Workgroup: Network Working Group
Internet-Draft: draft-ietf-tsvwg-natsupp-21
Published: 1 November 2020
Intended Status: Standards Track
Expires: 5 May 2021
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Stream Control Transmission Protocol (SCTP) Network Address Translation Support

Abstract

The Stream Control Transmission Protocol (SCTP) provides a reliable communications channel between two end-hosts in many ways similar to the Transmission Control Protocol (TCP). With the widespread deployment of Network Address Translators (NAT), specialized code has been added to NAT functions for TCP that allows multiple hosts to reside behind a NAT function and yet share a single IPv4 address, even when two hosts (behind a NAT function) choose the same port numbers for their connection. This additional code is sometimes classified as Network Address and Port Translation (NAPT).

This document describes the protocol extensions needed for the SCTP endpoints and the mechanisms for NAT functions necessary to provide similar features of NAPT in the single point and multipoint traversal scenario.

Finally, a YANG module for SCTP NAT is defined.

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

Stream Control Transmission Protocol (SCTP) [RFC4960] provides a reliable communications channel between two end-hosts in many ways similar to TCP [RFC0793]. With the widespread deployment of Network Address Translators (NAT), specialized code has been added to NAT functions for TCP that allows multiple hosts to reside behind a NAT function using private-use addresses (see [RFC6890]) and yet share a single IPv4 address, even when two hosts (behind a NAT function) choose the same port numbers for their connection. This additional code is sometimes classified as Network Address and Port Translation (NAPT). Please note that this document focuses on the case where the NAT function maps a single or multiple internal addresses to a single external address and vice versa.

To date, specialized code for SCTP has not yet been added to most NAT functions so that only a translation of IP addresses is supported. The end result of this is that only one SCTP-capable host can successfully operate behind such a NAT function and this host can only be single-homed. The only alternative for supporting legacy NAT functions is to use UDP encapsulation as specified in [RFC6951].

The NAT function in the document refers to NAPT functions described in Section 2.2 of [RFC3022], NAT64 [RFC6146], or DS-Lite AFTR [RFC6333].

This document specifies procedures allowing a NAT function to support SCTP by providing similar features to those provided by a NAPT for TCP (see [RFC5382] and [RFC7857]), UDP (see [RFC4787] and [RFC7857]), and ICMP (see [RFC5508] and [RFC7857]). This document also specifies a set of data formats for SCTP packets and a set of SCTP endpoint procedures to support NAT traversal. An SCTP implementation supporting these procedures can assure that in both single-homed and multi-homed cases a NAT function will maintain the appropriate state without the NAT function needing to change port numbers.

It is possible and desirable to make these changes for a number of reasons:

- It is desirable for SCTP internal end-hosts on multiple platforms to be able to share a NAT function's external IP address in the same way that a TCP session can use a NAT function.

- If a NAT function does not need to change any data within an SCTP packet, it will reduce the processing burden of NAT'ing SCTP by not needing to execute the CRC32c checksum used by SCTP.

- Not having to touch the IP payload makes the processing of ICMP messages by NAT functions easier.

An SCTP-aware NAT function will need to follow these procedures for generating appropriate SCTP packet formats.

When considering SCTP-aware NAT it is possible to have multiple levels of support. At each level, the Internal Host, Remote Host, and NAT function does or does not support the procedures described in this document. The following table illustrates the results of the various combinations of support and if communications can occur between two endpoints.

Internal Host	NAT Function	Remote Host	Communication
Support	Support	Support	Yes
Support	Support	No Support	Limited
Support	No Support	Support	None
Support	No Support	No Support	None
No Support	Support	Support	Limited
No Support	Support	No Support	Limited
No Support	No Support	Support	None
No Support	No Support	No Support	None

Table 1: Communication possibilities

From the table it can be seen that when a NAT function does not support SCTP-aware NAT no communication can occur. This assumes that the NAT function does not handle SCTP packets at all and all SCTP packets sent from behind a NAT function are discarded by the NAT function. In some cases, where the NAT function supports SCTP-aware NAT but one of the two hosts does not support the feature, communication possibly occurs but in a limited way. For example only one host can have a connection when a collision case occurs.

2. Conventions

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.

3. Terminology

This document uses the following terms, which are depicted in Figure 1. Familiarity with the terminology used in [RFC4960] and [RFC5061] is assumed.

Internal-Address (Int-Addr)
An internal address that is known to the internal host.

Internal-Port (Int-Port)
The port number that is in use by the host holding the Internal-Address.

Internal-VTag (Int-VTag)
The SCTP Verification Tag (VTag) (see Section 3.1 of [RFC4960]) that the internal host has chosen for an association. The VTag is a unique 32-bit tag that accompanies any incoming SCTP packet for this association to the Internal-Address.

Remote-Address (Rem-Addr)
The address that an internal host is attempting to contact.

Remote-Port (Rem-Port)
The port number used by the host holding the Remote-Address.

Remote-VTag (Rem-VTag)
The Verification Tag (VTag) (see Section 3.1 of [RFC4960]) that the host holding the Remote-Address has chosen for an association. The VTag is a unique 32-bit tag that accompanies any outgoing SCTP packet for this association to the Remote-Address.

External-Address (Ext-Addr)
An external address assigned to the NAT function, that it uses as a source address when sending packets towards a Remote-Address.

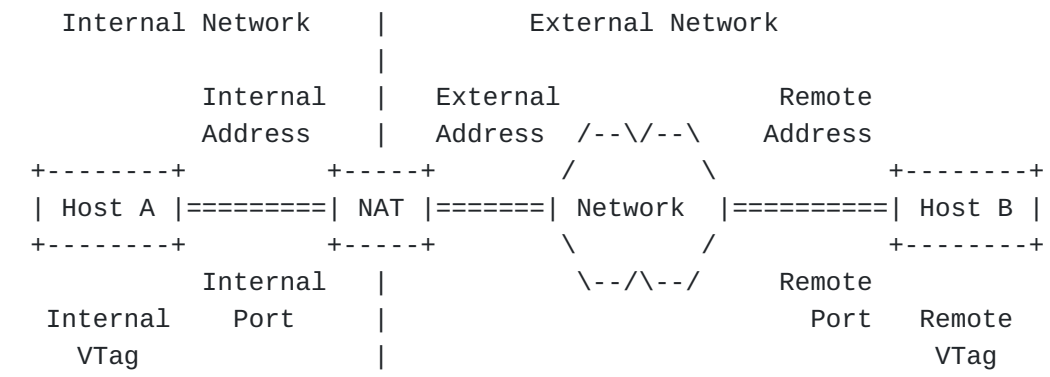


Figure 1: Basic Network Setup

4. Motivation and Overview

4.1. SCTP NAT Traversal Scenarios

This section defines the notion of single and multipoint NAT traversal.

4.1.1. Single Point Traversal

In this case, all packets in the SCTP association go through a single NAT function, as shown in Figure 2.

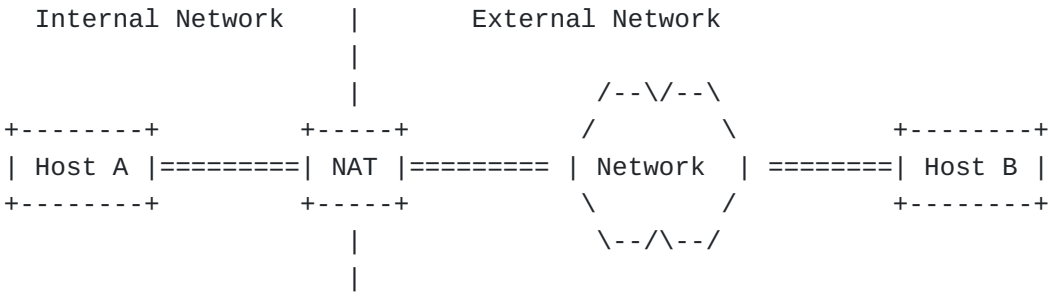


Figure 2: Single NAT Function Scenario

A variation of this case is shown in Figure 3, i.e., multiple NAT functions in the forwarding path between two endpoints.

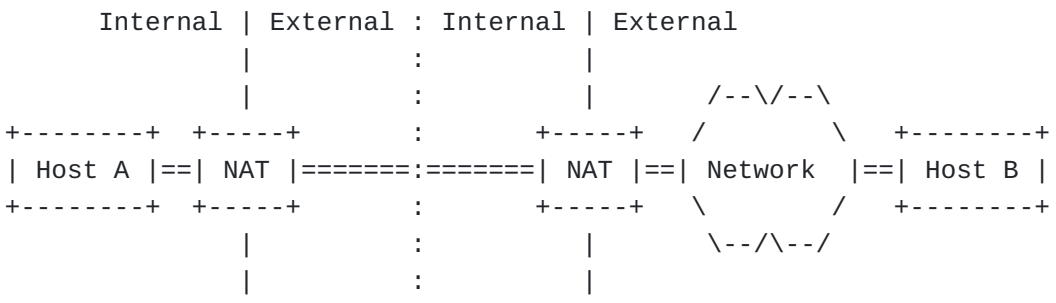


Figure 3: Serial NAT Functions Scenario

Although one of the main benefits of SCTP multi-homing is redundant paths, in the single point traversal scenario the NAT function represents a single point of failure in the path of the SCTP multi-homed association. However, the rest of the path can still benefit from path diversity provided by SCTP multi-homing.

The two SCTP endpoints in this case can be either single-homed or multi-homed. However, the important thing is that the NAT function in this case sees all the packets of the SCTP association.

4.1.2. Multipoint Traversal

This case involves multiple NAT functions and each NAT function only sees some of the packets in the SCTP association. An example is shown in Figure 4.

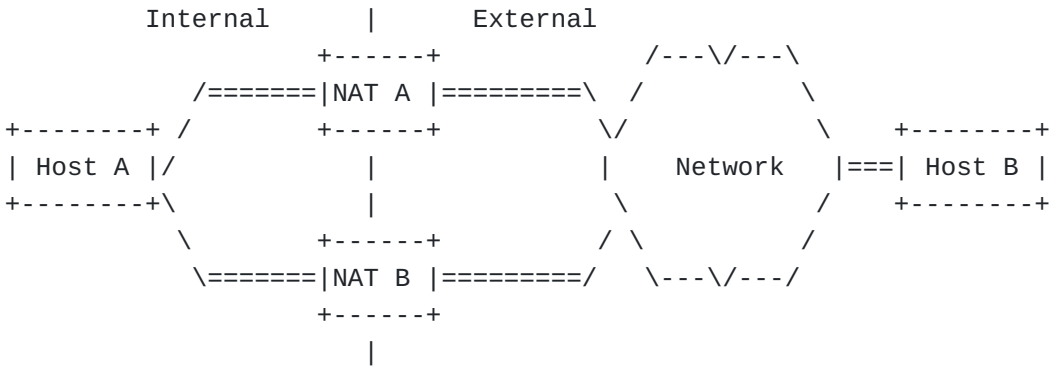


Figure 4: Parallel NAT Functions Scenario

This case does not apply to a single-homed SCTP association (i.e., both endpoints in the association use only one IP address). The advantage here is that the existence of multiple NAT traversal points can preserve the path diversity of a multi-homed association for the entire path. This in turn can improve the robustness of the communication.

4.2. Limitations of Classical NAPT for SCTP

Using classical NAPT possibly results in changing one of the SCTP port numbers during the processing which requires the recomputation of the transport layer checksum by the NAPT function. Whereas for UDP and TCP this can be done very efficiently, for SCTP the checksum (CRC32c) over the entire packet needs to be recomputed (see Appendix B of [RFC4960] for details of the CRC32c computation). This would considerably add to the NAT computational burden, however hardware support can mitigate this in some implementations.

