Mellanox CloudX, Mirantis Fuel Solution Guide

Rev 1.0
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Preface

About this Manual

This manual is a reference architecture and an installation guide for a small size OpenStack cloud of 2 -34 compute nodes based on Mellanox interconnect hardware and Mirantis Fuel software.

Audience

This manual is intended for IT engineers, System Architects or any personnel who is interested in understanding or deploying Mellanox CloudX™, using Mirantis Fuel.

Related Documentation

For additional information, see the following documents:

<table>
<thead>
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<th>Document</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mellanox OpenStack Reference Architecture</td>
<td><a href="http://www.mellanox.com/openstack/">http://www.mellanox.com/openstack/</a></td>
</tr>
<tr>
<td></td>
<td>NOTE: active support account required to access manual.</td>
</tr>
<tr>
<td>HowTo Install Mirantis Fuel OpenStack</td>
<td><a href="http://community.mellanox.com/docs/DOC-1449">http://community.mellanox.com/docs/DOC-1449</a></td>
</tr>
<tr>
<td>with Mellanox Adapters Support</td>
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<tr>
<td>HowTo Configure 56GbE Link on Mellanox Adapters</td>
<td><a href="http://community.mellanox.com/docs/DOC-1460">http://community.mellanox.com/docs/DOC-1460</a></td>
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<td>and Switches</td>
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<tr>
<td>Mellanox OFED Driver Installation and Configuration for SR-IOV</td>
<td><a href="http://community.mellanox.com/docs/DOC-1317">http://community.mellanox.com/docs/DOC-1317</a></td>
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<tr>
<td>Mirantis Openstack installation guide</td>
<td><a href="http://docs.mirantis.com/fuel/fuel-4.1/">http://docs.mirantis.com/fuel/fuel-4.1/</a></td>
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<tr>
<td>HowTo Configure iSER Block Storage for OpenStack Cloud with Mellanox ConnectX-3 Adapters</td>
<td><a href="http://community.mellanox.com/docs/DOC-1462">http://community.mellanox.com/docs/DOC-1462</a></td>
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1 Overview

Mellanox CloudX™ is reference architecture for the most efficient cloud infrastructure which makes use of open source cloud software, such as OpenStack, while running on Mellanox® interconnect technology. CloudX utilizes off-the-shelf building blocks (servers, storage, interconnect and software) to form flexible and cost-effective private, public, and hybrid clouds. In addition, it incorporates virtualization with high-bandwidth and low-latency interconnect solutions while significantly reducing data center costs. Built around the fastest interconnect technology of 40Gb/s and 56Gb/s Ethernet, CloudX provides the fastest data transfer and most effective utilization of computing, storage and Flash SSD components.

Based on Mellanox high-speed, low-latency converged fabric, CloudX provides significant cost reductions in CAPEX and OPEX in the following means:

- High VM rate per compute node
- Efficient CPU utilization due to hardware offloads
- High throughput per server, for compute and hypervisor tasks
- Fast, low-latency access to storage

Mirantis OpenStack is one of the most progressive, flexible, open distributions of OpenStack. In a single commercially supported package, Mirantis OpenStack combines the latest innovations from the open source community with the testing and reliability expected of enterprise software.

The integration of Mirantis Fuel software and Mellanox Hardware generates the best solution for cloud provider.

The solution discussed in this guide is based on Mirantis Fuel 4.1 software (OpenStack Havana release) which provides the following features:

- SR-IOV support on the compute nodes
- iSER (iSCSI over RDMA) block storage protocol for Cinder
- Fabric speeds of up to 56GbE based on Mellanox SX1036 Ethernet switch systems
2 Virtualization

Single Root IO Virtualization (SR-IOV) allows a single physical PCIe device to present itself as multiple devices on the PCIe bus. Mellanox ConnectX®-3 adapters are capable of exposing up to 127 virtual instances called Virtual Functions (VFs). These VFs can then be provisioned separately. Each VF can be viewed as an additional device associated with a Physical Function (PF). The VF shares the same resources with the PF, and its number of ports equals those of the PF.

SR-IOV is commonly used in conjunction with an SR-IOV enabled hypervisor to provide virtual machines (VMs) with direct hardware access to network resources, thereby improving performance.

