

Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: February 19, 2018

M. Boucadair
Orange
S. Sivakumar
Cisco Systems
C. Jacquenet
Orange
S. Vinapamula
Juniper Networks
Q. Wu
Huawei
August 18, 2017

**A YANG Data Model for Network Address Translation (NAT) and Network
Prefix Translation (NPT)
draft-ietf-opsawg-nat-yang-00**

Abstract

For the sake of network automation and the need for programming Network Address Translation (NAT) function in particular, a data model for configuring and managing the NAT is essential. This document defines a YANG data model for the NAT function. NAT44, NAT64, and NPTv6 are covered in this document.

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1. Introduction

This document defines a data model for Network Address Translation (NAT) and Network Prefix Translation (NPT) capabilities using the YANG data modeling language [[RFC6020](#)].

Traditional NAT is defined in [[RFC2663](#)], while Carrier Grade NAT (CGN) is defined in [[RFC6888](#)]. Unlike traditional NAT, the CGN is used to optimize the usage of global IP address space at the scale of a domain: a CGN is not managed by end users, but by service providers instead. This document covers both traditional NATs and CGNs.

This document also covers the NAT64 [[RFC6146](#)] and IPv6 Network Prefix Translation (NPTv6) [[RFC6296](#)].

Sample examples are provided in [Appendix A](#).

1.1. Terminology

This document makes use of the following terms:

- o Basic NAT44: translation is limited to IP addresses alone ([Section 2.1 of \[RFC3022\]](#)).
- o Network Address/Port Translator (NAPT): translation in NAPT is extended to include IP addresses and transport identifiers (such as a TCP/UDP port or ICMP query ID); refer to [Section 2.2 of \[RFC3022\]](#).
- o Destination NAT: is a translation that acts on the destination IP address and/or destination port number. This flavor is usually deployed in load balancers or at devices in front of public servers.
- o Port-restricted IPv4 address: An IPv4 address with a restricted port set. Multiple hosts may share the same IPv4 address; however, their port sets must not overlap [[RFC7596](#)].
- o Restricted port set: A non-overlapping range of allowed external ports to use for NAT operation. Source ports of IPv4 packets translated by a NAT must belong to the assigned port set. The port set is used for all port-aware IP protocols [[RFC7596](#)].
- o Internal Host: A host that may solicit a NAT or an NPTv6 (or both) capability to send to and receive traffic from the Internet.
- o Internal Address/prefix: The IP address/prefix of an internal host.

- o External Address: The IP address/prefix assigned by a NAT/NPTv6 to an internal host; this is the address that will be seen by a remote host on the Internet.
- o Mapping: denotes a state at the NAT that is necessary for network address and/or port translation.
- o Dynamic implicit mapping: is created implicitly as a side effect of traffic such as an outgoing TCP SYN or an outgoing UDP packet. A validity lifetime is associated with this mapping.
- o Dynamic explicit mapping: is created as a result of an explicit request, e.g., PCP message [[RFC6887](#)]. A validity lifetime is associated with this mapping.
- o Static explicit mapping: is created manually. This mapping is likely to be maintained by the NAT function till an explicit action is executed to remove it.

The usage of the term NAT in this document refers to any NAT flavor (NAT44, NAT64, etc.) indifferently.

This document uses the term "session" as defined in [[RFC2663](#)] and [[RFC6146](#)] for NAT64.

1.2. Tree Diagrams

The meaning of the symbols in these diagrams is as follows:

- o Brackets "[" and "]" enclose list keys.
- o Curly braces "{" and "}" contain names of optional features that make the corresponding node conditional.
- o Abbreviations before data node names: "rw" means configuration (read-write), "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" a container with presence, and "*" denotes a "list" or "leaf-list".
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.

2. Overview of the NAT YANG Data Model

2.1. Overview

The NAT YANG data model is designed to cover dynamic implicit mappings and static explicit mappings. The required functionality to instruct dynamic explicit mappings is defined in separate documents such as [[I-D.boucadair-pcp-yang](#)]. Considerations about instructing explicit dynamic means (e.g., [[RFC6887](#)], [[RFC6736](#)], or [[RFC8045](#)]) are out of scope.

A single NAT device can have multiple NAT instances; each of these instances is responsible for serving a group of internal hosts. This document does not make any assumption about how internal hosts are associated with a given NAT instance.

The data model assumes that each NAT instance can be enabled/disabled, be provisioned with a specific set of configuration data, and maintains its own mapping tables.

To accommodate deployments where [[RFC6302](#)] is not enabled, this YANG model allows to instruct a NAT function to log the destination port number. The reader may refer to [[I-D.ietf-behave-ipfix-nat-logging](#)] which provides the templates to log the destination ports.

2.2. Various NAT Flavors

The following modes are supported:

1. Basic NAT44
2. NAPT
3. Destination NAT
4. Port-restricted NAT
5. NAT64
6. NPTv6
7. Combination of Basic NAT/NAPT and Destination NAT
8. Combination of port-restricted and Destination NAT

[[I-D.ietf-softwire-dslite-yang](#)] specifies an extension to support DS-Lite.

2.3. TCP, UDP and ICMP NAT Behavioral Requirements

This document assumes [[RFC4787](#)][[RFC5382](#)][[RFC5508](#)] are enabled by default.

Furthermore, the data model relies upon the recommendations detailed in [[RFC6888](#)] and [[RFC7857](#)].

2.4. Other Transport Protocols

The module is structured to support other protocols than UDP, TCP, and ICMP. The mapping table is designed so that it can indicate any transport protocol. For example, this module may be used to manage a DCCP-capable NAT that adheres to [\[RFC5597\]](#).

Future extensions can be defined to cover NAT-related considerations that are specific to other transport protocols such as SCTP [\[I-D.ietf-tsvwg-natsupp\]](#). Typically, the mapping entry can be extended to record two optional SCTP-specific parameters: Internal Verification Tag (Int-VTag) and External Verification Tag (Ext-VTag).

2.5. IP Addresses Used for Translation

This data model assumes that blocks of IP external addresses (external-ip-address-pool) can be provisioned to the NAT function. These blocks may be contiguous or not.

This behavior is aligned with [\[RFC6888\]](#) which specifies that a NAT function should not have any limitations on the size or the contiguity of the external address pool. In particular, the NAT function must be configurable with contiguous or non-contiguous external IPv4 address ranges.

Likewise, one or multiple IP address pools may be configured for Destination NAT (dst-ip-address-pool).

2.6. Port Set Assignment

Port numbers can be assigned by a NAT individually (that is, a single port is assigned on a per session basis). Nevertheless, this port allocation scheme may not be optimal for logging purposes. Therefore, a NAT function should be able to assign port sets (e.g., [\[RFC7753\]](#)) to optimize the volume of the logging data (REQ-14 of [\[RFC6888\]](#)). Both features are supported in the NAT YANG data model.

When port set assignment is activated (i.e., port-allocation-type==port-range-allocation), the NAT can be provided with the size of the port set to be assigned (port-set-size).

2.7. Port-Restricted IP Addresses

Some NATs require to restrict the port numbers (e.g., Lightweight 4over6 [\[RFC7596\]](#), MAP-E [\[RFC7597\]](#)). Two schemes of port set assignments (port-set-restrict) are supported in this document:

- o Simple port range: is defined by two port values, the start and the end of the port range [[RFC8045](#)].
- o Algorithmic: an algorithm is defined in [[RFC7597](#)] to characterize the set of ports that can be used.

2.8. NAT Mapping Entries

A TCP/UDP mapping entry maintains an association between the following information:

```
(internal-src-address, internal-src-port) (internal-dst-address,  
internal-dst-port) <=> (external-src-address, external-src-port)  
(external-dst-address, external-dst-port)
```

An ICMP mapping entry maintains an association between the following information:

```
(internal-src-address, internal-dst-address, internal ICMP/ICMPv6  
identifier) <=> (external-src-address, external-dst-address,  
external ICMP/ICMPv6 identifier)
```

To cover TCP, UDP, and ICMP, the NAT YANG model assumes the following structure of a mapping entry:

type: Indicates how the mapping was instantiated. For example, it may indicate whether a mapping is dynamically instantiated by a packet or statically configured.

transport-protocol: Indicates the transport protocol (e.g., UDP, TCP, ICMP) of a given mapping.

internal-src-address: Indicates the source IP address as used by an internal host.

internal-src-port: Indicates the source port number (or ICMP identifier) as used by an internal host.

external-src-address: Indicates the source IP address as assigned by the NAT.

external-src-port: Indicates the source port number (or ICMP identifier) as assigned by the NAT.

internal-dst-address: Indicates the destination IP address as used by an internal host when sending a packet to a remote host.

internal-dst-port: Indicates the destination IP address as used by an internal host when sending a packet to a remote host.

external-dst-address: Indicates the destination IP address used by a NAT when processing a packet issued by an internal host towards a remote host.

external-dst-port: Indicates the destination port number used by a NAT when processing a packet issued by an internal host towards a remote host.