An SCTP endpoint can have multiple addresses but only has a single port number to use. To make multipoint traversal work, all the NAT functions involved need to recognize the packets they see as belonging to the same SCTP association and perform port number translation in a consistent way. One possible way of doing this is to use a pre-defined table of port numbers and addresses configured within each NAT function. Other mechanisms could make use of NAT to NAT communication. Such mechanisms have not been deployed on a wide scale base and thus are not a preferred solution. Therefore an SCTP variant of NAT function has been developed (see Section 4.3).

4.3. The SCTP-Specific Variant of NAT

In this section it is allowed that there are multiple SCTP capable hosts behind a NAT function that share one External-Address. Furthermore, this section focuses on the single point traversal scenario (see Section 4.1.1).

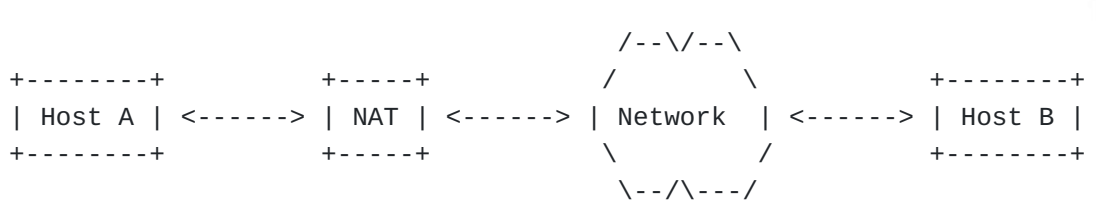
The modification of outgoing SCTP packets sent from an internal host is simple: the source address of the packets has to be replaced with the External-Address. It might also be necessary to establish some state in the NAT function to later handle incoming packets.

Typically, the NAT function has to maintain a NAT binding table of Internal-VTag, Internal-Port, Remote-VTag, Remote-Port, Internal-Address, and whether the restart procedure is disabled or not. An entry in that NAT binding table is called a NAT-State control block. The function Create() obtains the just mentioned parameters and returns a NAT-State control block. A NAT function MAY allow creating NAT-State control blocks via a management interface.

For SCTP packets coming from the external realm of the NAT function the destination address of the packets has to be replaced with the Internal-Address of the host to which the packet has to be delivered, if a NAT state entry is found. The lookup of the Internal-Address is based on the Remote-VTag, Remote-Port, Internal-VTag and the Internal-Port.

The entries in the NAT binding table need to fulfill some uniqueness conditions. There can not be more than one entry NAT binding table with the same pair of Internal-Port and Remote-Port. This rule can be relaxed, if all NAT binding table entries with the same Internal-Port and Remote-Port have the support for the restart procedure disabled (see Section 5.3.1). In this case there can not be no more than one entry with the same Internal-Port, Remote-Port and Remote-VTag and no more than one NAT binding table entry with the same Internal-Port, Remote-Port, and Int-VTag.

The processing of outgoing SCTP packets containing an INIT chunk is described in the following figure. The scenario shown is valid for all message flows in this section.




```
            INIT[Initiate-Tag]
 Int-Addr:Int-Port ------> Rem-Addr:Rem-Port
                  Rem-VTag=0

            Create(Initiate-Tag, Int-Port, 0, Rem-Port, Int-Addr,
                   IsRestartDisabled)
            Returns(NAT-State control block)

          Translate To:

                       INIT[Initiate-Tag]
          Ext-Addr:Int-Port ------> Rem-Addr:Rem-Port
                           Rem-VTag=0
```

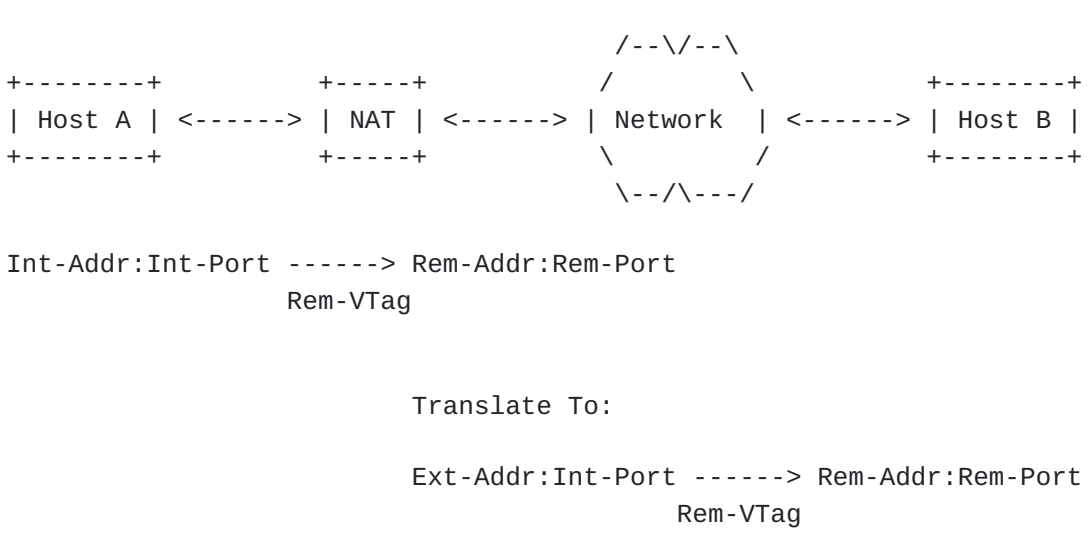
Normally a NAT binding table entry will be created.

However, it is possible that there is already a NAT binding table entry with the same Remote-Port, Internal-Port, and Internal-VTag but different Internal-Address and the restart procedure is disabled. In this case the packet containing the INIT chunk MUST be dropped by the NAT and a packet containing an ABORT chunk SHOULD be sent to the SCTP host that originated the packet with the M bit set and 'VTag and Port Number Collision' error cause (see Section 5.1.1 for the format). The source address of the packet containing the ABORT chunk MUST be the destination address of the packet containing the INIT chunk.

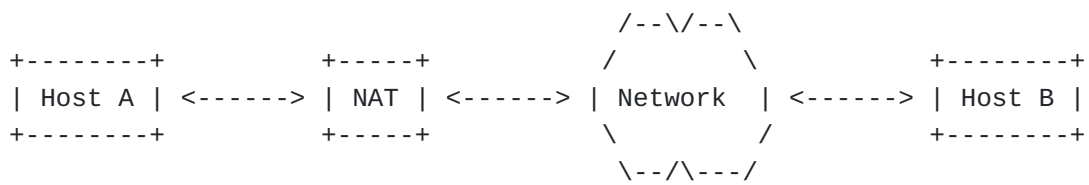
If an outgoing SCTP packet contains an INIT or ASCONF chunk and a matching NAT binding table entry is found, the packet is processed as a normal outgoing packet.

It is also possible that a NAT binding table entry with the same Remote-Port and Internal-Port exists without an Internal-VTag conflict but there exists a NAT binding table entry with the same port numbers but a different Internal-Address and the restart procedure is not disabled. In such a case the packet containing the INIT chunk MUST be dropped by the NAT function and a packet containing an ABORT chunk SHOULD be sent to the SCTP host that originated the packet with the M bit set and 'Port Number Collision' error cause (see Section 5.1.1 for the format).

The processing of outgoing SCTP packets containing no INIT chunks is described in the following figure.



The processing of incoming SCTP packets containing an INIT ACK chunk is described in the following figure. The Lookup() function getting as input the Internal-VTag, Internal-Port, Remote-VTag, and Remote-Port, returns the corresponding entry of the NAT binding table and updates the Remote-VTag by substituting it with the value of the Initiate-Tag of the INIT ACK chunk. The wildcard character signifies that the parameter's value is not considered in the Lookup() function or changed in the Update() function, respectively.

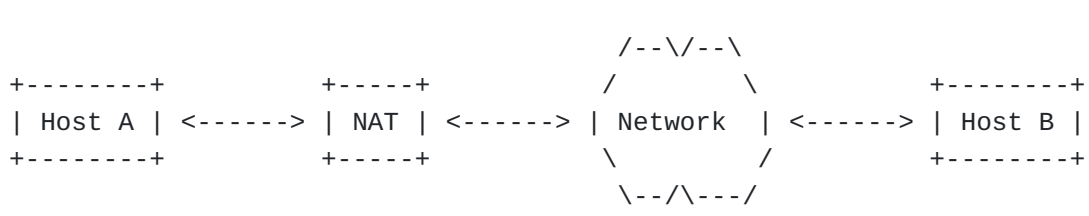


```
                                    /--\/--\
+--------+          +-----+        /        \          +--------+
| Host A | <------> | NAT | <----> | Network  | <------> | Host B |
+--------+          +-----+        \        /          +--------+
                                    \--/\---/
```

```
                                      INIT ACK[Initiate-Tag]
                           Ext-Addr:Int-Port <---- Rem-Addr:Rem-Port
                                                   Int-VTag

        Lookup(Int-VTag, Int-Port, *, Rem-Port)
        Update(*, *, Initiate-Tag, *)

        Returns(NAT-State control block containing Int-Addr)

              INIT ACK[Initiate-Tag]
 Int-Addr:Int-Port <------ Rem-Addr:Rem-Port
                 Int-VTag
```

In the case where the Lookup function fails because it does not find an entry, the SCTP packet is dropped. If it succeeds, the Update routine inserts the Remote-VTag (the Initiate-Tag of the INIT ACK chunk) in the NAT-State control block.

The processing of incoming SCTP packets containing an ABORT or SHUTDOWN COMPLETE chunk with the T bit set is illustrated in the following figure.



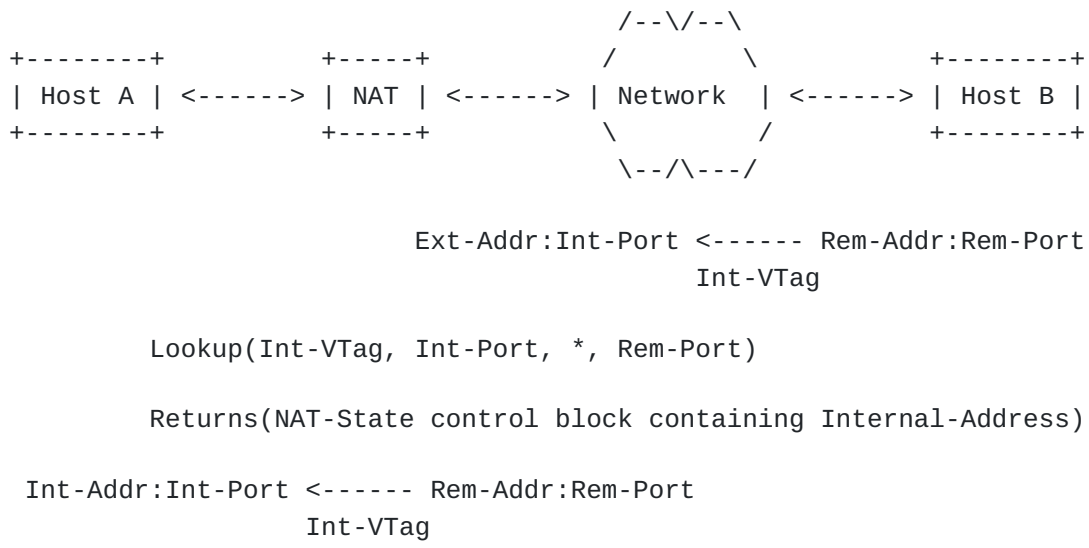
```
                                    /--\/--\
+--------+          +-----+        /        \          +--------+
| Host A | <------> | NAT | <----> | Network  | <------> | Host B |
+--------+          +-----+        \        /          +--------+
                                    \--/\---/
```

```
                           Ext-Addr:Int-Port <------ Rem-Addr:Rem-Port
                                                     Rem-VTag

        Lookup(*, Int-Port, Rem-VTag, Rem-Port)

        Returns(NAT-State control block containing Int-Addr)

 Int-Addr:Int-Port <------ Rem-Addr:Rem-Port
                 Rem-VTag
```

For an incoming packet containing an INIT chunk a table lookup is made only based on the addresses and port numbers. If an entry with

a Remote-VTag of zero is found, it is considered a match and the Remote-VTag is updated. If an entry with a non-matching Remote-VTag is found or no entry is found, the incoming packet is silently dropped. If an entry with a matching Remote-VTag is found, the incoming packet is forwarded. This allows the handling of INIT collision through NAT functions.

