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SDN Integration with Nuage Networks

Deployment Guide for the Nuage Networks Software-Defined Networking Solution Within Oracle Cloud Infrastructure

March 2023, version 2.1

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Revision History

The following revisions have been made to this document since its initial publication.

DATE	REVISION
March 2023	• Updated OCI screenshots • Removed obsolete link from “Resources”
November 2021	• Updated steps and deleted outdated screenshots • Updated template and edited for clarity and style
April 2019	Initial publication

Table of Contents

Overview

This technical paper is a detailed deployment guide for the Nuage Networks from Nokia software-defined networking (SDN) solution within Oracle Cloud Infrastructure (OCI). It describes the reference architecture, installation steps, and testing procedures performed during the build. It is intended for network architects and network administrators who want to seamlessly extend their on-premises services to the cloud by using the Nuage Networks SDN solution.

Software Requirements

This paper was written based on the following software requirements:

- Nuage Networks Virtual Routing and Switching (VRS) and Virtualized Services Controller (VSC) for KVM, release 5.3.3
- Oracle Linux 7.4 or later
- CentOS 7

Assumptions

This paper makes the following assumptions:

- You know KVM and how to work with the hypervisor.
- You know Linux system administration and can set and edit network files.
- You know the Nuage Networks SDN solution, including Virtual Routing and Switching (VRS), Virtualized Services Controller (VSC), and Virtualized Services Directory (VSD).
- You understand how to install an operating system as a guest, or you know how to copy a virtual disk image between disks.
- You understand how your guest shares storage.
- You have created the required resources for your environment, such as a virtual cloud network (VCN) and network-related information.
- You know how to provision a bare metal compute instance.
- Your KVM host has internet access.
- You have a Nuage Networks VRS and VSC qcow2 image for KVM. You import this virtual machine image in qcow2 format.

Target Scenario

The scenario covered in this paper extends the data center through the SDN overlay.

Technical Architecture

The Nuage Networks Virtualized Services Platform (VSP) is an SDN solution that provides data center and cloud network virtualization. It automatically provides connectivity between compute resources that have been created.

Nuage Networks uses a quick Open vSwitch (OVS) replacement on the bare metal servers in OCI to connect the Nuage Networks VRS to the controller. After the VRS is connected to the VSC and the control plane and data plane (infrastructure) connectivity is established through an IPSec VPN tunnel, the rest is defined in the cloud solution.

The following diagram shows the architecture and infrastructure requirements.

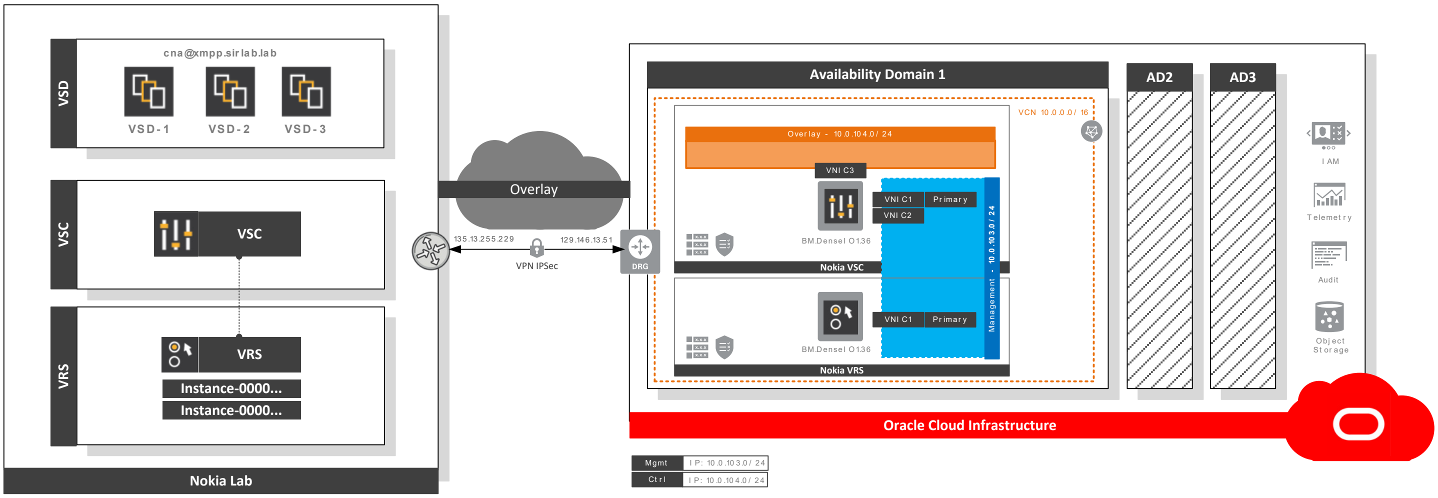


Figure 1: Nuage Networks SDN Architecture

The Nuage Networks VSP software suite has the following key products:

- **Virtualized Services Directory (VSD)**: A policy, business logic, and analytics engine that supports the abstract definition of network services. Administrators can use RESTful APIs to VSD to define service designs and incorporate enterprise policies.
- **Virtualized Services Controller (VSC)**: A control plane for the data center network. VSC maintains a full per-tenant view of network and service topologies. By using network APIs that use interfaces such as OpenFlow, VSC programs the data center network independent of data center networking hardware.
- **Virtual Routing and Switching (VRS)**: A virtual endpoint for network services. VRS detects changes in the compute environment as they occur, and it triggers policy-based responses to ensure that applications have the network connectivity that they need.