In order to cover both NAT64 and NAT44 flavors in particular, the NAT mapping structure allows to include an IPv4 or an IPv6 address as an internal IP address. Remaining fields are common to both NAT schemes.

For example, the mapping that will be created by a NAT64 upon receipt of a TCP SYN from source address 2001:db8:aaaa::1 and source port number 25636 to destination IP address 2001:db8:1234::198.51.100.1 and destination port number 8080 is characterized as follows:

- o type: dynamically implicit mapping.
- o transport-protocol: TCP (6)
- o internal-src-address: 2001:db8:aaaa::1
- o internal-src-port: 25636
- o external-src-address: T (an IPv4 address configured on the NAT64)
- o external-src-port: t (a port number that is chosen by the NAT64)
- o internal-dst-address: 2001:db8:1234::198.51.100.1
- o internal-dst-port: 8080
- o external-dst-address: 198.51.100.1
- o external-dst-port: 8080

The mapping that will be created by a NAT44 upon receipt of an ICMP request from source address 198.51.100.1 and ICMP identifier (ID1) to destination IP address 198.51.100.11 is characterized as follows:

- o type: dynamically implicit mapping.
- o transport-protocol: ICMP (1)
- o internal-src-address: 198.51.100.1
- o internal-src-port: ID1
- o external-src-address: T (an IPv4 address configured on the NAT44)
- o external-src-port: ID2 (an ICMP identifier that is chosen by the NAT44)
- o internal-dst-address: 198.51.100.11

The mapping that will be created by a NAT64 upon receipt of an ICMP request from source address 2001:db8:aaaa::1 and ICMP identifier

(ID1) to destination IP address 2001:db8:1234::198.51.100.1 is characterized as follows:

- o type: dynamically implicit mapping.
- o transport-protocol: ICMPv6 (58)
- o internal-src-address: 2001:db8:aaaa::1
- o internal-src-port: ID1
- o external-src-address: T (an IPv4 address configured on the NAT64)
- o external-src-port: ID2 (an ICMP identifier that is chosen by the NAT64)
- o internal-dst-address: 2001:db8:1234::198.51.100.1
- o external-dst-address: 198.51.100.1

Note that a mapping table is maintained only for stateless NAT functions. Obviously, no mapping table is maintained for NPTv6 given that it is stateless and transport-agnostic.

2.9. Resource Limits

In order to comply with CGN deployments in particular, the data model allows limiting the number of external ports per subscriber (port-quota) and the amount of state memory allocated per mapping and per subscriber (mapping-limit and connection-limit). According to [\[RFC6888\]](#), the model allows for the following:

- o Per-subscriber limits are configurable by the NAT administrator.
- o Per-subscriber limits are configurable independently per transport protocol.
- o Administrator-adjustable thresholds to prevent a single subscriber from consuming excessive CPU resources from the NAT (e.g., rate-limit the subscriber's creation of new mappings) can be configured.

2.10. Tree Structure

The tree structure of the NAT data model is provided below:

```

module: ietf-nat
  +--rw nat-module
    +--rw nat-instances
      +--rw nat-instance* [id]
        +--rw id                               uint32
        +--rw name?                             string
        +--rw enable?                           boolean
        +--ro nat-capabilities
        | +--ro nat-flavor*                       identityref

```



```

| +--ro nat44-flavor*                               identityref
| +--ro restricted-port-support?                     boolean
| +--ro static-mapping-support?                     boolean
| +--ro port-randomization-support?                 boolean
| +--ro port-range-allocation-support?              boolean
| +--ro port-preservation-suport?                   boolean
| +--ro port-parity-preservation-support?            boolean
| +--ro address-roundrobin-support?                 boolean
| +--ro paired-address-pooling-support?              boolean
| +--ro endpoint-independent-mapping-support?        boolean
| +--ro address-dependent-mapping-support?           boolean
| +--ro address-and-port-dependent-mapping-support?  boolean
| +--ro endpoint-independent-filtering-support?       boolean
| +--ro address-dependent-filtering?                 boolean
| +--ro address-and-port-dependent-filtering?        boolean
+--rw external-ip-address-pool* [pool-id]
| +--rw pool-id                                     uint32
| +--rw external-ip-pool?   inet:ipv4-prefix
+--rw port-set-restrict
| +--rw (port-type)?
|   +--:(port-range)
|     | +--rw start-port-number?   inet:port-number
|     | +--rw end-port-number?     inet:port-number
|     +--:(port-set-algo)
|       +--rw psid-offset?          uint8
|       +--rw psid-len              uint8
|       +--rw psid                  uint16
+--rw dst-nat-enable?                boolean
+--rw dst-ip-address-pool* [pool-id]
| +--rw pool-id                       uint32
| +--rw dst-in-ip-pool?               inet:ip-prefix
| +--rw dst-out-ip-pool?              inet:ip-prefix
+--rw nat64-prefixes* [nat64-prefix]
| +--rw nat64-prefix                  inet:ipv6-prefix
| +--rw destination-ipv4-prefix* [ipv4-prefix]
|   +--rw ipv4-prefix                 inet:ipv4-prefix
+--rw nptv6-prefixes* [pool-id]
| +--rw pool-id                       uint32
| +--rw internal-ipv6-prefix?         inet:ipv6-prefix
| +--rw external-ipv6-prefix?        inet:ipv6-prefix
+--rw supported-transport-protocols* [transport-protocol-id]
| +--rw transport-protocol-id         uint8
| +--rw transport-protocol-name?      string
+--rw subscriber-mask-v6?             uint8
+--rw subscriber-match* [sub-match-id]
| +--rw sub-match-id                  uint32
| +--rw sub-mask                      inet:ip-prefix
+--rw nat-pass-through* [nat-pass-through-id]

```



```
| +--rw nat-pass-through-id      uint32
| +--rw nat-pass-through-pref?   inet:ip-prefix
| +--rw nat-pass-through-port?   inet:port-number
+--rw paired-address-pooling?     boolean
+--rw nat-mapping-type?          enumeration
+--rw nat-filtering-type?        enumeration
+--rw port-quota* [quota-type]
| +--rw port-limit?             uint16
| +--rw quota-type              enumeration
+--rw port-allocation-type?      enumeration
+--rw address-roundrobin-enable? boolean
+--rw port-set
| +--rw port-set-size?          uint16
| +--rw port-set-timeout?       uint32
+--rw udp-timeout?               uint32
+--rw tcp-idle-timeout?          uint32
+--rw tcp-trans-open-timeout?    uint32
+--rw tcp-trans-close-timeout?   uint32
+--rw tcp-in-syn-timeout?        uint32
+--rw fragment-min-timeout?      uint32
+--rw icmp-timeout?             uint32
+--rw per-port-timeout* [port-number]
| +--rw port-number             inet:port-number
| +--rw port-timeout            inet:port-number
+--rw hold-down-timeout?         uint32
+--rw hold-down-max?            uint32
+--rw mapping-limit
| +--rw limit-per-subscriber?    uint32
| +--rw limit-per-vrf?          uint32
| +--rw limit-per-subnet?       inet:ip-prefix
| +--rw limit-per-instance      uint32
| +--rw limit-per-udp           uint32
| +--rw limit-per-tcp           uint32
| +--rw limit-per-icmp          uint32
+--rw connection-limit
| +--rw limit-per-subscriber?    uint32
| +--rw limit-per-vrf?          uint32
| +--rw limit-per-subnet?       inet:ip-prefix
| +--rw limit-per-instance      uint32
| +--rw limit-per-udp           uint32
| +--rw limit-per-tcp           uint32
| +--rw limit-per-icmp          uint32
+--rw algs* [alg-name]
| +--rw alg-name                string
| +--rw alg-transport-protocol?  uint32
| +--rw alg-transport-port?      inet:port-number
| +--rw alg-status?             boolean
+--rw all-algs-enable?          boolean
```



```
+--rw logging-info
| +--rw logging-enable?          boolean
| +--rw destination-address      inet:ip-prefix
| +--rw destination-port        inet:port-number
| +--rw (protocol)?
|   +--:(syslog)
|     | +--rw syslog?            boolean
|     +--:(ipfix)
|       | +--rw ipfix?           boolean
|       +--:(ftp)
|         +--rw ftp?             boolean
+--rw notify-pool-usage
| +--rw pool-id?                 uint32
| +--rw notify-pool-hi-threshold percent
| +--rw notify-pool-low-threshold? percent
+--rw mapping-table
| +--rw mapping-entry* [index]
|   +--rw index                  uint32
|   +--rw type?                  enumeration
|   +--rw transport-protocol     uint8
|   +--rw internal-src-address   inet:ip-prefix
|   +--rw internal-src-port
|     | +--rw (port-type)?
|     |   +--:(single-port-number)
|     |     | +--rw single-port-number?  inet:port-number
|     |     +--:(port-range)
|     |       +--rw start-port-number?    inet:port-number
|     |       +--rw end-port-number?      inet:port-number
|   +--rw external-src-address   inet:ip-prefix
|   +--rw external-src-port
|     | +--rw (port-type)?
|     |   +--:(single-port-number)
|     |     | +--rw single-port-number?  inet:port-number
|     |     +--:(port-range)
|     |       +--rw start-port-number?    inet:port-number
|     |       +--rw end-port-number?      inet:port-number
|   +--rw internal-dst-address?   inet:ip-prefix
|   +--rw internal-dst-port
|     | +--rw (port-type)?
|     |   +--:(single-port-number)
|     |     | +--rw single-port-number?  inet:port-number
|     |     +--:(port-range)
|     |       +--rw start-port-number?    inet:port-number
|     |       +--rw end-port-number?      inet:port-number
|   +--rw external-dst-address?   inet:ip-prefix
|   +--rw external-dst-port
|     | +--rw (port-type)?
|     |   +--:(single-port-number)
```



```

|      |      |  +--rw single-port-number?  inet:port-number
|      |      +--:(port-range)
|      |      +--rw start-port-number?      inet:port-number
|      |      +--rw end-port-number?        inet:port-number
|      +--rw lifetime?                      uint32
+--ro statistics
  +--ro traffic-statistics
    | +--ro sent-packet?      yang:zero-based-counter64
    | +--ro sent-byte?       yang:zero-based-counter64
    | +--ro rcvd-packet?     yang:zero-based-counter64
    | +--ro rcvd-byte?       yang:zero-based-counter64
    | +--ro dropped-packet?   yang:zero-based-counter64
    | +--ro dropped-byte?     yang:zero-based-counter64
  +--ro mapping-statistics
    | +--ro total-mappings?    uint32
    | +--ro total-tcp-mappings? uint32
    | +--ro total-udp-mappings? uint32
    | +--ro total-icmp-mappings? uint32
  +--ro pool-stats
    +--ro pool-id?            uint32
    +--ro address-allocated?  uint32
    +--ro address-free?       uint32
    +--ro port-stats
      +--ro ports-allocated?  uint32
      +--ro ports-free?       uint32

