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Network Address Translation (NAT) Behavioral Requirements Updates draft-ietf-tsvwg-behave-requirements-update-08

Abstract

This document clarifies and updates several requirements of RFC4787, RFC5382, and RFC5508 based on operational and development experience. The focus of this document is NAT44.

This document updates RFCs 4787, 5382, and 5508.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

[RFC4787], [RFC5382], and [RFC5508] contributed to enhance Network Address Translation (NAT) interoperability and conformance. Operational experience gained through widespread deployment and evolution of NAT indicates that some areas of the original documents need further clarification or updates. This document provides such clarifications and updates.

1.1. Scope

The goal of this document is to clarify and update the set of requirements listed in [RFC4787], [RFC5382], and [RFC5508]. The document focuses exclusively on NAT44.

The scope of this document has been set so that it does not create new requirements beyond those specified in the documents cited above.

Carrier-Grade NAT (CGN) related requirements are defined in [RFC6888].

1.2. Terminology

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].

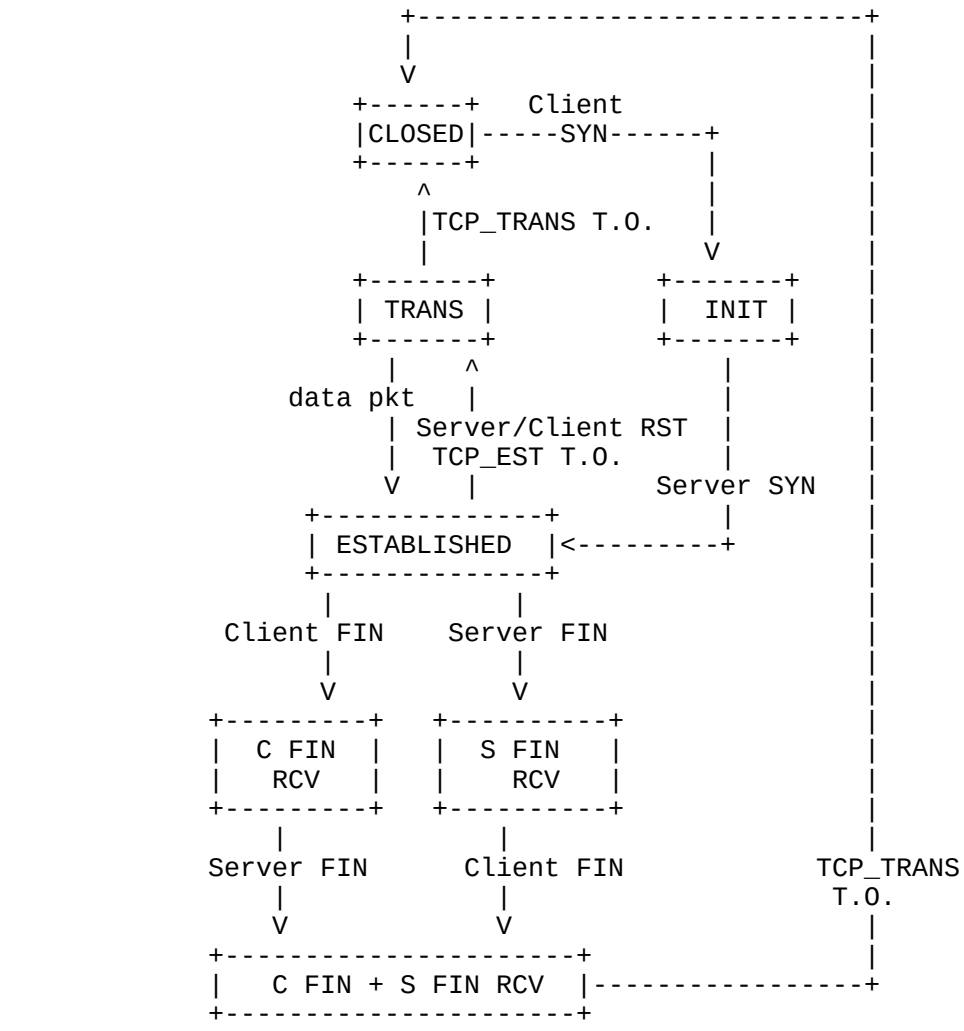
The reader is assumed to be familiar with the terminology defined in: [RFC2663],[RFC4787],[RFC5382], and [RFC5508].

