Port Control Protocol
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Network Address Translation (NAT) Behavioral Requirements Updates draft-penno-behave-rfc4787-5382-5508-bis-04

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 NAPT44.

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 RFC 2119 [RFC2119].

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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This Internet-Draft will expire on July 11, 2013.

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1. Terminology

The reader should be familiar with all terms defined in RFC2663 [RFC2663],RFC4787 [RFC4787],RFC5382 [RFC5382],RFC5508 [RFC5508]

2. Introduction

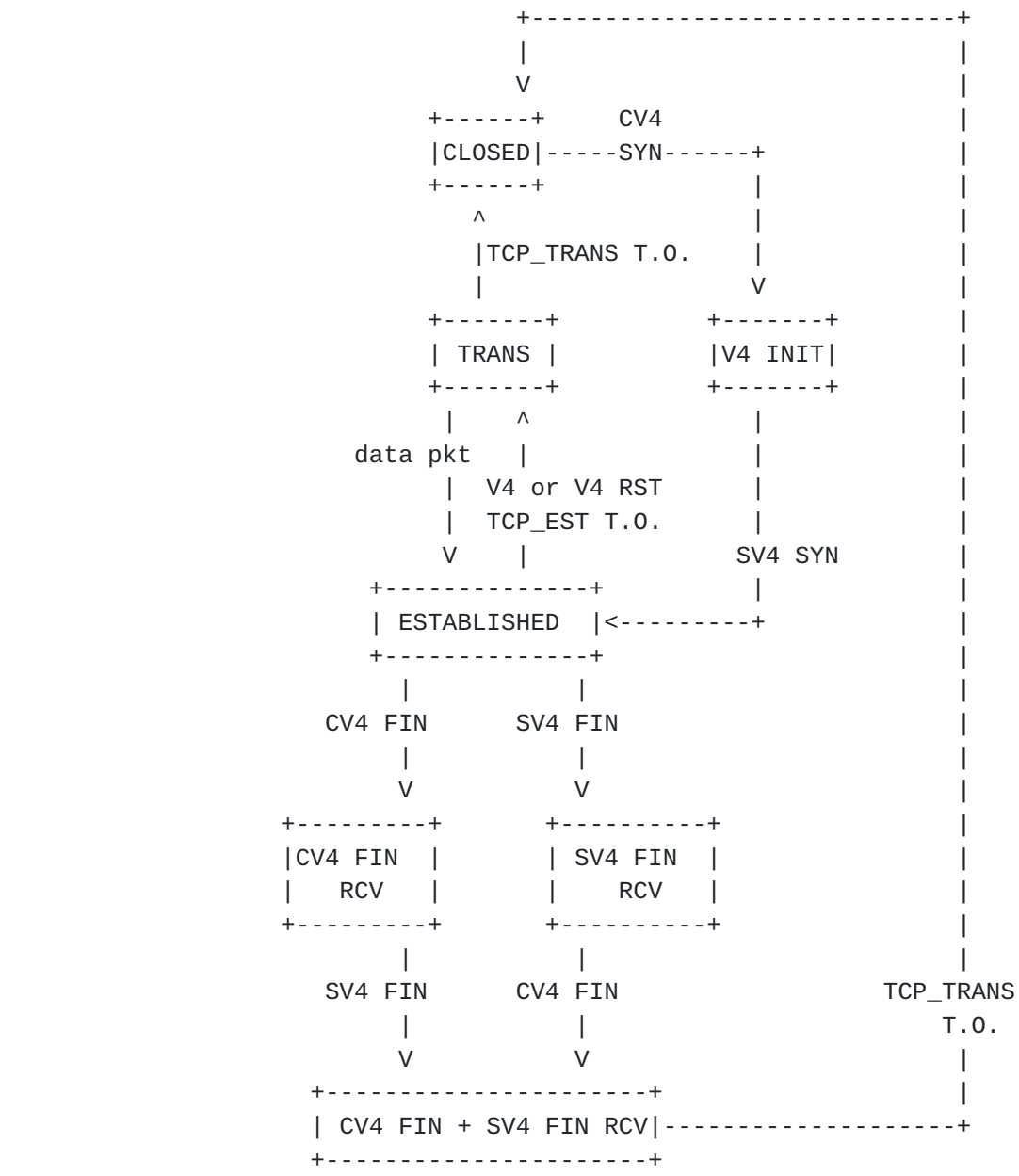
[RFC4787], [RFC5382] and [RFC5508] greatly advanced NAT interoperability and conformance. But with widespread deployment and evolution of NAT more development and operational experience was acquired some areas of the original documents need further clarification or updates. This documents provides such clarifications and updates.

