Turbo
CG-NAT

6WIND Turbo CG-NAT Deployment Guide

Release 2.2

6WIND S.A.
1, place Charles de Gaulle
78180 Montigny-le-Bretonneux
France
http://www.6wind.com

Notice

Contents

1. Overview

The purpose of this document is to guide the user in deploying the vRouter for a CG-NAT (Carrier Grade Network Address Translation) use case. It focuses on the concepts that are relevant to this specific use case, in order to provide a practical example. Exhaustive documentation of the vRouter features that are not covered in the use case can be found in the standard vRouter documentation (https://doc.6wind.com/turbo-cg-nat-2.x/).

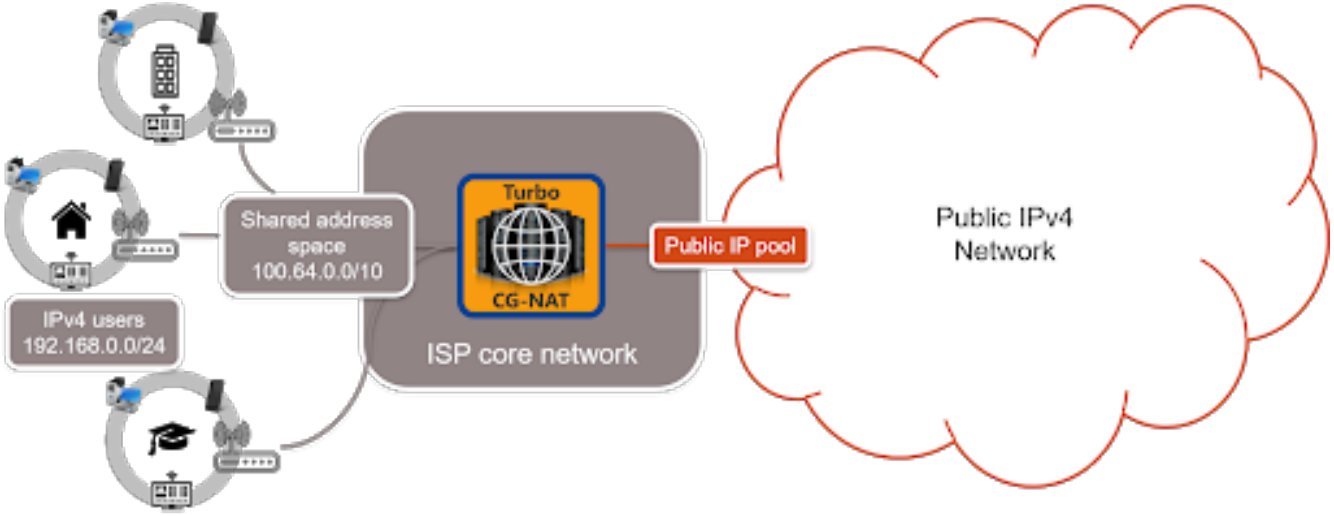
Follow the Getting Started guide (https://doc.6wind.com/turbo-cg-nat-2.x/getting-started/index.html) to install the software in your environment and get a remote console with SSH.

2. Use case: NAT444

2.1 Overview

One approach to cope with the public IPv4 address exhaustion is to share the remaining or available IPv4 addresses among a larger number of customers. It can be done by using CG-NAT.

CG-NAT, also known as Large Scale NAT, is a highly scalable NAT placed in the ISP core network, between the customer premises equipment (CPE) and the Internet.



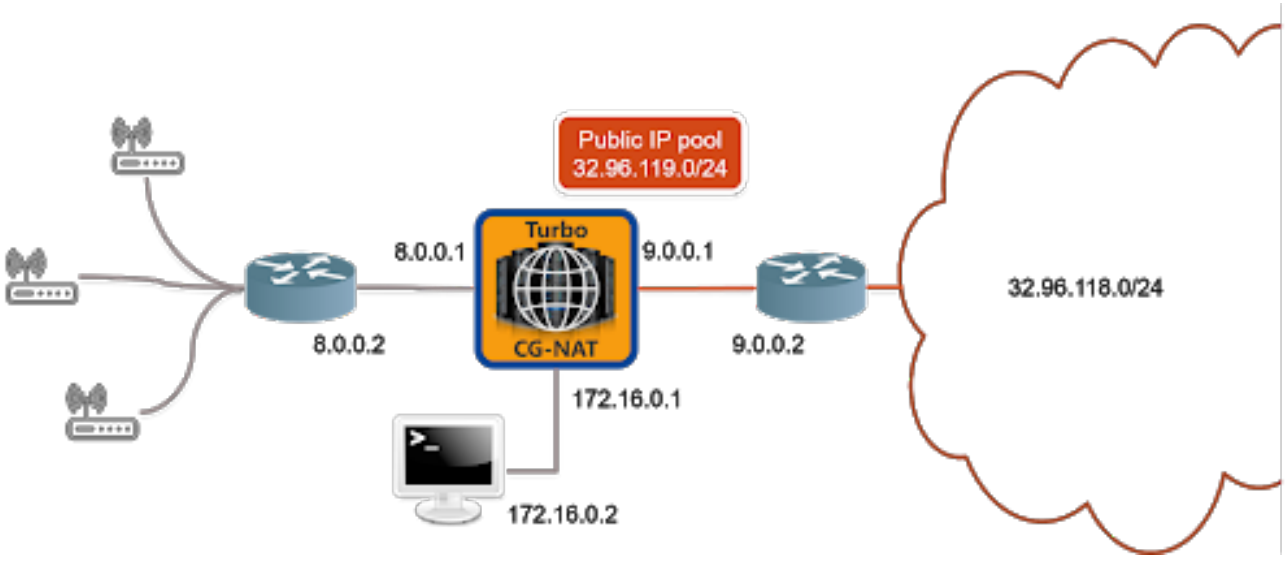
In NAT44(4), there are three IPv4 networks:

- A private IPv4 network within the user network (behind the CPE),
- A different private IPv4 network for the user to provider links (between the CPE and the vRouter), known as the Shared address space,
- A public IPv4 network on the outside of the vRouter.

