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IPv6 Router Advertisement Option for DNS Configuration

Status of This Memo

This memo defines an Experimental Protocol for the Internet community. It does not specify an Internet standard of any kind. Discussion and suggestions for improvement are requested. Distribution of this memo is unlimited.

Abstract

This document specifies a new IPv6 Router Advertisement option to allow IPv6 routers to advertise DNS recursive server addresses to IPv6 hosts.

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1. Introduction

Neighbor Discovery (ND) for IP Version 6 and IPv6 Stateless Address Autoconfiguration provide ways to configure either fixed or mobile nodes with one or more IPv6 addresses, default routers and some other parameters [2][3]. To support the access to additional services in the Internet that are identified by a DNS name, such as a web server, the configuration of at least one recursive DNS server is also needed for DNS name resolution.

It is infeasible for nomadic hosts, such as laptops, to be configured manually with a DNS resolver each time they connect to a different wireless LAN (WLAN) such as IEEE 802.11 a/b/g [12]-[15]. Normally, DHCP [6]-[8] is used to locate such resolvers. This document provides an alternate, experimental mechanism which uses a new IPv6 Router Advertisement (RA) option to allow IPv6 routers to advertise DNS recursive server addresses to IPv6 hosts.

1.1. Applicability Statements

The only standards-track DNS configuration mechanism in the IETF is DHCP, and its support in hosts and routers is necessary for reasons of interoperability.

RA-based DNS configuration is a useful, optional alternative in networks where an IPv6 host's address is autoconfigured through IPv6 stateless address autoconfiguration, and where the delays in acquiring server addresses and communicating with the servers are critical. RA-based DNS configuration allows the host to acquire the nearest server addresses on every link. Furthermore, it learns these addresses from the same RA message that provides configuration information for the link, thereby avoiding an additional protocol run. This can be beneficial in some mobile environments, such as with Mobile IPv6 [10].

The advantages and disadvantages of the RA-based approach are discussed in [9] along with other approaches, such as the DHCP and well-known anycast addresses approaches.

1.2. Coexistence of RDNSS Option and DHCP Option

The RDNSS (Recursive DNS Server) option and DHCP option can be used together [9]. To order the RA and DHCP approaches, the O (Other stateful configuration) flag can be used in the RA message [2]. If no RDNSS option is included in the RA messages, an IPv6 host may perform DNS configuration through DHCPv6 [6]-[8] regardless of whether the O flag is set or not.

2. Definitions

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 [1].

3. Terminology

This document uses the terminology described in [2] and [3]. In addition, four new terms are defined below:

- Recursive DNS Server (RDNSS): Server which provides a recursive DNS resolution service for translating domain names into IP addresses as defined in [4] and [5].
- RDNSS Option: IPv6 RA option to deliver the RDNSS information to IPv6 hosts [2].
- DNS Server List: A data structure for managing DNS Server Information in the IPv6 protocol stack in addition to the Neighbor Cache and Destination Cache for Neighbor Discovery [2].
- Resolver Repository: Configuration repository with RDNSS addresses 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 defines a new ND option called RDNSS option that contains the addresses of recursive DNS servers. Existing ND transport mechanisms (i.e., advertisements and solicitations) are used. This works in the same way that hosts learn about routers and prefixes. An IPv6 host can configure the IPv6 addresses of one or more RDNSSes via RA messages periodically sent by a router or solicited by a Router Solicitation (RS).

Through the RDNSS option, along with the prefix information option based on the ND protocol ([2] and [3]), an IPv6 host can perform network configuration of its IPv6 address and RDNSS simultaneously without needing a separate message exchange for the RDNSS information. The RA option for RDNSS can be used on any network that supports the use of ND.

This approach requires RDNSS information to be configured in the routers sending the advertisements. The configuration of RDNSS addresses in the routers can be done by manual configuration. The automatic configuration or redistribution of RDNSS information is

possible by running a DHCPv6 client on the router [6]-[8]. The automatic configuration of RDNSS addresses in routers is out of scope for this document.

5. Neighbor Discovery Extension

The IPv6 DNS configuration mechanism in this document needs a new ND option in Neighbor Discovery: the Recursive DNS Server (RDNSS) 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.

