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Discovering PREF64 in Router Advertisements
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Abstract

This document specifies a Neighbor Discovery option to be used in Router Advertisements to communicate NAT64 prefixes to hosts.

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1. Introduction

NAT64 [RFC6146] with DNS64 [RFC6147] is a widely-deployed mechanism to provide IPv4 access on IPv6-only networks. In various scenarios, the host must be aware of the NAT64 prefix in use by the network. This document specifies a Neighbor Discovery [RFC4861] option to be used in Router Advertisements to communicate NAT64 prefixes to hosts.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Terminology

PREF64 (or NAT64 prefix): an IPv6 prefix used for IPv6 address synthesis [RFC6146];

NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers [RFC6146];

RA: Router Advertisement, a message used by IPv6 routers to advertise their presence together with various link and Internet parameters [RFC4861];

DNS64: a mechanism for synthesizing AAAA records from A records [RFC6147];

2. Use cases for communicating the NAT64 prefix to hosts

On networks employing NAT64, it is useful for hosts to know the NAT64 prefix for several reasons, including the following:

- Enabling DNS64 functions on end hosts. In particular:
  - Local DNSSEC validation (DNS64 in stub-resolver mode). As discussed in [RFC6147] section 2, the stub resolver in the host "will try to obtain (real) AAAA RRs, and in case they are not available, the DNS64 function will synthesize AAAA RRs for internal usage." This is required in order to use DNSSEC on a NAT64 network.
  - Trusted DNS server. AAAA synthesis is required for the host to be able to use a DNS server not provided by the network (e.g., a DNS-over-TLS [RFC7858] or DNS-over-HTTPS [RFC8484] server with which the host has an existing trust relationship).
  - Networks with no DNS64 server. Hosts that support AAAA synthesis and that are aware of the NAT64 prefix in use do not need the network to perform the DNS64 function at all.
- Enabling NAT64 address translation functions on end hosts. For example:
  - IPv4 address literals on an IPv6-only host. As described in [RFC8305] section 7.1, IPv6-only hosts connecting to IPv4 address literals can translate the IPv4 literal to an IPv6 literal.
  - 464XLAT [RFC6877]. 464XLAT requires the host be aware of the NAT64 prefix.

3. Why include the NAT64 prefix in Router Advertisements

Fate sharing: NAT64 requires routing to be configured. IPv6 routing configuration requires receiving an IPv6 Router Advertisement [RFC4861]. Therefore using Router Advertisements to provide hosts with NAT64 prefix ensures that NAT64 reachability information shares fate with the rest of network configuration on the host.

Atomic configuration: including the NAT64 prefix in the Router Advertisement minimizes the number of packets required to configure a host. Only one packet (a Router Advertisement) is required to

complete the network configuration. This speeds up the process of connecting to a network that supports NAT64/DNS64, and simplifies host implementation by removing the possibility that the host can have an incomplete layer 3 configuration (e.g., IPv6 addresses and prefixes, but no NAT64 prefix).

Updatability: it is possible to change the NAT64 prefix at any time, because when it changes, it is possible to notify hosts by sending a new Router Advertisement.

Deployability: all IPv6 hosts and networks are required to support Neighbor Discovery [RFC4861] so just a minor extension to the existing implementation is required. Other options such as [RFC7225] require implementing other protocols (e.g. PCP [RFC7225]) which could be considered an obstacle for deployment.

4. Usage Guidelines

This option specifies exactly one NAT64 prefix for all IPv4 destinations. If the network operator desires to route different parts of the IPv4 address space to different NAT64 devices, this can be accomplished by routing more specifics of the NAT64 prefix to those devices. For example, if the operator is using the RFC1918 address space, e.g. 10.0.0.0/8 internally and would like to route 10.0.0.0/8 through NAT64 device A and the rest of the IPv4 space through NAT64 device B, and the operator's NAT64 prefix is 2001:db8:a:b::/96, then the operator can route 2001:db8:a:b::a00:0/104 to NAT64 A and 2001:db8:a:b::/96 to NAT64 B.

This option may appear more than once in a Router Advertisement (e.g. in case of graceful renumbering the network from one NAT64 prefix to another). Host behaviour with regards to synthesizing IPv6 addresses from IPv4 addresses SHOULD follow the recommendations given in Section 3 of [RFC7050], limited to the NAT64 prefixes that have non-zero lifetime.

In a network (or a provisioning domain) that provides both IPv4 and NAT64, it may be desirable for certain IPv4 addresses not to be translated. An example might be private address ranges that are local to the network/provisioning domain and should not be reached through the NAT64. This type of configuration cannot be conveyed to hosts using this option, or through other NAT64 prefix provisioning mechanisms such as [RFC7050] or [RFC7225]. This problem does not apply in IPv6-only networks, because in such networks, the host does not have an IPv4 address and cannot reach any IPv4 destinations without the NAT64.