2.2 Configuration

2.2.1 Network Topology

For this use case, we consider the following topology:



2.2.2 Interfaces configuration

Allocate the ports that will be involved in data plane processing to the fast path.

```
vrouter> edit running
vrouter running config# / system fast-path
vrouter running fast-path#! port pci-b0s4
vrouter running fast-path# port pci-b0s5
```

All physical and logical interfaces are configured under the main VRF (Virtual Routing and Forwarding) in this example.

```
vrouter running config# vrf main
```

Create Ethernet interfaces, attach them to a port of a NIC (Network Interface Card) and configure IP addresses.

```
vrouter running vrf main# interface physical lan
vrouter running physical lan#! port pci-b0s4
vrouter running physical lan# ipv4 address 8.0.0.1/24
vrouter running physical lan# .. physical wan
vrouter running physical wan#! port pci-b0s5
vrouter running physical wan# ipv4 address 9.0.0.1/24
```

See also:

See the User's Guide for more information regarding:

- CLI basics (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/basics/index.html)
- fast path configuration (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/system/fast-path.html)
- interfaces configuration (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/network-interface/index.html)

2.2.3 Routing configuration

Configure routes towards the LAN and WAN, plus a blackhole route to drop the incoming public traffic that doesn't match an existing connection.

```
vrouter running physical wan# / vrf main routing static
vrouter running static# ipv4-route 100.64.0.0/10 next-hop 8.0.0.2
vrouter running static# ipv4-route 32.96.118.0/24 next-hop 9.0.0.2
vrouter running static# ipv4-route 32.96.119.0/24 next-hop blackhole
```

See also:

See the User's Guide for more information regarding:

- Routing configuration (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/routing/index.html)

2.2.4 CG-NAT configuration

Pool

A CG-NAT pool contains a list of IPv4 addresses used to change the IPv4 source address and port of a packet.

The vRouter implements a feature called Port Block Allocation. Each time a new user sends a packet through the vRouter, a block of ports is allocated to the user from one of the IP addresses in the pool. Each public IP is divided into blocks of ports, whose size and range is defined in the pool configuration.

Here is an example of pool configuration.

```
vrouter running static# / vrf main cg-nat
vrouter running cg-nat#! pool mypool
vrouter running pool mypool#! address 32.96.119.0/24
vrouter running pool mypool#! port-range 1024 65535
vrouter running pool mypool#! block-size 512
```

Note: The `!` in the prompt indicates that the current configuration is invalid. This is because a rule is required to complete the CG-NAT configuration.

Rule

A CG-NAT rule defines the matching criteria to NAT packets and the pool to use to translate them, replacing the source IP address and port of the packet with an IP address from the pool and a port from the range. It also specifies the number of blocks from the pool to associate to each user.

Here is an example of rule configuration.


```
vrouter running pool mypool#! .. rule 1
vrouter running rule 1#! match
vrouter running match#! source address 100.64.0.0/10
vrouter running match#! outbound-interface wan
vrouter running match#! .. translate-to
vrouter running translate-to#! pool-name mypool
vrouter running translate-to# max-blocks-per-user 4
```

The ! in the prompt has disappeared, meaning that the configuration is now valid. It can be committed.

```
vrouter running translate-to# commit
Configuration committed.
```

See also:

See the User's Guide for more information regarding:

- CG-NAT configuration & behavior (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/ip-networking/cgnat.html)

2.3 Status

2.3.1 State

To review the CG-NAT state, use the following command.

```
vrouter> show state / vrf main cg-nat
cg-nat
 enabled true
 pool mypool
     address 32.96.119.1-32.96.119.254
     block-size 256
     port-range 1024 65535
     ..
 rule 1
     match
         source
             address 100.64.0.0/10
             ..
         outbound-interface wan
         ..
     translate-to
         pool-name mypool
         max-blocks-per-user 2
         active-block-timeout 0
         user-timeout 180
         port-algo random
         endpoint-mapping dependent
```

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```
        endpoint-filtering dependent
        hairpinning false
        ..
    ..
 options
    conntrack
        behavior tcp-window-check enabled true
        behavior tcp-rst-strict-order enabled true
        timeouts
            icmp closed 0
            icmp new 30
            icmp established 60
            udp closed 0
            udp new 30
            udp established 120
            gre-pptp closed 0
            gre-pptp new 600
            gre-pptp established 18000
            tcp syn-sent 30
            tcp simsyn-sent 30
            tcp syn-received 60
            tcp established 7440
            tcp fin-sent 120
            tcp fin-received 120
            tcp close-wait 60
            tcp fin-wait 120
            tcp last-ack 30
            tcp time-wait 120
            tcp closed 10
            ..
        ..
    ..
 logging
    enabled false
    ..
 ..
```

2.3.2 Statistics

To display the CG-NAT statistics, the following command can be used.

```
vrouter> show cg-nat statistics
Packets passed:
        0 default pass
        33317355 ruleset pass
        260836153 state pass
Packets blocked:
        0 default block
```

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```
        0 ruleset block
Hairpining Stats:
        0 hairpin packets
        0 loop-hairpin drop
        0 self-hairpin drop
State and NAT entries:
        33077173 state allocations
        0 state reverse
        39496338 state destructions
        0 state allocation failures
        9726101 NAT entry allocations
        13127681 NAT entry destructions
        0 NAT entry allocation failures
        0 NAT port allocation failures
CGNat entries:
        0 USER allocations
        20000 USER destructions
        0 USER allocation failures
        120000 Block allocations
        180000 Block destructions
        0 Block allocation failures
        0 No IP Public
        0 Full IP Public
NAT64 Stats:
        0 udp null checksum packet drops
Invalid packet state cases:
        1310 cases in total
        1310 TCP case invalid first packet
        0 TCP case RST
        1310 TCP case invalid transition
        0 TCP case I
        0 TCP case II
        0 TCP case III
Packet race cases:
        0 USER association race
        0 USER creation race
        0 NAT association race
        0 duplicate state race
```

State/NAT/BLOCK/USER allocation statistics increase when the vRouter processes traffic properly.

