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Recommendations for Prefix Binding in the Context of Softwire Dual-Stack Lite

Abstract

This document discusses issues induced by the change of the Dual-Stack Lite (DS-Lite) Basic Bridging BroadBand (B4) IPv6 address and sketches a set of recommendations to solve those issues.

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1. Introduction

IPv6 deployment models assume IPv6 prefixes are delegated by Service Providers to the connected CPEs (Customer Premises Equipment) or hosts, which in turn derive IPv6 addresses from that prefix. In the case of Dual-Stack Lite (DS-Lite) [RFC6333], which is an IPv4 service continuity mechanism over an IPv6 network, the Basic Bridging BroadBand (B4) element derives an IPv6 address for the IPv4-in-IPv6 softwire setup purposes.

The B4 element might obtain a new IPv6 address for a variety of reasons that include (but are not limited to) a reboot of the CPE, power outage, DHCPv6 lease expiry, or other actions undertaken by the Service Provider. If this occurs, traffic forwarded to a B4's previous IPv6 address may never reach its destination or may be delivered to another B4 that now uses the address formerly assigned to the original B4. This situation affects all mapping types, both implicit (e.g., by sending a TCP SYN) and explicit (e.g., using Port Control Protocol (PCP) [RFC6887]). The problem is further elaborated in Section 2.

This document proposes recommendations to soften the impact of such renumbering issues (Section 4).

This document complements [RFC6908].

1.1. 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].

2. The Problem

Since private IPv4 addresses assigned to hosts serviced by a B4 element overlap across multiple CPEs, the IPv6 address of a B4 element plays a key role in demultiplexing connections, enforcing policies, and in identifying associated resources assigned for each of the connections maintained by the Address Family Transition Router (AFTR) [RFC6333]. For example, these resources maintain state of Endpoint-Independent Mapping (EIM) as defined in Section 4.1 of [RFC4787], Endpoint-Independent Filtering (EIF) as defined in Section 5 of [RFC4787], preserve the external IPv4 address assigned in the AFTR (i.e., "IP address pooling" behavior as defined in Section 4.1 of [RFC4787]), PCP mappings, etc.

However, the IPv6 address used by the B4 element may change for some reason, e.g., because of a change in the CPE itself or because of privacy extensions enabled for generating the IPv6 address (e.g., [RFC7217] or [RFC4941]). Whenever the B4's IPv6 address changes, the associated mappings created in the AFTR are no longer valid. This may result in the creation of a new set of mappings in the AFTR.

Furthermore, a misbehaving user may be tempted to change the B4's IPv6 address in order to "grab" more ports and resources at the AFTR side. This behavior can be seen as a potential denial-of-service (DoS) attack from misbehaving users. Note that this DoS attack can be achieved whatever the port assignment policy enforced by the AFTR may be (individual ports, port sets, randomized port bulks, etc.).

Service Providers may want to enforce policies in order to limit the usage of the AFTR resources on a per-subscriber basis for fairness of resource usage (see REQ-4 of [RFC6888]). These policies are used for dimensioning purposes and also to ensure that AFTR resources are not exhausted. If the derived B4's IPv6 address can change, resource tracking using that address will give incomplete results. Also, whenever the B4's IPv6 address changes, enforcing policies based on that address doesn't resolve stale mappings hanging around in the system, consuming not only system resources, but also reducing the available quota of resources per subscriber. Clearing those mappings can be envisaged, but that will cause a lot of churn in the AFTR and could be disruptive to existing connections; this is not desirable. More concretely, if stale mappings have not been migrated to the new B4's IPv6 address so that packets can be forwarded to the appropriate B4, all incoming packets that are associated with those mappings will be rejected by the AFTR. Such behavior is not desirable because it's detrimental to quality of experience.

When application servers are hosted behind a B4 element, and when there is a change of the B4's IPv6 address that results in a change of the external IPv4 address and/or the external port number at the AFTR side, these servers have to advertise their change (see Section 1.1 of [RFC7393]). Some means to discover the change of B4's IPv6 address, the external IPv4 address, and/or the external port are therefore required. Latency issues are likely to be experienced when an application server has to advertise its newly assigned external IPv4 address and port, and the application clients have to discover that newly assigned address and/or port and re-initiate connections with the application server.

A solution to these problems is to enforce policies based on the IPv6 prefix assigned to subscribers that have DS-Lite service instead of based on the B4's IPv6 address. Section 3 introduces the subscriber-mask that is meant to derive the IPv6 prefix assigned to a subscriber's CPE from the source IPv6 address of a packet received from a B4 element.

3. Introducing Subscriber-Mask

The subscriber-mask is defined as an integer that indicates the length of significant bits to be applied on the source IPv6 address (internal side) to identify unambiguously a CPE.

Subscriber-mask is an AFTR system-wide configuration parameter that is used to enforce generic per-subscriber policies. Applying these generic policies does not require configuring every subscriber's prefix.

Subscriber-mask must be configurable; the default value is 56. The default value is motivated by current practices to assign IPv6 prefix lengths of /56 to end-sites (e.g., [RIPE], [LACNIC]).

Example: suppose the 2001:db8:100:100::/56 prefix is assigned to a CPE that is DS-Lite enabled. Suppose also that the 2001:db8:100:100::1 address is the IPv6 address used by the B4 element that resides in that CPE. When the AFTR receives a packet from this B4 element (i.e., the source address of the IPv4-in-IPv6 packet is 2001:db8:100:100::1), the AFTR applies the subscriber-mask (e.g., 56) on the source IPv6 address to compute the associated prefix for this B4 element (that is, 2001:db8:100:100::/56). Then, the AFTR enforces policies based on that prefix (2001:db8:100:100::/56), not on the exact source IPv6 address.