The processing of other incoming SCTP packets is described in the following figure.



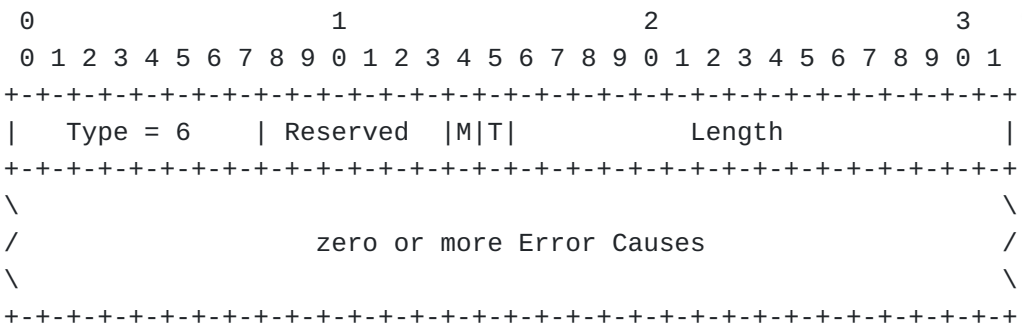
5. Data Formats

This section defines the formats used to support NAT traversal. Section 5.1 and Section 5.2 describe chunks and error causes sent by NAT functions and received by SCTP endpoints. Section 5.3 describes parameters sent by SCTP endpoints and used by NAT functions and SCTP endpoints.

5.1. Modified Chunks

This section presents existing chunks defined in [RFC4960] for which additional flags are specified by this document.

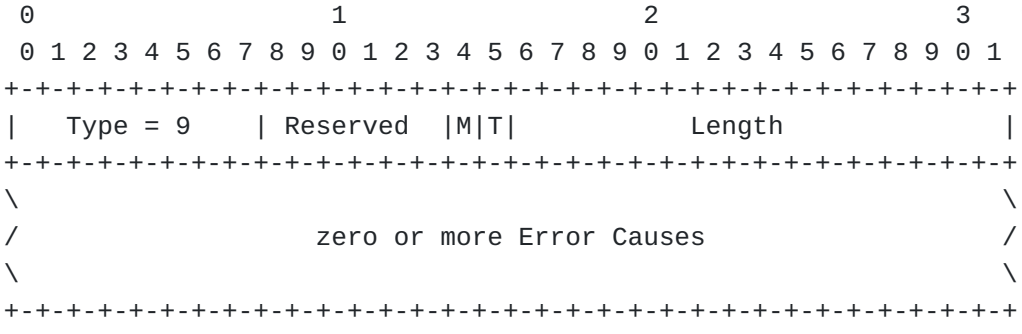
5.1.1. Extended ABORT Chunk



The ABORT chunk is extended to add the new 'M bit'. The M bit indicates to the receiver of the ABORT chunk that the chunk was not generated by the peer SCTP endpoint, but instead by a middle box (e.g., NAT).

[NOTE to RFC-Editor: Assignment of M bit to be confirmed by IANA.]

5.1.2. Extended ERROR Chunk



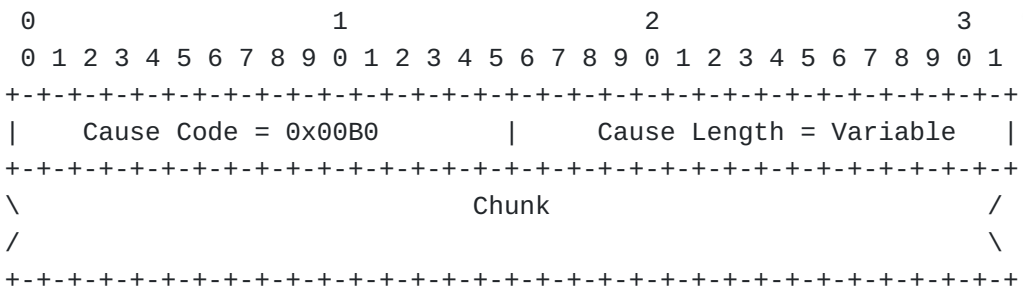
The ERROR chunk defined in [RFC4960] is extended to add the new 'M bit'. The M bit indicates to the receiver of the ERROR chunk that the chunk was not generated by the peer SCTP endpoint, but instead by a middle box.

[NOTE to RFC-Editor: Assignment of M bit to be confirmed by IANA.]

5.2. New Error Causes

This section defines the new error causes added by this document.

5.2.1. VTag and Port Number Collision Error Cause



Cause Code: 2 bytes (unsigned integer)

This field holds the IANA defined cause code for the 'VTag and Port Number Collision' Error Cause. IANA is requested to assign the value 0x00B0 for this cause code.

Cause Length: 2 bytes (unsigned integer)

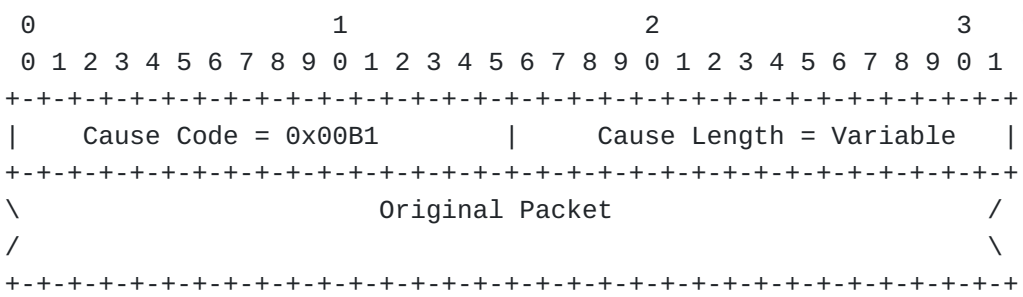
This field holds the length in bytes of the error cause. The value MUST be the length of the Cause-Specific Information plus 4.

Chunk: variable length

The Cause-Specific Information is filled with the chunk that caused this error. This can be an INIT, INIT ACK, or ASCONF chunk. Note that if the entire chunk will not fit in the ERROR chunk or ABORT chunk being sent then the bytes that do not fit are truncated.

[NOTE to RFC-Editor: Assignment of cause code to be confirmed by IANA.]

5.2.2. Missing State Error Cause



Cause Code: 2 bytes (unsigned integer)

This field holds the IANA defined cause code for the 'Missing State' Error Cause. IANA is requested to assign the value 0x00B1 for this cause code.

Cause Length: 2 bytes (unsigned integer)

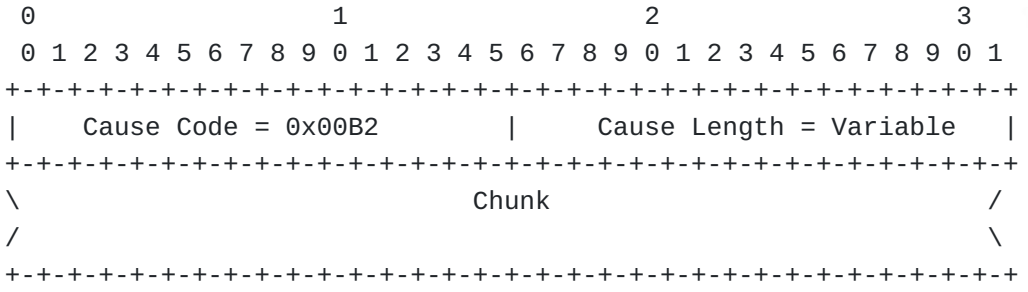
This field holds the length in bytes of the error cause. The value MUST be the length of the Cause-Specific Information plus 4.

Original Packet: variable length

The Cause-Specific Information is filled with the IPv4 or IPv6 packet that caused this error. The IPv4 or IPv6 header MUST be included. Note that if the packet will not fit in the ERROR chunk or ABORT chunk being sent then the bytes that do not fit are truncated.

[NOTE to RFC-Editor: Assignment of cause code to be confirmed by IANA.]

5.2.3. Port Number Collision Error Cause



Cause Code: 2 bytes (unsigned integer)

This field holds the IANA defined cause code for the 'Port Number Collision' Error Cause. IANA is requested to assign the value 0x00B2 for this cause code.

Cause Length: 2 bytes (unsigned integer)

This field holds the length in bytes of the error cause. The value MUST be the length of the Cause-Specific Information plus 4.

Chunk: variable length

The Cause-Specific Information is filled with the chunk that caused this error. This can be an INIT, INIT ACK, or ASCONF chunk. Note that if the entire chunk will not fit in the ERROR chunk or ABORT chunk being sent then the bytes that do not fit are truncated.

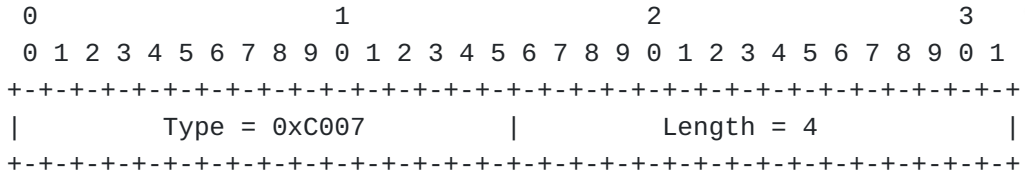
[NOTE to RFC-Editor: Assignment of cause code to be confirmed by IANA.]

5.3. New Parameters

This section defines new parameters and their valid appearance defined by this document.

5.3.1. Disable Restart Parameter

This parameter is used to indicate that the restart procedure is requested to be disabled. Both endpoints of an association MUST include this parameter in the INIT chunk and INIT ACK chunk when establishing an association and MUST include it in the ASCONF chunk when adding an address to successfully disable the restart procedure.



Parameter Type: 2 bytes (unsigned integer)
This field holds the IANA defined parameter type for the Disable Restart Parameter. IANA is requested to assign the value 0xC007 for this parameter type.

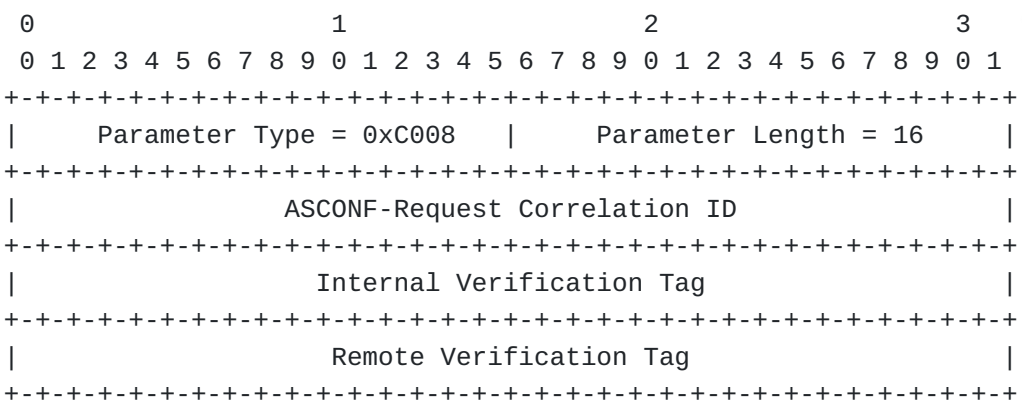
Parameter Length: 2 bytes (unsigned integer)
This field holds the length in bytes of the parameter. The value MUST be 4.

[NOTE to RFC-Editor: Assignment of parameter type to be confirmed by IANA.]

This parameter MAY appear in INIT, INIT ACK and ASCONF chunks and MUST NOT appear in any other chunk.

5.3.2. VTags Parameter

This parameter is used to help a NAT function to recover from state loss.



