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Stream Control Transmission Protocol (SCTP) Network Address Translation
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Status of this Memo

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Abstract

Stream Control Transmission Protocol [RFC4960] (Stewart, R., “Stream Control Transmission Protocol,” September 2007.) provides a reliable

communications channel between two end-hosts in many ways similar to TCP [RFC0793] (Postel, J., “Transmission Control Protocol,” September 1981.). With the widespread deployment of Network Address Translators (NAT), specialized code has been added to NAT for TCP that allows multiple hosts to reside behind a NAT and yet use only a single globally unique IPv4 address, even when two hosts (behind a NAT) choose the same port numbers for their connection. This additional code is sometimes classified as Network Address and Port Translation or NAPT. To date, specialized code for SCTP has NOT yet been added to most NATs so that only pure NAT is available. The end result of this is that only one SCTP capable host can be behind a NAT.
This document describes an SCTP specific variant of NAT which provides similar features of NAPT in the single point and multi-point traversal scenario.

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1. Introduction

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Stream Control Transmission Protocol [RFC4960] (Stewart, R., “Stream Control Transmission Protocol,” September 2007.) provides a reliable communications channel between two end-hosts in many ways similar to TCP [RFC0793] (Postel, J., “Transmission Control Protocol,” September 1981.). With the widespread deployment of Network Address Translators (NAT), specialized code has been added to NAT for TCP that allows multiple hosts to reside behind a NAT and yet use only a single globally unique IPv4 address, even when two hosts (behind a NAT) choose the same port numbers for their connection. This additional code is sometimes classified as Network Address and Port Translation or NAPT. To date, specialized code for SCTP has NOT yet been added to most NATs so that only true NAT is available. The end result of this is that only one SCTP capable host can be behind a NAT.
This document proposes an SCTP specific variant NAT that provides the NAPT functionality without changing SCTP port numbers. The authors feel 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's public IP address, much as TCP does today.

- If a NAT 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 required by SCTP.

- Not having to touch the IP payload makes the processing of ICMP messages in NATs easier.

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2. Conventions

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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] (Bradner, S., “Key words for use in RFCs to Indicate Requirement Levels,” March 1997.).

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3. Terminology

For this discussion we will use several terms, which we will define and point out in a figure.

*Private-Address (Priv-Addr) - The private address that is known to the internal host.

*Internal-Port (Int-Port) - The port number that is in use by the host holding the Private-Address. Normally this is the port that will be translated by the NAPT to a different port number.

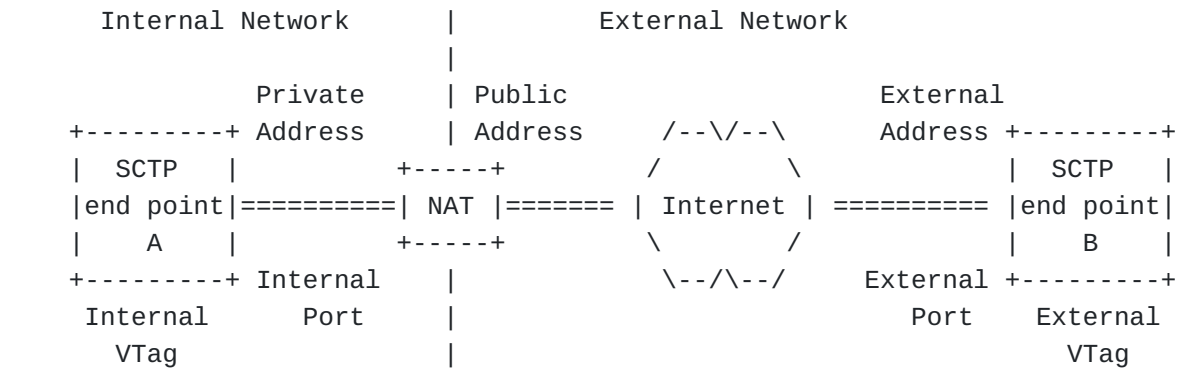
*Internal-VTag (Int-VTag) - The Verification Tag that the internal host has chosen for its communication. The VTag is a unique 32 bit tag that must accompany any incoming SCTP packet for this association to the Private-Address.

*External-Address (Ext-Addr) - The address that an internal host is attempting to contact.

*External-Port (Ext-Port) - The port number of the peer process at the External-Address.

*External-VTag (Ext-VTag) - The Verification Tag that the host holding the External-Address has chosen for its communication. The VTag is a unique 32 bit tag that must accompany any incoming SCTP packet for this association to the External-Address.

*Public-Address (Pub-Addr) - The public address assigned to the NAT box which it uses as a source address when sending packets towards the External-Address.



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4. SCTP NAT Traversal Scenarios

4.1. Single Point Traversal

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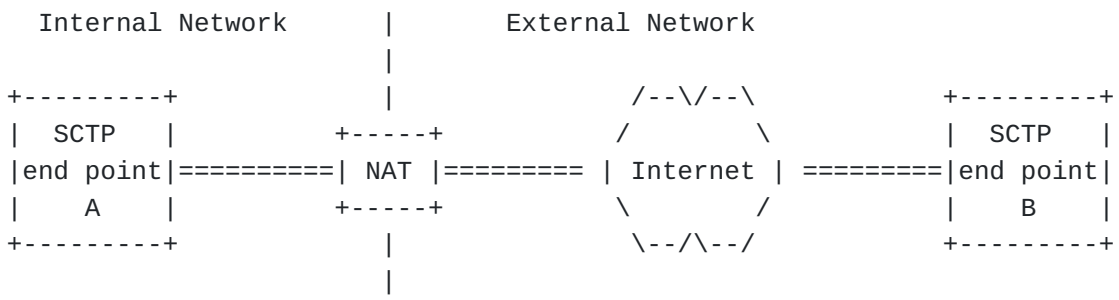
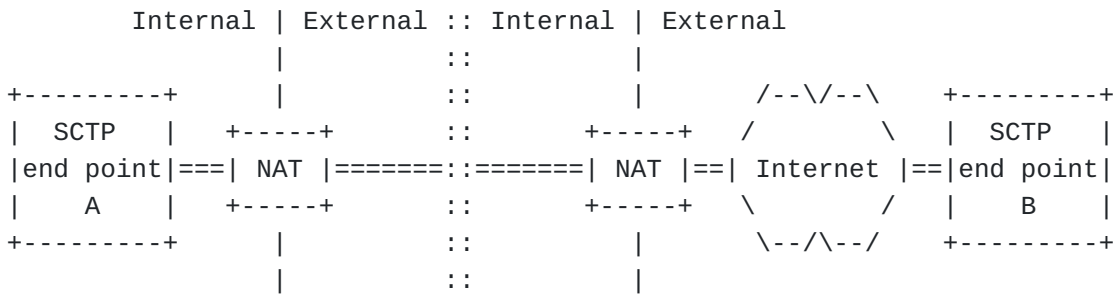
In this case, all packets in the SCTP association go through a single NAT, as shown below:



A variation of this case is shown below, i.e., multiple NATs in a single path:



The two SCTP endpoints in this case can be either single-homed or multi-homed. However, the important thing is that the NAT (or NATs) in this case sees ALL the packets of the SCTP association.
In this single point traversal scenario, we must acknowledge that while one of the main benefits of SCTP multi-homing is redundant paths, the NAT function represents a single point of failure in the path of the SCTP multi-home association. However, the rest of the path may still benefit from path diversity provided by SCTP multi-homing.

4.2. Multi Point Traversal

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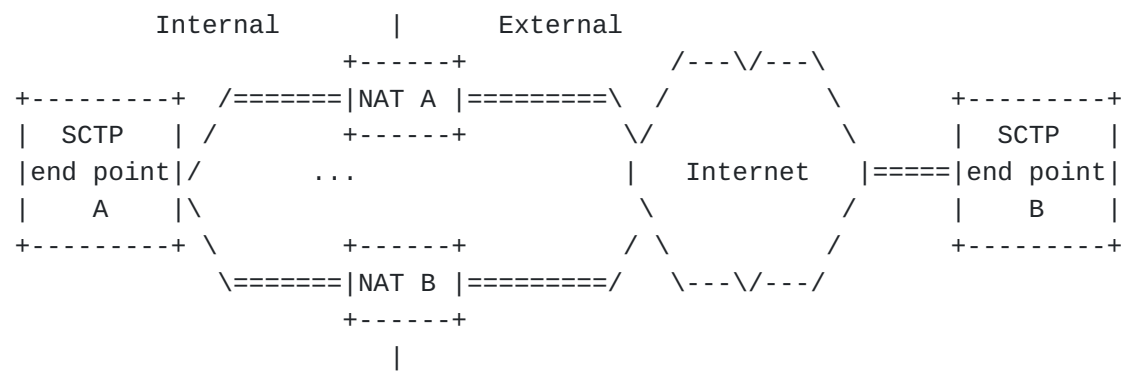
This case involves multiple NATs and each NAT only sees some of the packets in the SCTP association. An example is shown below:



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. To make this work, however, all the NATs involved must recognize the packets they see as belonging to the same SCTP association and perform address translation in a consistent way. This may require that a pre-defined table of ports and addresses were shared between the NATs. Other external management schemes that help multiple NATs coordinate a multi-homed SCTP association could be investigated.

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5. The SCTP specific variant of NAT

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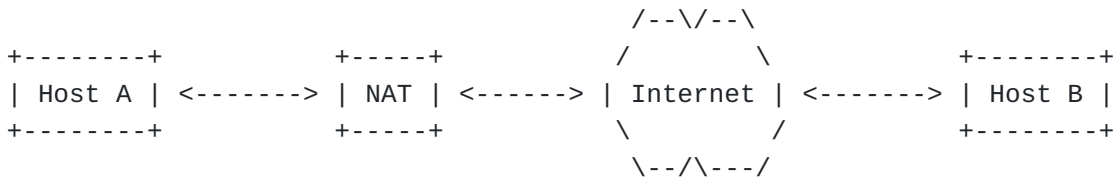
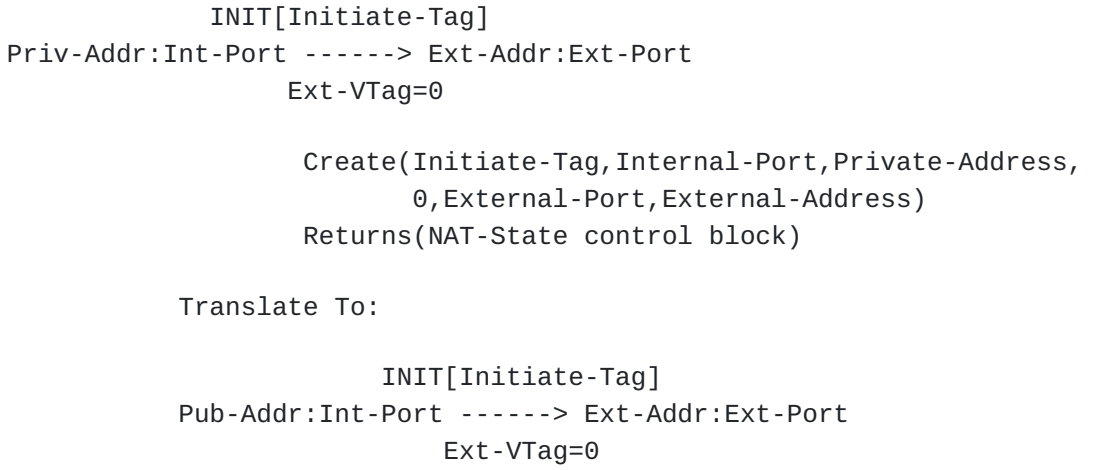
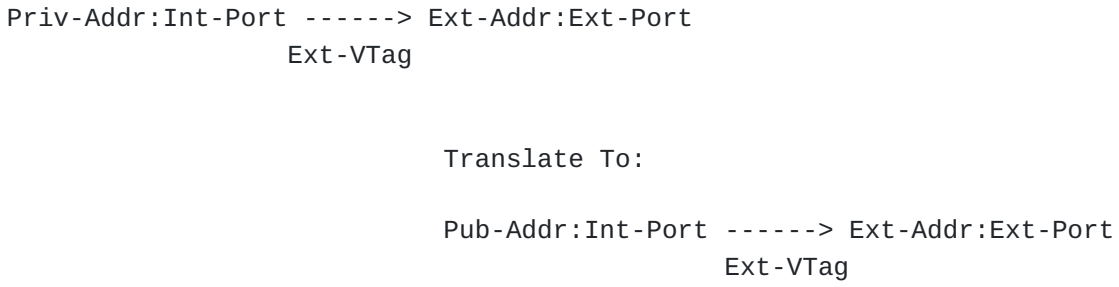
In this section we assume that we have multiple SCTP capable hosts behind a NAT which has one Public-Address. Furthermore we are focusing in this section on the single point traversal scenario.
The modification of SCTP packets sent to the public Internet is easy. The source address of the packet has to be replaced with the Public-Address. It may also be necessary to establish some state in the NAT box to handle incoming packets, which is discussed later.
For SCTP packets coming from the public Internet the destination address of the packets has to be replaced with the Private-Address of the host the packet has to be delivered to. The lookup of the Private-Address is based on the External-VTag, External-Port, External-Address, Internal-VTag and the Internal-Port.
For the SCTP NAT processing the NAT box has to maintain a table of Internal-VTag, Internal-Port, Private-Address, External-VTag, External-Port and External-Address. An entry in that table is called a NAT state control block.
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.