In this document, the term "NAT" refers to both "Basic NAT" and "Network Address/Port Translator (NAPT)" (see Section 3 of [RFC4787]). As a reminder, Basic NAT and NAPT are two variations of traditional NAT, in that translation in Basic NAT is limited to IP addresses alone, whereas translation in NAPT is extended to include IP address and Transport identifier (such as TCP/UDP port or ICMP query ID) (refer to Section 2 of [RFC3022]).

2. TCP Session Tracking

[RFC5382] specifies TCP timers associated with various connection states but does not specify the TCP state machine a NAT44 should follow as a basis to apply such timers.

Update: The TCP state machine depicted in Figure 1, adapted from [RFC6146], SHOULD be implemented by a NAT for TCP session tracking purposes.



Legend:

* Messages sent or received from the server are prefixed with "Server".
* Messages sent or received from the client are prefixed with "Client".
* "C" means "Client-side"
* "S" means "Server-side".
* TCP_EST T.O: refers to the established connection idle timeout as defined in [RFC5382].
* TCP_TRANS T.O: refers to the transitory connection idle timeout as defined in [RFC5382].

Figure 1: Simplified version of the TCP State Machine

2.1. TCP Transitory Connection Idle-Timeout

The transitory connection idle-timeout is defined as the minimum time a TCP connection in the partially open or closing phases must remain idle before the NAT considers the associated session a candidate for removal (REQ-5 of [RFC5382]). But [RFC5382] does not clearly state whether these can be configured separately.

Clarification: This document clarifies that a NAT SHOULD provide different configurable parameters for configuring the open and closing idle timeouts.

To accommodate deployments that consider a partially open timeout of 4 minutes as being excessive from a security standpoint, a NAT MAY allow the configured timeout to be less than 4 minutes. However, a minimum default transitory connection idle-timeout of 4 minutes is RECOMMENDED.

2.2. TCP RST

[RFC5382] leaves the handling of TCP RST packets unspecified.

Update: This document adopts a similar default behavior as in [RFC6146]. Concretely, when the NAT receives a TCP RST matching an existing mapping, it MUST translate the packet according to the NAT mapping entry. Moreover, the NAT SHOULD wait for 4 minutes before deleting the session and removing any state associated with it if no packets are received during that 4 minutes timeout.

Notes:

* Admittedly, the NAT has to verify whether received TCP RST packets belong to a connection. This verification check is required to avoid off-path attacks.

* If the NAT removes immediately the NAT mapping upon receipt of a TCP RST message, stale connections may be maintained by endpoints if the first RST message is lost between the NAT and the recipient.

3. Port Overlapping Behavior

REQ-1 from [RFC4787] and REQ-1 from [RFC5382] specify a specific port overlapping behavior; that is the external IP address and port can be reused for connections originating from the same internal source IP address and port irrespective of the destination. This is known as endpoint-independent mapping (EIM).

Update: This document clarifies that this port overlapping behavior may be extended to connections originating from different internal source IP addresses and ports as long as their destinations are different.

The following mechanism MAY be implemented by a NAT:

If destination addresses and ports are different for outgoing connections started by local clients, a NAT MAY assign the same external port as the source ports for the connections. The port overlapping mechanism manages mappings between external packets and internal packets by looking at and storing their 5-tuple (protocol, source address, source port, destination address, destination port).

This enables concurrent use of a single NAT external port for multiple transport sessions, which allows a NAT to successfully process packets in an IP address resource limited network (e.g., deployment with high address space multiplicative factor (refer to Appendix B. of [RFC6269])).

