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Improving the Reaction of Customer Edge Routers to Renumbering Events
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Abstract

In scenarios where network configuration information becomes invalid without any explicit signaling of that condition (such as when a Customer Edge Router crashes and reboots without knowledge of the previously-employed configuration information), hosts on the local network will continue using stale network configuration information for an unacceptably long period of time, thus resulting in connectivity problems. This document specifies improvements to Customer Edge Routers that help mitigate the aforementioned problem for typical residential and small office scenarios. This document updates RFC7084.

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1. Introduction

In scenarios where network configuration information becomes invalid without any explicit signaling of that condition, nodes on the local network will continue using stale information for an unacceptably long period of time, thus resulting in connectivity problems. This problem is documented in detail in [I-D.ietf-v6ops-slaac-renum].

This document specifies improvements to Customer Edge (CE) Routers that help mitigate the aforementioned problem for residential and small office scenarios. It specifies recommendations for the default behavior of CE Routers, and does not preclude the availability of configuration knobs that might allow an operator or user to manually-configure the CE Router to deviate from these recommendations. This document updates RFC7084.

2. Requirements Language

Take careful note: Unlike other IETF documents, the key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are not used as described in [RFC2119]. This document uses these keywords not strictly for the purpose of interoperability, but rather for the purpose of establishing industry-common baseline functionality. As such, the document points to several other specifications (preferable in RFC or stable form) to provide additional guidance to implementers regarding any protocol implementation required to produce a successful CE router that interoperates successfully with a particular subset of currently deploying and planned common IPv6 access networks.

Note: the aforementioned terms are used in exactly the same way as in [RFC7084], with the above explanation copied verbatim from Section 1.1 of [RFC7084].

3. Improved Customer Edge Router Behavior

This section specifies and clarifies requirements for Customer Edge Routers that can help mitigate the problem discussed in Section 1, particularly when they employ prefixes learned via DHCPv6-Prefix Delegation (DHCPv6-PD) [RFC8415] on the WAN-side with Stateless Address Autoconfiguration (SLAAC) [RFC4862] or DHCPv6 [RFC8415] on the LAN-side. The recommendations in this document help improve robustness at the Customer Edge Router (on which the user or ISP may have no control), and do not preclude implementation of host-side improvements such as those specified in [I-D.ietf-6man-slaac-renum].

This document specifies additional LAN-side requirements to requirements L-1 through L-14 specified in [RFC7084]:

- L-15: CE routers MUST NOT advertise prefixes via SLAAC or assign addresses or delegate prefixes via DHCPv6 on the LAN-side, employing lifetimes that exceed the remaining lifetimes of the corresponding prefixes learned from the WAN-side via DHCPv6-PD. For more details, see Section 3.1.

- L-16: CE routers SHOULD advertise capped SLAAC option lifetimes and capped DHCPv6 IA Address Option and IA Prefix Option lifetimes, as specified in Section 3.2.

- L-17: CE routers MUST signal stale configuration information as specified in Section 3.3.

- L-18: CE routers SHOULD NOT automatically send DHCPv6-PD RELEASE messages upon reboot events.

3.1. Interface Between WAN-side and LAN-side

The "Preferred Lifetime" and "Valid Lifetime" of Prefix Information Options (PIOs) [RFC4861] corresponding to prefixes learned via DHCPv6-PD MUST NOT span past the remaining preferred and valid lifetimes of the corresponding DHCPv6-PD prefixes. This means that the advertised "Preferred Lifetime" and "Valid Lifetime" MUST be dynamically adjusted such that they never span past the remaining preferred and valid lifetimes of the corresponding prefixes delegated via DHCPv6-PD on the WAN-side.

Similarly, the "preferred-lifetime" and "valid-lifetime" of DHCPv6 IA Address Options and DHCPv6 IA Prefix Options employed with DHCPv6 on the LAN-side MUST NOT span past the remaining preferred and valid lifetimes of the corresponding prefixes leased via DHCPv6-PD on the WAN-side. This means that the advertised "Preferred Lifetime" and "Valid Lifetime" MUST be dynamically adjusted such that the advertised lifetimes never span past the remaining preferred and valid lifetimes of the corresponding prefixes delegated to the CE Router on the WAN-side via DHCPv6-PD.

CE Routers providing stateful address configuration via DHCPv6 SHOULD set the DHCPv6 IA Address Option preferred-lifetime to the lesser of the remaining preferred lifetime and ND_PREFERRED_LIMIT, and the valid-lifetime of the same option to the lesser of the remaining valid lifetime and ND_VALID_LIMIT.