The following diagram depicts the components in the solution:

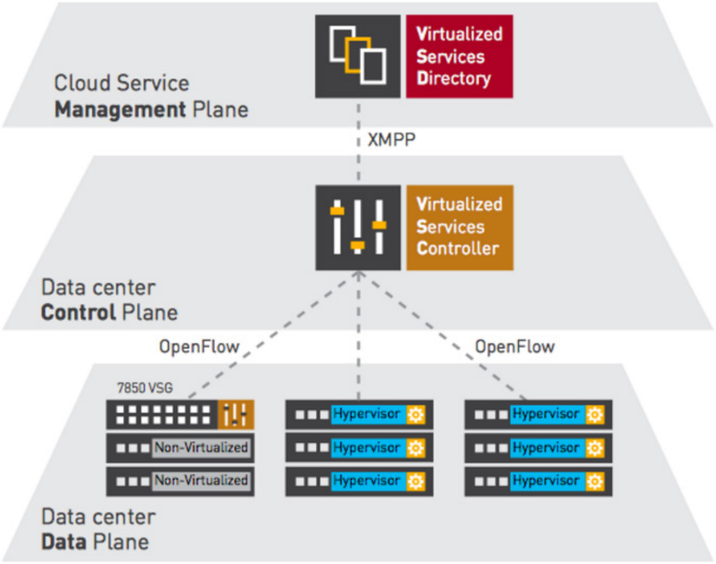


Figure 2: Nuage Networks VSP

This paper deploys and configures both VSC and VRS in OCI and connects to the customer's network. The VSD remains in the customer's facilities and is out of the scope of this paper.

The following diagram illustrates the steps for deploying Nuage Networks VSC and VRS in OCI. You can automate this process through Terraform.

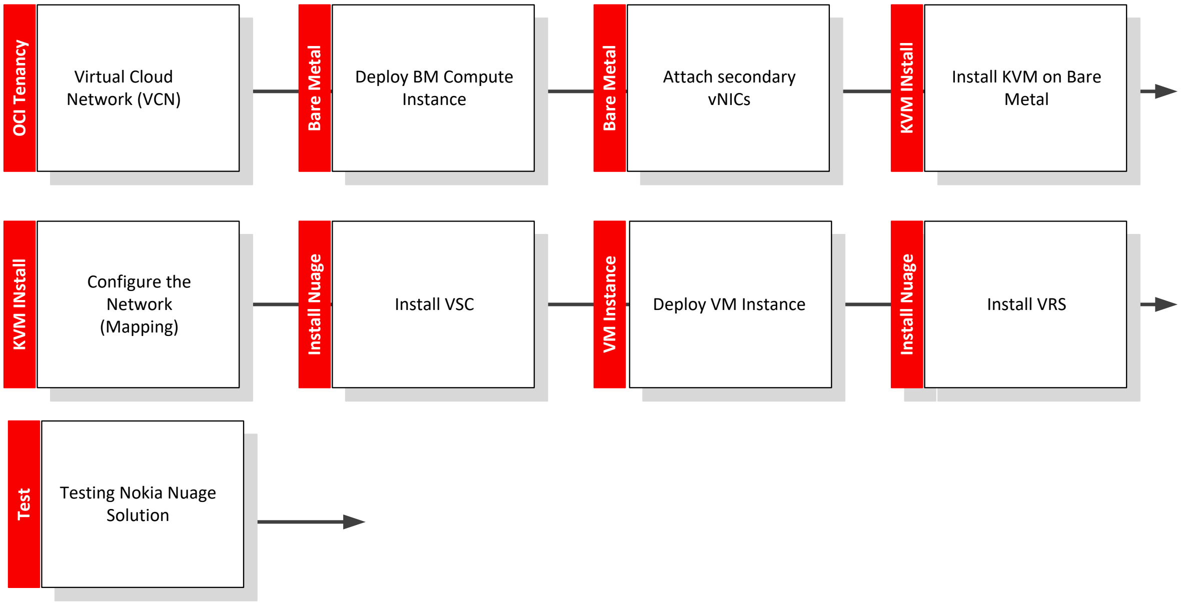


Figure 3: High-Level Deployment Flow

Deploying SDN Integration with Nuage Networks on OCI

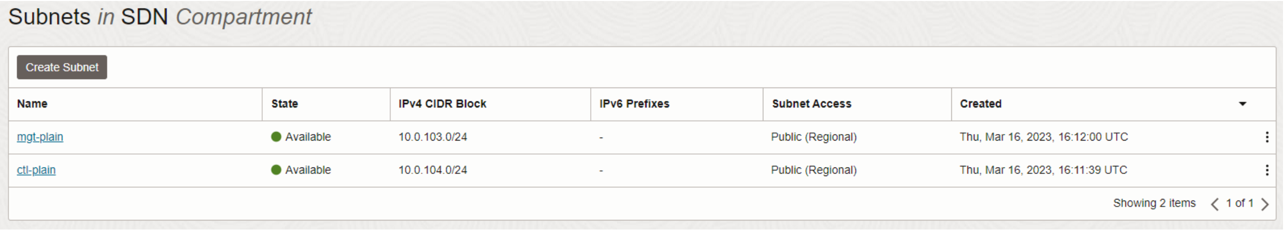
Perform the following tasks to deploy SDN integration with Nuage networks on OCI.