It should be noted that normally a NAT control block will be created. However, it is possible that there is already a NAT control block with the same External-Address, External-Port, External-VTag, Internal-VTag but different Private-Address. In this case the INIT SHOULD be dropped and an ABORT MAY be sent back.
The processing of outgoing SCTP packets containing no INIT-chunk is described in the following figure.



The processing of incoming SCTP packets containing INIT-ACK chunks is described in the following figure.

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

              Lookup(Internal-VTag,Internal-Port,*,
                     0,External-Port,External-Address)
              Update(*, *, *, Initiate-Tag, *, *)

              Returns(NAT-State control block containing Private-Address)

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

In the case Lookup fails, the SCTP packet is dropped. The Update routine inserts the External-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 described in the following figure.

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

               Lookup(0, Internal-Port, *,External-VTag,
                      External-Port, External-Address)

               Returns(NAT-State control block containing Private-Address)

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

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

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

                 Lookup(Internal-VTag, Internal-Port, *,
                        *, External-Port, External-Address)

                 Returns(NAT-State control block containing Local-Address)

   Priv-Addr:Int-Port <------ Ext-Addr:Ext-Port
                      Int-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 an

Internal-VTag of zero is found, it is considered a match and the Internal-VTag is updated.
This allows the handling of INIT-collision through NAT.

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6. Handling of internal port number collisions

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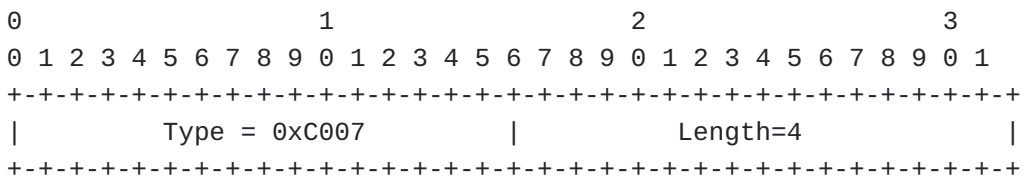
There is one drawback of the SCTP specific variant of NAT compared to a NAPT solution like the ones available for TCP. Consider the case where two hosts in the Private-Address space want to set up an SCTP association with the same server running on the same host in the Internet. This means that the External-Port and the External-Address are the same. If they both choose the same Internal-Port the server cannot distinguish 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 NAT_SUPPORTED parameter in the INIT-chunk which is defined as follows:



When the server receives this parameter it will also use the verification tag to look up the association. However, this will make it impossible to restart such associations.

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7. Handling of internal port number and verification tag collisions

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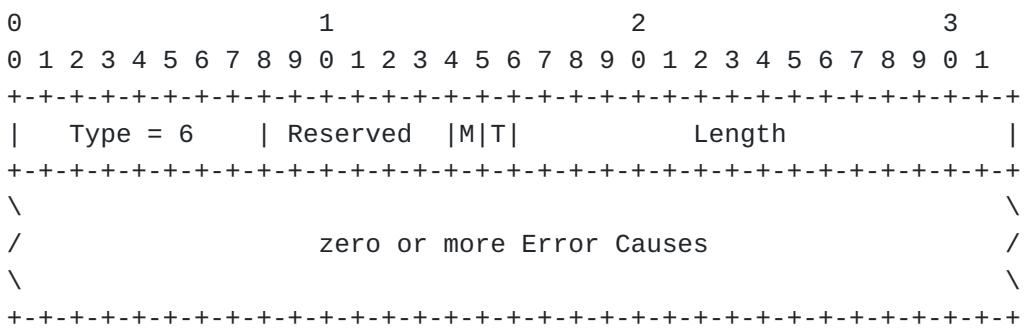
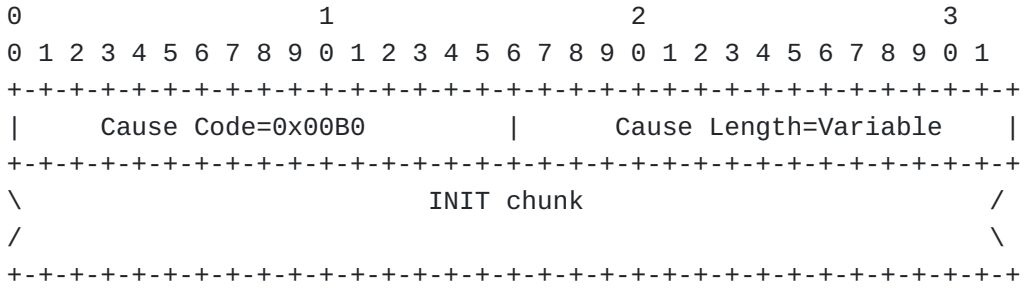
Consider the case where two hosts in the Private-Address space want to set up an SCTP association with the same server running on the same host in the Internet. This means that the External-Port and the External-Address are the same. If they both choose the same Internal-Port and Internal-VTag, the NAT box cannot distinguish incoming packets anymore. But this is very unlikely. The Internal-VTags are chosen at random and if the Internal-Ports are also chosen from the ephemeral port range at random this gives a 46 bit random number which has to match. In the TCP like NAPT case the NAT box can control the 16 bit Natted Port.
However, in this unlikely event the NAT box MUST respond to the INIT chunk by sending an ABORT chunk with the M-bit set. The source address of the packet containing the ABORT chunk MUST be the destination address of the SCTP packet containing the INIT chunk. The sender of the

packet containing the INIT chunk MAY start the association setup procedure after choosing a new initiate tag.
The ABORT chunk defined in [RFC4960] (Stewart, R., “Stream Control Transmission Protocol,” September 2007.) is therefore extended by using the following format:



The following error cause with cause code 0x00B0 (Colliding NAT table entry) SHOULD be included in the ABORT chunk:



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8. Handling of missing state

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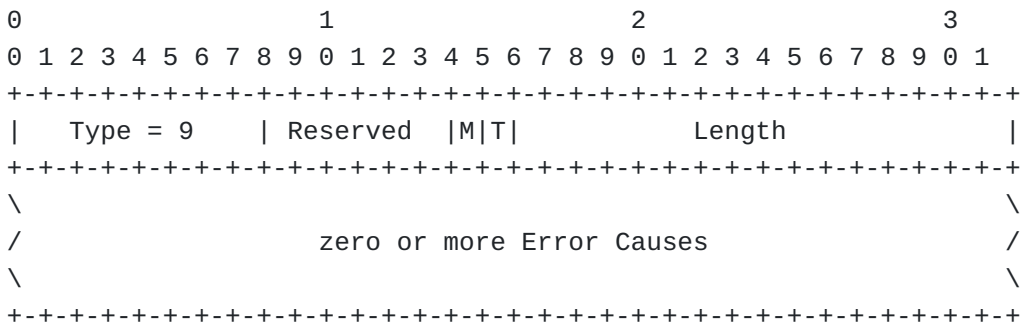
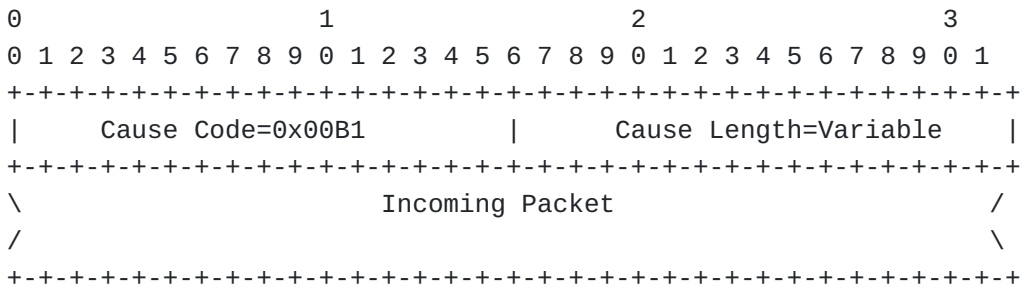
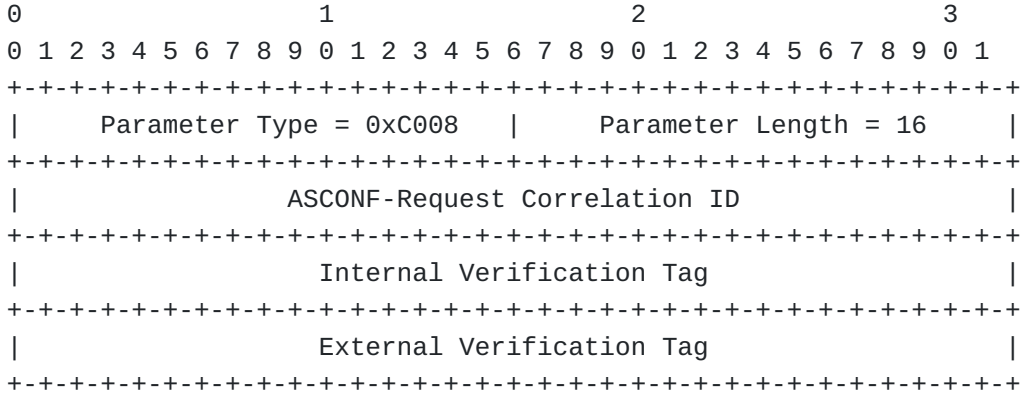
If the NAT box receives a packet for which the lookup procedure does not find an entry in the NAT table, a packet containing an ERROR packet is sent back with the M-bit set. The source address of the packet containing the ERROR chunk MUST be the destination address of the incoming SCTP packet. The verification tag is reflected.
The ERROR chunk defined in [RFC4960] (Stewart, R., “Stream Control Transmission Protocol,” September 2007.) is therefore extended by using the following format:



The following error cause with cause code 0x00B1 (Missing NAT table entry) SHOULD be included in the ERROR chunk:



If an end-point receives a packet with this ERROR chunk it MAY send an SCTP packet with an ASCONF chunk containing an Add IP Address parameter followed by a vtag parameter:



If the NAT box receives a packet for which it has no NAT table entry and the packet contains an ASCONF chunk with a vtag parameter, the NAT box MUST update its NAT table according to the verification tags in the vtag parameter.

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9. Multi Point Traversal considerations

If a multi-homed SCTP end-point behind a NAT connects to a peer, it first sets up the association single-homed. Then it adds each IP address using ASCONF chunks. The address to add is the wildcard address and the lookup address also. The ASCONF chunks SHOULD also contain a vtag parameter.

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10. Handling of fragmented SCTP packets

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A NAT box MUST support IP reassembly of received fragmented SCTP packets. The fragments may arrive in any order.
When an SCTP packet has to be fragmented by the NAT box and the IP header forbids fragmentation a corresponding ICMP packet SHOULD be sent.

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11. Simplification for small NATs

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Small NAT boxes, i.e. NAT boxes which only have to support a small number of concurrent SCTP associations, MAY not take the external address into account when processing packets. Therefore the External-Address could also be removed from the NAT table.
This simplification may make implementing a NAT box easier, however, the collision probability is higher than using a mapping which takes the external address into account.

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12. Various examples of NAT traversals

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12.1. Single-homed client to single-homed server

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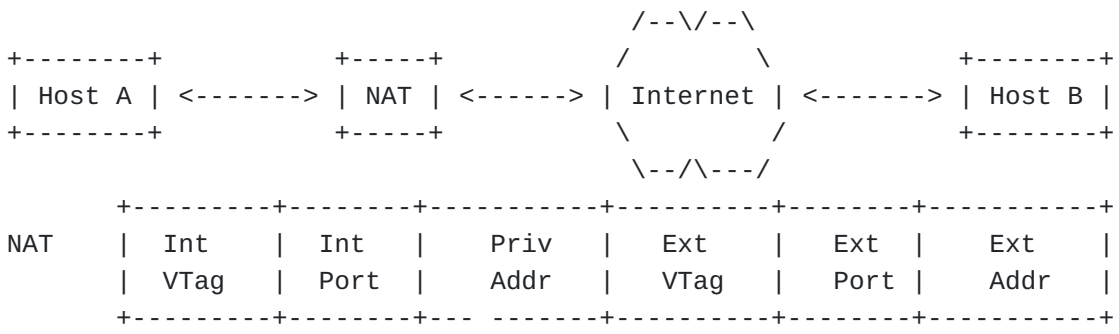
The internal client starts the association with the external server via a four-way-handshake.



