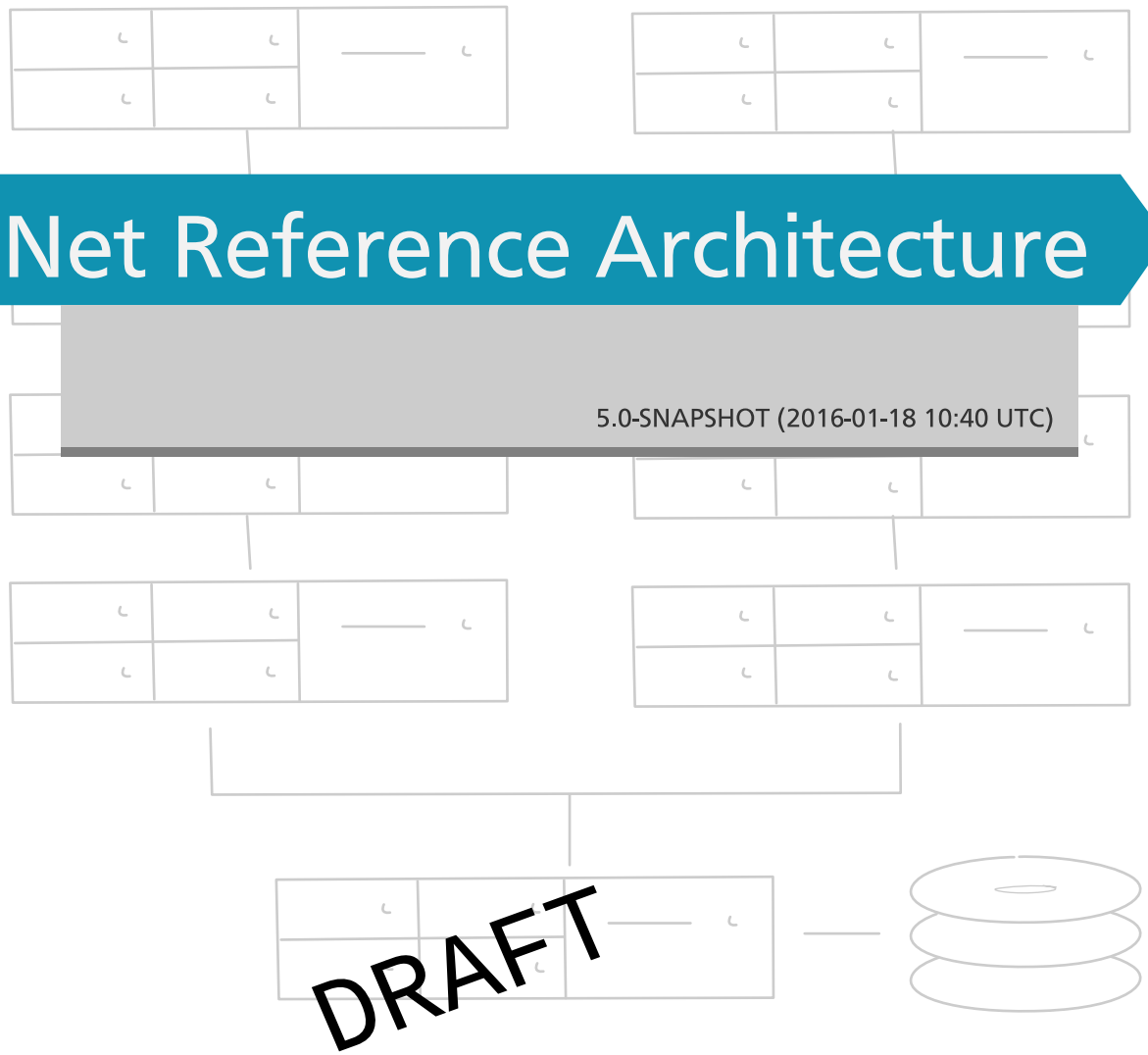
MidoNet Reference Architecture

5.0-SNAPSHOT (2016-01-18 10:40 UTC)



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MidoNet Reference Architecture

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MidoNet is a network virtualization software for Infrastructure-as-a-Service (IaaS) clouds.

It decouples your IaaS cloud from your network hardware, creating an intelligent software abstraction layer between your end hosts and your physical network.