4. Recommendations

In order to mitigate the issues discussed in Section 2, the following recommendations are made:

1. A policy SHOULD be enforced at the AFTR to limit the number of active DS-Lite softwires per subscriber. The default value MUST be 1.

   This policy aims to prevent a misbehaving subscriber from mounting several DS-Lite softwires that would consume additional AFTR resources (e.g., get more external ports if the quota were enforced on a per-softwire basis, consume extra processing due to a large number of active softwires).

2. Resource contexts created and maintained by the AFTR SHOULD be based on the delegated IPv6 prefix instead of the B4's IPv6 address. The AFTR derives the delegated prefix from the B4's IPv6 address by means of a configured subscriber-mask (Section 3). Administrators SHOULD configure per-prefix limits of resource usage, instead of per-tunnel limits. These resources include the maximum number of active flows, the maximum number of PCP-created mappings, NAT pool resources, etc.

3. In the event a new IPv6 address is assigned to the B4 element, the AFTR SHOULD migrate existing state to be bound to the new IPv6 address. This operation ensures that traffic destined to the previous B4's IPv6 address will be redirected to the newer B4's IPv6 address. The destination IPv6 address for tunneling return traffic from the AFTR SHOULD be the last seen as the B4's IPv6 source address from the CPE.

   This recommendation avoids stale mappings at the AFTR and minimizes the risk of service disruption for subscribers.

   The AFTR uses the subscriber-mask to determine whether two IPv6 addresses belong to the same CPE (e.g., if the subscriber-mask is set to 56, the AFTR concludes that 2001:db8:100:100::1 and 2001:db8:100:100::2 belong to the same CPE assigned with 2001:db8:100:100::/56).

   As discussed in Section 5, changing the source B4's IPv6 address may be used as an attack vector. Packets with a new B4's IPv6 address from the same prefix SHOULD be rate-limited. It is RECOMMENDED to set this rate limit to 30 minutes; other values can be set on a per-deployment basis.

One side effect of migrating mapping state is that a server deployed behind an AFTR does not need to update its DNS records (if any) by means of dynamic DNS, for example. If a dedicated mapping is instantiated, migrating the state during its validity lifetime will ensure that the same external IP address and port are assigned to that server.

4. In the event of change of the CPE WAN's IPv6 prefix, unsolicited PCP ANNOUNCE messages SHOULD be sent by the B4 element to internal hosts connected to the PCP-capable CPE so that they update their mappings accordingly.

   This allows internal PCP clients to update their mappings with the new B4's IPv6 address and to trigger updates to rendezvous servers (e.g., dynamic DNS). A PCP-based dynamic DNS solution is specified in [RFC7393].

5. When a new prefix is assigned to the CPE, stale mappings may exist in the AFTR. This will consume both implicit and explicit resources. In order to avoid such issues, stable IPv6 prefix assignment is RECOMMENDED.

6. If for any reason an IPv6 prefix has to be reassigned, it is RECOMMENDED to reassign an IPv6 prefix (that was previously assigned to a given CPE) to another CPE only when all the resources in use associated with that prefix are cleared from the AFTR. Doing so avoids redirecting traffic, destined to the previous prefix owner, to the new one.

5. Security Considerations

Security considerations related to DS-Lite are discussed in [RFC6333].

Enforcing the recommendations documented in Section 4 together with rate-limiting softwires with new source IPv6 addresses from the same prefix defend against DoS attacks that would result in varying the B4's IPv6 address to exhaust AFTR resources. A misbehaving CPE can be blacklisted by enforcing appropriate policies based on the prefix derived from the subscriber-mask.

6. Privacy Considerations

A CPE connected to a DS-Lite network is identified by a set of information that is specific to each network domain (e.g., service credentials, device identifiers, etc.). This document does not make any assumption nor introduce new requirements on how such identification is implemented network-wide.

This document adheres to Sections 6 and 8 of [RFC6333] for handling IPv4-in-IPv6 packets and IPv4 translation operations. In particular, this document does not leak extra information in packets exiting a DS-Lite network domain.

The recommendations in Section 4 (item 6, in particular) ensure that the traffic is forwarded to a legitimate CPE. If those recommendations are not implemented, privacy concerns may arise. For example, if an IPv6 prefix is reassigned while mapping entries associated with that prefix are still active in the AFTR, sensitive data that belong to a previous prefix owner may be disclosed to the new prefix owner.

These recommendations do not interfere with privacy extensions for generating IPv6 addresses (e.g., [RFC7217] or [RFC4941]). These recommendations allow a CPE to generate new IPv6 addresses with privacy extensions without experiencing DS-Lite service degradation. Even if activating privacy extensions makes it more difficult to track a CPE over time when compared to using a permanent Interface Identifier, tracking a CPE is still possible based on the first 64 bits of the IPv6 address. This is even exacerbated for deployments relying on stable IPv6 prefixes.

This document does not nullify the privacy effects that may motivate the use of non-stable IPv6 prefixes. Particularly, the subscriber-mask does not enable identifying a CPE across renumbering (even within a DS-Lite network domain). This document mitigates some of the undesired effects of reassigning an IPv6 prefix to another CPE (e.g., update a rendezvous service, clear stale mappings).

7. References

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