Create the Network Infrastructure (VCN and Subnets)

1. Log in to the Oracle Cloud Console.
2. From the navigation menu, select **Networking** and then select **Virtual Cloud Networks.**
3. Click **Create VCN**.
4. Create a VCN with two public subnets, as shown in the following image.

   In this example, one subnet is named **ctl-plain** and is created in AD-1 with a CIDR block of 10.0.104.0/24. The other subnet is named **mgt-plain** and is created in AD-1 with a CIDR block of 10.0.103.0/24.

   Both subnets use the default route table, security list, and DHCP options.

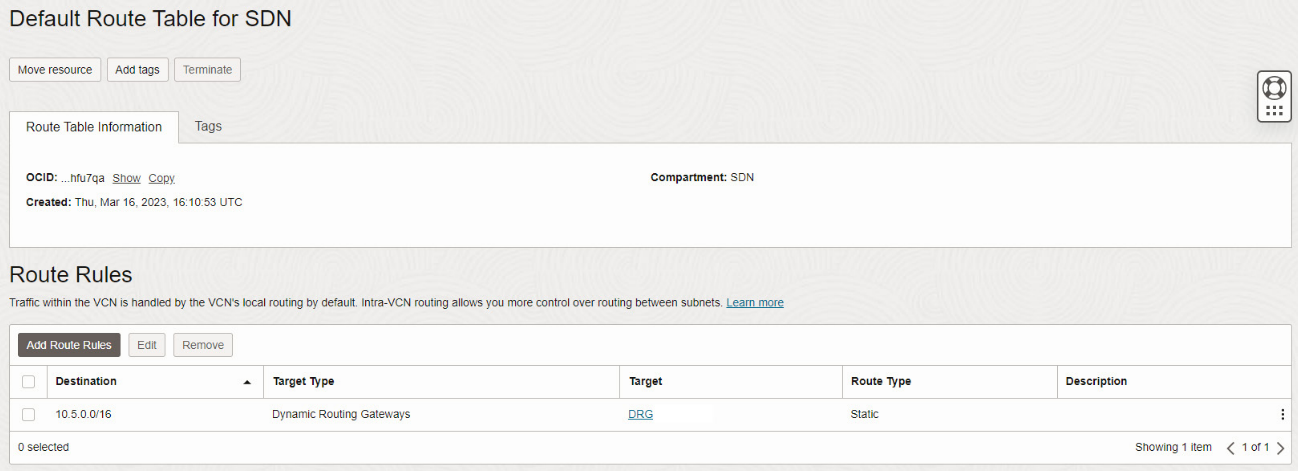


Subnets *in* SDN *Compartment*

Name	State	IPv4 CIDR Block	IPv6 Prefixes	Subnet Access	Created
mgt-plain	● Available	10.0.103.0/24	-	Public (Regional)	Thu, Mar 16, 2023, 16:12:00 UTC
ctl-plain	● Available	10.0.104.0/24	-	Public (Regional)	Thu, Mar 16, 2023, 16:11:39 UTC

Showing 2 items 1 of 1

The following image shows the configuration of the default route table. We created a dynamic routing gateway (DRG) to connect the VCN with the on-premises network using a VPN. The CIDR block 10.5.0.0/16 is the subnet used to connect the VCN with the on-premises environment through the VPN.



Default Route Table for SDN

OCID: ...hfu7qa Show Copy

Compartment: SDN

Created: Thu, Mar 16, 2023, 16:10:53 UTC

Route Rules

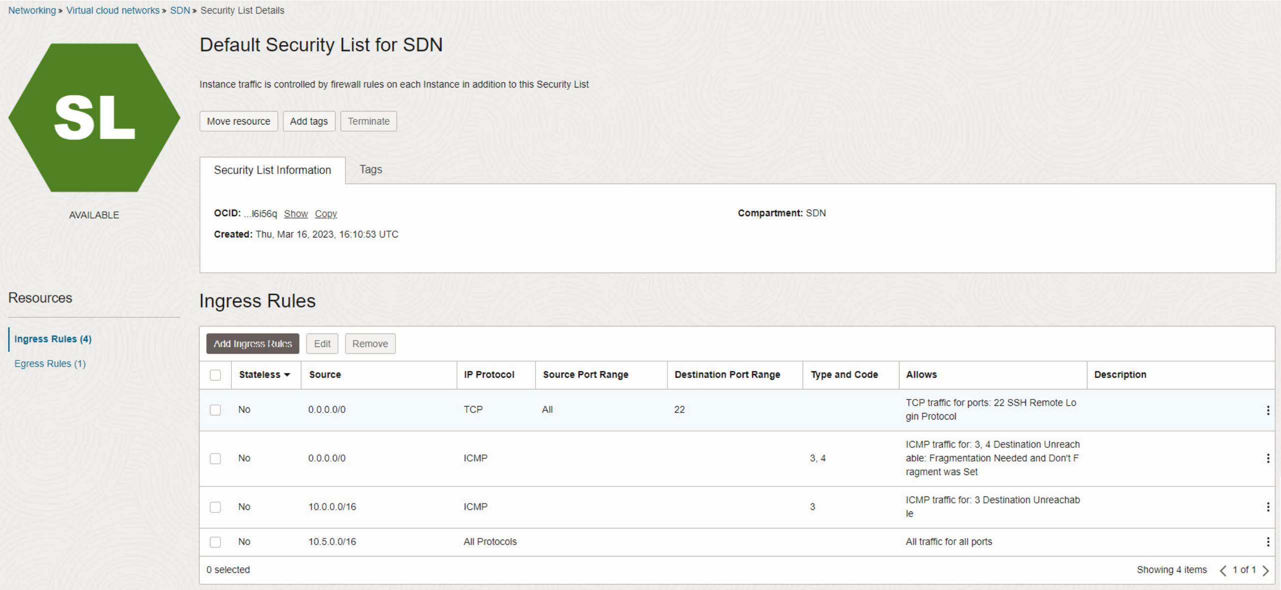
Traffic within the VCN is handled by the VCN's local routing by default. Intra-VCN routing allows you more control over routing between subnets. Learn more