2.3.3 Listing users

The following command can be used to list the current users of the CG-NAT.

```
vrouter> show cg-nat user rule-id 1
100.64.0.1 -> 32.96.120.54
        1/2 tcp blocks, 0/2 udp blocks, 0/2 icmp blocks, 0/2 gre blocks
```

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```
        0 no port errors, 0 no block errors, 0 full public ip errors
```

For each user, we can see how many port blocks are used.

The different possible errors are:

- no port: A new session has been rejected because no ports were available in the active block.
- no block: A new session has been rejected because no blocks are available in the block memory pool.
- full public IP: A new session has been rejected because the public IP allocated to this user doesn't have any more blocks available.

2.4 Monitoring with Grafana

Here we will show how to export KPIs (Key Performance Indicators) to a time-series database which can then be used with a graphical tool like Grafana. This assumes that InfluxDB and Grafana have been installed on 172.16.0.2 following this documentation (https://github.com/6WIND/supervision-grafana).

```
vrouter> edit running
vrouter running config# / vrf main interface physical mgt
vrouter running physical mgt#! port pci-b0s6
vrouter running physical mgt# ipv4 address 172.16.0.1/24
vrouter running physical mgt# / system kpi enabled true
vrouter running physical mgt# / vrf main kpi
vrouter running kpi# telegraf influxdb-output url http://172.16.0.2:8086 database␣
↪telegraf
vrouter running kpi# interface lan
vrouter running kpi# interface wan
vrouter running kpi# commit
```

See also:

For more details, see:

- User's Guide KPI section (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/monitoring/kpi.html)
- 6WIND Grafana Setup on github (https://github.com/6WIND/supervision-grafana)

2.5 Logging

2.5.1 On the console

To enable logs, use the following command.

```
vrouter running config# vrf main cg-nat logging enabled true
vrouter running config# commit
```


This command displays the CG-NAT logs on the console:

```
vrouter running config# show log service cg-nat
-- Logs begin at Thu 2019-07-18 11:50:25 UTC, end at Thu 2019-07-18 15:28:05 UTC. -
↪-
Jun 11 08:02:46 vrouter systemd[1]: Started Fast Path cgnat log daemon.
Jun 11 08:02:46 vrouter fp-cgnat-logd[4269]: CGNAT Log listen on 5001
Jun 11 08:03:09 vrouter fp-cgnat-logd[4269]: USER 100.64.0.1 (matching rule 1):␣
↪NEW BLOCK (pool "mypool", ip public 32.96.119.1, proto 6, port 1024 - 1536) at␣
↪Tue Jun 11 08:03:09 2019
Jun 11 08:07:30 vrouter fp-cgnat-logd[4269]: USER 100.64.0.1 (matching rule 1):␣
↪DESTROY BLOCK (pool "mypool", ip public 32.96.119.1, proto 6, port 1024 - 1536)␣
↪at Tue Jun 11 08:07:30 2019
```

See also:

See the User's Guide for more information regarding:

- Logging (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/system/logging.html)

2.5.2 Towards an external framework

In this section, we will explain how to export CG-NAT logs to an external logging framework. As an example, we will use Logstash and Kibana from the Elastic Stack (https://www.elastic.co/products/log-monitoring) to gather the logs and display them in a user-friendly way.

We assume that Elastic, Logstash and Kibana have been installed on a server accessible on the 172.16.0.2 IP address, following the Elastic documentation (https://www.elastic.co/guide/en/elastic-stack/current/installing-elastic-stack.html).

Here is the Logstash configuration, including the IP address and port of the syslog server and filters to parse and format the CG-NAT log messages before storing them in Elastic:

```
input {
  udp {
    host => "172.16.0.2"
    port => 10514
    type => syslog
  }
}

filter {
  if [type] == "syslog" {
        grok {
        match => { "message" => "%{POSINT:syslog_pri}>%{SYSLOGTIMESTAMP:syslog_
↪timestamp} %{SYSLOGHOST:syslog_hostname} %{DATA:syslog_program}(?:\[%
↪{POSINT:syslog_pid}\])?: %{GREEDYDATA:syslog_message}" }
        add_field => [ "received_at", "%{@timestamp}" ]
        add_field => [ "received_from", "%{host}" ]
        }
```

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```
    date {
          match => [ "syslog_timestamp", "MMM  d HH:mm:ss", "MMM dd HH:mm:ss" ]
    }
  }
}

# Second level of filtering specific for CG-NAT logs
filter {
    if [type] == "syslog" {
        if [syslog_program] == "fp-cgnat-logd" {
            grok {
                match => [ "message", "USER %{IP:prv_ip} \(matching rule %
↪{POSINT:rule}\)\: %{DATA:action} BLOCK \(pool %{DATA:pool}\, ip public %{IP:pub_
↪ip}\, proto %{POSINT:proto}\, port %{POSINT:start_port} \- %{POSINT:end_port}\)␣
↪at %{GREEDYDATA:time}"]}

            if "_grokparsefailure" in [tags] { drop {} }
            date {
                match => [ "time", "EEE MMM dd HH:mm:ss YYYY", "EEE MMM  d␣
↪HH:mm:ss YYYY", "ISO8601" ]
                timezone => "Etc/GMT"
                target => "action_date"
            }
            mutate { add_tag => [ "CG-NAT log" ] }
            translate {
                field => "proto"
                destination => "sproto"
                dictionary => {
                    "1" => "ICMP"
                    "6" => "TCP"
                    "17" => "UDP"
                }
            }
        }
    }
}

output {
    if [type] == "syslog" {
        if [syslog_program] == "fp-cgnat-logd" {
            elasticsearch { hosts => [ "127.0.0.1:9200" ] }
            stdout { codec => rubydebug }
        }
    }
}
```