```

notifications:

```

+---n nat-event
  +--ro id?                                -> /nat-module/nat-instances/nat-
instance/id
  +--ro notify-pool-threshold              percent

```

3. NAT YANG Module

<CODE BEGINS> file "ietf-nat@2017-08-03.yang"

```

module ietf-nat {
  namespace "urn:ietf:params:xml:ns:yang:ietf-nat";

  //namespace to be assigned by IANA
  prefix "nat";

  import ietf-inet-types { prefix inet; }
  import ietf-yang-types { prefix yang; }

  organization "IETF OPSAWG Working Group";

  contact

```


"Mohamed Boucadair <mohamed.boucadair@orange.com>
Senthil Sivakumar <ssenthil@cisco.com>
Christsian Jacquenet <christian.jacquenet@orange.com>
Suresh Vinapamula <sureshk@juniper.net>
Qin Wu <bill.wu@huawei.com>";

description

"This module is a YANG module for NAT implementations
(including NAT44 and NAT64 flavors).

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

```
revision 2017-08-03 {
  description "Integrates comments from OPSAWG CFA.";
  reference "-08";
}

revision 2017-07-03 {
  description "Integrates comments from D. Wing and T. Zhou.";
  reference "-07";
}

revision 2015-09-08 {
  description "Fixes few YANG errors.";

  reference "-02";
}

revision 2015-09-07 {
  description "Completes the NAT64 model.";
  reference "01";
}

revision 2015-08-29 {
  description "Initial version.";
  reference "00";
}
```



```
/*
 * Definitions
 */

typedef percent {
    type uint8 {
        range "0 .. 100";
    }
    description
        "Percentage";
}

/*
 * Identities
 */

identity nat-type {
    description
        "Base identity for nat type.";
}

identity nat44 {
    base nat:nat-type;
    description
        "Identity for traditional NAT support.";

    reference
        "RFC 3022";
}

identity basic-nat {
    //base nat:nat-type;
    base nat:nat44;
    description
        "Identity for Basic NAT support.";

    reference
        "RFC 3022";
}

identity napt {
    //base nat:nat-type;
    base nat:nat44;
    description
        "Identity for NAPT support.";

    reference
        "RFC 3022";
}
```



```
}

identity restricted-nat {
  //base nat:nat-type;
  base nat:nat44;
  description
    "Identity for Port-Restricted NAT support.";

  reference
    "RFC 7596.";
}
```

```
identity dst-nat {
  base nat:nat-type;
  description
    "Identity for Destination NAT support.";
}
```

```
identity nat64 {
  base nat:nat-type;
  description
    "Identity for NAT64 support.";

  reference
    "RFC 6146.";
}
```

```
identity nptv6 {
  base nat:nat-type;
  description
    "Identity for NPTv6 support.";

  reference
    "RFC 6296.";
}
```

```
/*
 * Grouping
 */
```

```
// Timers
```

```
grouping timeouts {
  description
    "Configure values of various timeouts.";
}
```



```
leaf udp-timeout {
  type uint32;
  units "seconds";
  default 300;
  description
    "UDP inactivity timeout. That is the time a mapping
     will stay active without packets traversing the NAT.";

  reference
    "RFC 4787.";
}

leaf tcp-idle-timeout {
  type uint32;
  units "seconds";
  default 7440;
  description
    "TCP Idle timeout should be
     2 hours and 4 minutes.";

  reference
    "RFC 5382.";
}

leaf tcp-trans-open-timeout {
  type uint32;
  units "seconds";
  default 240;
  description
    "The value of the transitory open connection
     idle-timeout.
     Section 2.1 of \[RFC7857\] clarifies that a NAT
     should provide different configurable

     parameters for configuring the open and
     closing idle timeouts.
     To accommodate deployments that consider
     a partially open timeout of 4 minutes as being
     excessive from a security standpoint, a NAT may
     allow the configured timeout to be less than
     4 minutes.
     However, a minimum default transitory connection
     idle-timeout of 4 minutes is recommended.";

  reference
    "RFC 7857.";
}
```



```
leaf tcp-trans-close-timeout {
  type uint32;
  units "seconds";
  default 240;
  description
    "The value of the transitory close connection
    idle-timeout.
    Section 2.1 of \[RFC7857\] clarifies that a NAT
    should provide different configurable
    parameters for configuring the open and
    closing idle timeouts.";

  reference
    "RFC 7857.";
}

leaf tcp-in-syn-timeout {
  type uint32;
  units "seconds";
  default 6;
  description
    "A NAT must not respond to an unsolicited
    inbound SYN packet for at least 6 seconds
    after the packet is received. If during
    this interval the NAT receives and translates
    an outbound SYN for the connection the NAT
    must silently drop the original unsolicited
    inbound SYN packet.";

  reference
    "RFC 5382.";
}

leaf fragment-min-timeout {

  type uint32;
  units "seconds";
  default 2;
  description
    "As long as the NAT has available resources,
    the NAT allows the fragments to arrive
    over fragment-min-timeout interval.
    The default value is inspired from RFC6146.";
}

leaf icmp-timeout {
  type uint32;
  units "seconds";
```



```
    default 60;
    description
        "An ICMP Query session timer must not expire
        in less than 60 seconds. It is recommended
        that the ICMP Query session timer be made
        configurable";

    reference
        "RFC 5508.";
}

list per-port-timeout {
    key port-number;

    description
        "Some NATs are configurable with short timeouts
        for some ports, e.g., as 10 seconds on
        port 53 (DNS) and NTP (123) and longer timeouts
        on other ports.";

    leaf port-number {
        type inet:port-number;
        description
            "A port number.";
    }

    leaf port-timeout {
        type inet:port-number;
        mandatory true;
        description
            "Timeout for this port";
    }
}

leaf hold-down-timeout {

    type uint32;
    units "seconds";
    default 120;
    description
        "Hold down timer. Ports in the
        hold down pool are not reassigned until
        this timer expires.
        The length of time and the maximum
        number of ports in this state must be
        configurable by the administrator
        [RFC6888]. This is necessary in order
        to prevent collisions between old
```


and new mappings and sessions. It ensures that all established sessions are broken instead of redirected to a different peer.";

```
reference
    "REQ#8 of RFC 6888.";
}
```

```
leaf hold-down-max {
```

```
    type uint32;
```

```
    description
```