NAT	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr

Host A sends INIT:

INIT[Initiate-Tag = 1234]
10.0.0.1:1 ------> 100.0.0.1:2
Ext-VTtag = 0

NAT creates entry:

NAT	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	0	2	100.0.0.1

INIT[Initiate-Tag = 1234]
101.0.0.1:1 ----------> 100.0.0.1:2
Ext-VTtag = 0

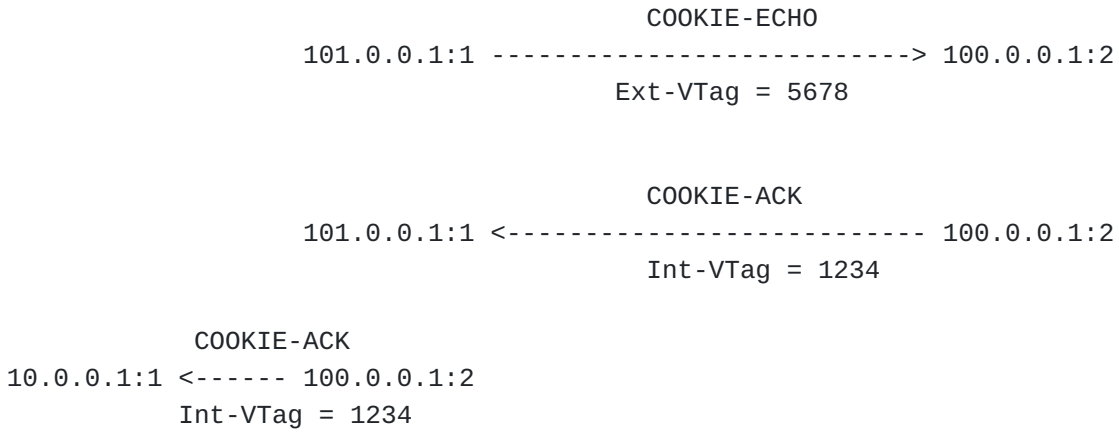
INIT-ACK[Initiate-Tag = 5678]
101.0.0.1:1 <---------- 100.0.0.1:2
Int-VTag = 1234

NAT updates entry:

NAT	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	5678	2	100.0.0.1

INIT-ACK[Initiate-Tag = 5678]
10.0.0.1:1 <------ 100.0.0.1:2
Int-VTag = 1234

COOKIE-ECHO
10.0.0.1:1 ------> 100.0.0.1:2
Ext-VTag = 5678



12.2. Single-homed client to multi-homed server

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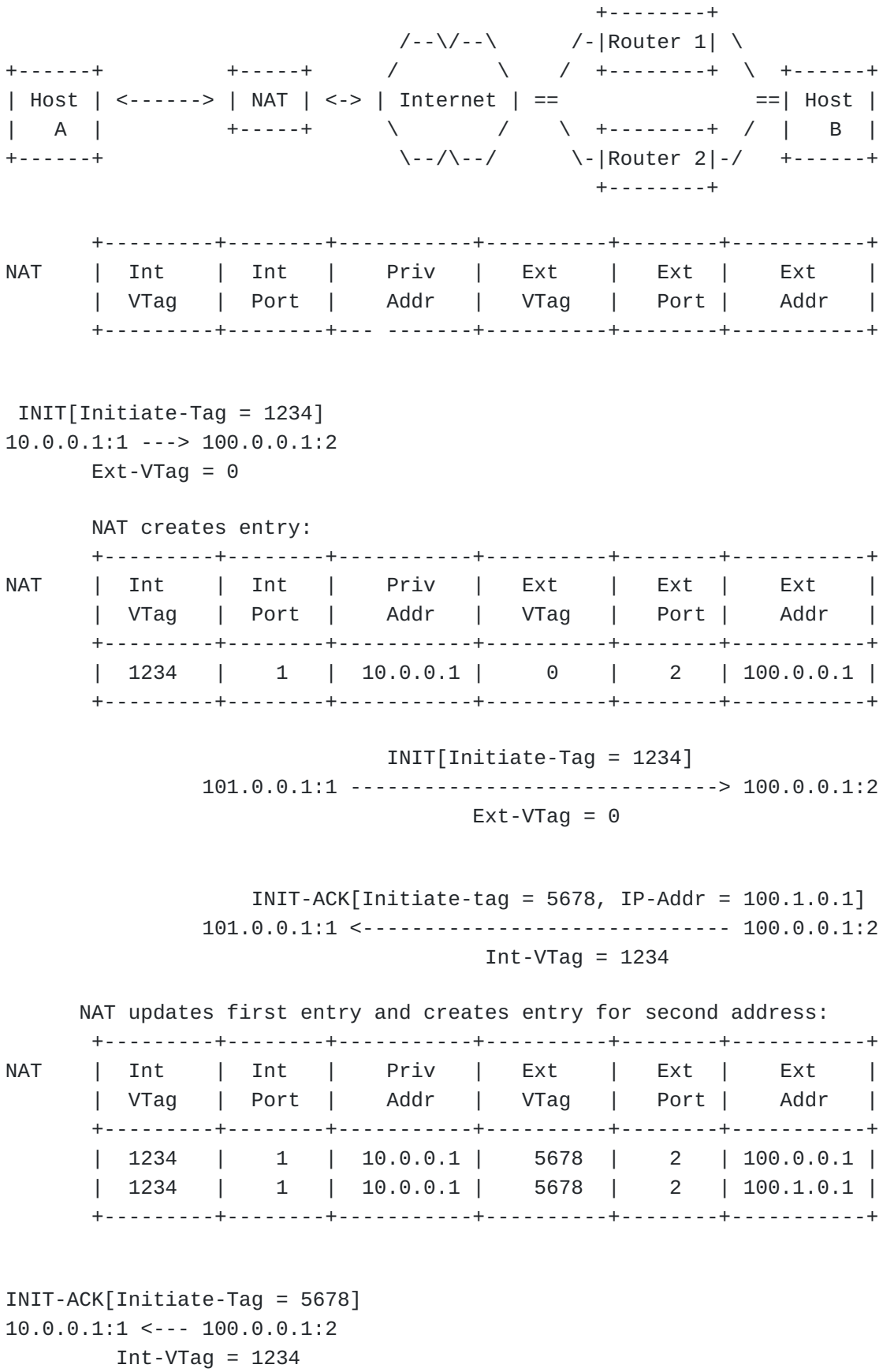
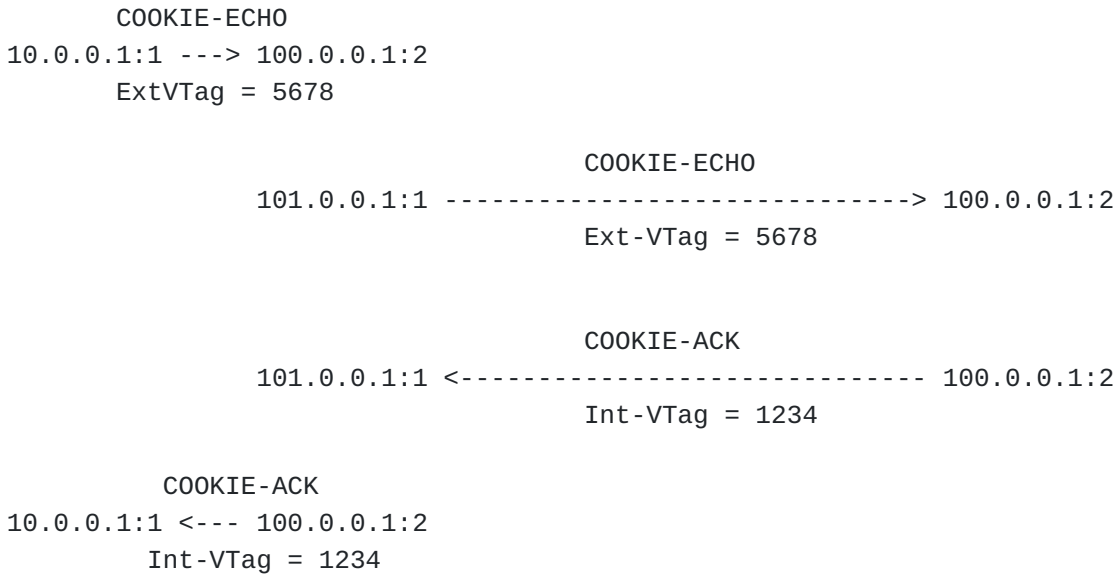
The internal client is single-homed whereas the external server is multi-homed. The server includes its addresses in the INIT-ACK chunk, which results in two NAT entries.