Parameter Type: 2 bytes (unsigned integer)
This field holds the IANA defined parameter type for the VTags Parameter. IANA is requested to assign the value 0xC008 for this parameter type.

Parameter Length: 2 bytes (unsigned integer)
This field holds the length in bytes of the parameter. The value MUST be 16.

ASCONF-Request Correlation ID: 4 bytes (unsigned integer)
This is an opaque integer assigned by the sender to identify each request parameter. The receiver of the ASCONF Chunk will copy this 32-bit value into the ASCONF Response Correlation ID field of the ASCONF ACK response parameter. The sender of the packet containing the ASCONF chunk can use this same value in the ASCONF ACK chunk to find which request the response is for. Note that the receiver MUST NOT change this 32-bit value.

Internal Verification Tag: 4 bytes (unsigned integer)
The Verification Tag that the internal host has chosen for the association. The Verification Tag is a unique 32-bit tag that accompanies any incoming SCTP packet for this association to the Internal-Address.

Remote Verification Tag: 4 bytes (unsigned integer)
The Verification Tag that the host holding the Remote-Address has chosen for the association. The VTag is a unique 32-bit tag that accompanies any outgoing SCTP packet for this association to the Remote-Address.

[NOTE to RFC-Editor: Assignment of parameter type to be confirmed by IANA.]

This parameter MAY appear in ASCONF chunks and MUST NOT appear in any other chunk.

6. Procedures for SCTP Endpoints and NAT Functions

If an SCTP endpoint is behind an SCTP-aware NAT, a number of problems can arise as it tries to communicate with its peers:

- IP addresses can not be included in the SCTP packet. This is discussed in Section 6.1.

- More than one host behind a NAT function could select the same VTag and source port number when communicating with the same peer server. This creates a situation where the NAT function will not be able to tell the two associations apart. This situation is discussed in Section 6.2.

- If an SCTP endpoint is a server communicating with multiple peers and the peers are behind the same NAT function, then the these peers cannot be distinguished by the server. This case is discussed in Section 6.3.

- A restart of a NAT function during a conversation could cause a loss of its state. This problem and its solution is discussed in Section 6.4.

- NAT functions need to deal with SCTP packets being fragmented at the IP layer. This is discussed in Section 6.5.

- An SCTP endpoint can be behind two NAT functions in parallel providing redundancy. The method to set up this scenario is discussed in Section 6.6.

The mechanisms to solve these problems require additional chunks and parameters, defined in this document, and modified handling procedures from those specified in [RFC4960] as described below.

6.1. Association Setup Considerations for Endpoints

The association setup procedure defined in [RFC4960] allows multi-homed SCTP endpoints to exchange its IP-addresses by using IPv4 or IPv6 address parameters in the INIT and INIT ACK chunks. However, this does not work when NAT functions are present.

Every association setup from a host behind a NAT function MUST NOT use multiple internal addresses. The INIT chunk MUST NOT contain an IPv4 Address parameter, IPv6 Address parameter, or Supported Address Types parameter. The INIT ACK chunk MUST NOT contain any IPv4 Address parameter or IPv6 Address parameter using non-global addresses. The INIT chunk and the INIT ACK chunk MUST NOT contain any Host Name parameters.

If the association is intended to be finally multi-homed, the procedure in Section 6.6 MUST be used.

The INIT and INIT ACK chunk SHOULD contain the Disable Restart parameter defined in Section 5.3.1.

6.2. Handling of Internal Port Number and Verification Tag Collisions

Consider the case where two hosts in the Internal-Address space want to set up an SCTP association with the same service provided by some remote hosts. This means that the Remote-Port is the same. If they both choose the same Internal-Port and Internal-VTag, the NAT function cannot distinguish between incoming packets anymore. However, this is unlikely. The Internal-VTags are chosen at random and if the Internal-Ports are also chosen from the ephemeral port range at random (see [RFC6056]) this gives a 46-bit random number that has to match.

The same can happen with the Remote-VTag when a packet containing an INIT ACK chunk or an ASCONF chunk is processed by the NAT function.

6.2.1. NAT Function Considerations

If the NAT function detects a collision of internal port numbers and verification tags, it SHOULD send a packet containing an ABORT chunk with the M bit set if the collision is triggered by a packet containing an INIT or INIT ACK chunk. If such a collision is triggered by a packet containing an ASCONF chunk, it SHOULD send a packet containing an ERROR chunk with the M bit. The M bit is a new bit defined by this document to express to SCTP that the source of this packet is a "middle" box, not the peer SCTP endpoint (see Section 5.1.1). If a packet containing an INIT ACK chunk triggers the collision, the corresponding packet containing the ABORT chunk MUST contain the same source and destination address and port numbers as the packet containing the INIT ACK chunk. If a packet containing an INIT chunk or an ASCONF chunk, the source and destination address and port numbers MUST be swapped.

The sender of the packet containing an ERROR or ABORT chunk MUST include the error cause with cause code 'VTag and Port Number Collision' (see Section 5.2.1).

6.2.2. Endpoint Considerations

The sender of the packet containing the INIT chunk or the receiver of a packet containing the INIT ACK chunk, upon reception of a packet containing an ABORT chunk with M bit set and the appropriate error cause code for colliding NAT binding table state is included, SHOULD reinitiate the association setup procedure after choosing a

new initiate tag, if the association is in COOKIE-WAIT state. In any other state, the SCTP endpoint MUST NOT respond.

The sender of the packet containing the ASCONF chunk, upon reception of a packet containing an ERROR chunk with M bit set, MUST stop adding the path to the association.

6.3. Handling of Internal Port Number Collisions

When two SCTP hosts are behind an SCTP-aware NAT it is possible that two SCTP hosts in the Internal-Address space will want to set up an SCTP association with the same server running on the same remote host. If the two hosts choose the same internal port, this is considered an internal port number collision.

For the NAT function, appropriate tracking can be performed by assuring that the VTags are unique between the two hosts.

6.3.1. NAT Function Considerations

The NAT function, when processing the packet containing the INIT ACK chunk, SHOULD note in its NAT binding table if the association supports the disable restart extension. This note is used when establishing future associations (i.e. when processing a packet containing an INIT chunk from an internal host) to decide if the connection can be allowed. The NAT function does the following when processing a packet containing an INIT chunk:

* If the packet containing the INIT chunk is originating from an internal port to a remote port for which the NAT function has no matching NAT binding table entry, it MUST allow the packet containing the INIT chunk creating an NAT binding table entry.

* If the packet containing the INIT chunk matches an existing NAT binding table entry, it MUST validate that the disable restart feature is supported and, if it does, allow the packet containing the INIT chunk to be forwarded.

* If the disable restart feature is not supported, the NAT function SHOULD send a packet containing an ABORT chunk with the M bit set.

The 'Port Number Collision' error cause (see Section 5.2.3) MUST be included in the ABORT chunk sent in response to the packet containing an INIT chunk.

If the collision is triggered by a packet containing an ASCONF chunk, a packet containing an ERROR chunk with the 'Port Number Collision' error cause SHOULD be sent in response to the packet containing the ASCONF chunk.

6.3.2. Endpoint Considerations

For the remote SCTP server this means that the Remote-Port and the Remote-Address are the same. If they both have chosen the same Internal-Port the server cannot distinguish between both associations based on the address and port numbers. For the server it looks like the association is being restarted. To overcome this limitation the client sends a Disable Restart parameter in the INIT chunk.

When the server receives this parameter it does the following:

* It MUST include a Disable Restart parameter in the INIT ACK to inform the client that it will support the feature.

* It MUST disable the restart procedures defined in [RFC4960] for this association.

Servers that support this feature will need to be capable of maintaining multiple connections to what appears to be the same peer (behind the NAT function) differentiated only by the VTags.

6.4. Handling of Missing State

6.4.1. NAT Function Considerations

If the NAT function receives a packet from the internal network for which the lookup procedure does not find an entry in the NAT binding table, a packet containing an ERROR chunk SHOULD be sent back with the M bit set. The source address of the packet containing the ERROR chunk MUST be the destination address of the packet received from the internal network. The verification tag is reflected and the T bit is set. Such a packet containing an ERROR chunk SHOULD NOT be sent if the received packet contains an ASCONF chunk with the VTags parameter or an ABORT, SHUTDOWN COMPLETE or INIT ACK chunk. A packet containing an ERROR chunk MUST NOT be sent if the received packet contains an ERROR chunk with the M bit set. In any case, the packet SHOULD NOT be forwarded to the remote address.

If the NAT function receives a packet from the internal network for which it has no NAT binding table entry and the packet contains an ASCONF chunk with the VTags parameter, the NAT function MUST update its NAT binding table according to the verification tags in the VTags parameter and, if present, the Disable Restart parameter.

When sending a packet containing an ERROR chunk, the error cause 'Missing State' (see Section 5.2.2) MUST be included and the M bit of the ERROR chunk MUST be set (see Section 5.1.2).

6.4.2. Endpoint Considerations

Upon reception of this packet containing the ERROR chunk by an SCTP endpoint the receiver takes the following actions:

- It SHOULD validate that the verification tag is reflected by looking at the VTag that would have been included in an outgoing packet. If the validation fails, discard the received packet containing the ERROR chunk.

- It SHOULD validate that the peer of the SCTP association supports the dynamic address extension. If the validation fails, discard the received packet containing the ERROR chunk.

- It SHOULD generate a packet containing a new ASCONF chunk containing the VTags parameter (see Section 5.3.2) and the Disable Restart parameter (see Section 5.3.1) if the association is using the disable restart feature. By processing this packet the NAT function can recover the appropriate state. The procedures for generating an ASCONF chunk can be found in [RFC5061].

The peer SCTP endpoint receiving such a packet containing an ASCONF chunk SHOULD add the address and respond with an acknowledgment if the address is new to the association (following all procedures defined in [RFC5061]). If the address is already part of the association, the SCTP endpoint MUST NOT respond with an error, but instead SHOULD respond with a packet containing an ASCONF ACK chunk acknowledging the address and take no action (since the address is already in the association).

Note that it is possible that upon receiving a packet containing an ASCONF chunk containing the VTags parameter the NAT function will realize that it has an 'Internal Port Number and Verification Tag collision'. In such a case the NAT function SHOULD send a packet containing an ERROR chunk with the error cause code set to 'VTag and Port Number Collision' (see Section 5.2.1).

If an SCTP endpoint receives a packet containing an ERROR chunk with 'Internal Port Number and Verification Tag collision' as the error cause and the packet in the Error Chunk contains an ASCONF with the VTags parameter, careful examination of the association is necessary. The endpoint does the following:

- It MUST validate that the verification tag is reflected by looking at the VTag that would have been included in the outgoing packet. If the validation fails, it MUST discard the packet.

- It MUST validate that the peer of the SCTP association supports the dynamic address extension. If the peer does not support this

extension, it MUST discard the received packet containing the ERROR chunk.

* If the association is attempting to add an address (i.e. following the procedures in Section 6.6) then the endpoint MUST NOT consider the address part of the association and SHOULD make no further attempt to add the address (i.e. cancel any ASCONF timers and remove any record of the path), since the NAT function has a VTag collision and the association cannot easily create a new VTag (as it would if the error occurred when sending a packet containing an INIT chunk).

* If the endpoint has no other path, i.e. the procedure was executed due to missing a state in the NAT function, then the endpoint MUST abort the association. This would occur only if the local NAT function restarted and accepted a new association before attempting to repair the missing state (Note that this is no different than what happens to all TCP connections when a NAT function looses its state).

6.5. Handling of Fragmented SCTP Packets by NAT Functions

SCTP minimizes the use of IP-level fragmentation. However, it can happen that using IP-level fragmentation is needed to continue an SCTP association. For example, if the path MTU is reduced and there are still some DATA chunk in flight, which require packets larger than the new path MTU. If IP-level fragmentation can not be used, the SCTP association will be terminated in a non-graceful way.