2.1. Scope

This document focuses solely on NAPT44 and its goal is to clarify, fill gaps or update requirements of [RFC4787], [RFC5382] and [RFC5508]. It is out of the scope of this document the creation of completely new requirements not associated with the documents cited above. New requirements would be better served elsewhere and if they are CGN specific in [I-D.ietf-behave-lsn-requirements]

3. TCP Session Tracking

[RFC5382] specifies TCP timers associated with various connection states but does not specify the TCP state machine a NAPT44 should use as a basis to apply such timers. The TCP state machine below, adapted from [RFC6146], provides guidance on how TCP session tracking could be implemented - it is non-normative.



(postamble)

3.1. TCP Transitory Connection Idle-Timeout

[RFC5382]:REQ-5 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. But the document does not clearly states if these can be configured separately. This document clarifies that a NAT device SHOULD provide different knobs for configuring the open and closing idle timeouts. This document further acknowledges that most TCP flows are very short (less than 10 seconds) [FLOWRATE][TCPWILD] and therefore a partially open timeout

of 4 minutes might be excessive if security is a concern. Therefore it MAY be configured to be less than 4 minutes in such cases. There also may be a case that timeout of 4 minutes might be excessive. The case and the solution are written below.

3.1.1. Port resources limited case

After IPv4 addresses run out, IPv4 address resources will be further restricted site-by-site. If global IPv4 address are shared between several clients, assignable port resources at each client will be limited.

NAT is a tool that is widely used to deal with this IPv4 address shortage problem. However, the demand for resources to provide Internet access to users and devices will continue to increase. IPv6 is a fundamental solution to this problem, but the deployment of IPv6 will take time.

In some cases, e.g. browsing a dynamic web page for a map service, a lot of sessions are used by the browser, and a number of ports are eaten up in a short time. What is worse is that when a NAT is between a PC and a server, TIME_WAIT state of each TCP connection is kept for certain period, typically for four minutes, which consumes port resources. Therefore, new connections cannot be established.

This problem is caused or worsened by the following behavior.

> TIME_WAIT state assigned for a TCP connection remains active for 2MSL after the last ACK to the last FIN is transferred.

To reuse resources effectively, reducing TIME_WAIT without making any bad effect is important. To reduce TIME_WAIT, [RFC6191] is proposed for clients and remote hosts. To prevent bad effects, there is a PAWS mechanism, which prevent the old duplicate problem. We propose mechanisms adopting to NAT, to change the TIME_WAIT behavior that make it possible to save addresses and ports resources.

3.1.1.1. RFC6191 Reducing the TIME-WAIT State Using TCP Timestamps

[RFC6191] defines a mechanism for reducing the TIME_WAIT state using TCP timestamps and sequence numbers. When a connection request is received with a four-tuple that is in the TIME-WAIT state, the connection request may be accepted if the sequence number or the timestamp of the incoming SYN segment is greater than the last sequence number seen on the previous incarnation of the connection

3.1.1.2. TCP TIME_WAIT

The TCP TIME_WAIT state is described in [RFC0793]. The TCP TIME_WAIT state needs to be kept for 2MSL before a connection is CLOSED, for the reasons below.

1: In the event that packets from a session are delayed in the in-between network, and delivered to the end relatively later, we should prevent the packets from being transferred and interpreted as a packet that belongs to a new session.

2: If the remote TCP has not received the acknowledgment of its connection termination request, it will re-send the FIN packet several times.