"Maximum ports in the Hold down timer pool. Ports in the hold down pool are not reassigned until hold-down-timeout expires. The length of time and the maximum number of ports in this state must be configurable by the administrator [[RFC6888](#)]. This is necessary in order to prevent collisions between old and new mappings and sessions. It ensures that all established sessions are broken instead of redirected to a different peer.";

```
reference
    "REQ#8 of RFC 6888.";
}
}
```

```
// Set of ports
```

```
grouping port-set {
```

```
    description
```

"Indicates a set of ports. It may be a simple port range, or use the PSID algorithm to represent a range of transport layer ports which will be used by a NAPT.";

```
    choice port-type {
```

```
        default port-range;
```

```
        description
```

"Port type: port-range or port-set-algo.";

```
        case port-range {
```

```
            leaf start-port-number {
```



```
        type inet:port-number;
        description
            "Begining of the port range.";

        reference
            "Section 3.2.9 of RFC 8045";
    }

    leaf end-port-number {

        type inet:port-number;
        description
            "End of the port range.";

        reference
            "Section 3.2.10 of RFC 8045";
    }
}

case port-set-algo {

    leaf psid-offset {
        type uint8 {
            range 0..16;
        }
        description
            "The number of offset bits. In Lightweight 4over6,
            the default value is 0 for assigning one contiguous
            port range. In MAP-E/T, the default value is 6,
            which excludes system ports by default and assigns
            port ranges distributed across the entire port space.";
    }

    leaf psid-len {
        type uint8 {
            range 0..15;
        }
        mandatory true;
        description
            "The length of PSID, representing the sharing ratio for an
            IPv4 address.";
    }

    leaf psid {
        type uint16;
        mandatory true;
        description
            "Port Set Identifier (PSID) value, which identifies a set
```



```
        of ports algorithmically.";
    }
}

}

// port numbers: single or port-range

grouping port-number {
    description
        "Individual port or a range of ports.";

    choice port-type {
        default single-port-number;
        description
            "Port type: single or port-range.";

        case single-port-number {
            leaf single-port-number {
                type inet:port-number;
                description
                    "Used for single port numbers.";
            }
        }

        case port-range {
            leaf start-port-number {
                type inet:port-number;
                description
                    "Begining of the port range.";

                reference
                    "Section 3.2.9 of RFC 8045.";
            }

            leaf end-port-number {
                type inet:port-number;
                description
                    "End of the port range.";

                reference
                    "Section 3.2.10 of RFC 8045.";
            }
        }
    }
}
```



```
// Mapping Entry
```

```
    grouping mapping-entry {
        description
            "NAT mapping entry.";

        leaf index {
            type uint32;
            description
                "A unique identifier of a mapping entry.";
        }

        leaf type {
            type enumeration {
                enum "static" {
                    description
                        "The mapping entry is manually configured.";
                }

                enum "dynamic-explicit" {
                    description
                        "This mapping is created by an outgoing
                        packet.";
                }

                enum "dynamic-implicit" {
                    description
                        "This mapping is created by an explicit
                        dynamic message.";
                }
            }
            description
                "Indicates the type of a mapping entry. E.g.,
                a mapping can be: static, implicit dynamic or explicit
dynamic.";
        }

        leaf transport-protocol {
            type uint8;
            mandatory true;
            description
                "Upper-layer protocol associated with this mapping.
                Values are taken from the IANA protocol registry.
                For example, this field contains 6 (TCP) for a TCP
                mapping or 17 (UDP) for a UDP mapping.";
        }

        leaf internal-src-address {
```

```
type inet:ip-prefix;
```

```
    mandatory true;
    description
      "Corresponds to the source IPv4/IPv6 address/prefix
       of the packet received on an internal
       interface.";
  }

  container internal-src-port {

    description
      "Corresponds to the source port of the
       packet received on an internal interface.
       It is used also to carry the internal
       source ICMP identifier.";

    uses port-number;

  }

  leaf external-src-address {
    type inet:ip-prefix;
    mandatory true;
    description
      "Source IP address/prefix of the packet sent
       on an external interface of the NAT.";
  }

  container external-src-port {

    description
      "Source port of the packet sent
       on an external interafce of the NAT.
       It is used also to carry the external
       source ICMP identifier.";

    uses port-number;

  }

  leaf internal-dst-address {
    type inet:ip-prefix;
    description
      "Corresponds to the destination IP address/prefix
       of the packet received on an internal interface of the NAT.
       For example, some NAT implementations support the translation

       both source and destination addresses and ports,
       sometimes referred to as 'Twice NAT'.";
  }
}
```