This document contains useful information on preparing for your installation of MidoNet network virtualization, including the recommended hardware. More specifically, this document:

- Provides an overview of MidoNet.
- Outlines the necessary hardware and operating system software for configuring MidoNet network virtualization for OpenStack® and other cloud controllers.
- Provides a general overview of Border Gateway Protocol (BGP) setup and the MidoNet network architecture.

Caution

This document is a DRAFT. It may be MISSING relevant information or contain UNTESTED information. Use it at your own risk.

Note

Please consult the MidoNet Mailing Lists or Chat if you need assistance.

Table of Contents

Preface vi
Conventions vi
1. MidoNet overview 1
MidoNet key features 1
Recommended Hardware 2
Requirements for installation 2
OpenStack integration 3
2. MidoNet network architecture 4
Internal and underlay network 4
Underlay network 5
BGP setup and Layer-3 topologies 6
Virtual routers 6
Provider router 7
Compute Host Agents 7
Bridges 7
Metadata server 8
3. Solution components 9
State Management 9
4. MidoNet gateway nodes 12
Gateway node requirements 12
Gateway node connectivity 12
5. Midolman 13
Recommended installation nodes 13
Configuration guidelines 13
Network accessibility considerations 13
6. MidoNet Cluster 14
Recommended installation nodes 14
Fault-tolerant configuration guidelines 14
MidoNet REST API HTTP endpoint 14
MidoNet REST API HTTPS endpoint 14
7. MidoNet Command Line Interface 16

List of Figures

2.1. MidoNet Example Topology 4
2.2. Layer-3 Topology (Physical Underlay Network) 6
2.3. Layer-3 Topology (Virtual Overlay Network) 6

List of Tables

1.1. Recommended Deployment Hardware 2

Preface

Conventions

The MidoNet documentation uses several typesetting conventions.

Notices

Notices take these forms:

Note

A handy tip or reminder.

Important

Something you must be aware of before proceeding.

Warning

Critical information about the risk of data loss or security issues.

Command prompts

$ prompt

Any user, including the root user, can run commands that are prefixed with the $ prompt.

 # prompt

The root user must run commands that are prefixed with the # prompt. You can also prefix these commands with the **sudo** command, if available, to run them.

1. MidoNet overview

Table of Contents

MidoNet key features 1
Recommended Hardware 2
Requirements for installation 2
OpenStack integration 3

MidoNet is a distributed, de-centralized, software-defined virtual network platform for Infrastructure as a Service (IaaS).

MidoNet fully virtualizes the network functionality for IaaS products, such as OpenStack, providing functionally advanced, robust, scalable, and secure networks. MidoNet is an overlay network that runs software on standard x86 servers, and sits on top of any scalable network underlay (for example, physical servers and switches), pushing the intelligent network functions to the edge of the network, in software.

MidoNet sends virtual network traffic over tunnels created between the edges. The tunnels encapsulate the packets coming from virtual machines (VMs) and exterior ports, and decouple the virtual network traffic from the physical network. With this model, changes in the virtual network, for example, creating new virtual machines, don't affect the state of the underlay network. In addition, this clear separation between the virtual and physical networks allows the administrator to more easily maintain the IaaS platform.

MidoNet key features

These are the key features of MidoNet:

- Fully virtualized Layer 2 through 4 networking
- VLAN-less VLANs – Virtual L2 distributed isolation and switching with virtually none of the limitations of conventional VLANs
- Fully distributed architecture with no single points of failure
- Virtual L3 distributed routing
- Distributed load balancing and firewall services
- Stateful and stateless NAT
- Access Control Lists (ACLs)
- Restful API
- Monitoring of networking services
- VXLAN support: VXLAN tunnel zones, VXLAN L2 Gateway
- Zero-delay NAT connection tracking

Recommended Hardware

This section provides information about the hardware recommended for a MidoNet deployment.

Table 1.1. Recommended Deployment Hardware

Hardware	Requirements
Network State Database, API, and Agent Nodes	CPU: 64-bit x86, quad core or above Memory: ≥ 32GB RAM HDD: ≥ 30GB (available free disk space) NIC: 2 x ≥ 1Gbit
2 x GW Nodes	CPU: 64-bit x86, quad core or above Memory: ≥ 32GB RAM HDD: ≥ 30GB Network: 3 x ≥ 1Gbit
NIC Cards	For a high-performance data network: use NICs that support multiple queues and MSI-X
Top of Rack Switch	Non-blocking multilayer switch (L2/L3) with jumbo frame support
Hard Disks	Ideally, both the ZooKeeper transaction log and Cassandra data files need their own dedicated disks, with additional disks for other services on the host. However, for small POCs and small deployments, it is ok to share the Cassandra disk with other services and just leave the Zookeeper transaction log on its own.