Therefore, a NAT function MUST be able to handle IP-level fragmented SCTP packets. The fragments MAY arrive in any order.

When an SCTP packet can not be forwarded by the NAT function due to MTU issues and the IP header forbids fragmentation, the NAT MUST send back a "Fragmentation needed and DF set" ICMPv4 or PTB ICMPv6 message to the internal host. This allows for a faster recovery from this packet drop.

6.6. Multi Point Traversal Considerations for Endpoints

If a multi-homed SCTP endpoint behind a NAT function connects to a peer, it MUST first set up the association single-homed with only one address causing the first NAT function to populate its state. Then it SHOULD add each IP address using packets containing ASCONF chunks sent via their respective NAT functions. The address used in the Add IP address parameter is the wildcard address (0.0.0.0 or :: 0) and the address parameter in the ASCONF chunk SHOULD also contain the VTags parameter and optionally the Disable Restart parameter.

7. Various Examples of NAT Traversals

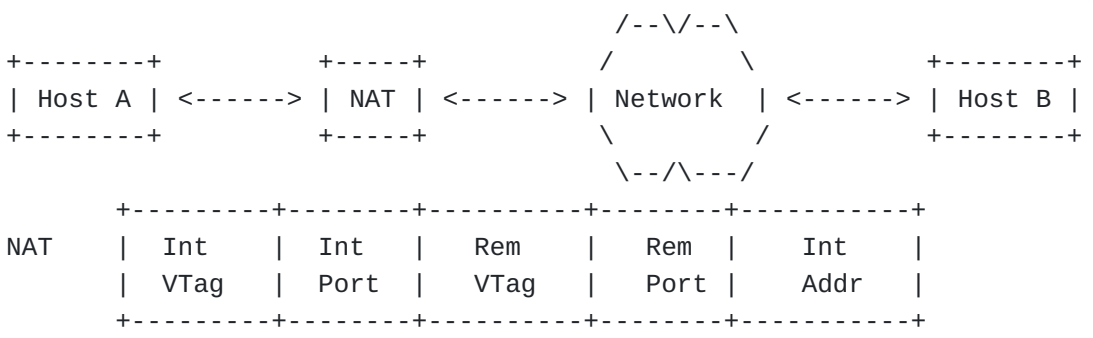
Please note that this section is informational only.

The addresses being used in the following examples are IPv4 addresses for private-use networks and for documentation as specified in [RFC6890]. However, the method described here is not limited to this NAT44 case.

The NAT binding table entries shown in the following examples do not include the flag indicating whether the restart procedure is supported or not. This flag is not relevant for these examples.

7.1. Single-homed Client to Single-homed Server

The internal client starts the association with the remote server via a four-way-handshake. Host A starts by sending a packet containing an INIT chunk.




```
   INIT[Initiate-Tag = 1234]
10.0.0.1:1 ------> 203.0.113.1:2
        Rem-VTtag = 0
```

A NAT binding tabled entry is created, the source address is substituted and the packet is sent on:

```
       NAT function creates entry:
       +---------+--------+----------+--------+-----------+
NAT    |  Int    |  Int   |   Rem    |   Rem  |    Int    |
       |  VTag   |  Port  |   VTag   |   Port |    Addr   |
       +---------+--------+----------+--------+-----------+
       |  1234   |    1   |     0    |    2   |  10.0.0.1 |
       +---------+--------+----------+--------+-----------+

                              INIT[Initiate-Tag = 1234]
                  192.0.2.1:1 ------------------------> 203.0.113.1:2
                                        Rem-VTtag = 0
```

Host B receives the packet containing an INIT chunk and sends a packet containing an INIT ACK chunk with the NAT's Remote-address as destination address.

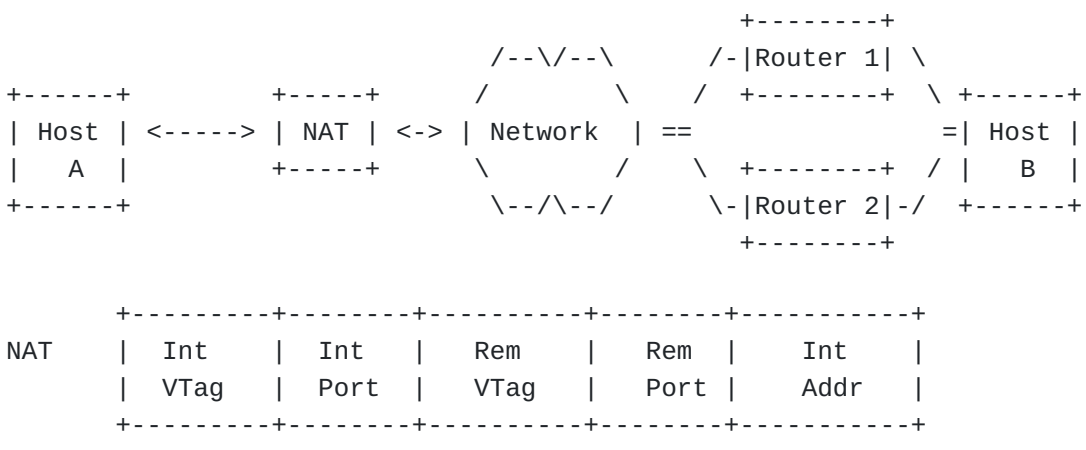
```
                                       /--\/--\
+--------+          +-----+           /        \           +--------+
| Host A | <------> | NAT | <------> | Network  | <------> | Host B |
+--------+          +-----+           \        /           +--------+
                                       \--/\---/

                                INIT ACK[Initiate-Tag = 5678]
                  192.0.2.1:1 <------------------------ 203.0.113.1:2
                                          Int-VTag = 1234
```

```
NAT function updates entry:
       +---------+--------+----------+--------+-----------+
NAT    |  Int    |  Int   |   Rem    |   Rem  |    Int    |
       |  VTag   |  Port  |   VTag   |   Port |    Addr   |
       +---------+--------+----------+--------+-----------+
       |  1234   |    1   |    5678  |    2   |  10.0.0.1 |
       +---------+--------+----------+--------+-----------+


INIT ACK[Initiate-Tag = 5678]
10.0.0.1:1 <------ 203.0.113.1:2
          Int-VTag = 1234
```

The handshake finishes with a COOKIE ECHO acknowledged by a COOKIE ACK.

7.2. Single-homed Client to Multi-homed Server

The internal client is single-homed whereas the remote server is multi-homed. The client (Host A) sends a packet containing an INIT chunk like in the single-homed case.



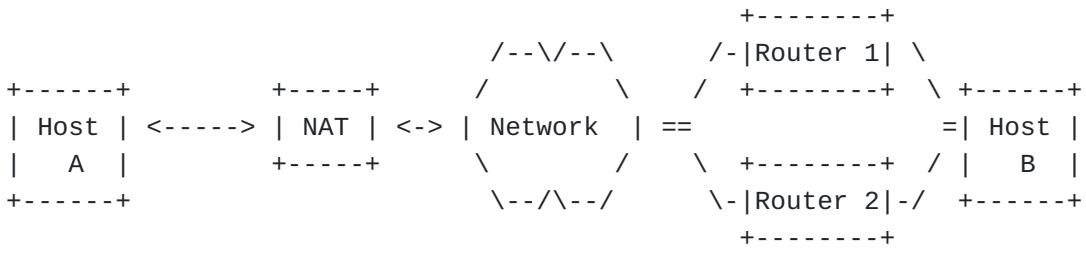
NAT	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr

NAT function creates entry:

```
      +---------+--------+----------+--------+-----------+
NAT   |  Int    |  Int   |   Rem    |   Rem  |    Int    |
      |  VTag   |  Port  |   VTag   |   Port |    Addr   |
      +---------+--------+----------+--------+-----------+
      |  1234   |    1   |     0    |    2   |  10.0.0.1 |
      +---------+--------+----------+--------+-----------+
```

```
                          INIT[Initiate-Tag = 1234]
              192.0.2.1:1 -------------------------> 203.0.113.1:2
                                Rem-VTag = 0
```

The server (Host B) includes its two addresses in the INIT ACK chunk.



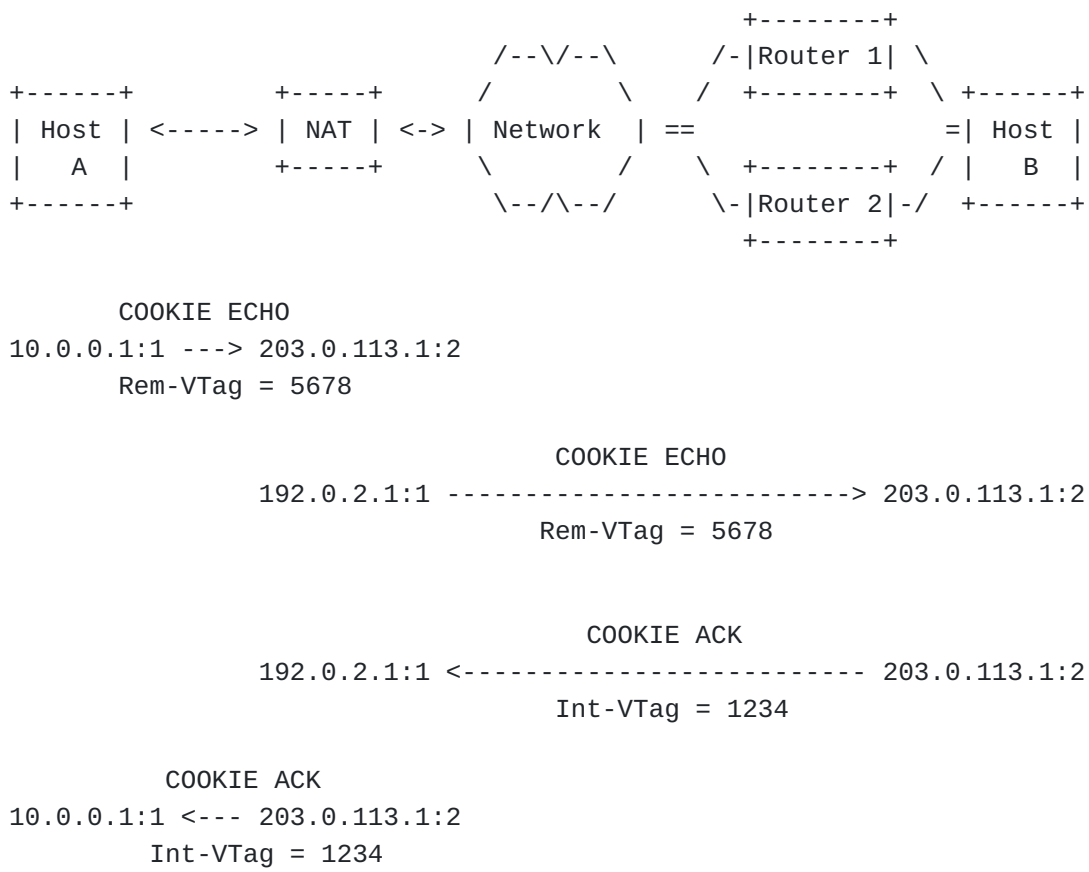

```
             INIT ACK[Initiate-tag = 5678, IP-Addr = 203.0.113.129]
              192.0.2.1:1 <------------------------- 203.0.113.1:2
                               Int-VTag = 1234
```

The NAT function does not need to change the NAT binding table for the second address:

```
          +---------+--------+----------+--------+-----------+
    NAT   |  Int    |  Int   |   Rem    |   Rem  |    Int    |
          |  VTag   |  Port  |   VTag   |   Port |    Addr   |
          +---------+--------+----------+--------+-----------+
          |  1234   |    1   |    5678  |    2   |  10.0.0.1 |
          +---------+--------+----------+--------+-----------+
```

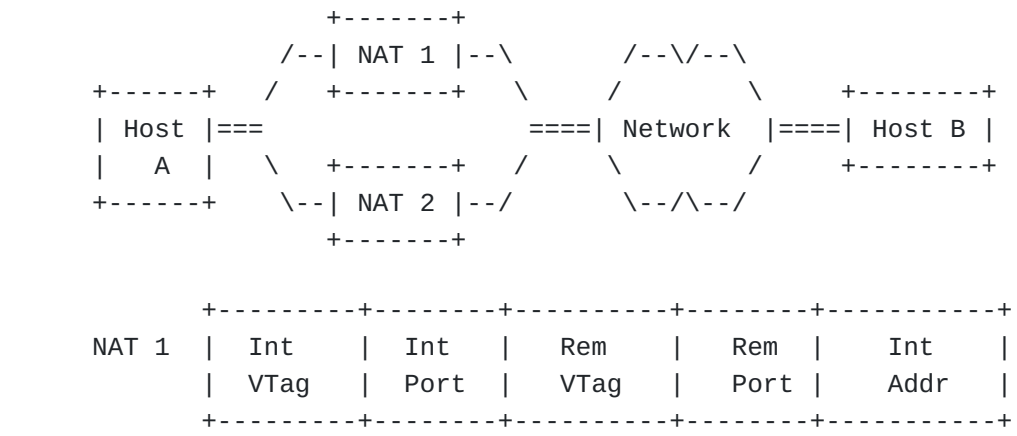
```
    INIT ACK[Initiate-Tag = 5678]
    10.0.0.1:1 <--- 203.0.113.1:2
             Int-VTag = 1234
```

The handshake finishes with a COOKIE ECHO acknowledged by a COOKIE ACK.