of


```
    container internal-dst-port {

        description
            "Corresponds to the destination port of the
             IP packet received on the internal interface.

             It is used also to carry the internal
             destination ICMP identifier.";

        uses port-number;
    }

    leaf external-dst-address {
        type inet:ip-prefix;
        description
            "Corresponds to the destination IP address/prefix
             of the packet sent on an external interface of the NAT.";
    }

    container external-dst-port {

        description
            "Corresponds to the destination port number of
             the packet sent on the external interface of the NAT.
             It is used also to carry the external
             destination ICMP identifier.";

        uses port-number;
    }

    leaf lifetime {
        type uint32;
        //mandatory true;

        description
            "When specified, it tracks the connection that is
             fully-formed (e.g., once the 3WHS TCP is completed)
             or the duration for maintaining an explicit mapping
             alive. Static mappings may not be associated with a
             lifetime. If no lifetime is associated with a
             static mapping, an explicit action is required to
             remove that mapping.";
    }
}

grouping nat-parameters {
    description
        "NAT parameters for a given instance";
```



```
list external-ip-address-pool {
    key pool-id;

    description
    "Pool of external IP addresses used to service
    internal hosts.
    Both contiguous and non-contiguous pools
    can be configured for NAT purposes.";

    leaf pool-id {
        type uint32;
        description
        "An identifier of the address pool.";
    }

    leaf external-ip-pool {
        type inet:ipv4-prefix;
        description

        "An IPv4 prefix used for NAT purposes.";
    }
}

container port-set-restrict {

    when "../nat-capabilities/restricted-port-support = 'true' ";

    description
    "Configures contiguous and non-contiguous port ranges";

    uses port-set;
}

leaf dst-nat-enable {
    type boolean;
    default false;

    description
    "Enable/Disable destination NAT.
    A NAT44 may be configured to enable Destination NAT, too.";
}

list dst-ip-address-pool {
    //if-feature dst-nat;
    when "../nat-capabilities/nat-flavor = 'dst-nat' ";

    key pool-id;
```



```
description
  "Pool of IP addresses used for destination NAT.";

leaf pool-id {
  type uint32;
  description
    "An identifier of the address pool.";
}

leaf dst-in-ip-pool {
  type inet:ip-prefix;
  description
    "Internal IP prefix/address";
}

leaf dst-out-ip-pool {
  type inet:ip-prefix;
  description
    "IP address/prefix used for destination NAT.";
}
}

list nat64-prefixes {

  //if-feature nat64;
  when "../nat-capabilities/nat-flavor = 'nat64' ";

  key nat64-prefix;

  description
    "Provides one or a list of NAT64 prefixes
    with or without a list of destination IPv4 prefixes.

    Destination-based Pref64::/n is discussed in
    Section 5.1 of \[RFC7050\]). For example:
    192.0.2.0/24 is mapped to 2001:db8:122:300::/56.
    198.51.100.0/24 is mapped to 2001:db8:122::/48.";

  reference
    "Section 5.1 of RFC7050.";

  leaf nat64-prefix {
    type inet:ipv6-prefix;
    //default "64:ff9b::/96";

    description
```



```
    "A NAT64 prefix. Can be NSP or a Well-Known
    Prefix (WKP).";

    reference
      "RFC 6052";
  }

  list destination-ipv4-prefix {

    key ipv4-prefix;

    description
      "An IPv4 prefix/address.";

    leaf ipv4-prefix {
      type inet:ipv4-prefix;
      description
        "An IPv4 address/prefix.";
    }
  }
}

list nptv6-prefixes {

  //if-feature nptv6;

  when "../nat-capabilities/nat-flavor = 'nptv6' ";

  key pool-id;

  description
    "Provides one or a list of (internal IPv6 prefix,
    external IPv6 prefix) required for NPTv6.

    In its simplest form, NPTv6 interconnects two network
    links, one of which is an 'internal' network link attached
    to a leaf network within a single administrative domain
    and the other of which is an 'external' network with
    connectivity to the global Internet.";

  reference
    "RFC 6296";

  leaf pool-id {
    type uint32;
    description
```



```
        "An identifier of the NPTv6 prefixes.";
    }

    leaf internal-ipv6-prefix {
        type inet:ipv6-prefix;

        description
            "An IPv6 prefix used by an internal interface of
            NPTv6.";

        reference
            "RFC 6296.";
    }

    leaf external-ipv6-prefix {
        type inet:ipv6-prefix;

        description
            "An IPv6 prefix used by the external interface of
            NPTv6.";

        reference
            "RFC 6296.";
    }
}

list supported-transport-protocols {

    key transport-protocol-id;

    description
        "Supported transport protocols.
        TCP and UDP are supported by default.";

    leaf transport-protocol-id {
        type uint8;
        mandatory true;
        description
            "Upper-layer protocol associated with this mapping.
            Values are taken from the IANA protocol registry.
            For example, this field contains 6 (TCP) for a TCP
            mapping or 17 (UDP) for a UDP mapping.";
    }

    leaf transport-protocol-name {
        type string;
        description
            "For example, TCP, UDP, DCCP, and SCTP.";
```



```
    }  
  }  
  
  leaf subscriber-mask-v6 {  
    type uint8 {  
      range "0 .. 128";  
    }  
  
    description  
      "The subscriber-mask is an integer that indicates  
      the length of significant bits to be applied on  
      the source IP address (internal side) to  
      unambiguously identify a CPE.  
  
      Subscriber-mask is a system-wide configuration  
      parameter that is used to enforce generic  
      per-subscriber policies (e.g., port-quota).  
  
      The enforcement of these generic policies does not  
      require the configuration of every subscriber's  
      prefix.  
  
      Example: suppose the 2001:db8:100:100::/56 prefix  
      is assigned to a NAT64 serviced CPE. Suppose also  
      that 2001:db8:100:100::1 is the IPv6 address used  
      by the client that resides in that CPE. When the  
      NAT64 receives a packet from this client,  
      it applies the subscriber-mask (e.g., 56) on  
      the source IPv6 address to compute the associated  
      prefix for this client (2001:db8:100:100::/56).  
      Then, the NAT64 enforces policies based on that  
      prefix (2001:db8:100:100::/56), not on the exact  
      source IPv6 address."  
  }  
  
  list subscriber-match {  
  
    key sub-match-id;  
  
    description  
      "IP prefix match."  
  
    leaf sub-match-id {  
      type uint32;  
      description  
        "An identifier of the subscriber masck."  
    }  
  }
```



```
    leaf sub-mask {
      type inet:ip-prefix;
      mandatory true;
      description
        "The IP address subnets that match
        should be translated. E.g., all addresses
        that belong to the 192.0.2.0/24 prefix must
        be processed by the NAT.";
    }
  }

  list nat-pass-through {

    key nat-pass-through-id;

    description
      "IP prefix NAT pass through.";

    leaf nat-pass-through-id {
      type uint32;
      description
        "An identifier of the IP prefix pass through.";
    }

    leaf nat-pass-through-pref {
      type inet:ip-prefix;
      description
        "The IP address subnets that match
        should not be translated. According to REQ#6
        of RFC6888, it must be possible to
        administratively turn off translation
        for specific destination addresses
        and/or ports.";
    }

    leaf nat-pass-through-port {
      type inet:port-number;
      description
        "The IP address subnets that match
        should not be translated. According to REQ#6
        of RFC6888, it must be possible to
        administratively turn off translation
        for specific destination addresses
        and/or ports.";
    }
  }
}
```



```
leaf paired-address-pooling {
    type boolean;
    default true;

    description
        "Paired address pooling informs the NAT
        that all the flows from an internal IP
        address must be assigned the same external
        address.";

    reference
        "RFC 4007.";
}

leaf nat-mapping-type {
    type enumeration {
        enum "eim" {
            description
                "endpoint-independent-mapping.";

            reference
                "Section 4 of RFC 4787.";
        }

        enum "adm" {
            description
                "address-dependent-mapping.";

            reference
                "Section 4 of RFC 4787.";
        }

        enum "edm" {
            description
                "address-and-port-dependent-mapping.";

            reference
                "Section 4 of RFC 4787.";
        }
    }
    description
        "Indicates the type of a NAT mapping.";
}

leaf nat-filtering-type {
    type enumeration {
        enum "eif" {
```



```
        description
            "endpoint-independent- filtering.";

        reference
            "Section 5 of RFC 4787.";
    }

    enum "adf" {
        description
            "address-dependent-filtering.";

        reference
            "Section 5 of RFC 4787.";
    }

    enum "edf" {
        description
            "address-and-port-dependent-filtering";

        reference
            "Section 5 of RFC 4787.";
    }
}

description
    "Indicates the type of a NAT filtering.";
}

list port-quota {
    when "../nat-capabilities/nat44-flavor = "+"
        "'napt' or "+"
        "../nat-capabilities/nat-flavor = "+"
        "'nat64'";

    key quota-type;

    description
        "Configures a port quota to be assigned per
        subscriber. It corresponds to the maximum
        number of ports to be used by a subscriber.";

    leaf port-limit {

        type uint16;

        description
            "Configures a port quota to be assigned per
```



```
subscriber. It corresponds to the maximum
number of ports to be used by a subscriber.";

reference
  "REQ-4 of RFC 6888.";
}

leaf quota-type {
  type enumeration {
    enum "all" {

      description
        "The limit applies to all protocols.";

      reference
        "REQ-4 of RFC 6888.";
    }

    enum "tcp" {
      description
        "TCP quota.";

      reference
        "REQ-4 of RFC 6888.";
    }

    enum "udp" {
      description
        "UDP quota.";

      reference
        "REQ-4 of RFC 6888.";
    }

    enum "icmp" {
      description
        "ICMP quota.";

      reference
        "REQ-4 of RFC 6888.";
    }
  }
  description
    "Indicates whether the port quota applies to
    all protocols or to a specific transport.";
}
```



```
leaf port-allocation-type {
  type enumeration {
    enum "random" {
      description
        "Port randomization is enabled.";
    }

    enum "port-preservation" {
      description
        "Indicates whether the NAT should
        preserve the internal port number.";
    }

    enum "port-parity-preservation" {
      description
        "Indicates whether the NAT should
        preserve the port parity of the
        internal port number.";
    }

    enum "port-range-allocation" {
      description
        "Indicates whether the NAT assigns a range
        of ports for an internal host.";
    }
  }
  description
    "Indicates the type of a port allocation.";
}

leaf address-roundrobin-enable {
  type boolean;

  description
    "Enable/disable address allocation
    round robin.";
}

container port-set {
  when "../port-allocation-type = 'port-range-allocation'";

  description
    "Manages port-set assignments.";

  leaf port-set-size {
    type uint16;
    description
```



```
        "Indicates the size of assigned port
        sets.";
    }

    leaf port-set-timeout {
        type uint32;
        description
            "Inactivity timeout for port sets.";
    }
}

uses timeouts;

container mapping-limit {

    description
        "Information about the configuration parameters that
        limits the mappings based upon various criteria.";

    leaf limit-per-subscriber {
        type uint32;

        description
            "Maximum number of NAT mappings per
            subscriber.";
    }

    leaf limit-per-vrf {
        type uint32;

        description
            "Maximum number of NAT mappings per
            VLAN/VRF.";
    }

    leaf limit-per-subnet {
        type inet:ip-prefix;

        description
            "Maximum number of NAT mappings per
            subnet.";
    }

    leaf limit-per-instance {
        type uint32;
        mandatory true;
    }
}
```



```
        description
            "Maximum number of NAT mappings per
            instance.";
    }

    leaf limit-per-udp {
        type uint32;
        mandatory true;

        description
            "Maximum number of UDP NAT mappings per
