

Network Configuration Example

Configuring Stateful NAT64 for Handling IPv4 Address Depletion

Release
11.3



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Release 11.3

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Stateful NAT64 Overview

Network Address Translation (NAT) is a mechanism for concealing a set of host addresses on a private network behind a pool of public addresses. NAT64 is a related technology that allows IPv6-only clients to contact IPv4 servers using Unicast UDP, TCP, or ICMP.

A public IPv4 address is shared among several IPv6-only clients. To accomplish this, NAT64 translates incoming IPv6 packets into IPv4 and vice versa. This solution allows ISPs to move to an IPv6 network while simultaneously handling IPv4 address depletion.

When stateful NAT64 is used in conjunction with DNS64, changes are not usually required in the IPv6 client or the IPv4 server. (DNS64 is not covered in this document. For details, see draft-ietf-behave-dns64-11, *DNS64: DNS extensions for Network Address Translation from IPv6 Clients to IPv4 Servers*, October 2010.)

Problems Resolved by NAT64

NAT64 solves the problem of IPv6 clients initiating connections to IPv4 servers. A cornerstone of the architecture is that NAT64 is easily deployable because it does not require changes to either the IPv6 client or the IPv4 server.

NAT64 today works much like a symmetric Network Address Port Translation (NAPT44). In NAPT, both the original source address and the source port are translated. The translated address and port are picked up from the corresponding NAT pool.

IPv6 packets originated by IPv6 clients are transparently translated to IPv4 by a NAT64 device. The device performs the packet header translation according to the IP/ICMP translation algorithm, translating the IPv4 addresses of IPv4 hosts to and from IPv6 addresses and assigning a prefix to the stateful NAT64 function for the translation. For basic functionality, you deploy the stateful NAT64 function in the NAT64 device, in addition to a few DNS64-enabled name servers accessible to the IPv6-only hosts. (For an analysis of the application scenarios, see draft-ietf-behave-v6v4-framework-108, *Framework for IPv4/IPv6 Translation*, August 2010.)

Configuring Address Translation

To perform IPv6-to-IPv4 translation, the NAT64 function binds an IPv6 address and port (called an IPv6 transport address) to an IPv4 address and port (called an IPv4 transport address). The translation maps the IPv6 transport addresses to IPv4 transport addresses and vice-versa. To create these mappings, the router running NAT64 has two pools of addresses: an IPv6 address pool (to represent IPv4 addresses in the IPv6 network) and an IPv4 address pool (to represent IPv6 addresses in the IPv4 network).

The IPv6 address pool is an IPv6 prefix assigned to the translator itself. This release supports only **IPv6 /96** prefixes, both the well-known prefix (**64:FF9B::/96**) and arbitrary **/96** prefixes. Due to the abundance of IPv6 address space, the prefix can be equal to or even bigger than the whole IPv4 address space. This allows each IPv4 address to be mapped into a different IPv6 address by simply concatenating the prefix with the IPv4 address being mapped and a suffix (that is, an IPv4 address X is mapped into the IPv6 address *Prefix:X:Suffix*).

The IPv4 address pool is a set of IPv4 addresses, normally a small prefix assigned by the local administrator. Because IPv4 address space is a scarce resource, the IPv4 address pool is small and typically not sufficient to establish permanent one-to-one mappings with IPv6 addresses. Thus, except for manually created mappings, mappings using the IPv4 address pool are created and released dynamically. Moreover, because of the IPv4 address scarcity, the mapping takes place between transport addresses rather than actual addresses.

For additional details about the translation algorithms, see the following documents:

- draft-ietf-behave-v6v4-xlate-23, *IP/ICMP Translation Algorithm*, September 2010.
- draft-ietf-behave-address-format-10, *IPv6 Addressing of IPv4/IPv6 Translators*, August 2010.

**Related
Documentation**

- [Example: Configuring Stateful NAT64 for Handling IPv4 Address Depletion on page 3](#)
- [Overview of Dual-Stack Lite](#)

Example: Configuring Stateful NAT64 for Handling IPv4 Address Depletion

This example configures Stateful NAT64 on an MX Series 3D Universal Edge router with a Services DPC. The configuration replicates the example flow found in draft-ietf-behave-v6v4-xlate-stateful-12, *Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers*, July 2010.