Mellanox ConnectX-3 adapters equipped with an onboard embedded switch (eSwitch) are capable of performing Layer-2 switching for the different VMs running on the server. Using the eSwitch yields even higher performance levels, as well as improves security and isolation.

The installation is capable of handling Mellanox NIC cards, it updates the correct firmware version which incorporates SR-IOV enablement and defines 16 VFs. Each spawned VM provisioned with one VF per network attached. The solution supports up to 16 VMs on a single compute node connected to single network or 8 VMs connected to 2 networks or any other combination which sums to 16 networks in total.

SR-IOV support for OpenStack is under development. Security groups are not supported with SR-IOV.

If the setup is based on Mellanox OEM NICs, make sure to have a compatible firmware version to OFED version 2.1-1.0.0 (or later). Make sure that this firmware version supports SR-IOV (click here for additional information).

Figure 1: eSwitch Architecture
2.1 eSwitch Capabilities and Characteristics

The main capabilities and characteristics of eSwitch are listed in the following:

- **Virtual switching:** Creating multiple logical virtualized networks. The eSwitch offload engines handle all networking operations up to the VM, thereby dramatically reducing software overheads and costs.
- **Performance:** Switching is handled by hardware as opposed to other applications that use a software-based switch. This enhances performance by reducing CPU overhead.
- **Security:** The eSwitch enables network isolation (using VLANs) and anti-MAC spoofing.
- **Monitoring:** Port counters are supported.

2.2 Performance Measurements

Many data center applications benefit from low-latency network communication while others require deterministic latency. Using regular TCP connectivity between VMs can create high latency and unpredictable delay behavior.

**Figure 2** shows the dramatic difference (20X improvement) delivered by SR-IOV connectivity running RDMA compared to para-virtualized vNIC running a TCP stream.

Using the direct connection of SR-IOV and ConnectX-3, the hardware eliminates software processing which delays packet movement. This result in consistent low-latency that allows application software to rely on deterministic packet transfer times.

**Figure 2: Latency Comparison**

![Latency Comparison Graph](graph_image)
3 Storage Acceleration

Data centers rely on communication between compute and storage nodes as compute servers read and write data from storage servers constantly. To maximize the server’s application performance, communication between the compute and storage nodes must have the lowest possible latency, highest possible bandwidth, and lowest CPU utilization.

*Figure 3: OpenStack Based IaaS Cloud POD Deployment Example*

Storage applications, relying on iSCSI over TCP communications protocol stack, continuously interrupt the processor to perform basic data movement tasks (packet sequence and reliability tests, re-ordering, acknowledgements, block level translations, memory buffer copying, etc). This causes data center applications that rely heavily on storage communication to suffer from reduced CPU efficiency, as the processor is busy sending data to and from the storage servers rather than performing application processing. The data path for applications and system processes must wait in line with protocols such as TCP, UDP, NFS, and iSCSI for their turn to use the CPU. This not only slows down the network, but also uses system resources that could otherwise have been used for executing applications faster.

Mellanox OpenStack solution extends the Cinder project by adding iSCSI running over RDMA (iSER). Leveraging RDMA Mellanox OpenStack delivers 6X better data throughput (for example, increasing from 1GB/s to 6GB/s) and while simultaneously reducing CPU utilization by up to 80% (see Figure 4).

Mellanox ConnectX®-3 adapters bypass the operating system and CPU by using RDMA, allowing much more efficient data movement. iSER capabilities are used to accelerate hypervisor traffic, including storage access, VM migration, and data and VM replication. The use of RDMA shifts data movement processing to the Mellanox ConnectX-3 hardware, which provides zero-copy message transfers for SCSI packets to the application, producing significantly faster performance, lower network latency, lower access time, and lower CPU overhead. iSER can provide 6X faster performance than traditional TCP/IP based iSCSI. The iSER protocol unifies the software development efforts of both Ethernet and InfiniBand communities, and reduces the number of storage protocols a user must learn and maintain.
RDMA bypass allows the application data path to effectively skip to the front of the line. Data is provided directly to the application immediately upon receipt without being subject to various delays due to CPU load-dependent software queues. This has three effects:

- The latency of transactions is incredibly low;
- Because there is no contention for resources, the latency is deterministic, which is essential for offering end users a guaranteed SLA;
- Bypassing the OS, using RDMA results in significant savings in CPU cycles. With a more efficient system in place, those saved CPU cycles can be used to accelerate application performance.