            subscriber.";
    }

    leaf limit-per-tcp {
        type uint32;
        mandatory true;

        description
            "Maximum number of TCP NAT mappings per
            subscriber.";
    }

    leaf limit-per-icmp {
        type uint32;
        mandatory true;

        description
            "Maximum number of ICMP NAT mappings per
            subscriber.";
    }
}

container connection-limit {

    description
        "Information about the configuration parameters that
        rate limit the translation based upon various
        criteria.";

    leaf limit-per-subscriber {
        type uint32;

        description
            "Rate-limit the number of new mappings and sessions
            per subscriber.";
    }
}
```



```
}

leaf limit-per-vrf {
    type uint32;

    description
        "Rate-limit the number of new mappings and sessions
        per VLAN/VRF.";
}

leaf limit-per-subnet {
    type inet:ip-prefix;

    description
        "Rate-limit the number of new mappings and sessions
        per subnet.";
}

leaf limit-per-instance {
    type uint32;
    mandatory true;

    description
        "Rate-limit the number of new mappings and sessions
        per instance.";
}

leaf limit-per-udp {
    type uint32;
    mandatory true;

    description
        "Rate-limit the number of new UDP mappings and sessions
        per subscriber.";
}

leaf limit-per-tcp {
    type uint32;
    mandatory true;

    description
        "Rate-limit the number of new TCP mappings and sessions
        per subscriber.";
}

leaf limit-per-icmp {
    type uint32;
```



```
        mandatory true;

        description
            "Rate-limit the number of new ICMP mappings and sessions
            per subscriber.";
    }
}

list algs {

    key alg-name;

    description
        "ALG-related features.";

    leaf alg-name {
        type string;

        description
            "The name of the ALG";
    }

    leaf alg-transport-protocol {
        type uint32;

        description
            "The transport protocol used by the ALG.";
    }

    leaf alg-transport-port {
        type inet:port-number;

        description
            "The port number used by the ALG.";
    }

    leaf alg-status {
        type boolean;

        description
            "Enable/disable the ALG.";
    }
}

leaf all-algs-enable {
    type boolean;
```



```
        description
            "Enable/disable all ALGs.";
    }

    container logging-info {
        description
            "Information about logging NAT events";

        leaf logging-enable {
            type boolean;

            description
                "Enable logging features as per Section 2.3
                of \[RFC6908\].";
        }

        leaf destination-address {
            type inet:ip-prefix;
            mandatory true;

            description
                "Address of the collector that receives
                the logs";
        }

        leaf destination-port {
            type inet:port-number;
            mandatory true;

            description
                "Destination port of the collector.";
        }

        choice protocol {

            description
                "Enable the protocol to be used for
                the retrieval of logging entries.";

            case syslog {
                leaf syslog {
                    type boolean;

                    description
                        "If SYSLOG is in use.";
                }
            }
        }
    }
```



```
    case ipfix {
      leaf ipfix {
        type boolean;

        description
          "If IPFIX is in use.";
      }
    }

    case ftp {
      leaf ftp {
        type boolean;

        description
          "If FTP is in use.";
      }
    }
  }

  container notify-pool-usage {
    description
      "Notification of pool usage when certain criteria
       are met.";

    leaf pool-id {
      type uint32;

      description
        "Pool-ID for which the notification
         criteria is defined";
    }

    leaf notify-pool-hi-threshold {
      type percent;
      mandatory true;

      description
        "Notification must be generated when the
         defined high threshold is reached.
         For example, if a notification is
         required when the pool utilization reaches
         90%, this configuration parameter must
         be set to 90%.";
    }

    leaf notify-pool-low-threshold {
      type percent;
```



```
        description
        "Notification must be generated when the defined
        low threshold is reached.
        For example, if a notification is required when
        the pool utilization reaches below 10%,
        this configuration parameter must be set to
        10%. ";
    }
}

} //nat-parameters group

container nat-module {
    description
    "NAT";

    container nat-instances {
        description
        "NAT instances";

        list nat-instance {

            key "id";

            description
            "A NAT instance.";

            leaf id {
                type uint32;

                description
                "NAT instance identifier.";

                reference
                "RFC 7659.";
            }

            leaf name {
                type string;

                description
                "A name associated with the NAT instance.";
            }

            leaf enable {
                type boolean;

                description
```



```
        "Status of the the NAT instance.";
    }

    container nat-capabilities {
        config false;

        description
            "NAT capabilities";

        leaf-list nat-flavor {
            type identityref {
                base nat-type;
            }
            description
                "Type of NAT.";
        }

        leaf-list nat44-flavor {

            when "../nat-flavor = 'nat44'";

            type identityref {
                base nat44;
            }
            description
                "Type of NAT44: Basic NAT or NAPT.";
        }

        leaf restricted-port-support {
            type boolean;

            description
                "Indicates source port NAT restriction
                support.";
        }

        leaf static-mapping-support {
            type boolean;

            description
                "Indicates whether static mappings are
                supported.";
        }

        leaf port-randomization-support {
            type boolean;
```



```
    description
      "Indicates whether port randomization is
       supported.";
  }

  leaf port-range-allocation-support {
    type boolean;

    description
      "Indicates whether port range
       allocation is supported.";
  }

  leaf port-preservation-suport {
    type boolean;

    description
      "Indicates whether port preservation
       is supported.";
  }

  leaf port-parity-preservation-support {
    type boolean;

    description
      "Indicates whether port parity
       preservation is supported.";
  }

  leaf address-roundrobin-support {
    type boolean;

    description
      "Indicates whether address allocation
       round robin is supported.";
  }

  leaf paired-address-pooling-support {
    type boolean;

    description
      "Indicates whether paired-address-pooling is
       supported";
  }

  leaf endpoint-independent-mapping-support {
    type boolean;
```



```
    description
      "Indicates whether endpoint-independent-mapping
      in Section 4 of RFC 4787 is supported.";
  }

  leaf address-dependent-mapping-support {
    type boolean;

    description
      "Indicates whether address-dependent-mapping
      is supported.";
  }

  leaf address-and-port-dependent-mapping-support {
    type boolean;

    description
      "Indicates whether address-and-port-dependent-mapping
      is supported.";
  }

  leaf endpoint-independent-filtering-support {
    type boolean;

    description
      "Indicates whether endpoint-independent-filtering
      is supported.";
  }

  leaf address-dependent-filtering {
    type boolean;

    description
      "Indicates whether address-dependent-filtering
      is supported.";
  }

  leaf address-and-port-dependent-filtering {
    type boolean;

    description
      "Indicates whether address-and-port-dependent
      is supported.";
  }
}

uses nat-parameters;
```



```
    container mapping-table {

        when "../nat-capabilities/nat-flavor = "+
            "'nat44' or "+
            "../nat-capabilities/nat-flavor = "+
            "'nat64' or "+
            "../nat-capabilities/nat-flavor = 'dst-nat'";

        description
            "NAT mapping table used to track
            sessions. Only applicable if NAT44,
            Destination NAT, or nat64 is supported.";

        list mapping-entry {
            key "index";

            description
                "NAT mapping entry.";

            uses mapping-entry;
        }
    }

    container statistics {

        config false;

        description
            "Statistics related to the NAT instance.
            Only applicable if nat44, dst-nat or nat64 is
            supported.";

        container traffic-statistics {
            description
                "Generic traffic statistics.";

            leaf sent-packet {
                type yang:zero-based-counter64;

                description
                    "Number of packets sent.";
            }

            leaf sent-byte {
                type yang:zero-based-counter64;

                description
```



```
        "Counter for sent traffic in bytes.";
    }

    leaf rcvd-packet {
        type yang:zero-based-counter64;

        description
            "Number of received packets.";
    }

    leaf rcvd-byte {
        type yang:zero-based-counter64;

        description
            "Counter for received traffic
            in bytes.";
    }

    leaf dropped-packet {
        type yang:zero-based-counter64;

        description
            "Number of dropped packets.";
    }

    leaf dropped-byte {
        type yang:zero-based-counter64;

        description
            "Counter for dropped traffic in
            bytes.";
    }
}

container mapping-statistics {

    when "../.. /nat-capabilities/nat-flavor = '"+
        "'nat44' or '"+
        "../.. /nat-capabilities/nat-flavor = '"+
        "'nat64' or '"+
        "../.. /nat-capabilities/nat-flavor = 'dst-nat'";

    description
        "Mapping statistics.";

    leaf total-mappings {
        type uint32;
```



```
        description
            "Total number of NAT mappings present
            at a given time. This variable includes
            all the static and dynamic mappings.";
    }

    leaf total-tcp-mappings {
        type uint32;
        description
            "Total number of TCP mappings present
            at a given time.";
    }

    leaf total-udp-mappings {
        type uint32;
        description
            "Total number of UDP mappings present
            at a given time.";
    }

    leaf total-icmp-mappings {
        type uint32;
        description
            "Total number of ICMP mappings present
            at a given time.";
    }
}

container pool-stats {

    when "../..//nat-capabilities/nat-flavor = '"+
        "'nat44' or '"+
        "../..//nat-capabilities/nat-flavor = '"+
        "'nat64'";

        description
            "Statistics related to address/prefix
            pool usage";

        leaf pool-id {
            type uint32;
            description
                "Unique Identifier that represents
                a pool of addresses/prefixes.";
        }
    }
```



```
    leaf address-allocated {
      type uint32;
      description
        "Number of allocated addresses in
         the pool";
    }

    leaf address-free {
      type uint32;
      description
        "Number of unallocated addresses in
         the pool at a given time.The sum of
         unallocated and allocated
         addresses is the total number of
         addresses of the pool.";
    }

    container port-stats {

      description
        "Statistics related to port
         usage.";

      leaf ports-allocated {
        type uint32;
        description
          "Number of allocated ports
           in the pool.";
      }

      leaf ports-free {
        type uint32;
        description
          "Number of unallocated addresses
           in the pool.";
      }
    }
  } //statistics
}

/*
 * Notifications
 */

notification nat-event {
```



```
    description
      "Notifications must be generated when the defined
       high/low threshold is reached. Related
       configuration parameters must be provided to
       trigger the notifications.";

    leaf id {
      type leafref {
        path
          "/nat-module/nat-instances/"
          + "nat-instance/id";
      }
      description
        "NAT instance ID.";
    }

    leaf notify-pool-threshold {
      type percent;
      mandatory true;
      description
        "A treshhold has been fired.";
    }
  }
}
<CODE ENDS>
```

4. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol [[RFC6241](#)]. The lowest NETCONF layer is the secure transport layer and the support of SSH is mandatory to implement secure transport [[RFC6242](#)]. The NETCONF access control model [[RFC6536](#)] provides means to restrict access by some users to a pre-configured subset of all available NETCONF protocol operations and data.

All data nodes defined in the YANG module which can be created, modified and deleted (i.e., config true, which is the default). These data nodes are considered sensitive. Write operations (e.g., edit-config) applied to these data nodes without proper protection can negatively affect network operations.

5. IANA Considerations

This document requests IANA to register the following URI in the "IETF XML Registry" [[RFC3688](#)]:

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

This document requests IANA to register the following YANG module in the "YANG Module Names" registry [[RFC6020](#)].

name: ietf-nat
namespace: urn:ietf:params:xml:ns:yang:ietf-nat
prefix: nat
reference: RFC XXXX

6. Acknowledgements

Many thanks to Dan Wing and Tianran Zhou for the review.

Thanks to Juergen Schoenwaelder for the comments on the YANG structure and the suggestion to use NMDA.

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Appendix A. Sample Examples

This section provides a non-exhaustive set of examples to illustrate the use of the NAT YANG module.

A.1. Traditional NAT44

Traditional NAT44 is a Basic NAT44 or NAPT that is used to share the same IPv4 address among hosts that are owned by the same subscriber. This is typically the NAT that is embedded in CPE devices.

This NAT is usually provided with one single external IPv4 address; disambiguating connections is achieved by rewriting the source port number. The XML snippet to configure the external IPv4 address in such case together with a mapping entry is depicted below:


```
<nat-instances>
  <nat-instance>
    <id>1</id>
    <name>NAT_Subscriber_A</name>
    ....
    <external-ip-address-pool>
      <pool-id>1</pool-id>
      <external-ip-pool>
        192.0.2.1
      </external-ip-pool>
    </external-ip-address-pool>
    ....
    <mapping-table>
      ....
      <external-src-address>
        192.0.2.1
      </external-src-address>
      ....
    </mapping-table>
  </nat-instance>
</nat-instances>
```

The following shows the XML excerpt depicting a dynamic UDP mapping entry maintained by a traditional NAT44. In reference to this example, the UDP packet received with a source IPv4 address (192.0.2.1) and source port number (1568) is translated into a UDP packet having a source IPv4 address (198.51.100.1) and source port (15000). The lifetime of this mapping is 300 seconds.


```
<mapping-entry>
  <index>15</index>
  <type>
    dynamic-explicit
  </type>
  <transport-protocol>
    17
  </transport-protocol>
  <internal-src-address>
    192.0.2.1
  </internal-dst-address>
  <internal-src-port>
    <single-port-number>
      1568
    </single-port-number>
  </internal-dst-port>
  <external-dst-address>
    198.51.100.1
  </external-dst-address>
  <external-dst-port>
    <single-port-number>
      15000
    </single-port-number>
  </external-dst-port>
  <lifetime>
    300
  </lifetime>
</mapping-entry>
```

[A.2.](#) CGN

The following XML snippet shows the example of the capabilities supported by a CGN as retrieved using NETCONF.


```
<nat-capabilities
  <nat-flavor>
    nat44
  </nat44-flavor>
  <restricted-port-support>
    false
  </restricted-port-support>
  <static-mapping-support>
    true
  </static-mapping-support>
  <port-randomization-support>
    true
  </port-randomization-support>
  <port-range-allocation-support>
    true
  </port-range-allocation-support>
  <port-preservation-suport>
    true
  </port-preservation-suport>
  <port-parity-preservation-support>
    false
  </port-parity-preservation-support>
  <address-roundrobin-support>
    true
  </address-roundrobin-support>
  <paired-address-pooling-support>
    true
  </paired-address-pooling-support>
  <endpoint-independent-mapping-support>
    true
  </endpoint-independent-mapping-support>
  <address-dependent-mapping-support>
    false
  </address-dependent-mapping-support>
  <address-and-port-dependent-mapping-support>
    false
  </address-and-port-dependent-mapping-support>
  <endpoint-independent-filtering-support>
    true
  </endpoint-independent-filtering-support>
  <address-dependent-filtering>
    false
  </address-dependent-filtering>
  <address-and-port-dependent-filtering>
    false
  </address-and-port-dependent-filtering>
</nat-capabilities>
```


The following XML snippet shows the example of a CGN that is provisioned with one contiguous pool of external IPv4 addresses (192.0.2.0/24). Further, the CGN is instructed to limit the number of allocated ports per subscriber to 1024. Ports can be allocated by the CGN by assigning ranges of 256 ports (that is, a subscriber can be allocated up to four port ranges of 256 ports each).

```
<nat-instances>
  <nat-instance>
    <id>1</id>
    <name>myCGN</name>
    ....
    <external-ip-address-pool>
      <pool-id>1</pool-id>
      <external-ip-pool>
        192.0.2.0/24
      </external-ip-pool>
    </external-ip-address-pool>
    <port-quota>
      <port-limit>
        1024
      </port-limit>
      <quota-type >
        all
      </quota-type >
    </port-quota>
    <port-allocation-type>
      port-range-allocation
    </port-allocation-type>
    <port-set>
      <port-set-size>
        256
      </port-set-size>
    </port-set>
    ....
  </nat-instance>
</nat-instances>
```

An administrator may decide to allocate one single port range per subscriber (port range of 1024 ports) as shown below:


```
<nat-instances>
  <nat-instance>
    <id>1</id>
    <name>myotherCGN</name>
    ....
    <external-ip-address-pool>
      <pool-id>1</pool-id>
      <external-ip-pool>
        192.0.2.0/24
      </external-ip-pool>
    </external-ip-address-pool>
    <port-quota>
      <port-limit>
        1024
      </port-limit>
      <quota-type >
        all
      </quota-type >
    </port-quota>
    <port-allocation-type>
      port-range-allocation
    </port-allocation-type>
    <port-set>
      <port-set-size>
        1024
      </port-set-size>
      ....
    </port-set>
    ....
  </nat-instance>
</nat-instances>
```

A.3. CGN Pass-Through

Figure 1 illustrates an example of the CGN pass-through feature.

X1:x1		X1':x1'		X2:x2
+---+from X1:x1		+---+from X1:x1		+---+
C to X2:x2		to X2:x2		S
l >>>>>>>>>>		C >>>>>>>>>>		e
i		G		r
e <<<<<<<<<<		N <<<<<<<<<<		v
n from X2:x2		from X2:x2		e
t to X1:x1		to X1:x1		r
+---+		+---+		+---+

Figure 1: CGN Pass-Through

For example, in order to disable NAT for communications issued by the client (192.0.2.25), the following configuration parameter must be set:

```
<nat-pass-through>
  ...
  <nat-pass-through-pref>192.0.2.25</nat-pass-through-pref>
  ...
</nat-pass-through>
```

[A.4.](#) NAT64

Let's consider the example of a NAT64 that should use 2001:db8:122:300::/56 to perform IPv6 address synthesis [[RFC6052](#)]. The XML snippet to configure the NAT64 prefix in such case is depicted below:

```
<nat64-prefixes>
  <nat64-prefix>
    2001:db8:122:300::/56
  </nat64-prefix>
</nat64-prefixes>
```

Let's now consider the example of a NAT64 that should use 2001:db8:122::/48 to perform IPv6 address synthesis [[RFC6052](#)] only if the destination address matches 198.51.100.0/24. The XML snippet to configure the NAT64 prefix in such case is shown below:

```
<nat64-prefixes>
  <nat64-prefix>
    2001:db8:122::/48
  </nat64-prefix>
  <destination-ipv4-prefix>
    <ipv4-prefix>
      198.51.100.0/24
    </ipv4-prefix>
  </destination-ipv4-prefix>
</nat64-prefixes>
```