□	Destination	Target Type	Target	Route Type	Description
□	10.5.0.0/16	Dynamic Routing Gateways	DRG	Static	

0 selected

Showing 1 item 1 of 1

The following image shows the configuration of the default security list. Port 22 is open for the internet to access the instances before the VPN is created, and subnet 10.5.0.0/16 is open for all protocols to permit traffic from the on-premises environment.



Networking » Virtual cloud networks » SDN » Security List Details
SL
AVAILABLE

Default Security List for SDN

Instance traffic is controlled by firewall rules on each Instance in addition to this Security List

OCID: ...l6i56q Show Copy

Compartment: SDN

Created: Thu, Mar 16, 2023, 16:10:53 UTC

Ingress Rules

□	Stateless	Source	IP Protocol	Source Port Range	Destination Port Range	Type and Code	Allows	Description
□	No	0.0.0.0/0	TCP	All	22		TCP traffic for ports: 22 SSH Remote Login Protocol	
□	No	0.0.0.0/0	ICMP			3, 4	ICMP traffic for: 3, 4 Destination Unreachable: Fragmentation Needed and Don't Fragment was Set	
□	No	10.0.0.0/16	ICMP			3	ICMP traffic for: 3 Destination Unreachable	
□	No	10.5.0.0/16	All Protocols				All traffic for all ports	

0 selected

Showing 4 items 1 of 1

Create an Instance for the VSC

Perform the following tasks to create an instance for the Virtualized Services Controller (VSC).

Deploy an Instance in OCI

To deploy a compute instance, the VCN and the subnets must already be deployed.

1. From the navigation menu in the Console, select **Compute** and then select **Instances**.
2. Click **Create instance**.
3. Provide a name for the instance (for example, **Instance-VSC**) and select an availability domain (**AD 1**).
4. Click **Change image** and select **CentOS 7**.

5. Click **Change shape**, select **Bare metal machine**, select **BM.Standard1.36**, and then click **Select shape**.
6. In the **Networking** section, select the VCN and the subnet (**mgt-plain**).
7. In the **Add SSH keys** section, upload an SSH public key file or paste the SSH key in the text box.
8. Click **Create**. After some minutes, the instance is deployed.

Install KVM Software in Linux (CentOS)

1. Log in to the instance SSH connection with any software like PuTTY or MobaXterm.
2. Edit the `/etc/default/grub` file and add the following line: `intel_iommu=on`.

```
GRUB_CMDLINE_LINUX="crashkernel=auto LANG=en_US.UTF-8 transparent_hugepage=never console=tty0
console=ttyS0,9600 libiscsi.debug_libiscsi_eh=1 rd.luks=0 rd.lvm=0 rd.md=0 rd.dm=0 ip=dhcp
netroot=iscsi:169.254.0.2::::iqn.2015-02.oracle.boot:uefi
iscsi_param=node.session.timeo.replacement_timeout=6000 net.ifnames=1 intel_iommu=on"
```

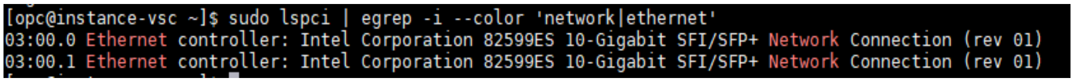
3. Run the following commands to install the KVM software, and start and enable the `libvirtd` service:

```
# sudo su -
# yum install qemu-kvm qemu-img virt-manager libvirt libvirt-python libvirt-client virt-
install virt-viewer bridge-utils
# systemctl start libvirtd
# systemctl enable libvirtd
```

Prepare the Network

1. Verify that you have two network controllers connected.

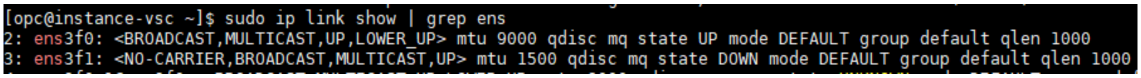
```
# sudo lspci | egrep -i --color 'network|ethernet'
```



```
[opc@instance-vsc ~]$ sudo lspci | egrep -i --color 'network|ethernet'
03:00.0 Ethernet controller: Intel Corporation 82599ES 10-Gigabit SFI/SFP+ Network Connection (rev 01)
03:00.1 Ethernet controller: Intel Corporation 82599ES 10-Gigabit SFI/SFP+ Network Connection (rev 01)
```