In Figure 4 it is clear that by performing hardware offload of the data transfers using the iSER protocol, the full capacity of the link is utilized to the maximum of the PCIe limit.

To summarize, network performance is a significant element in the overall delivery of data center services and benefits from high-speed interconnects. Unfortunately, the high CPU overhead associated with traditional storage adapters prevents systems from taking full advantage of these high-speed interconnects. The iSER protocol uses RDMA to shift data movement tasks to the network adapter and thus frees up CPU cycles that would otherwise be consumed executing traditional TCP and iSCSI protocols. Hence, using RDMA-based fast interconnects significantly increase data center application performance levels.

**Figure 4: RDMA Acceleration**
4 Networking

In this solution, we define the following node functions:

- Fuel node (master)
- Compute nodes
- Controllers (and network) node
- Storage node (+ JBODs)

The following five networks are required for this solution:

- Public network
- Admin (PXE) network
- Storage network
- Management network
- Private network

Besides the Fuel node that is connected only to the Public and Admin (PXE) networks, all other nodes are connected to all five networks. Although not all nodes may be required to connect to all networks, this is done by Fuel design.

Figure 5 - Solution Networking
4.1 Network Types

4.1.1 Admin (PXE) Network
The Admin (PXE) network is used for the cloud servers PXE boot and OpenStack installation. It uses the 1GbE port on the servers.

*Figure 6: PXE Network*

![PXE Network Diagram]

4.1.2 Storage Network
The Storage network is used for tenant storage traffic. The storage network is connected via the SX1036 (40/56GbE). It is recommended to connect all compute and storage nodes via port 2 in the ConnectX®-3 Pro network adapter.

The iSER protocol runs between the hypervisors and the Storage node over the 40/56GbE storage network.

The VLAN used for the storage network is configured by the Fuel UI.

*Figure 7: Storage Network*

![Storage Network Diagram]

4.1.3 Management Network
The Management network is an internal network which mediates among between the controller, storage, and compute nodes. It is connected with the SX1036 (40/56GbE switch). It is recommended to connect the relevant servers using port 1 in the ConnectX-3 Pro network adapter. The VLAN used for the management network is configured by the Fuel UI.
4.1.4 Private Networks

The private networks are used for communication among the tenant VMs. Each tenant may have several networks. If connectivity is required between networks owned by the same tenant, the Network node does the routing. It is recommended to connect the relevant servers through port 1 in the ConnectX-3 Pro network adapter (same port as the Management network). The VLAN used for the management network is configured via the Fuel UI.

Fuel 4.1 is based on OpenStack ‘Havana’ which does not support more than one network technology. This means that all the private networks in the OpenStack deployment should use Mellanox Neutron agent which is based on VLANs assigned to VFs.

The VLAN range used for private networks is configured by the Fuel UI.

Note: Allocate number of VLANs according to the number of private networks to be used.

4.1.5 Public Network

The public network enables external connectivity to all nodes (e.g. Internet). The public network runs on the 1GbE ports of each server. This network is also used to access the different OpenStack APIs.
The public network range is split into two parts:

- **Public range**: Allows external connectivity to the compute hypervisors and all other hosts
- **Floating IP range**: Enables VMs to communicate with the outside world and is a subset of addresses within the public network (via the controller node)

Another use for public access for hypervisors or node OS might be necessary (e.g. ssh access). However, the cloud owner must decide how to allow external connectivity to cloud servers, or cloud servers’ access to internet (either PXE or the Public network may be used).

![Figure 10: Public Network](image)

The floating IP uses the private network to pass traffic from the VMs to the Network node and then the Public network to pass traffic from the Network node to the Internet.
4.2 Physical Connectivity

The five networks discussed above can be connected using 1-2 1GbE switches and 1-2 SX1036 switches (40/56GbE switches) depending on the number of servers and the size of the switches.

In the case of up to 18 nodes (16 compute nodes), it is possible to use only one SX1036 switch (36 ports).