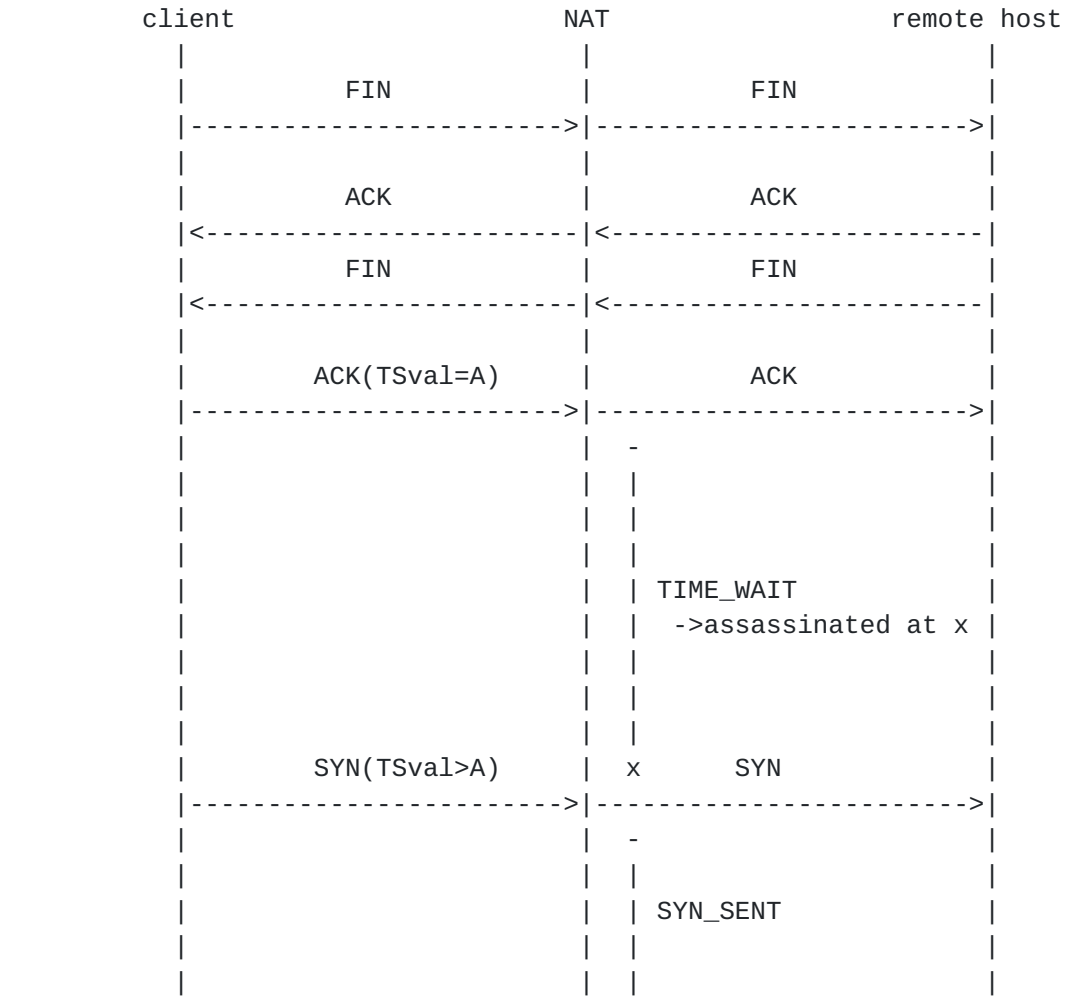
These points are important for the TCP to work without problems.

3.1.1.3. Protect Against Wrapped Sequence numbers (PAWS)

The TCP sequence number wraps frequently especially in a high bandwidth session. PAWS is used to prevent old duplicate packets that occurred in a previous session from being transferred to the new session whose valid TCP sequence numbers happen to overlap with the old duplicate packets. This is implemented by introducing TCP timestamp option, and checking the timestamp option value of each packet. PAWS is described in [RFC1323].

3.1.2. Proposal: Apply RFC6191 and PAWS to NAT

This section proposes to apply [RFC6191] mechanism at NAT. This mechanism MAY be adopted for both clients' and remote hosts' TCP active close.



(postamble)

Also, PAWS works to discard old duplicate packets at NAT. A packet can be discarded as an old duplicate if it is received with a timestamp or sequence number value less than a value recently received on the connection.