On the vRouter, logging to Logstash can be enabled with the following configuration.

```
vrouter running config# / vrf main logging syslog remote-server 172.16.0.2
```

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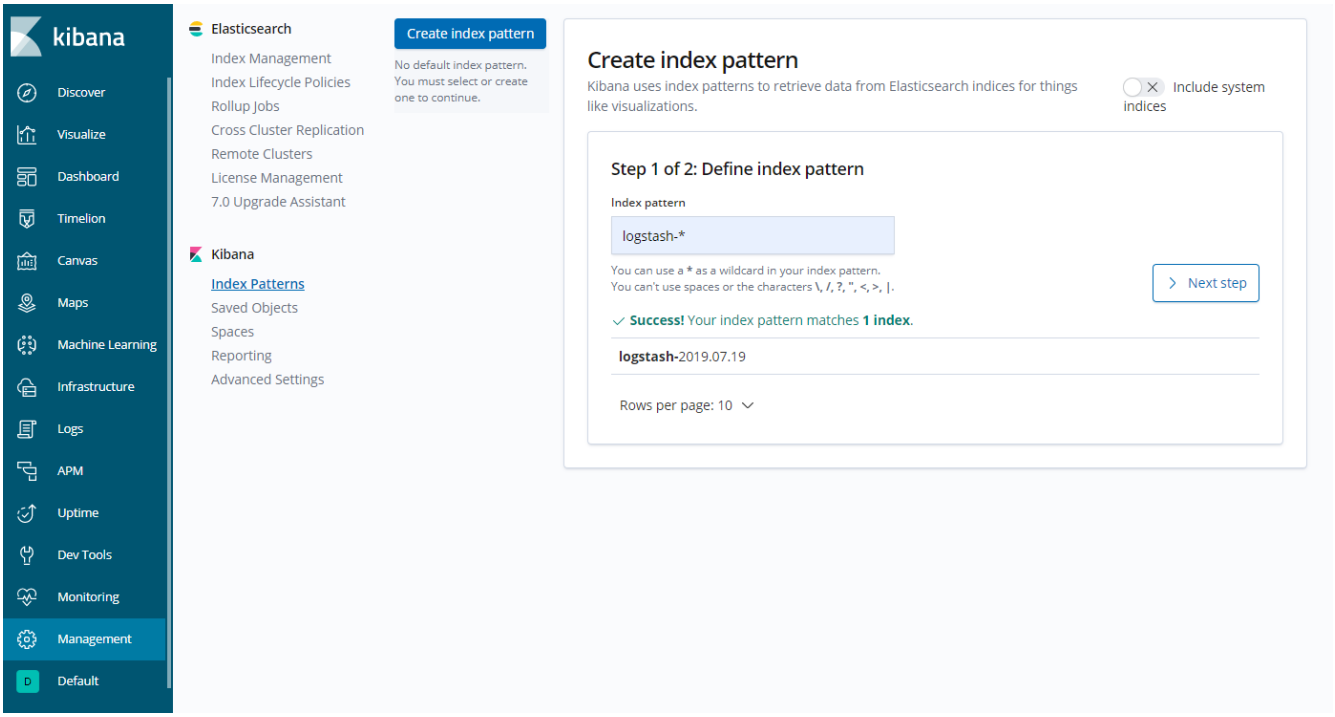
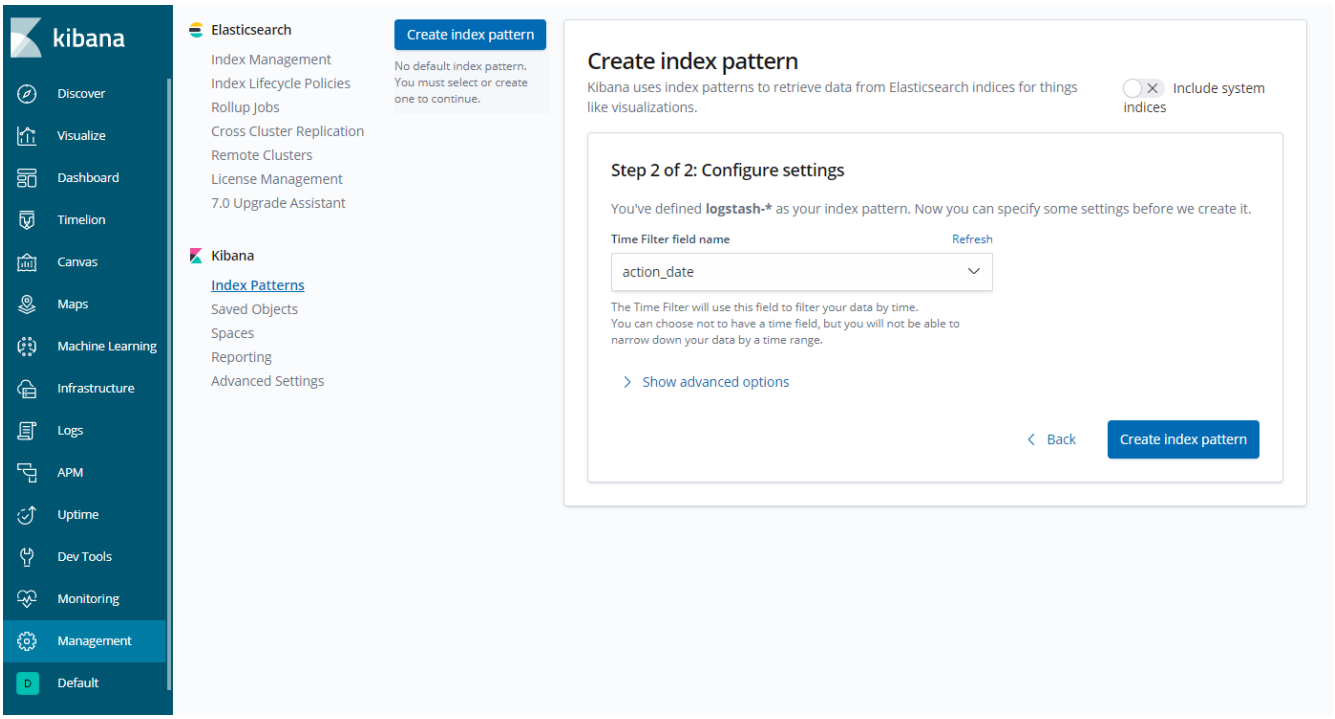
```
vrouter running remote-server 172.16.0.2# protocol udp
vrouter running remote-server 172.16.0.2# port 10514
vrouter running remote-server 172.16.0.2# commit
```