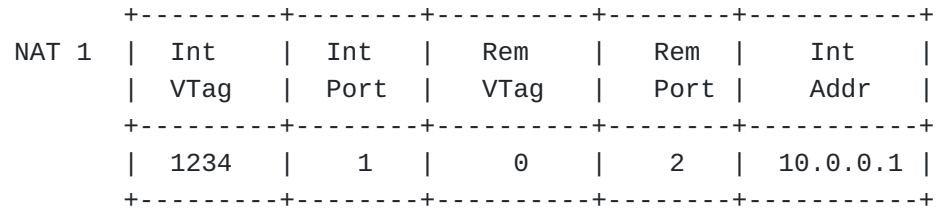


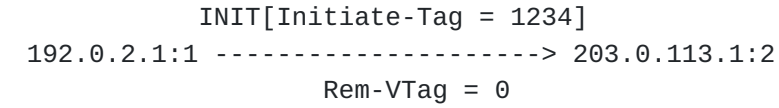
7.3. Multihomed Client and Server

The client (Host A) sends a packet containing an INIT chunk to the server (Host B), but does not include the second address.

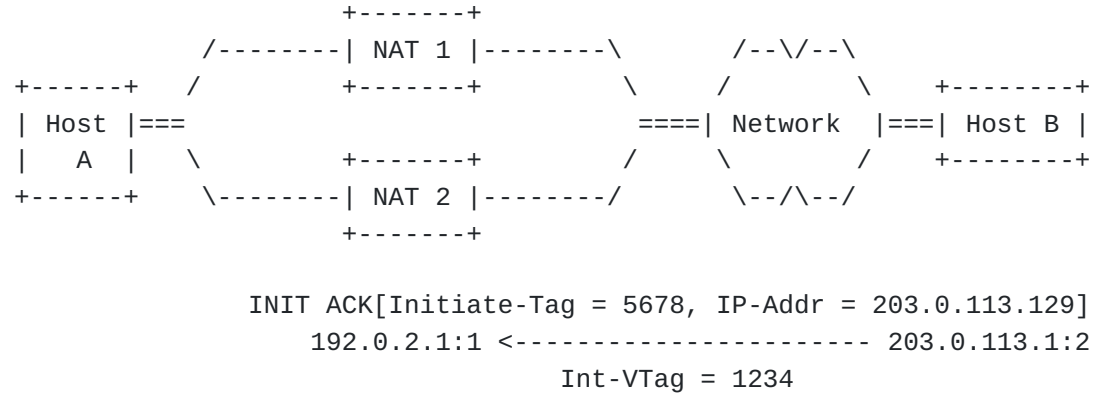


NAT function 1 creates entry:

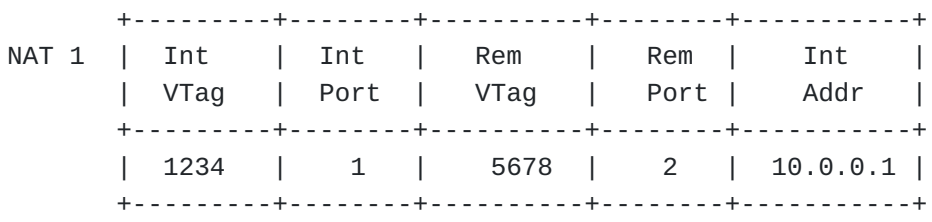




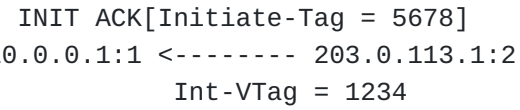
Host B includes its second address in the INIT ACK.



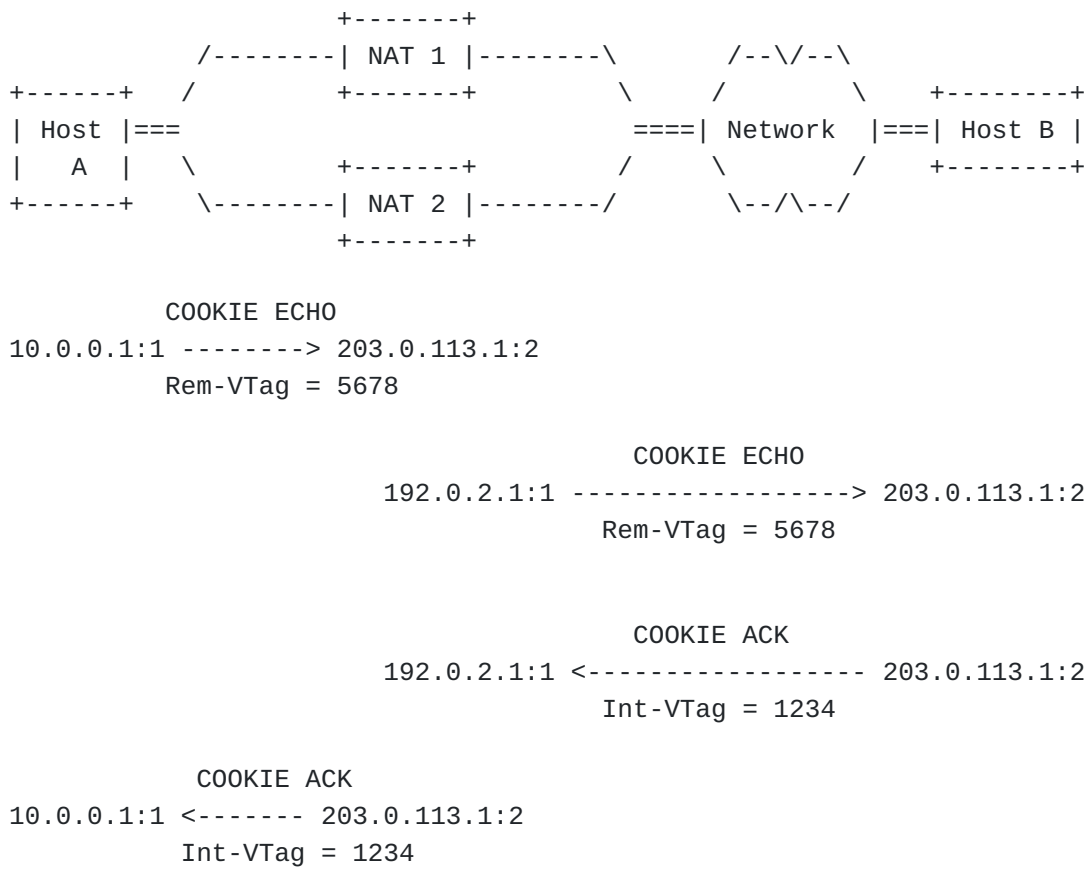
NAT function 1 does not need to update the NAT binding table for the second address:



NAT 1	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr
	1234	1	5678	2	10.0.0.1

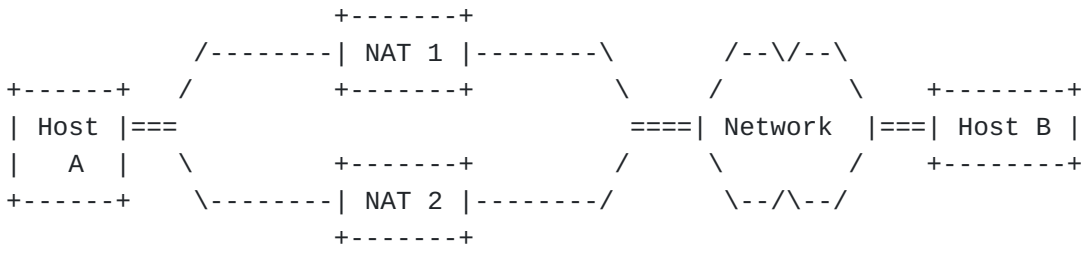


The handshake finishes with a COOKIE ECHO acknowledged by a COOKIE ACK.



Host A announces its second address in an ASCONF chunk. The address parameter contains a wildcard address (0.0.0.0 or ::0) to indicate that the source address has to be be added. The address parameter

within the ASCONF chunk will also contain the pair of VTags (remote and internal) so that the NAT function can populate its NAT binding table entry completely with this single packet.




```
ASCONF [ADD-IP=0.0.0.0, INT-VTag=1234, Rem-VTag = 5678]
10.1.0.1:1 --------> 203.0.113.129:2
         Rem-VTag = 5678
```

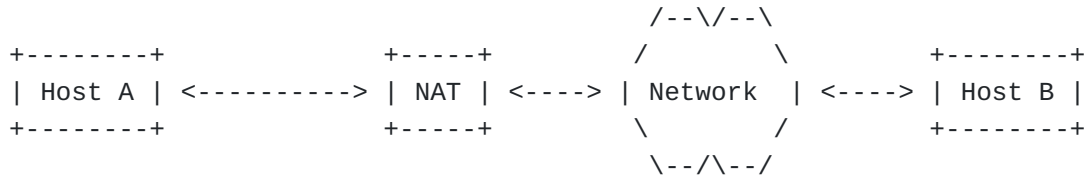
NAT function 2 creates a complete entry:

NAT 2	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr
	1234	1	5678	2	10.1.0.1

```
                ASCONF [ADD-IP, Int-VTag=1234, Rem-VTag = 5678]
                 192.0.2.129:1 -------------------> 203.0.113.129:2
                                  Rem-VTag = 5678

                                    ASCONF ACK
                 192.0.2.129:1 <------------------- 203.0.113.129:2
                                  Int-VTag = 1234

          ASCONF ACK
10.1.0.1:1 <----- 203.0.113.129:2
         Int-VTag = 1234
```

7.4. NAT Function Loses Its State

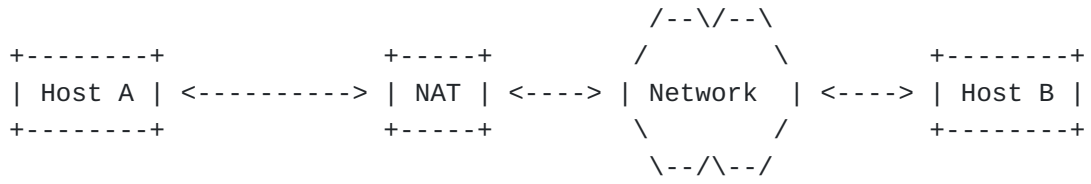
Association is already established between Host A and Host B, when the NAT function loses its state and obtains a new external address. Host A sends a DATA chunk to Host B.