Requirements for installation

Operating System

MidoNet works with the 64-bit versions of following operating systems:

- Ubuntu 14.04 LTS
- Red Hat Enterprise Linux 7
- CentOS 7

BGP Setup Requirements

You need the hardware and information listed below to configure BGP on the GW nodes.

- Two GW nodes connected to border routers. Typically, for load balancing, each GW node connects to a different border router.
- Each GW nodes needs at least two physical network interfaces, one on the internal network, and the other connected to the upstream border router.
- Autonomous system (AS) number of your local (private) network
- AS number of the remote (public) network (for example, your Internet service provider (ISP) or data center)

- The IP address(es) of the interface(s) on one or more border routers
- The IP addresses of the GW nodes' virtual ports
- For each GW node, the IP address of the advertising route

OpenStack integration

MidoNet works very well with OpenStack, taking over nearly all of the networking functions currently found in OpenStack, including Layer 2 network isolation, Layer 3 routing, security groups, floating IPs, and more.

MidoNet integrates with OpenStack by providing an OpenStack Networking plugin, as well as drivers for OpenStack Networking. End users can use the same OpenStack API, GUI, and CLI commands; MidoNet hooks into existing API calls and handles all the networking calls in a seamless manner.

You may also configure a management network that links all servers hosting OpenStack and MidoNet software. This network would provide out-of-band management of your cloud software.

You may arrange OpenStack deployment into two types of nodes: **Controller nodes** and **Compute nodes**.

- The Controller node typically hosts such services as: nova-api, nova-cert, nova-conductor, nova-scheduler, nova-consoleauth, and neutron.
- The Compute nodes typically host the nova-compute and hypervisor services. Nova-compute should not be installed on the Controller node.

Note

On RHEL distributions, "openstack" may be prepended to the OpenStack package name, for example, "**openstack-nova-api**".