2. Verify that the only physical NIC attached is `ensf0`.

```
# sudo ip link show | grep ens
```



```
[opc@instance-vsc ~]$ sudo ip link show | grep ens
2: ens3f0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9000 qdisc mq state UP mode DEFAULT group default qlen 1000
3: ens3f1: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN mode DEFAULT group default qlen 1000
```

3. Create a script to initialize the network for KVM.

```
# sudo su –
# vi /usr/bin/initialize-kvm-network.sh
```

4. Add the following text in the script:

```
#!/bin/bash

function build_sriov_vf {
    number_vfs=2
    vnic_json=`curl -s http://169.254.169.254/opc/v1/vnics/`
    vnic_count=`echo ${vnic_json} | jq -r 'length'`
    count=0

    for field in macAddr vlanTag
    do
        read -ra ${field} <<< `echo ${vnic_json} | jq -r '.[0:length] |.[].'"${field}"''`
    done
    while [ ${count} -lt ${vnic_count} ]
    do
    if [ ${vlanTag[${count}]} -eq 0 ]
    then
      physdev=`ip -o link show | grep ${macAddr[${count}]} | awk -F: '{gsub(/\s+/,"", $2);print $2}'`
      echo ${number_vfs} > /sys/class/net/${physdev}/device/sriov_numvfs
      wait
      bridge link set dev ${physdev} hwmode vepa
    fi

    if [ ${vlanTag[${count}]} -gt 0 ]
    then
      (( vf_index = count - 1 ))
      ip link set ${physdev} vf ${vf_index} mac ${macAddr[${count}]} spoofchk off
  fi

    (( count = count + 1 ))
  done
}

build_sriov_vf

#wait 30s to OS enable VFs
sleep 30s
```

5. Change permissions to the file to be able to run it.

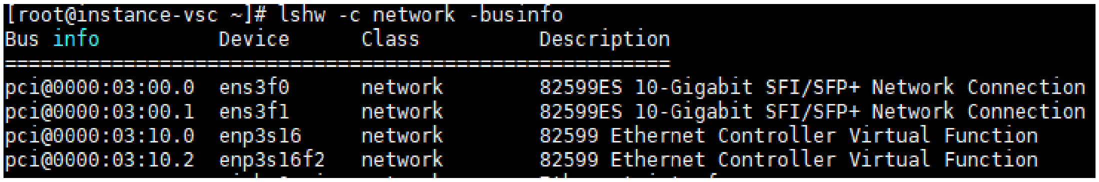
```
# chmod +x /usr/bin/initialize-kvm-network.sh
```

6. Run the script to enable virtual function devices.

```
# /usr/bin/initialize-kvm-network.sh
```

7. View the virtual devices created.

```
# lshw -c network -businfo
```

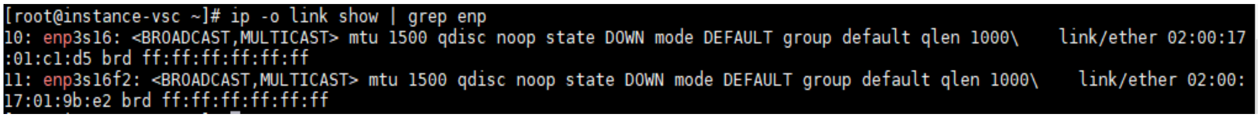


```
[root@instance-vsc ~]# lshw -c network -businfo
Bus info          Device      Class          Description
=======================================================
pci@0000:03:00.0  ens3f0      network        82599ES 10-Gigabit SFI/SFP+ Network Connection
pci@0000:03:00.1  ens3f1      network        82599ES 10-Gigabit SFI/SFP+ Network Connection
pci@0000:03:10.0  enp3s16     network        82599 Ethernet Controller Virtual Function
pci@0000:03:10.2  enp3s16f2   network        82599 Ethernet Controller Virtual Function
```

In the output, the virtual functions added are `enp3s16` and `enp3s16f2`.

8. View the MAC addresses of these virtual functions.

```
# ip -o link show | grep enp
```



```
[root@instance-vsc ~]# ip -o link show | grep enp
10: enp3s16: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT group default qlen 1000\    link/ether 02:00:17
:01:c1:d5 brd ff:ff:ff:ff:ff:ff
11: enp3s16f2: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT group default qlen 1000\    link/ether 02:00:
17:01:9b:e2 brd ff:ff:ff:ff:ff:ff
```

The following table shows the MAC addresses for this example:

VIRTUAL FUNCTION	MAC ADDRESS
enp3s16	02:00:17:01:c1:d5
enp3s16f2	02:00:17:01:9b:e2

9. Create a configuration file for each virtual function with the following information:

FILE	DETAILS

/etc/sysconfig/network-scripts/ifcfg-enp3s16	DEVICE=enp3s16
	BOOTPROTO=none
	ONBOOT=yes
	MACADDR="02:00:17:01:c1:d5"
	NM_CONTROLLED=no
	MTU=9000