This example contains the following sections:

- [Requirements on page 3](#)
- [Implementation on page 3](#)
- [Configuration on page 4](#)
- [Verifying NAT64 Operation on page 7](#)

Requirements

This functionality requires the following hardware:

- An MX Series 3D Universal Edge router with a Services DPC or an M Series Multiservice Edge router with a services PIC
- A name server with DNS64

Implementation

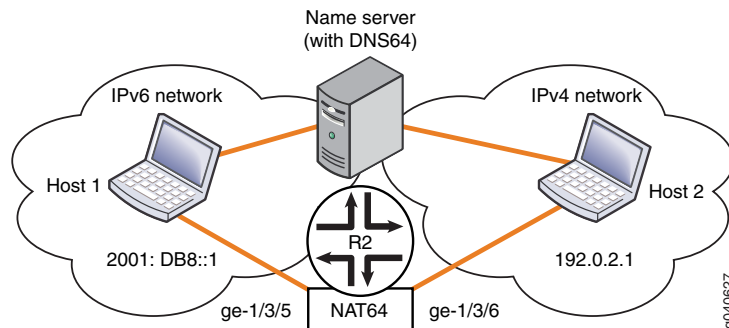
In Junos OS Release 10.2, Juniper Networks implemented stateful NAT64 in its Services Physical Interface Card (PIC) and Services Dense Port Concentrator (DPC). The system steers IPv6 packets coming from IPv6-only hosts to a Services DPC where the packets are translated to IPv4 according to the configuration. In the reverse path, the system sends IPv4 packets to the Services DPC where additional system processes reverse the translation and send the corresponding IPv6 packet back to the client.

Configuration Overview and Topology

[Figure 1 on page 4](#) shows an MX Series router, R2, implementing NAT64 with two Gigabit Ethernet interfaces and a Services DPC. The interface connected to the IPv4 network is **ge-1/3/6**, and the interface connected to the IPv6 network is **ge-1/3/5**.

Also shown is a local name server with DNS64 functionality, which the system uses as part of the translation process. The local name server is configured with the **/96** prefix assigned to the local NAT64 router.

Figure 1: NAT64 Topology



Configuration

To configure stateful NAT64 involves the following tasks:

- [Configuring the PIC and the Interfaces on page 4](#)
- [Configuring the NAT64 Pool on page 6](#)
- [Configuring the Service Set on page 7](#)

Configuring the PIC and the Interfaces

Step-by-Step Procedure

To configure the PIC and interfaces on Router R2:

1. Edit the **chassis** configuration to enable a Layer 3 service package. The service package with its associated service package (**sp-**) interface is used to manipulate traffic before it is delivered to its destination. For details about configuring packages, see the *Junos OS Services Interfaces Configuration Guide*.
2. Configure the service package at the **[edit chassis fpc pic adaptive-services]** hierarchy level. This example assumes that the PIC is in FPC 5, slot 0.

```
[edit chassis]
fpc 5 {
  pic 0 {
    adaptive-services {
      service-package layer-3;
    }
  }
}
```

3. Configure the **ge-1/3/5** interface connected to the IPv6 network.
 - a. Include the **family inet** (IPv4) and **family inet6** (IPv6) statements at the **[edit interfaces interface-name unit unit-number]** hierarchy level.
 - b. Include the IPv6 address at the **[edit interfaces unit unit-number family inet6 address]** hierarchy level.
 - c. Configure a service set at the **[edit interfaces interface-name unit unit-number family service input service-set]** and the **[edit interfaces interface-name unit unit-number family service output service-set]** hierarchy levels.

```
[edit interfaces]
ge-1/3/5 {
  description "IPv6-only domain";
  unit 0 {
    family inet;
    family inet6 {
      service {
        input {
          service-set set_0;
        }
        output {
          service-set set_0;
        }
      }
    }
    address 2001:DB8::1/64;
  }
}
```

