy and implementation choice as a local configuration option. However, in the case of multiple sources, the ability to store a total of at least three RDNSS addresses (or DNSSSL domain names) from the multiple sources is RECOMMENDED. The DNS options from Router Advertisements and DHCP SHOULD be stored into the DNS Repository and Resolver Repository so that information from DHCP appears there first and therefore takes precedence. Thus, the DNS information from DHCP takes precedence over that from RA for DNS queries. On the other hand, for DNS options announced by RA, if some RAs use the Secure Neighbor Discovery (SEND) protocol [[RFC3971](#)] for RA security, they MUST be preferred over those that do not use SEND. Refer to [Section 6](#) for the detailed discussion on SEND for RA DNS options.

[5.3.2](#). Warnings for DNS Options Configuration

There are two warnings for DNS options configuration: (i) warning for multiple sources of DNS options and (ii) warning for multiple network interfaces. First, in the case of multiple sources for DNS options (e.g., RA and DHCP), an IPv6 host can configure its IP addresses from these sources. In this case, it is not possible to control how the host uses DNS information and what source addresses it uses to send DNS queries. As a result, configurations where different information is provided by different sources may lead to problems. Therefore, the network administrator needs to configure different DNS options in the multiple sources in order to minimize the impact of such problems [[DHCPv6-SLAAC](#)].

Second, if different DNS information is provided on different network interfaces, this can lead to inconsistent behavior. The IETF worked on solving this problem for both DNS and other information obtained by multiple interfaces [[RFC6418](#)][[RFC6419](#)], and standardized the solution for RDNSS selection for multi-interfaced nodes in [[RFC6731](#)], which is based on DHCP.

[6](#). Security Considerations

In this section, we analyze security threats related to DNS options and then suggest recommendations to cope with such security threats.

[6.1](#). Security Threats

For the RDNSS option, an attacker could send an RA with a fraudulent RDNSS address, misleading IPv6 hosts into contacting an unintended

DNS server for DNS name resolution. Also, for the DNSSL option, an attacker can let IPv6 hosts resolve a host name without a DNS suffix into an unintended host's IP address with a fraudulent DNS Search List. These attacks are similar to ND attacks specified in [\[RFC4861\]](#) that use Redirect or Neighbor Advertisement messages to redirect traffic to individual addresses of malicious parties.

However, the security of these RA options for DNS configuration does not affect ND protocol security [\[RFC4861\]](#). This is because learning DNS information via the RA options cannot be worse than learning bad router information via the RA options. Therefore, the vulnerability of ND is not worse and is a subset of the attacks that any node attached to a LAN can do.

6.2. Recommendations

The Secure Neighbor Discovery (SEND) protocol [\[RFC3971\]](#) is designed as a security mechanism for ND. In this case, ND can use SEND to allow all the ND options including the RDNSS and DNSSL options to be automatically included in the signatures. Other approaches specified in [\[RFC4861\]](#) can be used for securing the RA options for DNS configuration.

It is common for network devices such as switches to include mechanisms to block unauthorized ports from running a DHCPv6 server to provide protection from rogue DHCPv6 servers [\[RFC7610\]](#). That means that an attacker on other ports cannot insert bogus DNS servers using DHCPv6. The corresponding technique for network devices is RECOMMENDED to block rogue Router Advertisement messages [\[RFC6104\]](#) including the RDNSS and DNSSL options from unauthorized nodes.

An attacker may provide a bogus DNS Search List option in order to cause the victim to send DNS queries to a specific DNS server when the victim queries non-FQDNs (fully qualified domain names). For this attack, the DNS resolver in IPv6 hosts can mitigate the vulnerability with the recommendations mentioned in [\[RFC1535\]](#), [\[RFC1536\]](#), and [\[RFC3646\]](#).

7. IANA Considerations

The RDNSS option defined in this document uses the IPv6 Neighbor Discovery Option type defined in [RFC 6106](#) [\[RFC6106\]](#), which was assigned by the IANA as follows:

Option Name	Type
Recursive DNS Server Option	25

The DNSSL option defined in this document uses the IPv6 Neighbor

Discovery Option type defined in [RFC 6106](#) [[RFC6106](#)], which was assigned by the IANA as follows:

Option Name	Type
DNS Search List Option	31

These options have been registered in the "Internet Control Message Protocol version 6 (ICMPv6) Parameters" registry (<http://www.iana.org/assignments/icmpv6-parameters/icmpv6-parameters.xhtml#icmpv6-parameters-5>).

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[Appendix A](#). Changes from [RFC 6106](#)

The following changes were made from [RFC 6106](#) "IPv6 Router Advertisement Options for DNS Configuration":

- o The generation of Router Solicitation to ensure that the RDNSS information is fresh before the expiry of the RDNSS option is removed in order to prevent multicast traffic on the link from increasing.
- o The lifetime's upper bound of $2 * \text{MaxRtrAdvInterval}$ was shown to lead to the expiry of these options on links with a relatively high rate of packet loss. This revision relaxes the upper bound and sets a higher default value to avoid this problem.
- o The addresses for recursive DNS servers in the RDNSS option can be not only global addresses, but also link-local addresses. The link-local addresses for RDNSSes should be registered into the resolver repository along with the corresponding link zone indices.
- o The recommendation that at most three RDNSS addresses to maintain by RDNSS options should be limited is removed. By this removal, the number of RDNSSes to maintain is up to an implementer's local policy.
- o The recommendation that at most three DNS domains to maintain by DNSSL options should be limited is removed. By this removal, when the set of unique DNSSL values are not equivalent, none of them are ignored for hostname lookups.
- o The section of implementation considerations for RA DNS Options is removed.

- o The usage of the keywords of SHOULD and RECOMMENDED in [RFC 2119](#) is removed in the recommendation of using SEND for secure ND. Instead of the keywords, SEND is specified as a possible solution for secure ND.

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