/etc/sysconfig/network-scripts/ifcfg-enp3s16f2	DEVICE=enp3s16f2
	BOOTPROTO=none
	ONBOOT=yes
	MACADDR="02:00:17:01:9b:e2"
	NM_CONTROLLED=no
	MTU=9000

10. To create each file, run the following commands and include the content on each file:

```
# vi /etc/sysconfig/network-scripts/ifcfg-enp3s16

# vi /etc/sysconfig/network-scripts/ifcfg-enp3s16f2
```

11. Create a VLAN configuration file for each virtual function device with the following information:

FILE	DETAILS

/etc/sysconfig/network-scripts/ ifcfg-enp3s16.vlan1	DEVICE=vlan1
	PHYSDEV=enp3s16
	BOOTPROTO=none
	ONBOOT=yes
	NM_CONTROLLED=no
	VLAN=yes

/etc/sysconfig/network-scripts/ ifcfg-enp3s16f2.vlan2	DEVICE=vlan2
	PHYSDEV=enp3s16f2
	BOOTPROTO=none
	ONBOOT=yes
	NM_CONTROLLED=no
	VLAN=yes

12. To create each file, run the following commands and include the content on each file:

```
# vi /etc/sysconfig/network-scripts/ifcfg-enp3s16.vlan1

# vi /etc/sysconfig/network-scripts/ifcfg-enp3s16f2.vlan2
```

13. Append the following entries to the `/usr/bin/initialize-kvm-network.sh` file:

```
ifup enp3s16
ifup enp3s16f2
ifup vlan1
ifup vlan2
```

14. To finish the procedure to establish the KVM network as a service, run the following commands:

```
# systemctl daemon-reload
# systemctl enable kvm-network.service
# systemctl start kvm-network.service
```

Installing and Configuring Virtualized Services Controller

The VSC is the control plane of the Nuage Networks VSP solution. It communicates with the hypervisor and collects the virtual machine (VM) information, such as MAC and IP addresses.

The VSC controller uses OpenFlow, which runs on TCP port 6333, to control the VRS module. It communicates with the Virtualized Services Directory (VSD) through the XMPP protocol, enabling the download of new policies for the VMs or just updates of policies. Communication between VSCs is done through multiprotocol border gateway protocol (MP-BGP). This is used for distribution of MAC/IP reachability information of VMs between VSCs.

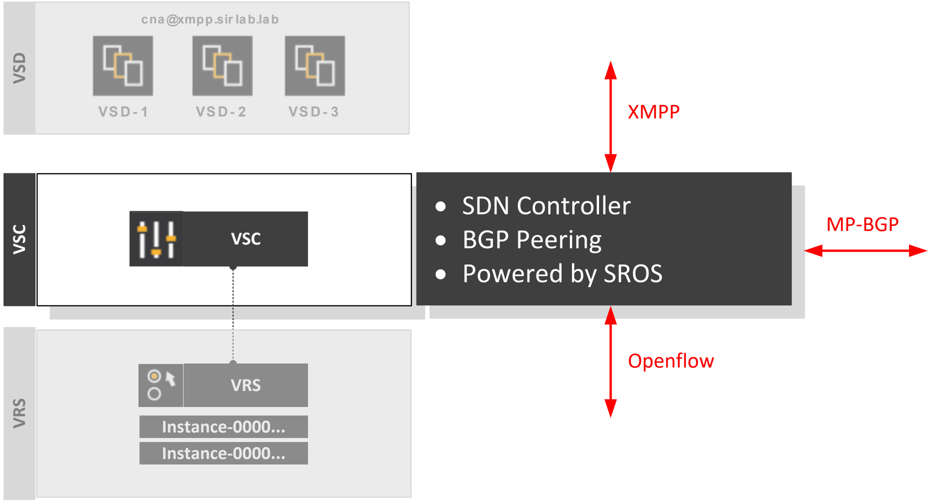


Figure 4: VSC Component

VSC is deployed on a bare metal instance. It has two subnets, a control interface connected to the underlay network, and a management network that connects the different components (VRS).

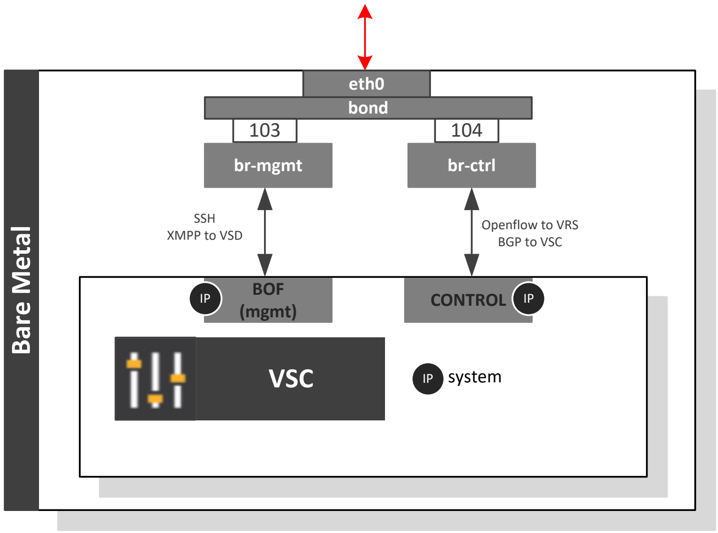


Figure 5: VSC Network Connectivity

Install VSC

This section describes the process of installing the Nuage Networks VSC software on the bare metal server in Oracle Cloud Infrastructure. At the end of the process, the VSC image runs in the server, and VSC prompts you to log in.