CE Routers providing DHCPv6-PD on the LAN-side SHOULD set the DHCPv6 IA Prefix Option preferred-lifetime to the lesser of the remaining preferred lifetime and ND_PREFERRED_LIMIT, and the valid-lifetime of the same option to the lesser of the remaining valid lifetime and ND_VALID_LIMIT.

RATIONALE:

* The lifetime values employed for the "Preferred Lifetime" (AdvPreferredLifetime) and "Valid Lifetime" (AdvValidLifetime) of SLAAC Prefix Information Options must never be larger than the remaining lifetimes for the corresponding prefix (as learned via DHCPv6-PD on the WAN-side). This is in line with the requirement from Section 6.3 of [RFC8415], which states that "if the delegated prefix or a prefix derived from it is advertised for stateless address autoconfiguration [RFC4862], the advertised preferred and valid lifetimes MUST NOT exceed the corresponding remaining lifetimes of the delegated prefix."

* The lifetime values of prefixes advertised on the LAN-side via SLAAC must be dynamically updated (rather than static values), otherwise the advertised lifetimes would eventually span past the DHCPv6-PD lifetimes.

* The same considerations apply for the valid-lifetime and preferred-lifetime of IA Address Options and IA Prefix Options employed with DHCPv6 on the LAN-side.

3.2. LAN-side Option Lifetimes

CE Routers SHOULD override the default PIO "Preferred Lifetime" and "Valid Lifetime" values from [RFC4861], and employ shorter lifetime values to improve the robustness to renumbering events, while complying with the requirements from Section 2.1 of this document and the recommendations in [RFC7772].

CE routers SHOULD set the Router Lifetime to ND_PREFERRED_LIMIT. CE routers SHOULD also set the PIO Preferred Lifetime to the lesser of the remaining preferred lifetime (see Section 3.1) and ND_PREFERRED_LIMIT, and the PIO Valid Lifetime to the lesser of the remaining valid lifetime and ND_VALID_LIMIT. Additionally, the Route Lifetime of Route Information Options (RIOs) [RFC4191], the Lifetime of Recursive DNS Search Options (RDNSSO) [RFC8106], and the Lifetime of DNS Search List Options (DNSSLO) [RFC8106] SHOULD be set to the lesser of the longest valid-lifetime in a DHCPv6 IA Prefix Option (received via DHCPv6 on the WAN-side) and ND_VALID_LIMIT, if any of these options are included in Router Advertisement messages.

CE Routers providing stateful address configuration via DHCPv6 SHOULD set the DHCPv6 IA Address Option preferred-lifetime to the lesser of the remaining preferred lifetime (see Section 3.1) and ND_PREFERRED_LIMIT, and the valid-lifetime of the same option to the lesser of the remaining valid lifetime and ND_VALID_LIMIT.

CE Routers providing DHCPv6-PD on the LAN-side SHOULD set the DHCPv6 IA Prefix Option preferred-lifetime to the lesser of the remaining preferred lifetime (see Section 3.1) and ND_PREFERRED_LIMIT, and the valid-lifetime of the same option to the lesser of the remaining valid lifetime and ND_VALID_LIMIT.

RATIONALE:

* The Valid Lifetime and Preferred Lifetime of PIOs have a direct impact on three different aspects:

+ The amount of time hosts may end up employing stale network configuration information (see [I-D.ietf-v6ops-slaac-renum]).

+ The amount of time CE Routers need to persist trying to deprecate stale network configuration information (e.g. to handle cases where nodes miss Router Advertisements and thus still consider the stale information as valid).

+ The amount of information that CE Routers need to maintain when e.g. multiple crash-and-reboot events occur in the timespan represented by the option lifetimes employed on the LAN-side.

* CE Routers need not employ the (possibly long) DHCPv6-PD lifetimes for the Valid Lifetime and Preferred Lifetime of PIOs sent in Router Advertisements messages to advertise sub-prefixes of the leased prefix. Instead, CPE Routers SHOULD use shorter values for the Valid Lifetime and Preferred Lifetime of PIOs, since subsequent Router Advertisement messages will nevertheless refresh the associated lifetimes, leading to the same effective lifetimes as specified by the WAN-side DHCPv6-PD lifetimes.

* Similarly, CE Routers need not employ the (possibly long) DHCPv6-PD lifetimes for the valid-lifetime and preferred-lifetime of IA Address Options and IA Prefix Option employed by DHCPv6 on the LAN-side, since the renewal of bindings by DHCPv6 clients will lead to the same effective lifetimes as specified by the WAN-side DHCPv6-PD lifetimes.