[A.5.](#) Static Mappings with Port Ranges

The following example shows a static mapping that instructs a NAT to translate packets issued from 192.0.2.1 and with source ports in the 100-500 range to 198.51.100.1:1100-1500.


```
<mapping-entry>
  <index>1</index>
  <type>static</type>
  <transport-protocol>6</transport-protocol>
  <internal-src-address>
    192.0.2.1
  </internal-dst-address>
  <internal-dst-port>
    <port-range>
      <start-port-number>
        100
      </start-port-number>
      <end-port-number>
        500
      </end-port-number>
    </port-range>
  </internal-dst-port>
  <external-src-address>
    198.51.100.1
  </external-dst-address>
  <external-src-port>
    <port-range>
      <start-port-number>
        1100
      </start-port-number>
      <end-port-number>
        1500
      </end-port-number>
    </port-range>
  </external-dst-port>
  ...
</mapping-entry>
```

[A.6.](#) Static Mappings with IP Prefixes

The following example shows a static mapping that instructs a NAT to translate packets issued from 192.0.2.1/24 to 198.51.100.1/24.


```
<mapping-entry>
  <index>1</index>
  <type>static</type>
  <transport-protocol>6</transport-protocol>
  <internal-src-address>
    192.0.2.1/24
  </internal-dst-address>
  <external-src-address>
    198.51.100.1/24
  </external-dst-address>
  ...
</mapping-entry>
```

[A.7.](#) Destination NAT

The following XML snippet shows an example a destination NAT that is instructed to translate packets having 192.0.2.1 as a destination IP address to 198.51.100.1.

```
<dst-ip-address-pool>
  <pool-id>1</pool-id>
  <dst-in-ip-pool>
    192.0.2.1
  </dst-in-ip-pool>
  <dst-out-ip-pool>
    198.51.100.1
  </dst-out-ip-pool>
</dst-ip-address-pool>
```

In order to instruct a NAT to translate TCP packets destined to 192.0.2.1:80 to 198.51.100.1:8080, the following XML snippet shows the static mapping to be configured on the NAT:


```
<mapping-entry>
  <index>1</index>
  <type>static</type>
  <transport-protocol>6</transport-protocol>
  <internal-dst-address>
    192.0.2.1
  </internal-dst-address>
  <internal-dst-port>
    <single-port-number>80</single-port-number>
  </internal-dst-port>
  <external-dst-address>
    198.51.100.1
  </external-dst-address>
  <external-dst-port>
    <single-port-number>8080</single-port-number>
  </external-dst-port>
</mapping-entry>
```

In order to instruct a NAT to translate TCP packets destined to 192.0.2.1:80 (http traffic) to 198.51.100.1 and 192.0.2.1:22 (ssh traffic) to 198.51.100.2, the following XML snippet shows the static mappings to be configured on the NAT:


```
<mapping-entry>
  <index>1</index>
  <type>static</type>
  <transport-protocol>6</transport-protocol>
  <internal-dst-address>
    192.0.2.1
  </internal-dst-address>
  <internal-dst-port>
    <single-port-number>
      80
    </single-port-number>
  </internal-dst-port>
  <external-dst-address>
    198.51.100.1
  </external-dst-address>
  ...
</mapping-entry>
<mapping-entry>
  <index>2</index>
  <type>static</type>
  <transport-protocol>
    6
  </transport-protocol>
  <internal-dst-address>
    192.0.2.1
  </internal-dst-address>
  <internal-dst-port>
    <single-port-number>
      22
    </single-port-number>
  </internal-dst-port>
  <external-dst-address>
    198.51.100.2
  </external-dst-address>
  ...
</mapping-entry>
```

The NAT may also be instructed to proceed with both source and destination NAT. To do so, in addition to the above sample to configure destination NAT, the NAT may be provided, for example with a pool of external IP addresses (198.51.100.0/24) to use for source address translation. An example of the corresponding XML snippet is provided hereafter:


```

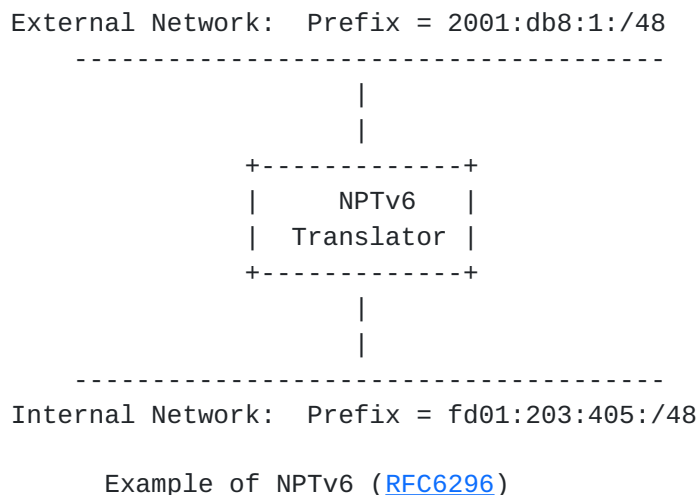
<external-ip-address-pool>
  <pool-id>1</pool-id>
  <external-ip-pool>
    198.51.100.0/24
  </external-ip-pool>
</external-ip-address-pool>

```

Instead of providing an external IP address to share, the NAT may be configured with static mapping entries that modifies the internal IP address and/or port number.

[A.8.](#) NPTv6

Let's consider the example of a NPTv6 translator that should rewrite packets with the source prefix (fd01:203:405:/48) with the external prefix (2001:db8:1:/48).



The XML snippet to configure NPTv6 prefixes in such case is depicted below:

```

<nptv6-prefixes>
  <pool-id>1</pool-id>
  <internal-ipv6-prefix>
    fd01:203:405:/48
  </internal-ipv6-prefix>
  <external-ipv6-prefix>
    2001:db8:1:/48
  </external-ipv6-prefix>
</nptv6-prefixes>

```

Figure 2 shows an example of an NPTv6 that interconnects two internal networks (fd01:203:405:/48 and fd01:4444:5555:/48); each is

translated using a dedicated prefix (2001:db8:1:/48 and 2001:db8:6666:/48, respectively).

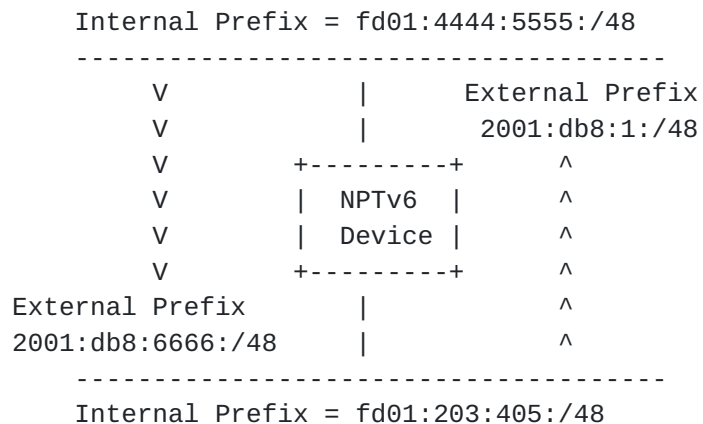


Figure 2: Connecting two Peer Networks ([RFC6296](#))

To that aim, the following configuration is provided to the NPTv6:

```

<nptv6-prefixes>
  <pool-id>1</pool-id>
  <internal-ipv6-prefix>
    fd01:203:405:/48
  </internal-ipv6-prefix>
  <external-ipv6-prefix>
    2001:db8:1:/48
  </external-ipv6-prefix>
</nptv6-prefixes>
<nptv6-prefixes>
  <pool-id>2</pool-id>
  <internal-ipv6-prefix>
    fd01:4444:5555:/48
  </internal-ipv6-prefix>
  <external-ipv6-prefix>
    2001:db8:6666:/48
  </external-ipv6-prefix>
</nptv6-prefixes>

```

Authors' Addresses

Mohamed Boucadair
 Orange
 Rennes 35000
 France

Email: mohamed.boucadair@orange.com

Senthil Sivakumar
Cisco Systems
7100-8 Kit Creek Road
Research Triangle Park, North Carolina 27709
USA

Phone: +1 919 392 5158
Email: ssenthil@cisco.com

Christian Jacquenet
Orange
Rennes 35000
France

Email: christian.jacquenet@orange.com

Suresh Vinapamula
Juniper Networks
1133 Innovation Way
Sunnyvale 94089
USA

Qin Wu
Huawei
101 Software Avenue, Yuhua District
Nanjing, Jiangsu 210012
China

Email: bill.wu@huawei.com