2. MidoNet network architecture

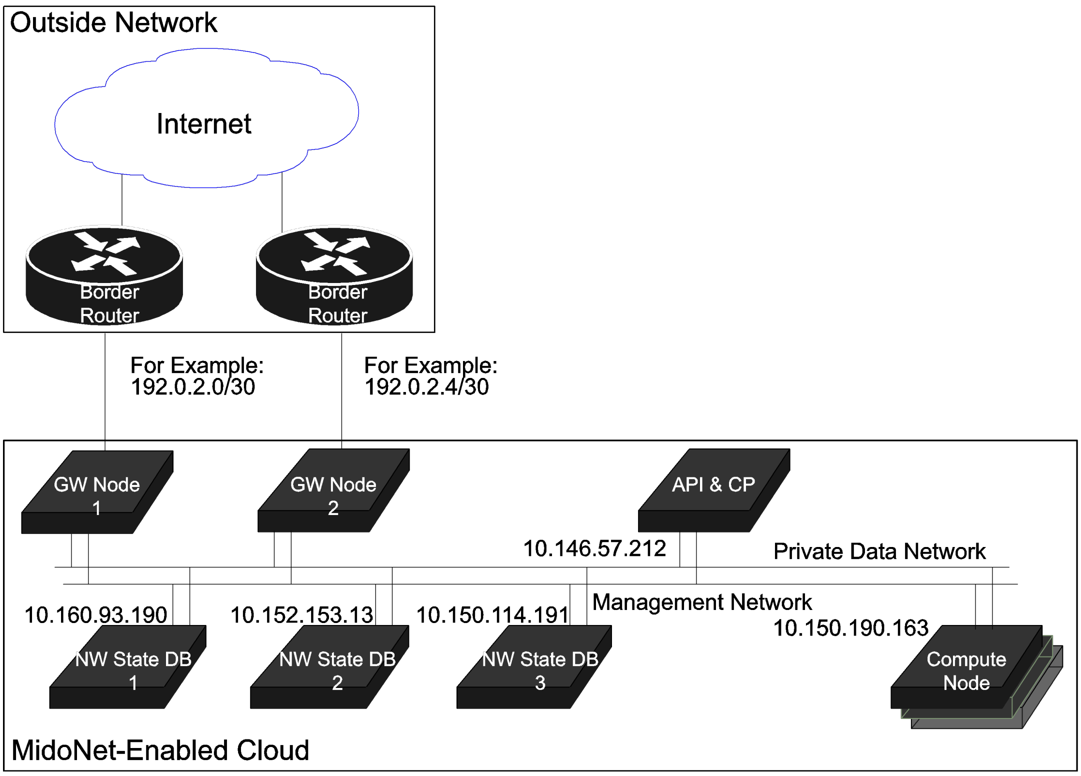
Table of Contents

Internal and underlay network 4
Underlay network 5
BGP setup and Layer-3 topologies 6
Virtual routers 6
Provider router 7
Compute Host Agents 7
Bridges 7
Metadata server 8

MidoNet operates an overlay network on top of an existing physical network. MidoNet Agents run in software on the edge of the network in both the GW (gateway) nodes, as well as on the compute hosts.

In addition to the MidoNet Agents, there is also a state-management system, which co-ordinates with each of the distributed agents. For centralized management, MidoNet also provides a RESTful API server.

Figure 2.1. MidoNet Example Topology



Internal and underlay network

MidoNet relies on IP reach-ability between all servers.

We therefore recommend an IP network using non-global IP addresses (see RFC 1918). In a very small deployment of one rack or less, a single Ethernet switch could serve as

the internal network, albeit representing a single point of failure. For larger deployments, a hierarchical IP-routed network, possibly with equal cost multi-path (ECMP), would be appropriate.

Underlay network

The underlay network is the physical network hosting the MidoNet software.

GRE and VXLAN tunnels

MidoNet uses tunneling for communication between physical hosts in the underlay. MidoNet supports two tunneling protocols:

- General Routing Encapsulation (GRE) protocol (MidoNet’s default tunneling protocol). GRE has a fixed wrapper size of 46 bytes.
- Virtual Extensible LAN (VXLAN) protocol. VXLAN adds an overhead of 50 bytes.

To avoid fragmentation and reassembly, you must allow for this overhead, by setting the appropriate Maximum Transmission Unit (MTU) size.

MTU size considerations for the underlay network

To allow for the overhead, with the default MTU size (1500) for the network up-link and virtual machines, the MTU size for physical network devices participating in GRE tunneling should be 1546. For VXLAN traffic to be functional, you should set the MTU size for physical network devices to 1550.

Important

Make sure the MTU of the virtual machines is not larger than the MTU of the up-link interface on the border gateway.

MTU size considerations for the overlay network

Optimal data-link settings will depend on your individual environment. MidoNet supports jumbo Ethernet frames. When configuring jumbo-frame support, please note that network interfaces in the MidoNet network should have an MTU size of at least 46 bytes or 50 bytes less than the MTU size of the underlay (physical) network (to allow for GRE and VXLAN encapsulation, respectively). Watch out for any MTU mismatch that may occur in the path of the virtual network traffic. Such a mismatch may result in IP fragmentation/defragmentation that may negatively impact network performance.

If your underlay network does not support Ethernet frames larger than 1500 bytes, you may need to run the MidoNet network with MTU settings of 1454 or 1450 bytes (to allow for GRE and VXLAN encapsulation, respectively). With this configuration, ensure that you configure the MTU size correctly for network interfaces inside virtual machines.

Offloading on L3 Gateway uplink NIC

Offloading on NICs is intended for end-hosts, not intermediate hosts. The NIC of the Gateway’s uplink should be treated like a router NIC.

If LRO is enabled at the L3 Gateway uplink NIC, the NIC may coalesce incoming TCP packets, handing MidoNet a packet that is larger than the MTU of the destination. The packet is therefore dropped because MidoNet does not provide large segment offload

(LSO, segmenting large TCP packets before transmitting) nor does it support IP fragmentation. For that reason, you must disable offload on L3 Gateway uplink NIC. Do the following on the uplink NIC:

```
# ethtool -K p2p1 lro off
```

Alternatively, you may add this to the network script file:

```
ETHTOOL_OPTS="lro off"
```

BGP setup and Layer-3 topologies

This section provides diagrams and information regarding BGP setup and Layer 3 topologies.

Figure 2.2, "Layer-3 Topology (Physical Underlay Network)" [6] shows an example underlying network infrastructure.