5. Option format

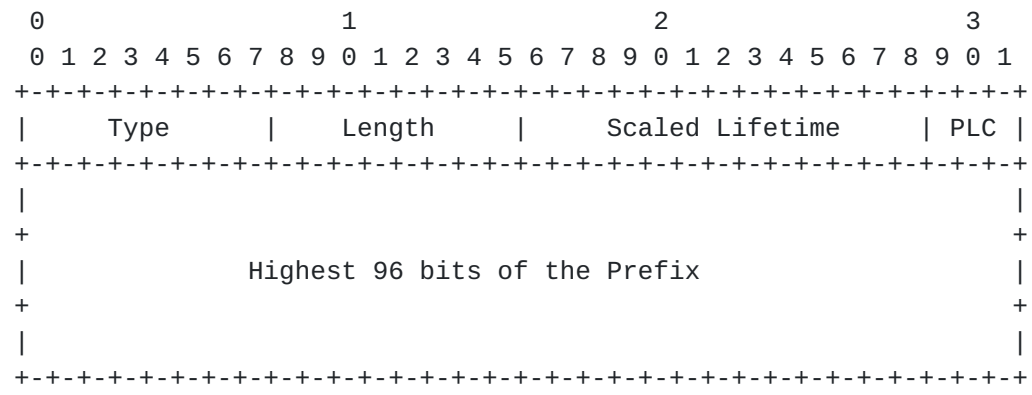

Figure 1: NAT64 Prefix Option Format

Fields:

Type	8-bit identifier of the PREF64 option type as assigned by IANA: TBD
Length	8-bit unsigned integer. The length of the option (including the Type and Length fields) is in units of 8 octets. The sender MUST set the length to 2. The receiver MUST ignore the PREF64 option if the length field value is not 2.
Scaled Lifetime	13-bit unsigned integer. The maximum time in units of 8 seconds over which this NAT64 prefix MAY be used. The value of the Scaled Lifetime field SHOULD by default be set to the lesser of 3 x MaxRtrAdvInterval divided by 8, or 8191. The receiver MUST multiply the Scaled Lifetime value by 8 (for example, by logical left shift) to calculate the maximum time in seconds the prefix MAY be used. Lifetime of 0 indicates that the prefix SHOULD NOT be used anymore. Router vendors SHOULD allow administrators to specify non-zero lifetime values which are not divisible by 8. In such cases the router SHOULD round the provided value up to the lesser of nearest integer divisible by 8, or 65528 and divide the result by 8 (or just perform a logical right-shift by 3) and set the Scaled Lifetime field to the resulting value. If such a non-zero lifetime value to be divided by 8 (to be subjected to a logical right-shift by 3) is less than 8 then the Scaled Lifetime field SHOULD by default be set to 1.
PLC (Prefix Length Code)	3-bit unsigned integer. This field encodes the NAT64 Prefix Length defined in [RFC6052]. The PLC field values 0, 1, 2, 3, 4 and 5 indicate the NAT64 prefix length of 96, 64, 56, 48, 40 and 32 bits respectively. The receiver MUST ignore the PREF64 option if the prefix length code field is not set to one of those values.
Highest 96 bits of the prefix	96-bit unsigned integer. Contains bits 0 - 95 of the NAT64 prefix.

6. Handling Multiple NAT64 Prefixes

In some cases a host may receive multiple NAT64 prefixes from different sources. Possible scenarios include (but are not limited to):

- the host is using multiple mechanisms to discover PREF64 prefixes (e.g. by using PCP [RFC7225]) and/or by resolving IPv4-only fully qualified domain name [RFC7050] in addition to receiving the PREF64 RA option);

- the PREF64 option presents in a single RA more than once;
- the host receives multiple RAs with different PREF64 prefixes on one or multiple interfaces.

When multiple PREF64 were discovered via RA PREF64 Option (the Option presents more than once in a single RA or multiple RAs were received), host behaviour with regards to synthesizing IPv6 addresses from IPv4 addresses SHOULD follow the recommendations given in Section 3 of [RFC7050], limited to the NAT64 prefixes that have non-zero lifetime.

When different PREF64 are discovered by using multiple mechanisms, hosts SHOULD select one source of information only. The RECOMMENDED order is:

- PCP-discovered prefixes [RFC7225], if supported;
- PREF64 discovered via RA Option;
- PREF64 resolving IPv4-only fully qualified domain name [RFC7050]

Note that if the network provides PREF64 both via this RA option and [RFC7225], hosts that receive the PREF64 via RA option may choose to use it immediately before waiting for PCP to complete, and therefore some traffic may not reflect any more detailed configuration provided by PCP.

7. PREF64 Consistency

Section 6.2.7 of [RFC4861] recommends that routers inspect RAs sent by other routers to ensure that all routers onlink advertise the consistent information. Routers SHOULD inspect valid PREF64 options received on a given link and verify the consistency. Detected inconsistencies indicate that one or more routers might be misconfigured. Routers SHOULD log such cases to system or network management. Routers SHOULD check and compare the following information:

- set of PREF64 with non-zero lifetime;
- set of PREF64 with zero lifetime.

Provisioning Domain (PvD, [RFC7556])-aware routers MUST only compare information scoped to the same implicit or explicit PvD.

8. IANA Considerations

The IANA is requested to assign a new IPv6 Neighbor Discovery Option type for the PREF64 option defined in this document.

Option Name	Type
PREF64 option	(TBD)

Table 1

The IANA registry for these options is:

https://www.iana.org/assignments/icmpv6-parameters [1]

9. Security Considerations

Because Router Advertisements are required in all IPv6 configuration scenarios, on IPv6-only networks, Router Advertisements must already be secured, e.g., by deploying RA guard [RFC6105]. Providing all configuration in Router Advertisements reduces the attack surface to be targeted by malicious attackers to provide hosts with invalid configuration as compared to distributing the configuration through multiple different mechanisms that need to be secured independently.

The security measures that must already be in place to ensure that Router Advertisements are only received from legitimate sources eliminate the problem of NAT64 prefix validation described in section 3.1 of [RFC7050].

10. Acknowledgements

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11.3. URIs

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