To make these mechanisms work, we should concern the case that there are several clients with nonsuccessive timestamp or sequence number values are connected to a NAT device (i.e. not monotonically increasing among clients). Two mechanisms to solve this mechanism and applying [RFC6191] and PAWS to NAT are described below. These mechanisms are optional.

3.1.2.1. Rewrite timestamp and sequence number values at NAT

Rewrite timestamp and sequence number values of outgoings packets at NAT to be monotonically increasing. This can be done by adopting following mechanisms at NAT.

A: Store the newest rewritten value of timestamp and sequence number as the "max value at the time".

B: NAT rewrite timestamp and sequence number values of incoming packets to be monotonically increasing.

When packets come back as replies from remote hosts, NAT rewrite again the timestamp and sequence number values to be the original values. This can be done by adopting following mechanisms at NAT.

C: Store the values of original timestamp and sequence number of packets, and rewritten values of those.

3.1.2.2. Split an assignable number of port space to each client

Adopt following mechanisms at NAT.

A: Choose clients that can be assigned ports.

B: Split assignable port numbers between clients.

Packets from other clients which are not chosen by these mechanisms are rejected at NAT, unless there is unassigned port left.

3.1.2.3. Resend the last ACK to the resended FIN

We should concern another case to make RFC6191 work at NAT. In case the remote TCP could not receive the acknowledgment of its connection termination request, NAT, on behalf of clients. resends the last ACK packet when it receives an FIN packet of the previous connection, and when the state of the previous connection is deleted from the NAT. This mechanism MAY be used when clients starts closing process, and the remote host could not receive the last ACK.

3.1.2.4. Remote host behavior of several implementations

To solve the port shortage problem on the client side, the behavior of remote host should be compliant to [RFC6191] or the mechanism written in 4.2.2.13 of [RFC1122], since NAT may reuse the same 5 tuple for a new connection.We have investigated behaviors of OSes (e.g., Linux, FreeBSD, Windows, MacOS), and found that they implemented the server side behavior of the above two.

3.2. TCP RST

[RFC5382] leaves the handling of TCP RST packets unspecified. This document does not try standardize such behavior but clarifies based on operational experience that a NAT that receives a TCP RST for an active mapping and performs session tracking MAY immediately delete the sessions and remove any state associated with it. If the NAT device that performs TCP session tracking receives a TCP RST for the first session that created a mapping, it MAY remove the session and the mapping immediately.

4. Port Overlapping behavior

There may be another solution to the address resource restricted environment written in 3.1.1. Also NAT are required to be maped endpoint-independent in [RFC4787] and [RFC5382] REQ-1, the mechanism below MAY be one optional implement to NAT.

If destination addresses and ports are different for outgoing connections started by local clients, 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 the 5-tuple (protocol, source address, source port, destination address, destination port) of them. This enables concurrent use of a single NAT external port for multiple transport sessions, which enables NAT to work correctly in IP address resource limited network.

Discussions:

[RFC4787]and[FC5382] requires "endpoint-independent mapping" at NAT, and port overlapping NAT cannot meet the requirement. This mechanism can degrade the transparency of NAT in that its mapping mechanism is endpoint-dependent and makes NAT traversal harder. However, if a NAT adopts endpoint-independent mapping together with endpoint-dependent filtering, then the actual behavior of the NAT will be the same as port overlapping NAT. It should also be noted that a lot of existing NAT devices(e.g., SEIL, FITELnet Series) adopted this port overlapping mechanism.

A: Reference URL for SEIL -> www.seil.jp

B: Reference URL for FITELnet -> www.furukawa.co.jp/fitelnet

The netfilter, which is a popular packet filtering mechanism for

Linux, also adopts port overlapping behavior.

5. Address Pooling Paired (APP)

[RFC4787]: REQ-2 [RFC5382]:ND Address Pooling Paired behavior for NAT is recommended in previous documents but behavior when a public IPv4 run out of ports is left undefined. This document clarifies that if APP is enabled new sessions from a subscriber that already has a mapping associated with a public IP that ran out of ports SHOULD be dropped. The administrator MAY provide a knob that allows a NAT device to starting using ports from another public IP when the one that anchored the APP mapping ran out of ports. This is trade-off between subscriber service continuity and APP strict enforcement. (NE: It is sometimes referred as 'soft-APP')

6. EIF Security

[RFC4787]:REQ-8 and [RFC5382]:REQ-3 End-point independent filtering could potentially result in security attacks from the public realm. In order to handle this, when possible there MUST be strict filtering checks in the inbound direction. A knob SHOULD be provided to limit the number of inbound sessions and a knob SHOULD be provided to enable or disable EIF on a per application basis. This is specially important in the case of Mobile networks where such attacks can consume radio resources and count against the user quota.