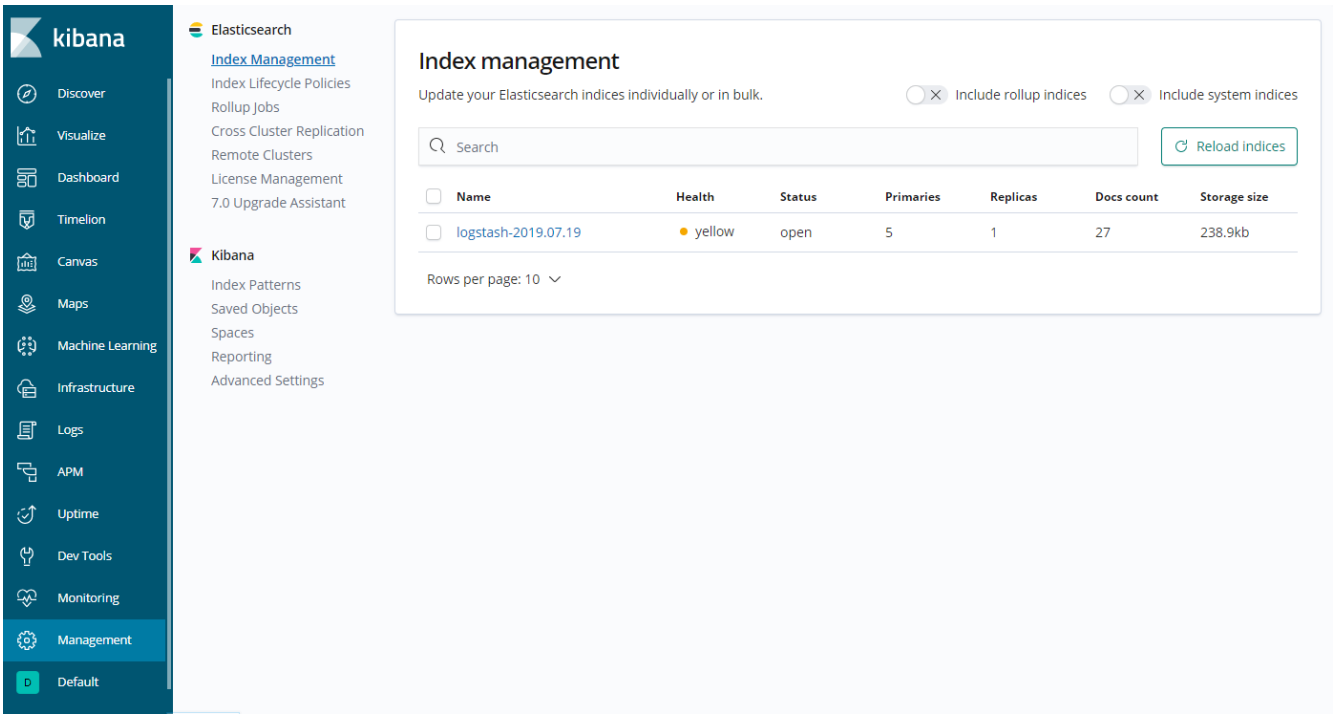
Let's now connect to Kibana using a web browser, pointing at http://172.16.0.2:5601. Click Management, Index Patterns, type logstash in the Index pattern text box, then click Next step.