+--------+
/--\/--\ /-|Router 1| \
+------+ +-----+ / \ / +--------+ \ +------+
| Host | <------> | NAT | <-> | Internet | == ==| Host |
| A | +-----+ \ / \ +--------+ / | B |
+------+ \--/\--/ \-|Router 2|-/ +------+
+--------+
NAT | Int VTag | Int Port | Priv Addr | Ext VTag | Ext Port | Ext Addr |
INIT[Initiate-Tag = 1234]
10.0.0.1:1 ---> 100.0.0.1:2
Ext-VTag = 0
NAT creates entry:
NAT | Int VTag | Int Port | Priv Addr | Ext VTag | Ext Port | Ext Addr |
| 1234 | 1 | 10.0.0.1 | 0 | 2 | 100.0.0.1 |
INIT[Initiate-Tag = 1234]
101.0.0.1:1 ----------> 100.0.0.1:2
Ext-VTag = 0
INIT-ACK[Initiate-tag = 5678, IP-Addr = 100.1.0.1]
101.0.0.1:1 <---------- 100.0.0.1:2
Int-VTag = 1234
NAT updates first entry and creates entry for second address:
NAT | Int VTag | Int Port | Priv Addr | Ext VTag | Ext Port | Ext Addr |
| 1234 | 1 | 10.0.0.1 | 5678 | 2 | 100.0.0.1 |
| 1234 | 1 | 10.0.0.1 | 5678 | 2 | 100.1.0.1 |
INIT-ACK[Initiate-Tag = 5678]
10.0.0.1:1 <--- 100.0.0.1:2
Int-VTag = 1234



12.3. Multihomed client and server

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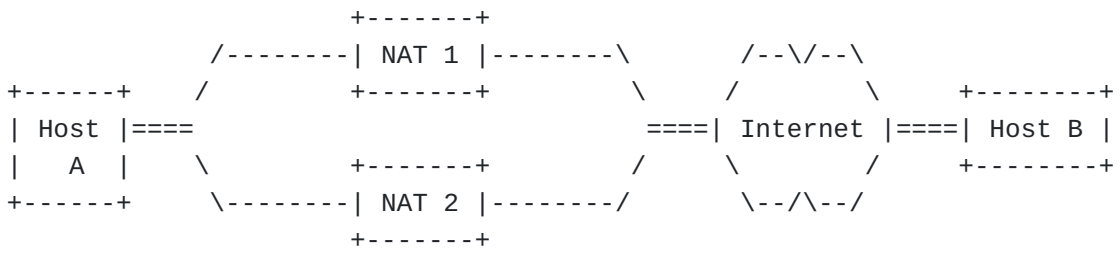

NAT 1	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr

INIT[Initiate-Tag = 1234]
10.0.0.1:1 --------> 100.0.0.1:2
Ext-VTag = 0

NAT 1 creates entry:

NAT 1	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	0	2	100.0.0.1

INIT[Initiate-Tag = 1234]
101.0.0.1:1 ------------------------> 100.0.0.1:2
ExtVTag = 0

INIT-ACK[Initiate-Tag = 5678, IP-Addr = 100.1.0.1]
101.0.0.1:1 <------------------------ 100.0.0.1:2
Int-VTag = 1234

NAT 1 updates first entry and creates complete entry for second address:

NAT 1	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	5678	2	100.0.0.1
	1234	1	10.0.0.1	5678	2	100.1.0.1