Figure 2.3, "Layer-3 Topology (Virtual Overlay Network)" [6] shows an example MidoNet virtual network overlaid on top of the underlying network architecture, along with BGP route-advertisement information.

Figure 2.2. Layer-3 Topology (Physical Underlay Network)

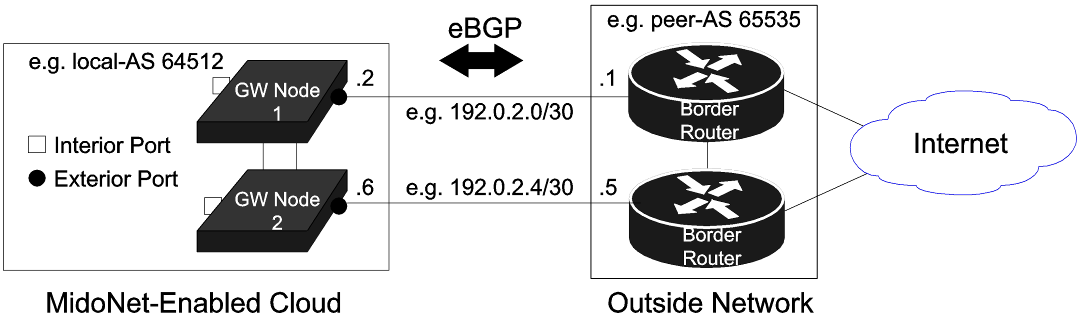
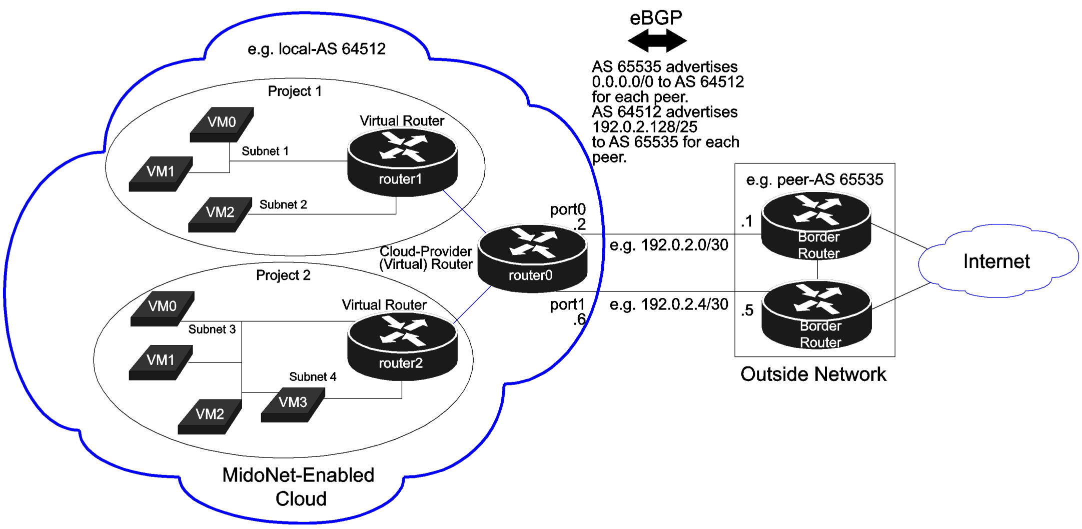


Figure 2.3. Layer-3 Topology (Virtual Overlay Network)



Virtual routers

A virtual router is an abstraction of a physical layer 3 (L3) router and is MidoNet's L3 forwarding element.

Like a physical router, on a virtual router, you can configure network interfaces (ports), network up-links (also ports, but ports that are bound to physical Ethernet interfaces that connect to upstream devices, typically physical routers and bridges). You can connect virtual routers to other routers and bridges.

Provider router

Provider router is an internal router in MidoNet that acts as the gateway router of the cloud.

It is created when an external network is created in Neutron. There is always only one Provider router in the system, even if there are multiple external networks.

A provider router gets created automatically when you create an external network in OpenStack.

Note that even though the provider router is a single virtual entity, its state is distributed in MidoNet, and it doesn't present a single point of failure as long as you have multiple Gateway Nodes providing connectivity to the external network.