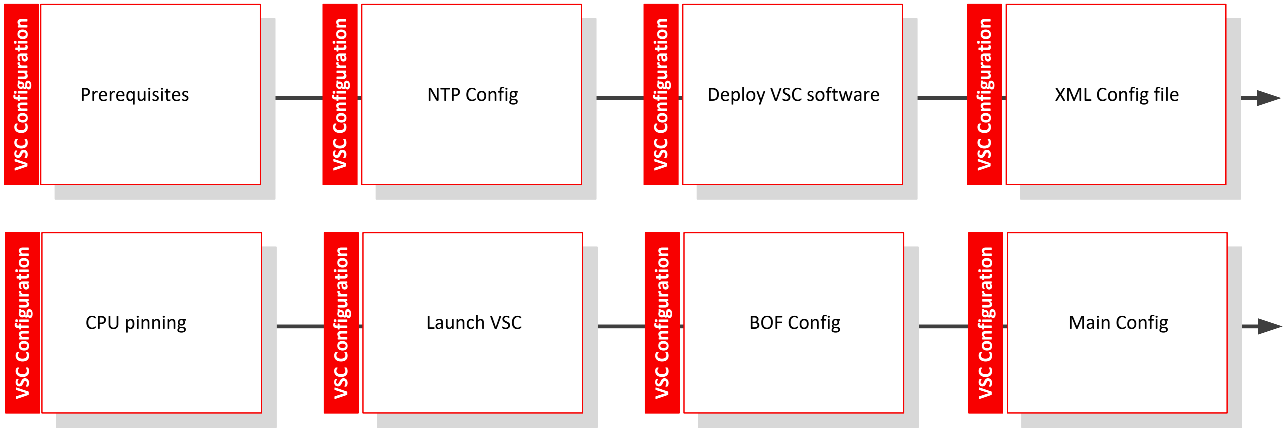


Figure 6: High-Level VSC Installation Flow

Prerequisites

Before deploying the VSC, you must meet the following requirements. Perform any necessary tasks as part of your planning exercise.

- An IP address is already assigned for the management network.
- Two independent network interfaces are set up for management and data traffic, connected to two Linux bridge interfaces. These instructions assume bridges br0 for management and br1 for data have been created and attached.
- At least one NTP server has been configured and synchronized. When you set up a server, you must set up an NTP server for all the components. When you define a VM, it gets a timestamp, which can’t deviate more than 10 seconds.
- A way to copy the VSC software files to the server is required.

After these requirements are met, install the required dependencies:

```
# yum install kvm libvirt bridge-utils service libvirtd start chkconfig libvirtd on
```

To Install the NTP Server

1. Install the NTP server.

   ```
   [opc@instance-vsc ~]$ sudo su
   [root@instance-vsc opc]# yum install ntp
   ```

2. To set your time zone, you might need to delete `/etc/localtime`. Check the `/etc/ntp.conf` file and synchronize with the required values.

   For this solution, we're adding the following lines:

   ```
   [root@instance-vsc opc]# cat >> /etc/ntp.conf << EOF
   server 0.centos.pool.ntp.org iburst
   server 1.centos.pool.ntp.org iburst
   server 2.centos.pool.ntp.org iburst
   server 3.centos.pool.ntp.org iburst
   EOF
   ```

3. Restart the NTP daemon.

   ```
   [root@instance-vsc opc]# service ntpd restart
   [root@instance-vsc ntp]# date
   Tue Mar 12 13:32:32 GMT 2019
   ```

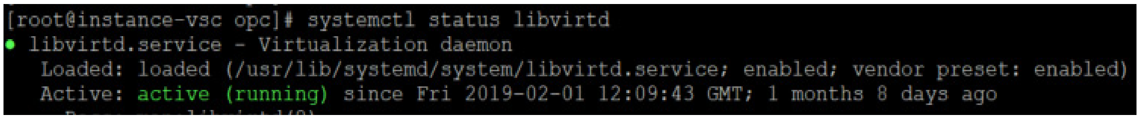
To Install VSC

Ensure that the previous section is completed before attempting this configuration. The libvirt API used to manage KVM includes a set of tools that allows you to create and manage VMs.

1. Start libvirtd and ensure that it's running.

   ```
   [root@instance-vsc opc]# systemctl start libvirtd
   ```

   Note: To automatically start libvirtd at boot time, enter `# systemctl enable libvirtd`.