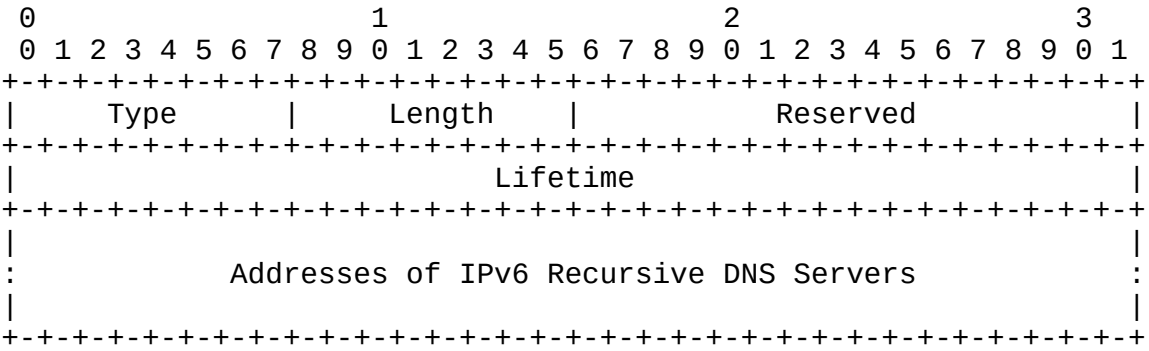

Figure 1: Recursive DNS Server (RDNSS) Option Format

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 sent), over which this RDNSS address MAY be used for name resolution. Hosts MAY send a Router Solicitation to ensure the RDNSS information is fresh before the interval expires. In order to provide fixed hosts with stable DNS service and allow mobile hosts to prefer local RDNSSes to remote RDNSSes, the value of Lifetime should be at least as long as the Maximum RA Interval (MaxRtrAdvInterval) in RFC 4861, and be at most as long as two times MaxRtrAdvInterval; Lifetime SHOULD be bounded as follows: MaxRtrAdvInterval <= Lifetime <= 2*MaxRtrAdvInterval. A value of all one bits (0xffffffff) represents infinity. A value of zero means that the RDNSS address 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.

5.2. Procedure of DNS Configuration

The procedure of DNS configuration through the RDNSS option is the same as with any other ND option [2].

5.2.1. Procedure in IPv6 Host

When an IPv6 host receives an RDNSS option through RA, it checks whether the option is valid.

- If the RDNSS option is valid, the host SHOULD copy the option's value into the DNS Server List and the Resolver Repository as long as the value of the Length field is greater than or equal to the minimum value (3). The host MAY ignore additional RDNSS addresses within an RDNSS option and/or additional RDNSS options within an RA when it has gathered a sufficient number of RDNSS addresses.

- If the RDNSS option is invalid (e.g., the Length field has a value less than 3), the host SHOULD discard the option.

6. Implementation Considerations

Note: This non-normative section gives some hints for implementing the processing of the RDNSS option in an IPv6 host.

For the configuration and management of RDNSS information, the advertised RDNSS addresses can be stored and managed in both the DNS Server List and the Resolver Repository.

In environments where the RDNSS information is stored in user space and ND runs in the kernel, it is necessary to synchronize the DNS Server List of RDNSS addresses in kernel space and the Resolver Repository in user space. For the synchronization, an implementation where ND works in the kernel should provide a write operation for updating RDNSS information from the kernel to the Resolver Repository. One simple approach is to have a daemon (or a program that is called at defined intervals) that keeps monitoring the lifetime of RDNSS addresses all the time. Whenever there is an expired entry in the DNS Server List, the daemon can delete the corresponding entry from the Resolver Repository.

6.1. DNS Server List Management

The kernel or user-space process (depending on where RAs are processed) should maintain a data structure called a DNS Server List which keeps the list of RDNSS addresses. Each entry in the DNS Server List consists of an RDNSS address and Expiration-time as follows:

- RDNSS address: IPv6 address of the Recursive DNS Server, which is available for recursive DNS resolution service in the network advertising the RDNSS option; such a network is called site in this document.