In a real deployment, most of the ports connected to the MidoNet Provider Router are up-link ports, and typically there are multiple unlink ports. (In the example network described above, the network is not connected to up-link ports.) Like other virtual ports with connections outside of MidoNet, each port is bound to a device (Ethernet interface) and a host. The host is a Gateway Node that is physically connected to the upstream router that goes out to a service provider.

For more information on creating external networks, refer to http://docs.openstack.org/havana/install-guide/install/apt/content/install-neutron.configure-networks.html

Compute Host Agents

MidoNet requires an agent to be installed on each compute host, which runs the VMs.

The MidoNet Agent on the compute host is responsible for most of the east/west traffic in the cloud, as well as the outgoing northbound traffic. We currently support the KVM hypervisor.

Bridges

Bridges are MidoNet's L2 forwarding elements.

You can create virtual ports on bridges. In turn, you can attach VMs to virtual ports on a bridge. All VMs attached to the same bridge are reachable through L2 connectivity. You can connect ports on virtual bridges to another virtual device or a physical machine.

Bridges store the mappings between MAC addresses of network devices that send received frames and the bridge ports they receive them from.

The bridge dynamically builds a table of the source MAC addresses and the bridge ports. The bridge uses this table to send frames destined for the network device to the correct bridge port. You can clear the MAC table.

Metadata server

The metadata server is used for storing instance VM configuration information, for example, authentication information or a VM customization script.

In an OpenStack environment, the metadata is stored in Nova Metadata API. MidoNet provides a Metadata Proxy implementation, which forwards metadata requests from VMs to the Nova Metadata API, in a similar way Neutron Metadata Proxy does.

Important

The Metadata Proxy creates an interface on the hypervisor hosts, named "metadata".

When using `iptables` it may be necessary to add a rule to accept traffic on that interface:

```
iptables -I INPUT 1 -i metadata -j ACCEPT
```

3. Solution components

Table of Contents

State Management 9

The MidoNet solution consists of these components:

- MidoNet Network State Database nodes
- MidoNet Gateway Nodes
- Servers running the MidoNet API, the MidoNet Agent (Midolman), and the Command Line Interface (CLI)
- OpenStack controller nodes hosting Nova and OpenStack Networking services
- OpenStack Compute nodes

State Management

A MidoNet Network State Database is a cluster of servers that stores MidoNet configuration, run-time state, and statistics data.

MidoNet stores configuration-state information in two different systems. MidoNet uses Apache™ Zookeeper™ and Cassandra™ for coordinating the operation between MidoNet Agents, as well as storing the network configuration and state (Network State Database nodes).

You should configure dedicated servers in this cluster to run the MidoNet Network State Database and the servers should not host other software. It is recommended to dedicate three servers to this role.

ZooKeeper

MidoNet uses Apache ZooKeeper to store critical path data about the virtual and physical network topology.

Examples of this type of data are: interconnects between virtual machines (VMs) and bridges and routers; Address Resolution Protocol (ARP) and ND tables; and host Universally Unique Identifier (UUID) and Internet Protocol (IP) address registrations. The MidoNet Agents and the MidoNet API Server manage the schema for ZooKeeper. Because of the nature of the information stored within ZooKeeper, the schema is optimized for integrity and consistency of the data across the cluster instead of speed.

Necessary software

MidoNet requires ZooKeeper version 3.4.5 (which is provided in the MidoNet repository).

You can also obtain ZooKeeper software from the Apache Software Foundation.

In addition to the ZooKeeper software itself, you also need a Java® Runtime Environment. We recommend OpenJDK™ 7, which is available as part of most Linux distributions.

Fault-tolerant configuration guidelines

We strongly recommend running at least three ZooKeeper instances.

With extremely small test and development environments (no more than three MidoNet Agents, including Gateway Nodes) you can run a single instance of ZooKeeper. For all production deployments, we strongly encourage using three instances.

For larger scale implementations (over a few dozen MidoNet Agents running, including Gateway Nodes), we recommend installing Cassandra and ZooKeeper on separate nodes optimized for their workloads. We also recommend running five or seven instances of ZooKeeper and Cassandra to reduce load and provide more resources to the rest of the cluster.

You should deploy ZooKeeper and Cassandra nodes in an odd number of instances, for example, 3, 7, or 9. This ensures a quorum in the event of a node failure. The number of node failures that the cluster can tolerate is one for a three-node cluster, two for a five-node cluster, three for a seven-node cluster, and so on.

To help manage ZooKeeper clusters, we recommend using the Exhibitor Supervisor System for ZooKeeper.