NAT	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr

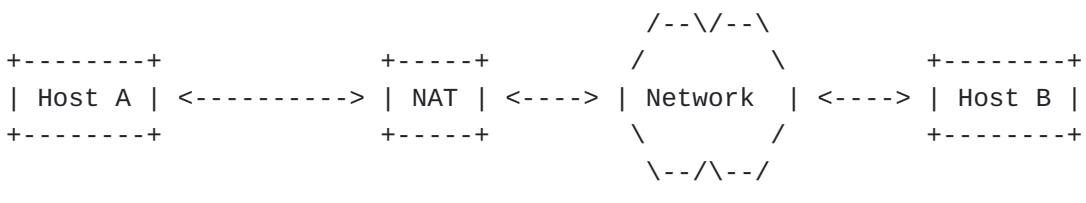
DATA
10.0.0.1:1 ----------> 203.0.113.1:2
Rem-VTag = 5678

The NAT function cannot find an entry in the NAT binding table for the association. It sends a packet containing an ERROR chunk with the M bit set and the cause "NAT state missing".



ERROR [M bit, NAT state missing]
10.0.0.1:1 <---------- 203.0.113.1:2
Rem-VTag = 5678

On reception of the packet containing the ERROR chunk, Host A sends a packet containing an ASCONF chunk indicating that the former information has to be deleted and the source address of the actual packet added.

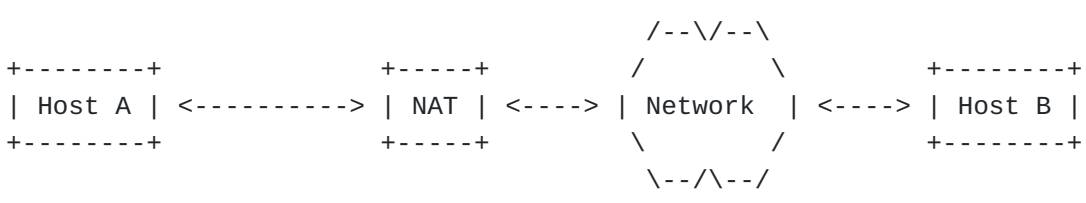


ASCONF [ADD-IP, DELETE-IP, Int-VTag=1234, Rem-VTag = 5678]
10.0.0.1:1 ----------> 203.0.113.129:2
Rem-VTag = 5678

NAT	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr
	1234	1	5678	2	10.0.0.1

ASCONF [ADD-IP, DELETE-IP, Int-VTag=1234, Rem-VTag = 5678]
192.0.2.2:1 ----------> 203.0.113.129:2
Rem-VTag = 5678

Host B adds the new source address to this association and deletes all other addresses from this association.



ASCONF ACK
192.0.2.2:1 <---------- 203.0.113.129:2
Int-VTag = 1234

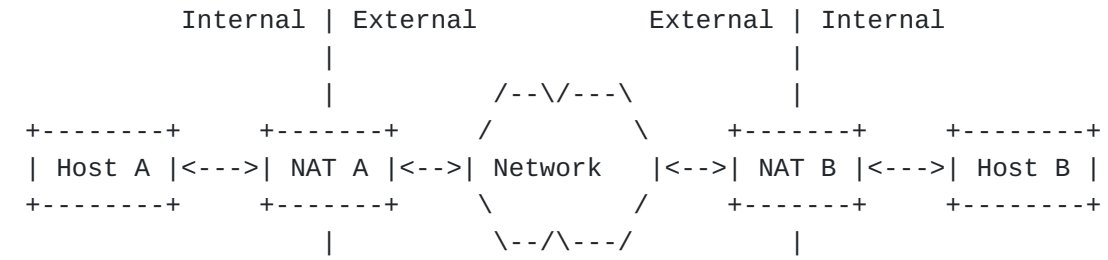
ASCONF ACK
10.1.0.1:1 <---------- 203.0.113.129:2
Int-VTag = 1234

DATA
10.0.0.1:1 ----------> 203.0.113.1:2
Rem-VTag = 5678

DATA
192.0.2.2:1 ----------> 203.0.113.129:2
Rem-VTag = 5678

7.5. Peer-to-Peer Communications

If two hosts, each of them behind a NAT function, want to communicate with each other, they have to get knowledge of the peer's external address. This can be achieved with a so-called rendezvous server. Afterwards the destination addresses are external, and the association is set up with the help of the INIT collision. The NAT functions create their entries according to their internal peer's point of view. Therefore, NAT function A's Internal-VTag and Internal-Port are NAT function B's Remote-VTag and Remote-Port, respectively. The naming (internal/remote) of the verification tag in the packet flow is done from the sending host's point of view.



NAT Binding Tables

	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr
NAT A					

	Int v-tag	Int port	Rem v-tag	Rem port	Int Addr
NAT B					

INIT[Initiate-Tag = 1234]
10.0.0.1:1 --> 203.0.113.1:2
Rem-VTag = 0

NAT function A creates entry:

```
          +---------+--------+----------+--------+-----------+
   NAT A  |  Int    |  Int   |   Rem    |   Rem  |    Int    |
          |  VTag   |  Port  |   VTag   |   Port |    Addr   |
          +---------+--------+----------+--------+-----------+
          |  1234   |    1   |     0    |    2   |  10.0.0.1 |
          +---------+--------+----------+--------+-----------+

                        INIT[Initiate-Tag = 1234]
                 192.0.2.1:1 ----------------> 203.0.113.1:2
                             Rem-VTag = 0
```

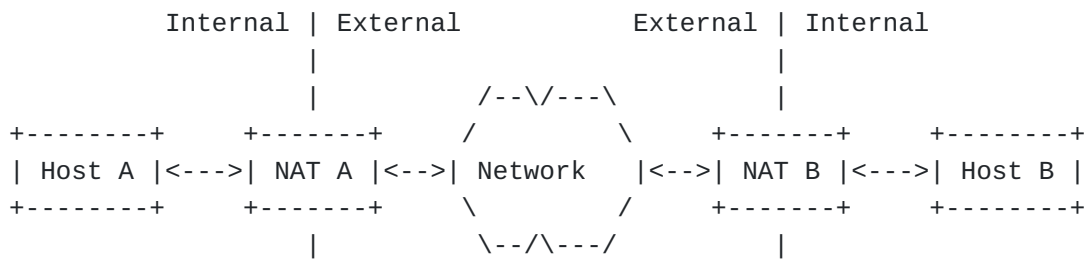
NAT function B processes the packet containing the INIT chunk, but cannot find an entry. The SCTP packet is silently discarded and leaves the NAT binding table of NAT function B unchanged.

```
          +---------+--------+----------+--------+-----------+
   NAT B  |  Int    |  Int   |   Rem    |   Rem  |    Int    |
          |  VTag   |  Port  |   VTag   |   Port |    Addr   |
          +---------+--------+----------+--------+-----------+
```

Now Host B sends a packet containing an INIT chunk, which is processed by NAT function B. Its parameters are used to create an entry.

```
         Internal | External           External | Internal
                  |                             |
                  |          /--\/---\          |
+--------+     +-------+     /         \     +-------+     +--------+
| Host A |<--->| NAT A |<-->| Network   |<-->| NAT B |<--->| Host B |
+--------+     +-------+     \         /     +-------+     +--------+
                  |          \--/\---/          |

                                       INIT[Initiate-Tag = 5678]
                                     192.0.2.1:1 <-- 10.1.0.1:2
                                                 Rem-VTag = 0

      +---------+--------+----------+--------+-----------+
NAT B |  Int    |  Int   |   Rem    |   Rem  |    Int    |
      |  VTag   |  Port  |   VTag   |   Port |    Addr   |
      +---------+--------+----------+--------+-----------+
      |  5678   |    2   |     0    |    1   |  10.1.0.1 |
      +---------+--------+----------+--------+-----------+

                        INIT[Initiate-Tag = 5678]
                 192.0.2.1:1  <--------------- 203.0.113.1:2
                             Rem-VTag = 0
```

NAT function A processes the packet containing the INIT chunk. As the outgoing packet containing an INIT chunk of Host A has already created an entry, the entry is found and updated:

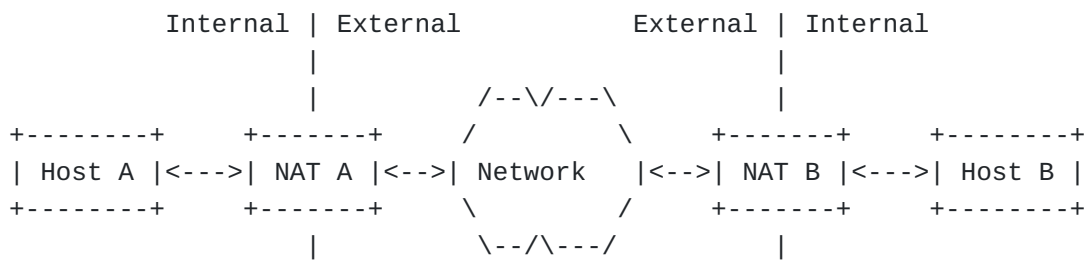


VTag != Int-VTag, but Rem-VTag == 0, find entry.

NAT A	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr
	1234	1	5678	2	10.0.0.1

INIT[Initiate-tag = 5678]
10.0.0.1:1 <-- 203.0.113.1:2
Rem-VTag = 0

Host A sends a packet containing an INIT ACK chunk, which can pass through NAT function B:



INIT ACK[Initiate-Tag = 1234]
10.0.0.1:1 --> 203.0.113.1:2
Rem-VTag = 5678

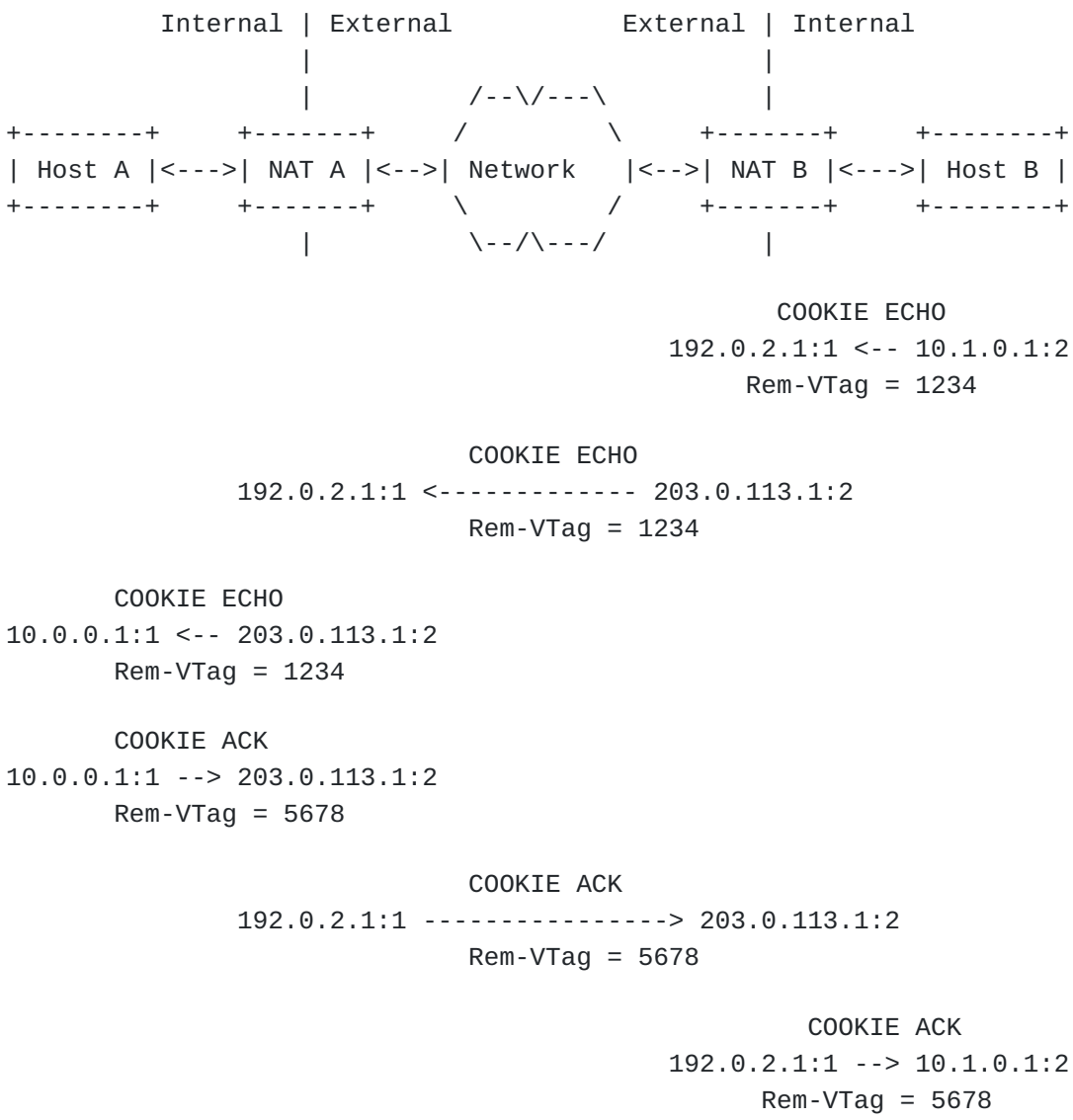
INIT ACK[Initiate-Tag = 1234]
192.0.2.1:1 ----------> 203.0.113.1:2
Rem-VTag = 5678