4. Configure the **ge-1/3/6** interface connected to the IPv4 network.
 - a. Include the **family inet** statement at the **[edit interfaces unit unit-number]** hierarchy level.
 - b. Include the IPv4 address at the **[edit interfaces unit unit-number family inet]** hierarchy level.

```
[edit interfaces]
ge-1/3/6 {
  description "Internet-IPv4 domain";
  unit 0 {
    family inet {
      address 192.0.1.1/16;
    }
  }
}
```

5. Configure the services interface, in this example, **sp-5/0/0**. This example configures a system log for any services on the local host.

The service package associated with this interface was configured in Step 2. Specify both the IPv4 and IPv6 address families at the **[edit interfaces interface-name unit unit-number]** hierarchy level. The service set you configure in ["Configuring the Service Set" on page 7](#) is associated with this interface.

```
[edit interfaces]
sp-5/0/0 {
  services-options {
    syslog {
      host local {
        services any;
        log-prefix XXXXXXXX;
      }
    }
  }
  unit 0 {
```

```

        family inet;
        family inet6;
    }
}

```

Configuring the NAT64 Pool

Step-by-Step Procedure Use this procedure to configure the NAT64 router, Router R2, with the /96 prefix to represent IPv4 addresses in the IPv6 address space. IPv6 packets addressed to a destination address containing the /96 prefix are then routed to the IPv6 interface of the NAT router. You also configure a single IPv4 transport address for the NAT pool.

This example shows how to configure the network address translation for the IPv4 address 203.0.113.1/32. It also shows how to configure the IPv6 prefix 64:FF9B::/96.

1. Configure an IPv4 transport address for the pool at the **[edit services nat pool *pool-name*]** hierarchy level.

```

[edit services nat]
pool src-pool-nat64 {
    address 203.0.113.0/24;
    port automatic;
}

```

2. Configure a NAT rule to translate the packets from the IPv6 network. NAT rules specify the traffic to be matched and the action to be taken when traffic matches the rule.

In this example, only one rule is required to accomplish the address translation. The rule selects all traffic coming from the source address on the IPv6 network, 2001:DB8::1/128. The transport address configured in Step 1 is then specified for the translation using the /96 prefix.

Configure the rule at the **[edit services nat rule *rule-name*]** hierarchy level as follows:

```

[edit services nat rule]
rule nat64 {
    match-direction input;
    term t1 {
        from {
            source-address {
                2001:DB8::0/96;
            }
            destination-address {
                64:FF9B::/96;
            }
        }
        then {
            translated {
                source-pool src-pool-nat64;
                destination-prefix 64:FF9B::/96;
                translation-type {
                    source dynamic;
                    destination static;
                }
            }
        }
    }
}

```

```

    }
  }
}

```

Configuring the Service Set

Step-by-Step Procedure To configure the service set for the NAT service on Router R2, you need to associate the previously configured rule (**nat64**) and service interface (**sp-5/0/0**) with the service set. You also include a system log configuration.

To configure these settings at the **[edit services service-set *service-set-name*]** hierarchy level:

1. Configure the system log.

```

[edit services service-set set_0]
syslog {
  host local {
    services any;
    log-prefix XXXSVC-SETYYY;
  }
}

```

2. Associate the NAT rule and the service interface with the service set at the **[edit services service-set *service-set-name*]** hierarchy level.

```

[edit services ]
service-set {
  nat-rules nat64;
  interface-service {
    service-interface sp-5/0/0;
  }
}

```

3. On Router R2, commit the configuration.

```

user@R2> commit check
configuration check succeeds
user@R2> commit

```

Verifying NAT64 Operation

You can use the following features to verify your NAT64 configuration:

- CLI commands on the router
- Logging

You can also use a test tool that can generate IPv6 flows directed to the MX Series router, using the well-known prefix (**64:FF9B::/96**) as the destination.

NAT64-related commands leverage the existing commands for NAPT44.