Accessibility considerations

The ZooKeeper cluster typically uses three ports: TCP/2181, TCP/2888, and TCP/3888.

The Exhibitor Supervisor typically also runs a web interface on TCP/8080.

The ZooKeeper cluster needs to be directly accessible to the following MidoNet components without a proxy:

- MidoNet Cluster server
- MidoNet Agents (including the MidoNet Gateway Node(s))
- Other ZooKeeper instances

We recommend using a network separate from the data path for MidoNet control messages. For example, you may use a management network for connectivity between the MidoNet API, MidoNet Network State Database, and MidoNet Agent nodes. You should establish the point-to-point tunnels between MidoNet Agents on the data path network.

If you use Exhibitor, make sure its web interface is accessible to system operators.

Cassandra

MidoNet uses Apache Cassandra version 2.0 to store flow state information, for example NAT bindings, connection tracking information, and to support VM migration.

While, MidoNet leverages Cassandra’s durability, fault tolerance, timed expirations, and low-latency read/writes, it only uses Cassandra as a backup rather than the primary datasource.

Necessary software

Cassandra requires a Java Runtime Environment (JRE).

We recommend OpenJDK 7, which is available as part of most Linux distributions or can be installed using the official installation guide (go to http://openjdk.java.net/ and navigate to the installing information).

Fault-tolerant configuration guidelines

The minimum recommended Cassandra setup is a three-node cluster with a replication factor (N) of three.

The MidoNet Agent (Midolman) uses QUORUM as a consistency policy of N/2 + 1, which translates to two in the suggested setup.

Accessibility considerations

Cassandra uses two IP addresses: one for intra-cluster communication (the listen_address parameter) and another one for client connections via remote procedure calls (RPC) (rpc_address).

4. MidoNet gateway nodes

Table of Contents

Gateway node requirements 12
Gateway node connectivity 12

In addition to the hardware required to run OpenStack and MidoNet, you need one or more servers to run at the edge of the network and connect your OpenStack deployment to the external network. These servers are referred to as "Gateway Nodes".

Gateway Nodes will handle more traffic (to and from external networks) than Compute nodes so you must make sure that you allocate more memory to the Gateway Nodes hosts.

Gateway node requirements

MidoNet interfaces directly with upstream routers via physical connections.

GW nodes need at least two physical network interfaces, one on the internal network, and the other connected to the upstream router. Depending on the use case and environment, the GW nodes may be handling much incoming and outgoing traffic. Therefore, we highly recommend NICs with multi-queue and MSI-X support, such as ones based on the 1Gbps Intel™ 82576 Ethernet controller, or the 10Gbps Intel 82599 Ethernet controller. Using such a NIC enables us to process receive events on multiple queues, and to handle IRQ events on multiple cores.

Gateway node connectivity

The MidoNet cloud deployment needs to be assigned a global IP range, which will be used by clients to access the VMs from the Internet.

MidoNet can use static routing, but we generally prefer to use BGP dynamic routing for fast fail over. All GW nodes advertise the same IP range via BGP so the upstream network should balance incoming flows over them. Typically, users assign a private Autonomous System (AS) to the MidoNet deployment, and set up BGP sessions for each edge.

5. Midolman

Table of Contents

Recommended installation nodes 13
Configuration guidelines 13
Network accessibility considerations 13

Midolman (the MidoNet Agent) is the daemon that runs on all hosts where traffic enters and leaves MidoNet.

It instructs the Open vSwitch kernel module on how to handle network traffic (what modifications to apply to packets and where to tunnel them to).

Midolman requires a Linux kernel that has the Open vSwitch kernel module installed and a Java 7 runtime in userspace (we recommend using OpenJDK 7).

Midolman is designed to work with Open vSwitch kernel module version 1.10.2 or later. If you need to update the kernel module, you may be able to find a later version of the module in the cloud software repositories for your distribution.

Recommended installation nodes

Where Midolman is being used to network virtual machines, you should generally install it on the host machines alongside the hypervisor.

If you are using it with the Border Gateway Protocol (BGP), you should install it on nodes with very few hops to the BGP peer (ideally one). Where there is north-south traffic for MidoNet, you should install Midolman on machines with sufficient bandwidth and proximity to the up-links to handle the traffic.

Configuration guidelines

Midolman requires that you specify the ZooKeeper and Cassandra server IP addresses in the Midolman configuration file.