7. EIF Protocol Independence

[RFC4787]:REQ-8 and[RFC5382]: REQ-3 Current RFCs do not specify whether EIF mappings are protocol independent. In other words, if a outbound TCP SYN creates a mapping it is left undefined whether inbound UDP packets create sessions and are forwarded. EIF mappings SHOULD be protocol independent in order allow inbound packets for protocols that multiplex TCP and UDP over the same IP: port through the NAT and maintain compatibility with stateful NAT64 RFC6146 [RFC6146]. But the administrator MAY provide a configuration knob to make it protocol dependent.

8. EIF Mapping Refresh

[RFC4787]: REQ-6 [RFC5382]: ND The NAT mapping Refresh direction MAY have a "NAT Inbound refresh behavior" of "True" but it does not clarifies how this 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. This document clarifies that even when a NAT device has a inbound refresh behavior of TRUE, that such packets SHOULD NOT refresh the mapping. Otherwise a simple attack of a packet every 2 minutes can keep the mapping indefinitely.

8.1. Outbound Mapping Refresh and Error Packets

In the case of NAT outbound refresh behavior there might be certain types of packets that should not refresh the mapping. For example, if the mapping is kept alive by ICMP Error or TCP RST outbound packets sent as response to inbound packets, these SHOULD NOT refresh the mapping.

9. EIM Protocol Independence

[RFC4787] [RFC5382]: REQ-1 Current RFCs do not specify whether EIM are protocol independent. In other words, if a outbound TCP SYN creates a mapping it is left undefined whether outbound UDP can reuse such mapping and create session. On the other hand, Stateful NAT64 [RFC6146] clearly specifies three binding information bases (TCP, UDP, ICMP). This document clarifies that EIM mappings SHOULD be protocol dependent . A knob MAY be provided in order allow protocols that multiplex TCP and UDP over the same source IP and port to use a single mapping.

10. Port Parity

A NAT devices MAY disable port parity preservation for dynamic mappings. Nevertheless, A NAT SHOULD support means to explicitly request to preserve port parity (e.g., [I-D.boucadair-pcp-rtp-rtcp]).

11. Port Randomization

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)."

12. IP Identification (IP ID)

A NAT SHOULD handle the Identification field of translated IPv4 packets as specified in Section 9 of [I-D.ietf-intarea-ipv4-id-update].

13. ICMP Query Mappings Timeout

Section 3.1 of [RFC5508] says that ICMP Query Mappings are to be maintained by NAT device. However, RFC doesn't discuss about the Query Mapping timeout values. Section 3.2 of that RFC only discusses about ICMP Query Session Timeouts. ICMP Query Mappings MAY be deleted once the last the session using the mapping is deleted.

14. Hairpinning Support for ICMP Packets

[RFC5508]:REQ-7 This requirement specifies that NAT devices enforcing Basic NAT MUST support traversal of hairpinned ICMP Query sessions. 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, NAT device can then translate to an internal IP. [RFC5508]:REQ-7 This requirement specifies that all NAT devices (i.e., Basic NAT as well as NAPT devices) MUST support the traversal of hairpinned ICMP Error messages. This too requires NAT devices 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 that RFC.

15. IANA Considerations

TBD

16. Security Considerations

In the case of EIF mappings due to high risk of resource crunch, a NAT device MAY provide a knob to limit the number of inbound sessions spawned from a EIF mapping.

[TCP-Security] contains a detailed discussion of the security

implications of TCP Timestamps and of different timestamp generation algorithms.

17. Acknowledgements

Thanks to Dan Wing, Suresh Kumar, Mayuresh Bakshi, Rajesh Mohan and Senthil Sivamular for review and discussions

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