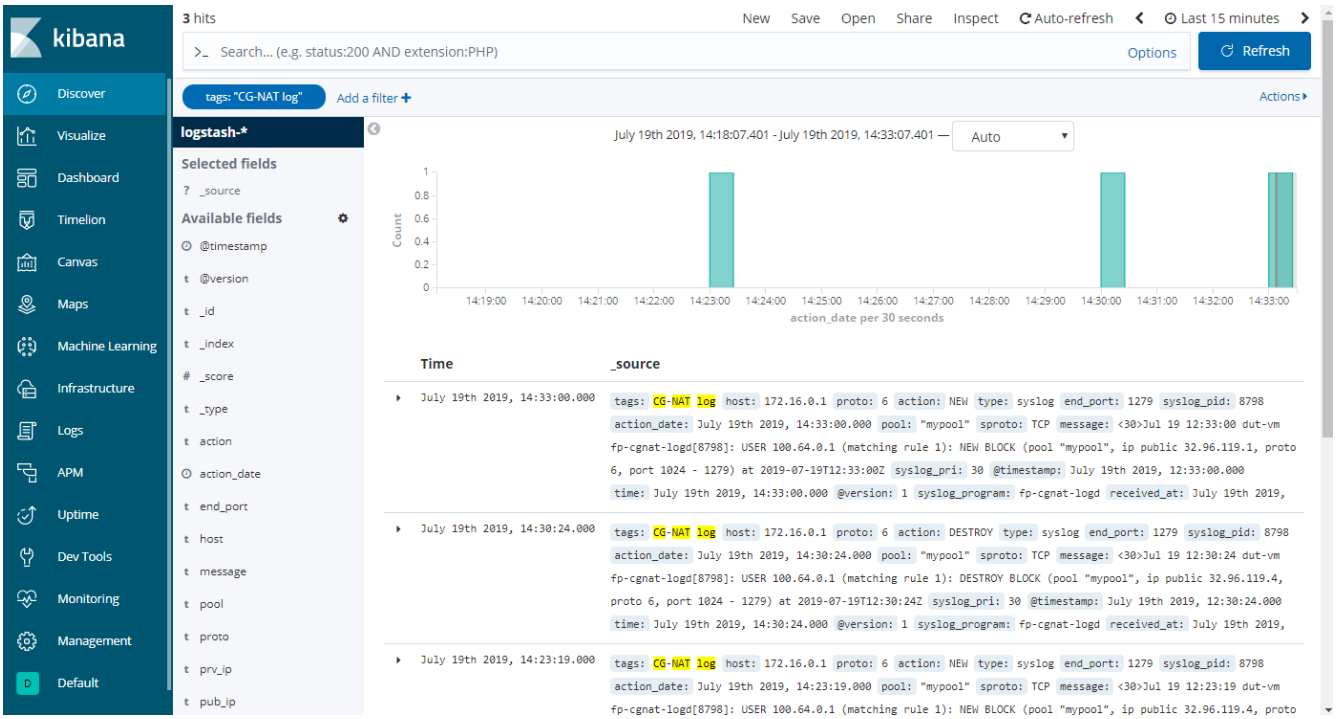
Select action_date as the Time Filter field name and click Create index pattern.



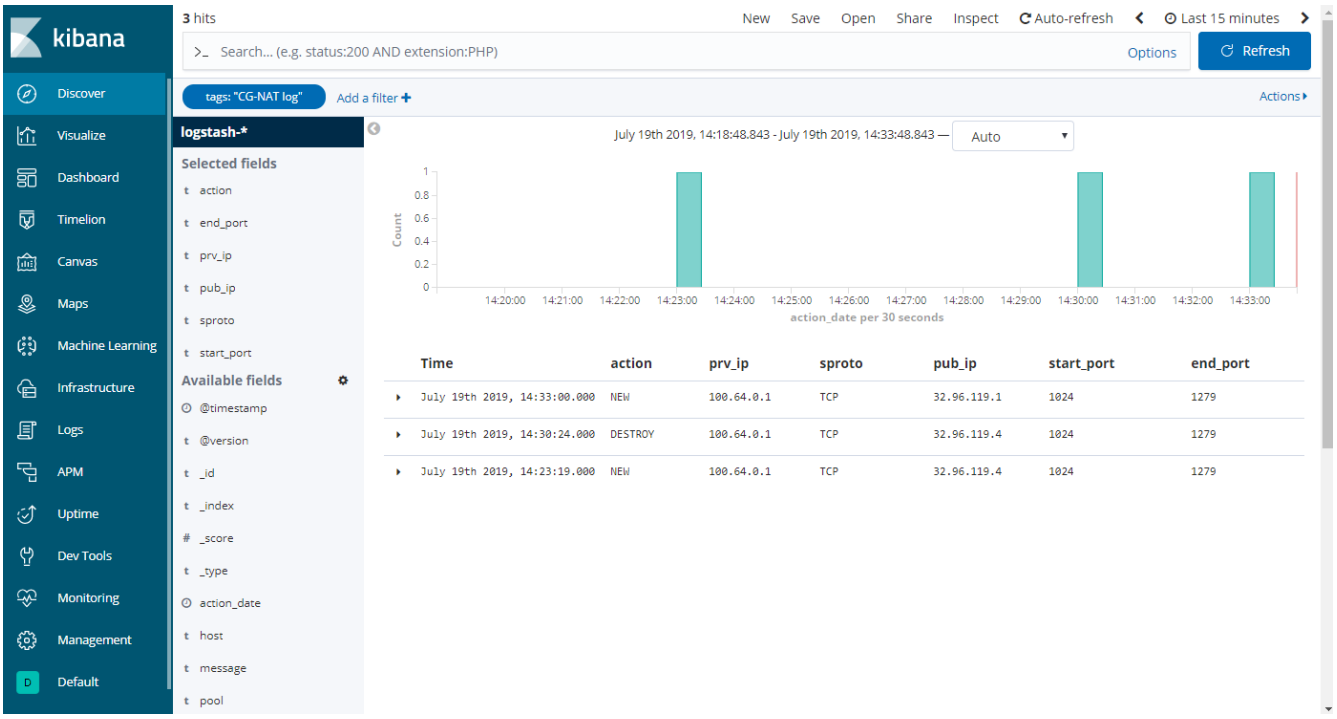
A logstash indice now appears in the Elasticsearch Index Management page:



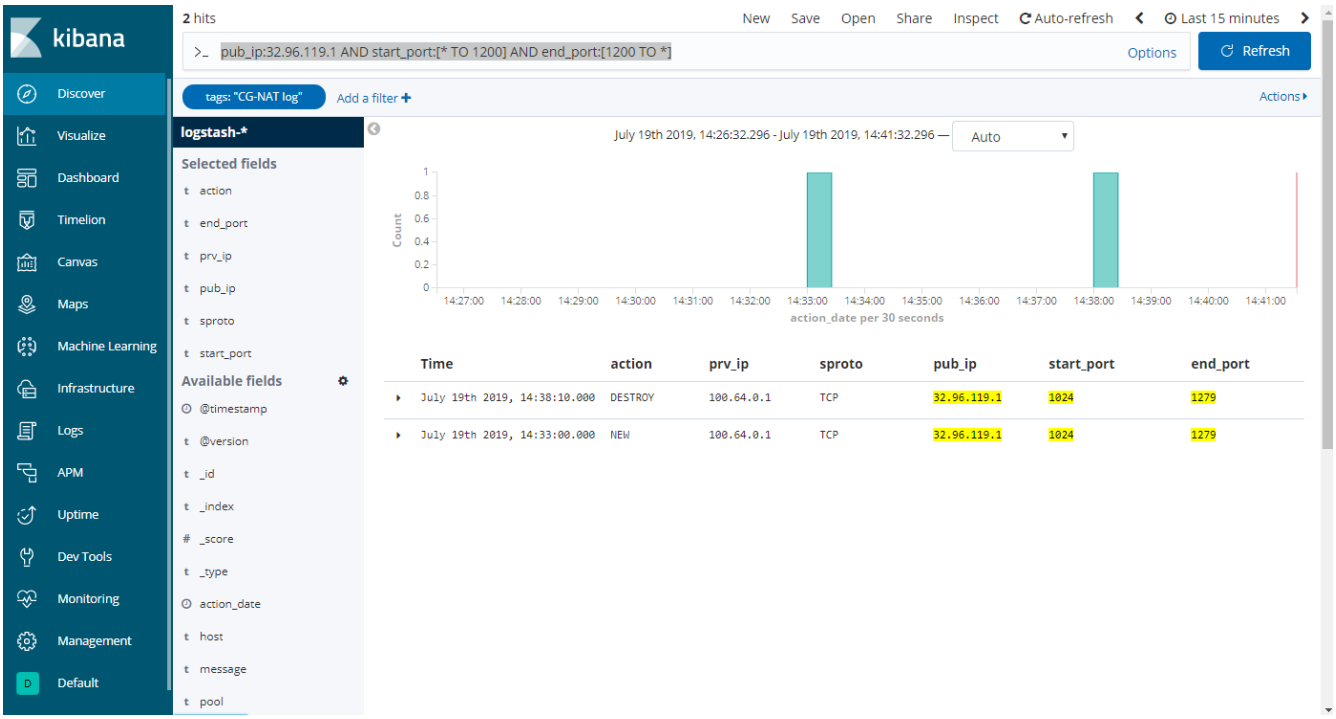
Click on Discover in the left menu; some logs are now displayed in the Kibana dashboard.



The final step is to clean the logs output. Add the following available fields: action, prv_ip, sproto, pub_ip, start_port, end_port.



Search can now be used to filter the logs on a public IP and port, for example using “pub_ip:32.96.119.1 AND start_port:[* TO 1200] AND end_port:[1200 TO *]” to search public IP 32.96.119.1 and port 1200.



2.6 Troubleshooting

2.6.1 Invalid packet state statistics

To display the CG-NAT statistics, use the following command.

```
vrouter> show cg-nat statistics
...
Invalid packet state cases:
...
   0 TCP case RST
...
   0 TCP case I
   0 TCP case II
   0 TCP case III
...
```

If the TCP case I, II or III statistics are incremented, you may disable TCP window checks as follows.

```
vrouter> edit running
vrouter running config# vrf main cg-nat options conntrack
vrouter running conntrack# behavior tcp-window-check enabled false
vrouter running conntrack# commit
```

If the TCP case RST statistic is incremented, you may disable TCP RST strict ordering as follows.

```
vrouter> edit running
vrouter running config# vrf main cg-nat options conntrack
vrouter running conntrack# behavior tcp-rst-strict-order enabled false
vrouter running conntrack# commit
```

Note: Disabling these features improves performance to the detriment of TCP robustness.

2.6.2 State/NAT/USER/Block Allocation Failures

```
vrouter> show cg-nat statistics
...
State and NAT entries:
...
   0 state allocation failures
...
   0 NAT entry allocation failures
   0 NAT port allocation failures
CGNat entries:
...
   0 USER allocation failures
...
   0 Block allocation failures
...
```

If one of these statistics is incremented, it means that one of the memory pools of the vRouter is full. Memory pool usage can be dumped using the following command.

```
vrouter> show cg-nat mempool-usage
cgnat_user_pool : 2000/10000 (20.00%)
cgnat_block_pool : 8000/80000 (10.00%)
table_pool : 0/1056 (0.00%)
conn_pool : 1056736/1056736 (100.00%)
nat_pool : 1056736/1056736 (100.00%)
```

In the example above, the connection and NAT memory pools are full. Their size must be increased as follows.

```
vrouter running config# / system
fast-path limits cg-nat
vrouter running cg-nat# max-conntracks 2000000
vrouter running cg-nat# max-nat-entries 2000000
vrouter running cg-nat# commit
```

Refer to the capability tuning section.

2.6.3 No IP Public errors

```
vrouter> show cg-nat statistics
...
CGNat entries:
...
   0 No IP Public
...
```

If this statistic is incremented, it means there are no blocks available in any public IP. This can be checked using the following command.

```
vrouter> show cg-nat pool-usage pool-name mypool
tcp block usage: 4095/4095 (100.0%)
udp block usage: 4095/4095 (100.0%)
icmp block usage: 4095/4095 (100.0%)
gre block usage: 4095/4095 (100.0%)
```

To solve this issue, add a new public IP to the pool using the following command.

```
vrouter> edit running
vourter running config# vrf main cg-nat pool mypool
vrouter running pool mypool#  address 32.96.120.0/24
vrouter running pool mypool# commit
```

2.6.4 NAT port allocation failures

There are two main reasons for port allocation failures:

- A user has consumed all its port blocks. The maximum number of blocks per user can be increased in the rule using the max-blocks-per-user command.
- No blocks are available on the public IP allocated to the user. In this case, the Full IP Public statistic is also incremented.