Among others, you can use the following CLI commands to verify your NAT64 configuration:

- **show services stateful-firewall flows**
- **show services stateful-firewall conversations**
- **show services nat pool detail**
- **show services nat mapping detail**
- **show services stateful-firewall statistics extensive**

In this example:

- In the Output (O) direction, the address of the IPv4 network is translated to the IPv6 address of the translation device (NAT source line).
- In the Output direction, the IPv4 transport address is translated to the address of the IPv6 network (NAT dest line).
- In the Input (I) direction, the address of the IPv6 network is translated to the IPv4 transport address (NAT source).
- In the Input direction, the IPv6 address of the translation device is translated to the address of the IPv4 network (NAT dest).

To confirm the NAT64 configuration, perform these tasks:

- [Display NAT64 Flows on page 8](#)
- [Display NAT64 Conversations on page 9](#)
- [Display Global NAT Pool-Related Statistics on page 11](#)
- [Check System Logs on page 11](#)
- [Verify That NAT64 Conversations Take Place on page 12](#)

Display NAT64 Flows

Purpose Display and verify that the NAT64 flows are created and contain correct network address translation.

Action To display the NAT64 flows on Router R2, use the **show services stateful-firewall flows** command.

```
user@R2> show services stateful-firewall flows
```

```
Interface: sp-5/0/0, Service set: set_0
```

Flow		State	Dir	Frm count
TCP	2001:db8::4:1160 -> 64:ff9b::c000:201:80	Forward	I	5
	NAT source 2001:db8::4:1160 -> 203.0.113.1:			
	NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP	2001:db8::2:1166 -> 64:ff9b::c000:201:80	Forward	I	5
	NAT source 2001:db8::2:1166 -> 203.0.113.1:1420			
	NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP	192.0.2.1:80 -> 203.0.113.1:1413	Forward	O	4
	NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:21286			
	NAT dest 203.0.113.1:1413 -> 2001:db8::4:1167			

```

TCP      2001:db8::3:1123  ->64:ff9b::c000:201:80    Forward  I          5
NAT source 2001:db8::3:1123  ->    203.0.113.1:1385
NAT dest  64:ff9b::c000:201:80 ->    192.0.2.1:80
TCP      192.0.2.1:80      ->    203.0.113.1:1376    Forward  O          4
NAT source 192.0.2.1:80      -> 64:ff9b::c000:201:21367
NAT dest  203.0.113.1:1376 ->    2001:db8::3:1120
TCP      2001:db8::3:1136  ->64:ff9b::c000:201:80    Forward  I          5
NAT source 2001:db8::3:1136  ->    203.0.113.1:1424
NAT dest  64:ff9b::c000:201:80 ->    192.0.2.1:80
TCP      2001:db8::4:1146  ->64:ff9b::c000:201:80    Forward  I          5
NAT source 2001:db8::4:1146  ->    203.0.113.1:1350
NAT dest  64:ff9b::c000:201:80 ->    192.0.2.1:80
TCP      2001:db8::3:1110  ->64:ff9b::c000:201:80    Forward  I          5
NAT source 2001:db8::3:1110  ->    203.0.113.1:1346
NAT dest  64:ff9b::c000:201:80 ->    192.0.2.1:80
TCP      192.0.2.1:80      ->    203.0.113.1:1428    Forward  O          4
NAT source 192.0.2.1:80      -> 64:ff9b::c000:201:21367
NAT dest  203.0.113.1:1428 ->    2001:db8::4:1172
TCP      192.0.2.1:80      ->    203.0.113.1:1393    Forward  O          4
NAT source 192.0.2.1:80      -> 64:ff9b::c000:201:80
NAT dest  203.0.113.1:1393 ->    2001:db8::2:1157
TCP      192.0.2.1:80      ->    203.0.113.1:1346    Forward  O          4
NAT source 192.0.2.1:80      -> 64:ff9b::c000:201:21367
NAT dest  203.0.113.1:1346 ->    2001:db8::3:1110
TCP      2001:db8::2:1148  ->64:ff9b::c000:201:80    Forward  I          5
NAT source 2001:db8::2:1148  ->    203.0.113.1:1366
NAT dest  64:ff9b::c000:201:80 ->    192.0.2.1:80
TCP      192.0.2.1:80      ->    203.0.113.1:1363    Forward  O          4

```

Meaning In the sample output, the NAT source and NAT destination addresses of the Input (I) and Output (O) directions are displayed. The NAT64 flows listed in this output are in no specific order.