INIT-ACK[Initiate-Tag = 5678]
10.0.0.1:1 <---------100.0.0.1:2
Int-VTag = 1234

```
          COOKIE-ECHO
10.0.0.1:1 --------> 100.0.0.1:2
          Ext-VTag = 5678

                                        COOKIE-ECHO
                        101.0.0.1:1 ----------------------> 100.0.0.1:2
                                        Ext-VTag = 5678


                                         COOKIE-ACK
                        101.0.0.1:1 <---------------------- 100.0.0.1:2
                                        Int-VTag = 1234

           COOKIE-ACK
10.0.0.1:1 <------- 100.0.0.1:2
           Int-VTag = 1234

Host A announces the second address

ASCONF [ADD-IP,INT-VTag=1234, Ext-VTag = 5678]
10.1.0.1:1 --------> 100.1.0.1:2
         Ext-VTag = 5678

      NAT 2 creates complete entry:
       +---------+--------+-----------+----------+--------+-----------+
NAT 2  |  Int    |  Int   |    Priv   |   Ext    |   Ext  |    Ext    |
       |  VTag   |  Port  |    Addr   |   VTag   |   Port |    Addr   |
       +---------+--------+-----------+----------+--------+-----------+
       |  1234   |    1   |  10.1.0.1 |    5678  |    2   | 100.1.0.1 |
       +---------+--------+-----------+----------+--------+-----------+


                 ASCONF [ADD-IP,Int-VTag=1234, Ext-VTag = 5678]
                    101.1.0.1:1 ------------------------> 100.1.0.1:2
                                       Ext-VTag = 5678

                                          ASCONF-ACK
                    101.1.0.1:1 <------------------------ 100.1.0.1:2
                                          Int-VTag = 1234

          ASCONF-ACK
10.1.0.1:1 <----- 100.1.0.1:2
         Int-VTag = 1234
```

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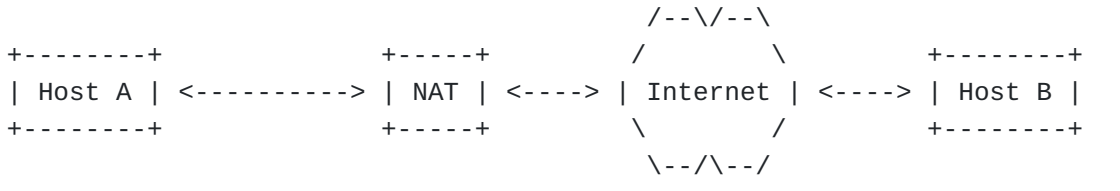
12.4. NAT loses its state

Assocation is already established between Host A and Host B.



NAT A	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	5678	2	100.0.0.1

The NAT loses its state and obtaines a new public address.

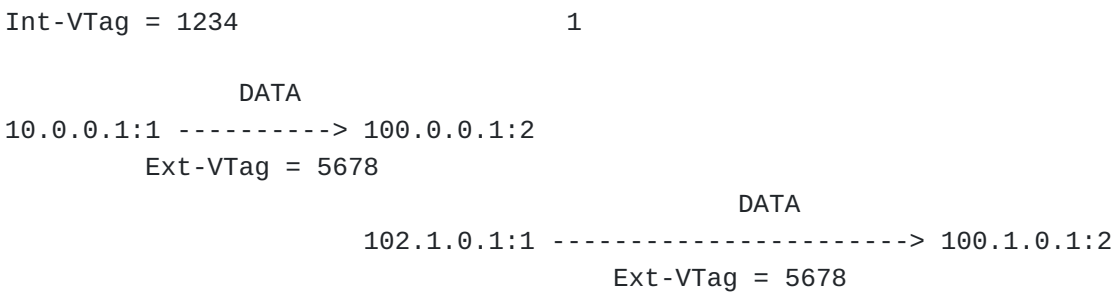
```
              DATA
10.0.0.1:1 ----------> 100.0.0.1:2
           Ext-VTag = 5678

                      NAT cannot find entry: sends ERROR message
  ERROR [M-Bit, NAT state missing]
10.0.0.1:1 <---------- 100.0.0.1:2
          Ext-VTag = 5678


ASCONF [ADD-IP,DELETE-IP,Int-VTag=1234, Ext-VTag = 5678]
10.0.0.1:1 ----------> 100.1.0.1:2
          Ext-VTag = 5678
```

NAT A	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	5678	2	100.0.0.1

```
        ASCONF [ADD-IP,DELETE-IP,Int-VTag=1234, Ext-VTag = 5678]
                      102.1.0.1:1 ----------------------> 100.1.0.1:2
                                          Ext-VTag = 5678
```

Host B adds new source address and deletes all former entries.

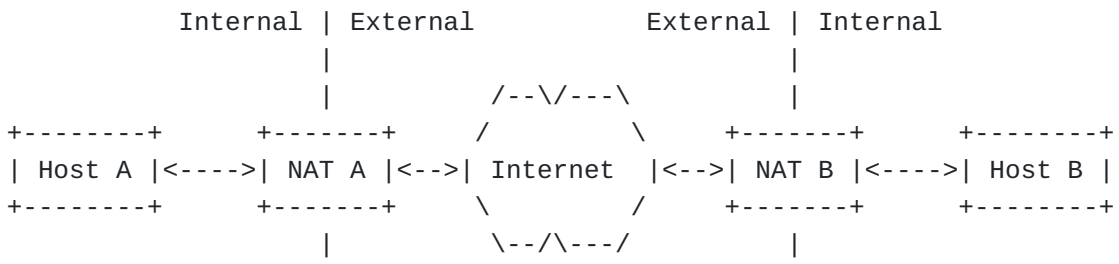
```
                                           ASCONF-ACK
                      102.1.0.1:1 <---------------------- 100.1.0.1:2
                                         Int-VTag = 1234

              ASCONF-ACK
10.1.0.1:1 <---------- 100.1.0.1:2
```



12.5. Peer-to-Peer Communication

TOC

If two hosts are behind NATs, they have to get knowledge of the peer's public address. This can be achieved with a so-called rendezvous server. Afterwards the destination addresses are public, and the association is set up with the help of the INIT collision. The NAT boxes create their entries according to their internal peer's point of view. Therefore, NAT A's Internal-VTag and Internal-Port are NAT B's External-VTag and External-Port, respectively. The naming of the verification tag in the packet flow is done from the sending peer's point of view.