- Expiration-time: The time when this entry becomes invalid. Expiration-time is set to the value of the Lifetime field of the RDNSS option plus the current system time. Whenever a new RDNSS option with the same address is received, this field is updated to have a new expiration time. When Expiration-time becomes less than the current system time, this entry is regarded as expired.

Note: An RDNSS address MUST be used only as long as both the RA router lifetime and the RDNSS option lifetime have not expired. The reason is that the RDNSS may not be currently reachable or may not provide service to the host’s current address (e.g., due to network ingress filtering [16][17]).

6.2. Synchronization between DNS Server List and Resolver Repository

When an IPv6 host receives the information of multiple RDNSS addresses within a site through an RA message with RDNSS option(s), it stores the RDNSS addresses (in order) into both the DNS Server List and the Resolver Repository. The processing of the RDNSS option(s) included in an RA message is as follows:

Step (a): Receive and parse the RDNSS option(s). For the RDNSS addresses in each RDNSS option, perform Step (b) through Step (d). Note that Step (e) is performed whenever an entry expires in the DNS Server List.

Step (b): For each RDNSS address, check the following: If the RDNSS address already exists in the DNS Server List and the RDNSS option's Lifetime field is set to zero, delete the corresponding RDNSS entry from both the DNS Server List and the Resolver Repository in order to prevent the RDNSS address from being used any more for certain reasons in network management, e.g., the breakdown of the RDNSS or a renumbering situation. The processing of this RDNSS address is finished here. Otherwise, go to Step (c).

Step (c): For each RDNSS address, if it already exists in the DNS Server List, then just update the value of the Expiration-time field according to the procedure specified in the second bullet of Section 6.1. Otherwise, go to Step (d).

Step (d): For each RDNSS address, if it does not exist in the DNS Server List, register the RDNSS address and lifetime with the DNS Server List and then insert the RDNSS address in front of the Resolver Repository. In the case where the data structure for the DNS Server List is full of RDNSS entries, delete from the DNS Server List the entry with the shortest expiration time (i.e., the entry that will expire first). The corresponding RDNSS address is also deleted from the Resolver Repository. In the order in the RDNSS option, position the newly added RDNSS addresses in front of the Resolver Repository so that the new RDNSS addresses may be preferred according to their order in the RDNSS option for the DNS name resolution. The processing of these RDNSS addresses is finished here. Note that, in the case where there are several routers advertising RDNSS option(s) in a subnet, the RDNSSes that have been announced recently are preferred.

Step (e): Delete each expired entry from the DNS Server List, and delete the RDNSS address corresponding to the entry from the Resolver Repository.

7. Security Considerations

The security of the RA option for RDNSS might be worse than ND protocol security [2]. However, any new vulnerability in this RA option is not known yet. In this context, it can be claimed that the vulnerability of ND is not worse and is a subset of the attacks that any node attached to a LAN can do independently of ND. A malicious node on a LAN can promiscuously receive packets for any router's MAC address and send packets with the router's MAC address as the source MAC address in the L2 header. As a result, L2 switches send packets addressed to the router to the malicious node. Also, this attack can send redirects that tell the hosts to send their traffic somewhere else. The malicious node can send unsolicited RA or Neighbor Advertisement (NA) replies, answer RS or Neighbor Solicitation (NS) requests, etc. Also, an attacker could configure a host to send out an RA with a fraudulent RDNSS address, which is presumably an easier avenue of attack than becoming a rogue router and having to process all traffic for the subnet. It is necessary to disable the RA RDNSS option in both routers and clients administratively to avoid this problem. All of this can be done independently of implementing ND. Therefore, it can be claimed that the RA option for RDNSS has vulnerabilities similar to those existing in current mechanisms.

If the Secure Neighbor Discovery (SEND) protocol is used as a security mechanism for ND, all the ND options including the RDNSS option are automatically included in the signatures [11], so the RDNSS transport is integrity-protected. However, since any valid SEND node can still insert RDNSS options, SEND cannot verify who is or is not authorized to send the options.

8. IANA Considerations

The IANA has assigned a new IPv6 Neighbor Discovery Option type for the RDNSS option defined in this document.

Option Name	Type
RDNSS option	25

The IANA registry for these options is:

http://www.iana.org/assignments/icmpv6-parameters

9. Acknowledgements

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