4. Address Pooling Paired (APP)

The "IP address pooling" behavior of "Paired" (APP) was recommended in REQ-2 from [RFC4787], but the behavior when an external IPv4 runs out of ports was left undefined.

Clarification: This document clarifies that if APP is enabled, new sessions from a host that already has a mapping associated with an external IP that ran out of ports SHOULD be dropped. A configuration parameter MAY be provided to allow a NAT to starting using ports from another external IP address when the one that anchored the APP mapping ran out of ports. Tweaking this configuration parameter is a trade-off between service continuity and APP strict enforcement. Note, this behavior is sometimes referred as ’soft-APP’.

As a reminder, the recommendation for the particular case of a CGN is that an implementation must use the same external IP address mapping for all sessions associated with the same internal IP address, be they TCP, UDP, ICMP, something else, or a mix of different protocols [RFC6888].

Update: This behavior SHOULD apply also for TCP.

5. Endpoint-Independent Mapping (EIM) Protocol Independence

REQ-1 from [RFC4787] and REQ-1 from [RFC5382] do not specify whether EIM are protocol-dependent or protocol-independent. For example, if an outbound TCP SYN creates a mapping, it is left undefined whether outbound UDP packets can reuse such mapping.

Update: EIM mappings SHOULD be protocol-dependent. A configuration parameter MAY be provided to allow protocols that multiplex TCP and UDP over the same source IP address and port number to use a single mapping. The default value of this configuration parameter MUST be protocol-dependent EIM.

This update is consistent with the stateful NAT64 [RFC6146] that clearly specifies three binding information bases (TCP, UDP, ICMP).

6. Endpoint-Independent Filtering (EIF) Protocol Independence

REQ-8 from [RFC4787] and REQ-3 from [RFC5382] do not specify whether mappings with endpoint-independent filtering (EIF) are protocol-independent or protocol-dependent. For example, if an outbound TCP SYN creates a mapping, it is left undefined whether inbound UDP packets matching that mapping should be accepted or rejected.

Update: EIF filtering SHOULD be protocol-dependent. A configuration parameter MAY be provided to make it protocol-independent. The default value of this configuration parameter MUST be protocol-dependent EIF.

This behavior is aligned with the update in Section 5.

Applications that can be transported over a variety of transport protocols and/or support transport fall back schemes won’t experience connectivity failures if the NAT is configured with protocol-independent EIM and protocol-independent EIF.

7. Endpoint-Independent Filtering (EIF) Mapping Refresh

The NAT mapping Refresh direction may have a "NAT Inbound refresh behavior" of "True" according to REQ-6 from [RFC4787], but [RFC4787] does not clarify how this behavior applies to EIF mappings. The issue in question is whether inbound packets that match an EIF mapping but do not create a new session due to a security policy should refresh the mapping timer.

Clarification: This document clarifies that even when a NAT has an inbound refresh behavior set to ’TRUE’, such packets SHOULD NOT

refresh the mapping. Otherwise a simple attack of a packet every 2 minutes can keep the mapping indefinitely.

Update: This behavior SHOULD apply also for TCP.

7.1. Outbound Mapping Refresh and Error Packets

Update: In the case of NAT outbound refresh behavior, ICMP Errors or TCP RST outbound packets, sent as response to inbound packets, SHOULD NOT refresh the mapping. Other packets which indicate the host is not interested in receiving packets MAY be configurable to also not refresh state, such as STUN error response [RFC5389] or IKE INVALID_SYNTAX [RFC7296].

8. Port Parity

Update: A NAT MAY disable port parity preservation for all dynamic mappings. Nevertheless, A NAT SHOULD support means to explicitly request to preserve port parity (e.g., [RFC7753]).

Note: According to [RFC6887], dynamic mappings are said to be dynamic in the sense that they are created on demand, either implicitly or explicitly:

1. Implicit dynamic mappings refer to mappings that are created as a side effect of traffic such as an outgoing TCP SYN or outgoing UDP packet. Implicit dynamic mappings usually have a finite lifetime, though this lifetime is generally not known to the client using them.