In case of up to 36 nodes (34 compute nodes), two SX1036 are necessary (one for the storage network and one for private/management networks.

In the ConnectX-3 Pro adapter, the lower port has the lower MAC address. When using Fuel UI to assign networks it is recommended to assign the Management and Private networks to port 1 (which has the lower MAC address) and the Storage network to the port with the higher MAC address.

For example:
4.3 Network Separation

VLANs should be configured on the switches to allow network separation. The VLANs to be configured on the switches should be aligned with the VLAN range configured in Fuel for the Management, Private and Storage networks.

4.4 Lossless Fabric (Flow-Control)

RDMA requires lossless fabric. To achieve that, flow control (global pause) should be enabled on all ports running RDMA and connected to the SX1036 Ethernet switch. This should be achieved by configuring global pause across all network hardware components.
5 Requirements

Mirantis Fuel defines the following node functions:

- Fuel node
- Compute nodes
- Controller node
- Storage nodes

5.1 Hardware Requirements

Table 1 lists the minimum requirements of hardware components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel node (master)</td>
<td>1</td>
<td>Intel server, 2 Gb Eth Ports, &gt;4 cores CPU, &gt;=8GB RAM, 0.5 TB SATA HDD</td>
</tr>
<tr>
<td>Compute nodes</td>
<td>2-34</td>
<td>Intel PCI-Ex Gen-3 server, at least one 8x PCI-Ex 3 slot, 2 Gb Eth Ports, &gt;4 cores CPU x 2, &gt;=128GB RAM RAM, 0.5 TB SATA HDD, SRIOV support in BIOS. ConnectX®-3 PRO VPI Dual Port network adapter. P/N: MCX354A-FCCT</td>
</tr>
<tr>
<td>Controller node</td>
<td>1</td>
<td>Intel PCI-Ex Gen 3 server, at least one 8x PCI-Ex 3 slot, &gt;2 x 1 Gb Eth Ports, &gt;4 cores CPU x 2, &gt;=32 GB RAM, 1 TB SAS HDD, SRIOV support in BIOS. ConnectX-3 PRO VPI Dual Port network adapter. P/N: MCX354A-FCCT</td>
</tr>
<tr>
<td>Storage node</td>
<td>1</td>
<td>(Click here)</td>
</tr>
<tr>
<td>Storage, Management Switch</td>
<td>1 or 2</td>
<td>Mellanox SX1036 40/56GbE 36 ports</td>
</tr>
<tr>
<td>Public, Admin (PXE) switch</td>
<td>1 or 2</td>
<td>1Gb switch (any switch)</td>
</tr>
<tr>
<td>56Gb/s cables</td>
<td>2 per server</td>
<td>FDR InfiniBand/56GbE copper cables up to 2m. P/N: MC2207130-XXX.</td>
</tr>
<tr>
<td>1Gb/s cables</td>
<td>2 per server</td>
<td></td>
</tr>
</tbody>
</table>

5.2 Operating Systems

All servers’ operating systems are installed with CentOS6.4 (Mirantis distro) via Fuel servers.

The VM should have the appropriate driver to support SR-IOV mode over Mellanox ConnectX-3.
6 Rack Configuration

6.1 34 Compute Nodes Setup

This section supplies a rack recommendation design for basic cloud setup up to 36 nodes (34 compute nodes).

Figure 13: Rack Configuration
6.1.1 Fuel Node

Figure 14: Fuel Node

6.1.2 Controller/Compute Node

Figure 15: Controller/Compute Node

6.1.3 Storage Node

Figure 16: Storage Node
6.2 16 Compute Nodes Setup

In setups with up to 18 nodes (16 compute nodes) it is possible to reduce the number of switches.

- Use only one 1GbE switch for all 1GbE networks (split via VLAN)
- Use only one 40/56GbE switch (SX1036) for both Private, Management and Storage networks (use VLANs to split the networks)

*Figure 17: Rack Configuration*
6.2.1 Fuel Node

**Figure 18: Fuel Node**

6.2.2 Controller/Compute Node

**Figure 19: Controller Node**

6.2.3 Storage Node

**Figure 20: Storage Node**
7 Installation and Configuration

For cloud installation and configuration click [here](#).
For storage node installation and configuration click [here](#).