3.3. Signaling Stale Configuration Information

In order to phase-out stale SLAAC configuration information:

o A CE router sending RAs that advertise dynamically-learned prefixes (e.g. via DHCPv6-PD) SHOULD record, on stable storage, the list of prefixes being advertised on each network segment, and the state of the "A" and "L" flags of the corresponding PIOs.

o Upon changes to the advertised prefixes, and after bootstrapping, the CE Router advertising prefix information via SLAAC proceeds as follows:

* Any prefixes that were previously advertised via Router Advertisement (RA) messages, but that have now become stale, MUST be advertised with a "Valid Lifetime" and a "Preferred Lifetime" set to 0, and the "A" and "L" bits unchanged.

  * The aforementioned advertisement SHOULD be performed for at least the "Valid Lifetime" previously employed for such prefix. Note: If requirement L-16 (Section 3.2) is followed, the Valid Lifetime need not be saved and the prefix can simply be advertised for a period of ND_VALID_LIMIT.

- CE Routers receiving DHCPv6 Prefix Delegations with a 0 valid-lifetime MUST advertise the corresponding sub-prefixes (as they would be generated for the same leased prefix with a non-zero lifetime) with a PIO with both the Preferred Lifetime and the Valid Lifetime set to 0, for at least the WAN-side DHCPv6-PD valid-lifetime, or for a period of ND_VALID_LIMIT if the recommended lifetimes from Section 3.2 are employed.

If a CE Router provides LAN-side DHCPv6 (address assignment or prefix delegation), then:

- The CE Router SHOULD record, on stable storage, the DHCPv6 address and delegated-prefix bindings corresponding to the LAN-side.

- If the CE Router finds that the prefix to be employed for address assignment and/or prefix delegation has changed (e.g., upon a crash-and-reboot event) or the CE Router receives DHCPv6 Prefix Delegations with 0 lifetimes, the CE Router MUST:

  * In Replies to DHCPv6 Request, Renew, Rebind messages, send 0 lifetimes for any address assignments or prefix delegations for the deprecated prefixes for at least the valid-lifetime previously employed for them, or for a period of ND_VALID_LIMIT if the recommended lifetimes from Section 3.2 are employed.

  * Initiate sending Reconfigure messages (if possible - i.e., client requests Reconfigure support and the CE Router offers it) to those clients with address assignments or prefix delegations for the deprecated prefixes.

RATIONALE:

  * IPv6 network renumbering is expected to take place in a planned manner, with old/stale prefixes being phased-out via reduced prefix lifetimes while new prefixes (with normal lifetimes) are introduced. However, a number of scenarios may lead to the so-called "flash-renumbering" events, where the prefix being employed on a network suddenly becomes invalid and replaced by a new prefix [I-D.ietf-v6ops-slaac-renum]. One such scenario is when a DHCPv6 server employs dynamic prefixes and the Customer Edge Router crashes and reboots. The requirements in

this section are meant to allow Customer Edge Routers to deprecate stale information in such scenarios.

* The recommendations in this section expand from requirement L-13 in Section 4.3 of [RFC7084].

* Host configuring addresses via SLAAC on the local network may employ addresses configured for the previously advertised prefixes for at most the "Valid Lifetime" of the corresponding PIO of the last received Router Advertisement message. Since Router Advertisement messages may be lost or fail to be received for various reasons, Customer Edge Routers need to try to deprecate stale prefixes for a period of time equal to the "Valid Lifetime" of the PIO employed when originally advertising the prefix.

* The requirement in this section is conveyed as a "SHOULD" (as opposed to a "MUST"), since we acknowledge that the requirement to store information on stable storage may represent a challenge for some implementations.

* Advertising DHCPv6-leased prefixes with zero lifetimes on the LAN-side would handle the case where a CE Router has no stable storage but receives the prefixes via DHCPv6 with 0 lifetimes.

4. Recommended Option Lifetimes Configuration Values

o ND_PREFERRED_LIMIT: 2700 seconds (45 minutes)

o ND_VALID_LIMIT: 5400 seconds (90 minutes)

RATIONALE:
These values represent a trade-off among a number of factors, including responsiveness and possible impact on the battery life of connected devices [RFC7772].

ND_PREFERRED_LIMIT is set according to the recommendations in [RFC7772] for Router Lifetime, following the rationale from Section 3.2 of [I-D.ietf-v6ops-slaac-renum].

ND_VALID_LIMIT is set to 2 * ND_PREFERRED_LIMIT to provide some additional leeway before configuration information is finally discarded by the host.

5. IANA Considerations

This document has no actions for IANA.

6. Security Considerations

This document discusses a problem that may arise in scenarios where dynamic IPv6 prefixes are employed, and proposes improvements to Customer Edge Routers [RFC7084] to mitigate the problem for residential or small office scenarios. It does not introduce new security issues.

7. Acknowledgments

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