2. Explicit dynamic mappings refer to mappings that are created as a result, for example, of explicit Port Control Protocol (PCP) MAP and PEER requests. Explicit dynamic mappings have a finite lifetime, and this lifetime is communicated to the client.

9. Port Randomization

Update: A NAT SHOULD follow the recommendations specified in Section 4 of [RFC6056], especially:

> "A NAPT that does not implement port preservation [RFC4787] [RFC5382] SHOULD obfuscate selection of the ephemeral port of a packet when it is changed during translation of that packet. A NAPT that does implement port preservation SHOULD obfuscate the ephemeral port of a packet only if the port must be changed as a result of the port being already in use for some other session. A NAPT that performs parity preservation and that

must change the ephemeral port during translation of a packet SHOULD obfuscate the ephemeral ports. The algorithms described in this document could be easily adapted such that the parity is preserved (i.e., force the lowest order bit of the resulting port number to 0 or 1 according to whether even or odd parity is desired)."

10. IP Identification (IP ID)

Update: A NAT SHOULD handle the Identification field of translated IPv4 packets as specified in Section 5.3.1 of [RFC6864].

11. ICMP Query Mappings Timeout

Section 3.1 of [RFC5508] specifies that ICMP Query Mappings are to be maintained by a NAT. However, the specification doesn't discuss Query Mapping timeout values. Section 3.2 of [RFC5508] only discusses ICMP Query Session Timeouts.

Update: ICMP Query Mappings MAY be deleted once the last session using the mapping is deleted.

12. Hairpinning Support for ICMP Packets

REQ-7 from [RFC5508] specifies that a NAT enforcing 'Basic NAT' must support traversal of hairpinned ICMP Query sessions.

Clarification: This implicitly means that address mappings from external address to internal address (similar to Endpoint Independent Filters) must be maintained to allow inbound ICMP Query sessions. If an ICMP Query is received on an external address, a NAT can then translate to an internal IP.

REQ-7 from [RFC5508] specifies that all NATs must support the traversal of hairpinned ICMP Error messages.

Clarification: This behavior requires a NAT to maintain address mappings from external IP address to internal IP address in addition to the ICMP Query Mappings described in Section 3.1 of [RFC5508].

13. IANA Considerations

This document does not require any IANA action.

14. Security Considerations

NAT behavioral considerations are discussed in [RFC4787], [RFC5382], and [RFC5508].

Because some of the clarifications and updates (e.g., Section 2) are inspired from NAT64, the security considerations discussed in Section 5 of [RFC6146] apply also for this specification.

The update in Section 3 allows for an optimized NAT resource usage. In order to avoid service disruption, the NAT must not invoke this functionality unless the packets are to be sent to distinct destination addresses.

Some of the updates (e.g., Section 7, Section 9, and Section 11) allow for an increased security compared to [RFC4787], [RFC5382], and [RFC5508]. Particularly:

- The updates in Section 7 and Section 11 prevent an illegitimate node to maintain mappings activated in the NAT while these mappings should be cleared.

- Port randomization (Section 9) complicates tracking hosts located behind a NAT.

Section 4 and Section 12 propose updates that increase the serviceability of a host located behind a NAT. These updates do not introduce any additional security concerns to [RFC4787], [RFC5382], and [RFC5508].

The updates in Section 5 and Section 6 allow for a better NAT transparency from an application standpoint. Hosts that require a restricted filtering behavior should enable specific policies (e.g., access control list (ACL)) either locally or by soliciting a dedicated security device (e.g., firewall). How a host updates its filtering policies is out of scope of this document.

The update in Section 8 induces security concerns that are specific to the protocol used to interact with the NAT. For example, if PCP is used to explicitly request parity preservation for a given mapping, the security considerations discussed in [RFC6887] should be taken into account.

The update in Section 10 may have undesired effects on the performance of the NAT in environments in which fragmentation is massively experienced. Such issue may be used as an attack vector against NATs.

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Dan Wing proposed some text for the configurable errors in Section 7.1.

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