Display NAT64 Conversations

Purpose Display and verify that the NAT64 conversations (collections of related flows) are correct.

Action To display NAT64 conversations on Router R2, use the **show services stateful-firewall conversations** command. In contrast to the **flows** command that reports all flows in no specific order, the output of the **conversations** command groups the flows that belong to a conversation for easy troubleshooting of communication between a specific pair of hosts.

```
user@R2> show services stateful-firewall conversations
```

```
Interface: sp-5/0/0, Service set: set_0
```

```
Conversation: ALG protocol: tcp
```

```
Number of initiators: 1, Number of responders: 1
```

```

Flow      State  Dir      Frm count
TCP      2001:db8::3:1188  ->64:ff9b::c000:201:80    Forward  I          5
NAT source 2001:db8::3:1188  ->    203.0.113.1:1580
NAT dest  64:ff9b::c000:201:80 ->    192.0.2.1:80
TCP      192.0.2.1:80      ->    203.0.113.1:1580    Forward  O          4
NAT source 192.0.2.1:80      -> 64:ff9b::c000:201:21303
NAT dest  203.0.113.1:1580 ->    2001:db8::3:1188

```

```
Conversation: ALG protocol: tcp
```

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm count
TCP 2001:db8::4:1213 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source 2001:db8::4:1213 -> 203.0.113.1:1551			
NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP 192.0.2.1:80 -> 203.0.113.1:1551	Forward	O	4
NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:21367			
NAT dest 203.0.113.1:1551 -> 2001:db8::4:1213			

Conversation: ALG protocol: tcp

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm count
TCP 2001:db8::3:1169 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source 2001:db8::3:1169 -> 203.0.113.1:1523			
NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP 192.0.2.1:80 -> 203.0.113.1:1523	Forward	O	4
NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:80			
NAT dest 203.0.113.1:1523 -> 2001:db8::3:1169			

Conversation: ALG protocol: tcp

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm count
TCP 2001:db8::2:1233 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source 2001:db8::2:1233 -> 203.0.113.1:1621			
NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP 192.0.2.1:80 -> 203.0.113.1:1621	Forward	O	4
NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:21367			
NAT dest 203.0.113.1:1621 -> 2001:db8::2:1233			

Conversation: ALG protocol: tcp

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm count
TCP 2001:db8::2:1218 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source 2001:db8::2:1218 -> 203.0.113.1:1575			
NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP 192.0.2.1:80 -> 203.0.113.1:1575	Forward	O	4
NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:21367			
NAT dest 203.0.113.1:1575 -> 2001:db8::2:1218			

Conversation: ALG protocol: tcp

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm count
TCP 2001:db8::4:1220 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source 2001:db8::4:1220 -> 203.0.113.1:1572			
NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP 192.0.2.1:80 -> 203.0.113.1:1572	Forward	O	4
NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:21367			
NAT dest 203.0.113.1:1572 -> 2001:db8::4:1220			

Conversation: ALG protocol: tcp

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm count
TCP 2001:db8::2:1211 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source 2001:db8::2:1211 -> 203.0.113.1:1554			
NAT dest 64:ff9b::c000:201:80 -> 192.0.2.1:80			
TCP 192.0.2.1:80 -> 203.0.113.1:1554	Forward	O	4
NAT source 192.0.2.1:80 -> 64:ff9b::c000:201:21286			
NAT dest 203.0.113.1:1554 -> 2001:db8::2:1211			

Conversation: ALG protocol: tcp

Number of initiators: 1, Number of responders: 1

Flow	State	Dir	Frm	count
TCP	2001:db8::2:1227 -> 64:ff9b::c000:201:80	Forward	I	5
NAT source	2001:db8::2:1227 ->	203.0.113.1:1603		
NAT dest	64:ff9b::c000:201:80 ->	192.0.2.1:80		

Meaning The sample output displays the NAT64 conversations between specific pairs of hosts.