NAT function B updates entry:

NAT B	Int VTag	Int Port	Rem VTag	Rem Port	Int Addr
	5678	2	1234	1	10.1.0.1

INIT ACK[Initiate-Tag = 1234]
192.0.2.1:1 --> 10.1.0.1:2
Rem-VTag = 5678

The lookup for COOKIE ECHO and COOKIE ACK is successful.



8. SCTP NAT YANG Module

This section defines a YANG module for SCTP NAT.

The terminology for describing YANG data models is defined in [RFC7950]. The meaning of the symbols in tree diagrams is defined in [RFC8340].

8.1. Tree Structure

This module augments NAT YANG module [RFC8512] with SCTP specifics. The module supports both classical SCTP NAT (that is, rewrite port numbers) and SCTP-specific variant where the ports numbers are not altered. The YANG "feature" is used to indicate whether SCTP-specific variant is supported.

The tree structure of the SCTP NAT YANG module is provided below:

```
module: ietf-nat-sctp
  augment /nat:nat/nat:instances/nat:instance
          /nat:policy/nat:timers:
    +--rw sctp-timeout?   uint32
  augment /nat:nat/nat:instances/nat:instance
         /nat:mapping-table/nat:mapping-entry:
    +--rw int-VTag?   uint32 {sctp-nat}?
    +--rw rem-VTag?   uint32 {sctp-nat}?
```

Concretely, the SCTP NAT YANG module augments the NAT YANG module (policy, in particular) with the following:

- The sctp-timeout is used to control the SCTP inactivity timeout. That is, the time an SCTP mapping will stay active without SCTP packets traversing the NAT. This timeout can be set only for SCTP. Hence, "/nat:nat/nat:instances/nat:instance/nat:policy/nat:transport-protocols/nat:protocol-id" MUST be set to '132' (SCTP).

In addition, the SCTP NAT YANG module augments the mapping entry with the following parameters defined in Section 3. These parameters apply only for SCTP NAT mapping entries (i.e., "/nat/instances/instance/mapping-table/mapping-entry/transport-protocol" MUST be set to '132');

- The Internal Verification Tag (Int-VTag)

- The Remote Verification Tag (Rem-VTag)

8.2. YANG Module

```
<CODE BEGINS> file "ietf-nat-sctp@2020-11-02.yang"
module ietf-nat-sctp {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-nat-sctp";
  prefix nat-sctp;

  import ietf-nat {
    prefix nat;
    reference
      "RFC 8512: A YANG Module for Network Address Translation
                 (NAT) and Network Prefix Translation (NPT)";
  }

  organization
    "IETF TSVWG Working Group";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/tsvwg/>
     WG List:  <mailto:tsvwg@ietf.org>

     Author:  Mohamed Boucadair
              <mailto:mohamed.boucadair@orange.com>";
  description
    "This module augments NAT YANG module with Stream Control
     Transmission Protocol (SCTP) specifics. The extension supports
     both a classical SCTP NAT (that is, rewrite port numbers)
     and a, SCTP-specific variant where the ports numbers are
     not altered.

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     Relating to IETF Documents
     (http://trustee.ietf.org/license-info).

     This version of this YANG module is part of RFC XXXX; see
     the RFC itself for full legal notices.";

  revision 2019-11-18 {
    description
      "Initial revision.";
    reference
      "RFC XXXX: Stream Control Transmission Protocol (SCTP)
                 Network Address Translation Support";
  }
```

```
  feature sctp-nat {
    description
      "This feature means that SCTP-specific variant of NAT
       is supported. That is, avoid rewriting port numbers.";
    reference
      "Section 4.3 of RFC XXXX.";
  }

  augment "/nat:nat/nat:instances/nat:instance"
        + "/nat:policy/nat:timers" {
    when "/nat:nat/nat:instances/nat:instance"
       + "/nat:policy/nat:transport-protocols"
       + "/nat:protocol-id = 132";
    description
      "Extends NAT policy with a timeout for SCTP mapping
       entries.";

    leaf sctp-timeout {
      type uint32;
      units "seconds";
      description
        "SCTP inactivity timeout. That is, the time an SCTP
         mapping entry will stay active without packets
         traversing the NAT.";
    }
  }

  augment "/nat:nat/nat:instances/nat:instance"
        + "/nat:mapping-table/nat:mapping-entry" {
    when "nat:transport-protocol = 132";
    if-feature "sctp-nat";
    description
      "Extends the mapping entry with SCTP specifics.";

    leaf int-VTag {
       type uint32;
       description
         "The Internal Verification Tag that the internal
          host has chosen for this communication.";
    }
    leaf rem-VTag {
      type uint32;
      description
         "The Remote Verification Tag that the remote
          peer has chosen for this communication.";
    }
  }
}
```

<CODE ENDS>

9. Socket API Considerations

This section describes how the socket API defined in [RFC6458] is extended to provide a way for the application to control NAT friendliness.

Please note that this section is informational only.

A socket API implementation based on [RFC6458] is extended by supporting one new read/write socket option.

9.1. Get or Set the NAT Friendliness (SCTP_NAT_FRIENDLY)

This socket option uses the option_level IPPROTO_SCTP and the option_name SCTP_NAT_FRIENDLY. It can be used to enable/disable the NAT friendliness for future associations and retrieve the value for future and specific ones.

```
struct sctp_assoc_value {
  sctp_assoc_t assoc_id;
  uint32_t assoc_value;
};
```

assoc_id
: This parameter is ignored for one-to-one style sockets. For one-to-many style sockets the application can fill in an association identifier or SCTP_FUTURE_ASSOC for this query. It is an error to use SCTP_{CURRENT|ALL}_ASSOC in assoc_id.

assoc_value
: A non-zero value indicates a NAT-friendly mode.

10. IANA Considerations

[NOTE to RFC-Editor: "RFCXXXX" is to be replaced by the RFC number you assign this document.]

[NOTE to RFC-Editor: The requested values for the chunk type and the chunk parameter types are tentative and to be confirmed by IANA.]

This document (RFCXXXX) is the reference for all registrations described in this section. The requested changes are described below.

10.1. New Chunk Flags for Two Existing Chunk Types

As defined in [RFC6096] two chunk flags have to be assigned by IANA for the ERROR chunk. The requested value for the T bit is 0x01 and for the M bit is 0x02.

This requires an update of the "ERROR Chunk Flags" registry for SCTP:

ERROR Chunk Flags

Chunk Flag Value	Chunk Flag Name	Reference
0x01	T bit	[RFCXXXX]
0x02	M bit	[RFCXXXX]
0x04	Unassigned	
0x08	Unassigned	
0x10	Unassigned	
0x20	Unassigned	
0x40	Unassigned	
0x80	Unassigned	

Table 2

As defined in [RFC6096] one chunk flag has to be assigned by IANA for the ABORT chunk. The requested value of the M bit is 0x02.

This requires an update of the "ABORT Chunk Flags" registry for SCTP:

ABORT Chunk Flags

Chunk Flag Value	Chunk Flag Name	Reference
0x01	T bit	[RFC4960]
0x02	M bit	[RFCXXXX]
0x04	Unassigned	
0x08	Unassigned	
0x10	Unassigned	
0x20	Unassigned	
0x40	Unassigned	
0x80	Unassigned	

Table 3

10.2. Three New Error Causes

Three error causes have to be assigned by IANA. It is requested to use the values given below.

This requires three additional lines in the "Error Cause Codes" registry for SCTP:

Error Cause Codes

Value	Cause Code	Reference
176	VTag and Port Number Collision	[RFCXXXX]
177	Missing State	[RFCXXXX]
178	Port Number Collision	[RFCXXXX]

Table 4

10.3. Two New Chunk Parameter Types

Two chunk parameter types have to be assigned by IANA. IANA is requested to assign these values from the pool of parameters with the upper two bits set to '11' and to use the values given below.

This requires two additional lines in the "Chunk Parameter Types" registry for SCTP:

Chunk Parameter Types

ID Value	Chunk Parameter Type	Reference
49159	Disable Restart (0xC007)	[RFCXXXX]
49160	VTags (0xC008)	[RFCXXXX]

Table 5

10.4. One New URI

An URI in the "ns" subregistry within the "IETF XML" registry has to be assigned by IANA ([RFC3688]):

```
URI: urn:ietf:params:xml:ns:yang:ietf-nat-sctp
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.
```

10.5. One New YANG Module

An YANG module in the "YANG Module Names" subregistry within the "YANG Parameters" registry has to be assigned by IANA ([RFC6020]):

```
Name: ietf-nat-sctp
Namespace: urn:ietf:params:xml:ns:yang:ietf-nat-sctp
Maintained by IANA: N
Prefix: nat-sctp
Reference: RFCXXXX
```

11. Security Considerations

State maintenance within a NAT function is always a subject of possible Denial Of Service attacks. This document recommends that at a minimum a NAT function runs a timer on any SCTP state so that old association state can be cleaned up.

Generic issues related to address sharing are discussed in [RFC6269] and apply to SCTP as well.

For SCTP endpoints not disabling the restart procedure, this document does not add any additional security considerations to the ones given in [RFC4960], [RFC4895], and [RFC5061].

SCTP endpoints disabling the restart procedure, need to monitor the status of all associations to mitigate resource exhaustion attacks by establishing a lot of associations sharing the same IP addresses and port numbers.

In any case, SCTP is protected by the verification tags and the usage of [RFC4895] against off-path attackers.

For IP-level fragmentation and reassembly related issues see [RFC4963].

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

All data nodes defined in the YANG module that can be created, modified, and deleted (i.e., config true, which is the default) are considered sensitive. Write operations (e.g., edit-config) applied to these data nodes without proper protection can negatively affect network operations. An attacker who is able to access the SCTP NAT function can undertake various attacks, such as:

- Setting a low timeout for SCTP mapping entries to cause failures to deliver incoming SCTP packets.

- Instantiating mapping entries to cause NAT collision.

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Acknowledgments

The authors wish to thank Mohamed Boucadair, Gorry Fairhurst, Bryan Ford, David Hayes, Alfred Hines, Karen E. E. Nielsen, Henning Peters, Maksim Proshin, Timo Völker, Dan Wing, and Qiaobing Xie for their invaluable comments.

In addition, the authors wish to thank David Hayes, Jason But, and Grenville Armitage, the authors of [DOI_10.1145_1496091.1496095], for their suggestions.

The authors also wish to thank Mohamed Boucadair for contributing the text related to the YANG module.

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