To list users with allocation failures to understand how many users are impacted, use the following command.

```
vrouter> show cg-nat user rule-id 1 threshold-errors 1
100.64.0.1 -> 32.96.119.108
   2/2 tcp blocks, 0/2 udp blocks, 0/2 icmp blocks, 0/2 gre blocks
   63 no port errors, 0 no block errors, 0 full public ip errors
```

To understand why a specific user has many connections, use the following command.

```
vrouter> show cg-nat conntracks rule-id 1 user-address 100.64.0.1
CON:
   vrfid 0 flags 0x6 alg none tsdiff 47 timeout 120
   forw proto 6 100.64.0.1:1024-> 32.96.118.2:6001 hash:be3505a5
   back proto 6 32.96.118.2:6001-> 32.96.119.108:1216 hash:92e65736
```

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```
   state 10:
      F { end 0 maxend 0 mwin 0 wscale 0 flags 1}
      T { end 0 maxend 0 mwin 0 wscale 0 flags 0}
   NAT: original address 100.64.0.1 proto 6 oport 1024 tport 1216
CON:
   vrfid 0 flags 0x6 alg none tsdiff 56 timeout 120
   forw proto 6 100.64.0.1:65024-> 32.96.118.2:6000 hash:913f8bf7
   back proto 6 32.96.118.2:6000-> 32.96.119.108:1024 hash:27051895
   state 10:
      F {end 0 maxend 0 mwin 0 wscale 0 flags 1}
      T {end 0 maxend 0 mwin 0 wscale 0 flags 0}
   NAT: original address 100.64.0.1 proto 6 oport 65024 tport 1024
...
```

2.6.5 Maximum number of blocks reached

If the maximum number of blocks is reached, it probably means that you have not allocated enough blocks per user. You can collect some statistics to get average/percentile block and port usage of all users with the following commands.

```
vrouter> show cg-nat block-statistics  rule-id 1
block-usage:
   1 user (with > 1 block = 1, ratio 100.00%)
   blocks per user: min = 2, max = 2, average = 2.00
   1 user (100.00%) have 2 blocks
vrouter> show cg-nat port-statistics  rule-id 1
port-usage:
   1 user (with > 1 port = 1, ratio 100.00%)
   ports per user: min = 128, max = 128, average = 128.00
   1 user (100.00%) have 128 ports
```

Then, you can decide to increase the number of blocks per user or the block size. Refer to the Changing parameters section.

2.6.6 Full IP Public errors

```
vrouter> show cg-nat statistics
...
CGNat entries:
...
   0 Full IP Public
...
```

The paired address pooling feature ensures the assignment of the same public IP address to all sessions originating from the same internal user, as described in RFC 4787 Req 2 (https://tools.ietf.org/html/rfc4787#page-22).

It means that when a user has started to use one public IP address, all its port blocks will be allocated from this same IP. Adding a new public IP to the pool won't solve the issue, as the user cannot allocate a block from a new public IP.

A possible way to recover such situation is to add new IP address to the pool, and then flush all the current connections of all users, as follows.

```
vrouter running config# / vrf main cg-nat pool mypool
vrouter running pool mypool#  address 32.96.120.0/24
vrouter running pool mypool# commit
Configuration committed.

vrouter running pool mypool# flush cg-nat user rule-id 1
```

See also:

See the User's Guide for more information regarding:

- CG-NAT troubleshooting (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/ip-networking/cgnat.html#troubleshooting)

2.7 Dimensioning

The maximum numbers for NAT entries, CPEs (users), conntracks (sessions), blocks and block sizes are defined in the configuration. These capabilities can be adjusted to adapt to the amount of memory available in the system.

The following table shows a list of different capability combinations and the corresponding memory requirement. This is empirical and may have to be tuned according to your use case.

Max conntracks	Max nat entries	Max cpe	Max blocks	Required memory
1M	1M	10K	80K	5 GB
2M	2M	20K	80K	6 GB
4M	4M	20K	80K	8 GB
8M	8M	20K	80K	12 GB
16M	16M	20K	80K	24 GB
30M	30M	20K	80K	32 GB

Here is an example to change the maximum number of conntracks.

```
vrouter> edit running
vrouter running config#
vrouter running config# system fast-path limits cg-nat max-conntracks 2000000
vrouter running config# commit
```

Modifying capabilities will automatically restart the fast path and interrupt packet processing. To check that the fast path is back up and running, use the following command.


```
vrouter running config# show state system fast-path
fast-path
   enabled stopping
   ..
vrouter running config#  show state system fast-path
fast-path
   enabled starting
   ..
vrouter running config# # show state system fast-path
fast-path
   enabled true
   ...
```

See also:

See the User's Guide for more information regarding:

- Fast path limits (https://doc.6wind.com/turbo-cg-nat-2.x/user-guide/cli/system/fast-path.html#fp-limits-configuration)

2.8 Limitations

Here are the known CG-NAT limitations of the vRouter.

Limitation	Impact
Paired address pooling cannot be disabled.	If a user consumes all its ports on a public IP address, a new public IP must be added to the pool and all the sessions must be flushed for the user to start using the new IP. Refer to the Full IP Public section.
Pools are not shareable.	A pool cannot be shared by two different rules.
Endpoint mapping/filtering	The supported modes are: Independent, Address-and-Port-Dependent.
No max-sessions-per-user parameter.	There is no option to limit the number of sessions per user. As a result, when the endpoint mapping/filtering modes are set to independent, a user can consume all the available conntracks.
Capabilities are not checked against available memory.	Configuring too high capabilities can prevent the system from working properly. Refer to the Capability tuning section.