Display Global NAT Pool-Related Statistics

Purpose Display and verify global NAT statistics related to pool usage.

Action To display global NAT pool-related statistics on Router R2, use the **show services nat pool detail** command. You normally use this command in conjunction with the **show services stateful-firewall flows** command used in [“Display NAT64 Flows” on page 8](#), which displays the source and output of the translation.

```
user@R2> show services nat pool detail
```

```
Interface: sp-5/0/0, Service set: set_0
NAT pool: src-pool-nat64, Translation type: dynamic
Address range: 203.0.113.1-203.0.113.254
Port range: 512-65535, Ports in use: 102, Out of port errors: 0, Max ports used: 192
NAT pool: _jpool_nat64_t1_, Translation type: static
Address range: 0.100.255.155-0.100.255.154
```

Meaning The sample output displays relevant statistics and information about the NAT64 pools.

Check System Logs

Purpose Check the system logs because the system creates detailed logs as sessions are created and deleted.

Action When a session is created based on the example setup, two logs are provided. The first log indicates the rule and term that the packet matched. The second log indicates the flow creation.

```
user@R2> show log messages
Oct 21 22:14:14 H1 (FPC Slot 5, PIC Slot 0) XXXSVC-SETYYY{set_0}[FWNAT]:
ASP_SFW_CREATE_ACCEPT_FLOW: proto 6 (TCP) application: any,
ge-1/3/5.0:2001:db8:0:0:0:0:0:1:1025 -> 64:ff9b:0:0:0:0:c000:201:80, creating
forward or watch flow ; source address and port translate to 203.0.113.1:1593 ;
destination address translates to 192.0.2.1
```

When the sessions end, the system creates a log indicating the NAT pool address and port release in addition to the delete flow log, as follows:

```
Oct 21 22:14:17 H1 (FPC Slot 5, PIC Slot 0)
XXXSVC-SETYYY{set_0}[FWNAT]:ASP_NAT_POOL_RELEASE: natpool release
203.0.113.1:1593[1]
Oct 21 22:14:17 H1 (FPC Slot 5, PIC Slot 0) XXXSVC-SETYYY{set_0}[FWNAT]:
ASP_SFW_DELETE_FLOW: proto 6 (TCP) application: any,
(null)(null)2001:db8:0:0:0:0:0:1:1025 -> 64:ff9b:0:0:0:0:c000:201:80, deleting
forward or watch flow ; source address and port translate to 203.0.113.1:1593 ;
destination address translates to 192.0.2.1
```

Meaning The sample output displays the log messages that can be seen when a session is created and when a session ends.

Verify That NAT64 Conversations Take Place

Purpose Verify that the NAT64 conversations are taking place. Current support for application-layer gateway (ALG) is limited to ICMP and traceroute.

Action To verify that the NAT64 conversations are occurring on Router R2, use the **show services stateful-firewall conversations** command. The following is sample output for an ICMP echo test (ping).

```
user@R2> show services stateful-firewall conversations
```

```
Interface: sp-5/0/0, Service set: set_0
```

```
Conversation: ALG protocol: icmpv6
```

```
Number of initiators: 1, Number of responders: 1
```

Flow			State	Dir	Frm count
ICMPV6	2001:db8::2	->64:ff9b::c000:201	Watch	I	21
NAT source	2001:db8::2	->	203.0.113.1		
NAT dest	64:ff9b::c000:201	->	192.0.2.1		
ICMP	192.0.2.1	->	203.0.113.1	Watch	0
NAT source	192.0.2.1	->	64:ff9b::c000:201		
NAT dest	203.0.113.1	->	2001:db8::2		

Meaning The sample output displays the results of the ICMP echo test.

- Related Documentation**
- [Stateful NAT64 Overview on page 1](#)
 - Example: Configuring Dual-Stack Lite for IPv6 Access