You can configure Midolman to detect node failures faster by reducing the ZooKeeper session timeout and session grace time values. However, this will also reduce the window of time after a transient outage that the system can recover from, instead of being treated as a node failure. Increasing these timeout values has the opposite effect. We don’t recommend making changes to the default timeout values, except possibly the session_gracetime setting value.

Network accessibility considerations

MidoNet Agent hosts in the same tunnel zone must have IP connectivity to each other.

They also require TCP connectivity to the ZooKeeper and Cassandra servers (the default TCP port numbers are 2181 for ZooKeeper and 9042 for Cassandra).

MidoNet Agents use the Domain Name System (DNS) to convert between hostnames and underlay network addresses. Verify that each server on which you install the MidoNet Agent has a resolvable hostname.

6. MidoNet Cluster

Table of Contents

Recommended installation nodes 14
Fault-tolerant configuration guidelines 14
MidoNet REST API HTTP endpoint 14
MidoNet REST API HTTPS endpoint 14

The MidoNet Cluster is a new type of node introduced in MidoNet v5 that replaces the MidoNet API. The MidoNet Cluster provides the REST API endpoint, and also hosts a number of management services such as VxLAN Gateway Controller.

Recommended installation nodes

The MidoNet Cluster can be installed on any node with access to the ZooKeeper cluster (which typically uses three ports: TCP/2181, TCP/2888, and TCP/3888.

For test/evaluation purposes MidoNet Cluster, ZooKeeper and Cassandra can coexist on the same physical host.

Note however that such configuration is discouraged for production deployments. In this case, each of MidoNet Cluster, ZooKeeper and Casandra should be placed in dedicated nodes.

Fault-tolerant configuration guidelines

In order to provide a fault-tolerant solution, we recommend running several instances of the MidoNet Cluster on different nodes and then exposing a common virtual IP (VIP) address using an external load balancer to distribute the API calls between the instances.

No special load balancer features are needed, so any load balancer will work.

MidoNet REST API HTTP endpoint

The MidoNet Cluster exposes a RESTful API running over the Hypertext Transfer Protocol (HTTP) that provides the integration point between external applications (including the cloud controller) and the internal MidoNet configurations. The REST API is stateless, so you can scale out this service by simply adding more Cluster nodes.

The MidoNet REST API supports OpenStack Keystone authentication.

The REST API will be exposed on port TCP/8181 by default. This port can be changed with the following mn-conf command:

```
echo "cluster.rest_api.http_port = $NEW_PORT" | mn-conf set -t default
```

MidoNet REST API HTTPS endpoint

HTTPS is also available and exposed on port TCP/8443 by default. This port can be changed with the following mn-conf command:

```
echo "cluster.rest_api.https_port = $NEW_PORT" | mn-conf set -t default
```

MidoNet Cluster will disable the HTTPS endpoint if the port is set to a value equal or less than 0, or if no keystore is accessible on the system.

The MidoNet Cluster will expect to find a keystore containing the certificate in `/etc/midonet-cluster/ssl/midonet.jks`.

This location can be overridden by setting the midonet.keystore_path system variable to a different path.

To generate a self-signed key, you can use the following procedure. Note that you will be prompted for passwords during this process, and need to keep the keystore password for later use.

```
openssl genrsa -des3 -out midonet.key 2048
openssl rsa -in midonet.key -out midonet.key
openssl req -sha256 -new -key midonet.key -out midonet.csr -subj '/CN=
localhost'
openssl x509 -req -days 365 -in midonet.csr -signkey midonet.key -out
 midonet.crt
```

Now we will combine the private key into the cert, because we generated them separately:

```
openssl pkcs12 -inkey midonet.key -in midonet.crt -export -out midonet.
pkcs12
```

And load the certificate into the keystore:

```
keytool -importkeystore -srckeystore midonet.pkcs12 -srcstoretype PKCS12 -
destkeystore midonet.jks
```

Now place the keystore in the default location:

```
mv midonet.jks /etc/midonet-cluster/ssl
```

For more advanced key management, including adding your own certificate to the keystore, please refer to the following documentation:

https://www.eclipse.org/jetty/documentation/current/configuring-ssl.html

7. MidoNet Command Line Interface

The MidoNet CLI is a command line interface that allows you to inspect and edit the MidoNet virtual topology.