NAT-Tables

NAT A	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr

NAT B	Int v-tag	Int port	Priv addr	Ext v-tag	Ext port	Ext addr

Host A sends INIT:

INIT[Initiate-Tag = 1234]
10.0.0.1:1 --> 100.0.0.1:2
Ext-VTag = 0

NAT A creates entry:

NAT A	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr
	1234	1	10.0.0.1	0	2	100.0.0.1

INIT[Initiate-Tag = 1234]
101.0.0.1:1 ----------> 100.0.0.1:2
Ext-VTag = 0

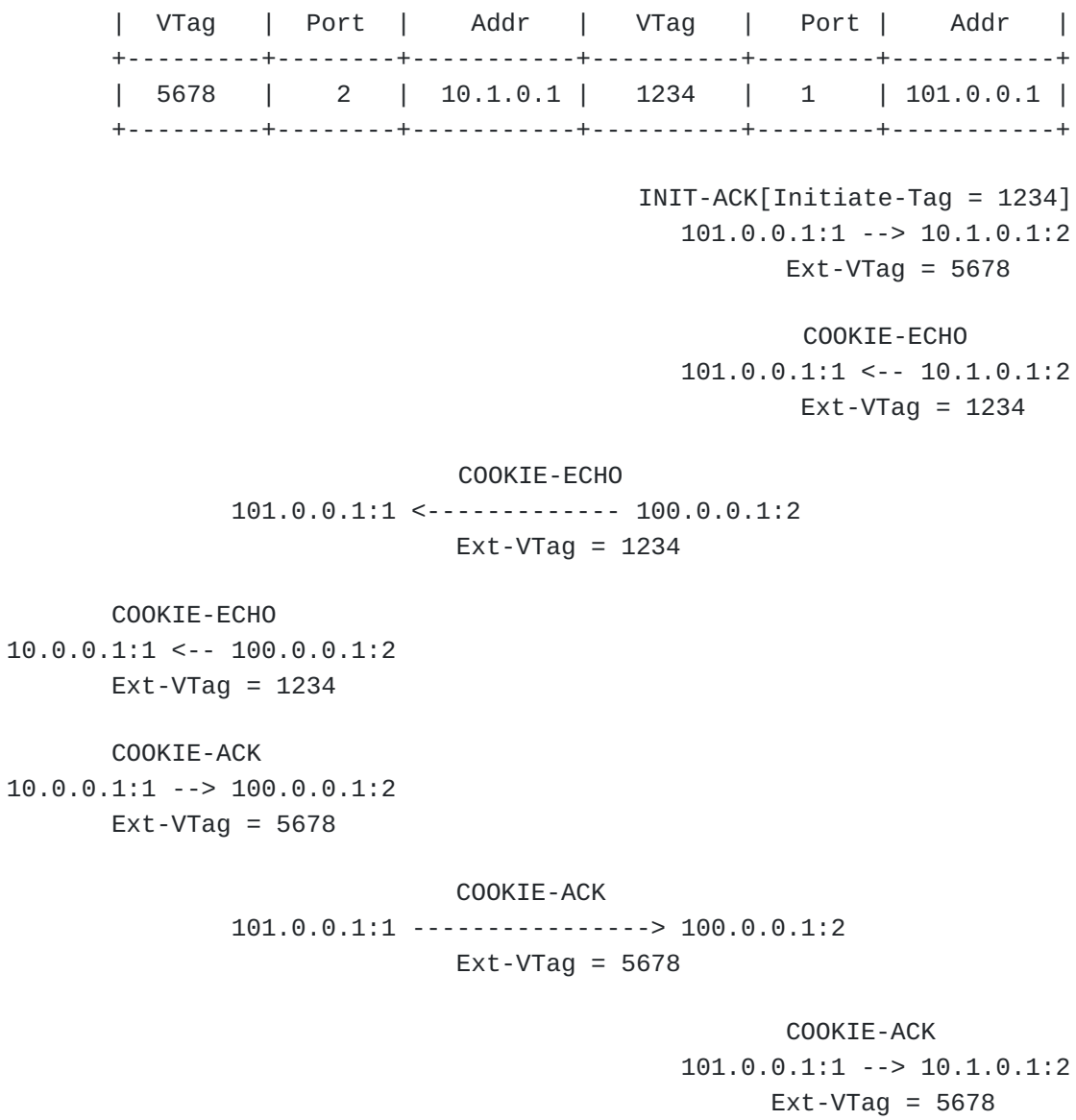
NAT B processes INIT

SCTP packet silently discarded

NAT B	Int VTag	Int Port	Priv Addr	Ext VTag	Ext Port	Ext Addr

Host B sends INIT:

```
                                          INIT[Initiate-Tag = 5678]
                                        101.0.0.1:1 <-- 10.1.0.1:2
                                                    Ext-VTag = 0

                                  NAT B processes INIT:

       +---------+--------+-----------+----------+--------+-----------+
NAT B  |  Int    |  Int   |    Priv   |   Ext    |   Ext  |    Ext    |
       |  VTag   |  Port  |    Addr   |   VTag   |   Port |    Addr   |
       +---------+--------+-----------+----------+--------+-----------+
       |  5678   |    2   |  10.1.0.1 |     0    |    1   | 101.0.0.1 |
       +---------+--------+-----------+----------+--------+-----------+

                                  NAT B forwards INIT:

                          INIT[Initiate-Tag = 5678]
                 101.0.0.1:1  <--------------- 100.0.0.1:2
                                  Ext-VTag = 0

                 NAT A processes INIT and updates entry:

                 VTag != Int-VTag, but Ext-VTag == 0, find entry.
       +---------+--------+-----------+----------+--------+-----------+
NAT A  |  Int    |  Int   |    Priv   |   Ext    |   Ext  |    Ext    |
       |  VTag   |  Port  |    Addr   |   VTag   |   Port |    Addr   |
       +---------+--------+-----------+----------+--------+-----------+
       |   1234  |   1    |  10.0.0.1 |   5678   |    2   | 100.0.0.1 |
       +---------+--------+-----------+----------+--------+-----------+

                 NAT A forwards INIT:

 INIT[Initiate-tag = 5678]
10.0.0.1:1 <-- 100.0.0.1:2
          Ext-VTag = 0

Host A send INIT-ACK:

INIT-ACK[Initiate-Tag = 1234]
10.0.0.1:1 --> 100.0.0.1:2
      Ext-VTag = 5678


                      INIT-ACK[Initiate-Tag = 1234]
                 101.0.0.1:1 ----------------> 100.0.0.1:2
                               Ext-VTag = 5678

                                          NAT B updates entry:

       +---------+--------+-----------+----------+--------+-----------+
NAT B  |  Int    |  Int   |    Priv   |   Ext    |   Ext  |    Ext    |
```



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13. IANA Considerations

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TBD

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14. Security considerations

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

15. Acknowledgments

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16. References

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16.1. Normative References

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16.2. Informative References

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