   ```
   [root@instance-vsc opc]# systemctl status libvirtd
   ● libvirtd.service - Virtualization daemon
      Loaded: loaded (/usr/lib/systemd/system/libvirtd.service; enabled; vendor preset: enabled)
      Active: active (running) since Fri 2019-02-01 12:09:43 GMT; 1 months 8 days ago
   ```

2. Copy the VSC software file to the destination host.

   ```
   [root@instance-vsc opc]# cd /var/lib/libvirt/images/
   [root@instance-vsc images]# scp admin@source_host :/share/nfs/nuage/5.3.3/ Nuage-VSC-5.3.3-128.tar.gz  ./ nuage-vsc- 5.3.3-128.tar.gz
   ```

3. Untar the VSC software file on the host. For this deployment, we're implementing a single disk.

   ```
   [root@instance-vsc images]# tar xzvf nuage-vsc- 5.3.3-128.tar.gz
   [root@instance-vsc images]# cd single_disk/
   [root@instance-vsc single_disk]#
   [root@instance-vsc single_disk]# cp vsc_singledisk.qcow2 ./vsc1.qcow2
   ```

4. Start the qcow2 installation:

   ```
   [root@instance-vsc single_disk]# chown qemu:qemu vsc1.qcow2
   ```

5. Use the `vsc.xml` file that was provided with the Nuage Networks software release to define a new VM. Edit the VSC XML configuration to rename the VM or the disk paths and filenames.

Note: In the following configuration, we pinned the vCPU to the available physical CPU. The `cputune` element provides details regarding the CPU tunable parameters. Use `vcpupin` to specify which of the bare metal instance's physical CPUs are pinned to the domain's vCPU. For more information about tuning the CPU, go to libvirt.org/formatdomain.html.

```
 [root@instance-vsc images]# cat vsc.xml
<domain type='kvm'>
  <name>vsc</name>
  <description>Timos VM</description>
  <memory>4147483</memory>
  <currentMemory>4147483</currentMemory>
  <vcpu current='4'>4</vcpu>
  <cputune>
    <vcpupin vcpu='0' cpuset='0'/>
    <vcpupin vcpu='1' cpuset='1'/>
    <vcpupin vcpu='2' cpuset='2'/>
    <vcpupin vcpu='3' cpuset='3'/>
  </cputune>
  <os>
    <type arch='x86_64' machine='rhel6.0.0'>hvm</type>
    <smbios mode='sysinfo'/>
  </os>
  <sysinfo type='smbios'>
    <system>
      <entry name='product'>Nuage Networks Virtual Services Controller</entry>
    </system>
  </sysinfo>
  <features>
    <apic/>
  </features>
  <cpu>
    <topology sockets='4' cores='1' threads='1'/>
  </cpu>
  <clock offset='utc'>
    <timer name='pit' tickpolicy='catchup'/>
    <timer name='rtc' tickpolicy='catchup'/>
  </clock>
  <on_poweroff>destroy</on_poweroff>
  <on_reboot>restart</on_reboot>
  <on_crash>coredump-destroy</on_crash>
  <devices>
    <emulator>/usr/libexec/qemu-kvm</emulator>
    <controller type='ide' index='0'>
      <alias name='ide0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x01' function='0x1'/>
    </controller>
    <controller type='usb' index='0'>
      <alias name='usb0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x01' function='0x2'/>
    </controller>
    <disk type='file' device='disk' snapshot='no'>
```

```
      <driver name='qemu' type='qcow2' cache='writethrough'/>
      <source file='/var/lib/libvirt/images/vsc.qcow2'/>
      <target dev='hda' bus='ide'/>
      <boot order='1'/>
    </disk>
    <interface type='bridge'>
      <source bridge='brV2MGMT'/>
      <model type='virtio'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x03' function='0x0'/>
    </interface>
    <interface type='bridge'>
      <source bridge='brV1CTRL'/>
      <model type='virtio'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x04' function='0x0'/>
    </interface>
    <serial type='pty'>
      <source path='/dev/pts/1'/>
      <target port='0'/>
      <alias name='serial0'/>
    </serial>
    <console type='pty' tty='/dev/pts/1'>
      <source path='/dev/pts/1'/>
      <target type='serial' port='0'/>
      <alias name='serial0'/>
    </console>
    </devices>
  <seclabel type='none'/>
</domain>


[root@instance-vsc images]#
```

6. Define the VSC.

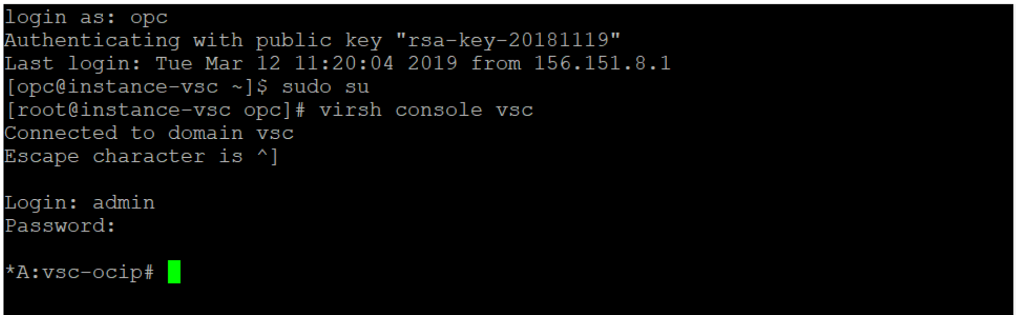
```
[root@instance-vsc opc]# virsh define vsc.xml
```

7. Configure the autostart.

```
[root@instance-vsc opc]# virsh autostart vsc1
```

8. Log in to the Console.

```
[root@instance-vsc opc]# virsh console vsc1
```



```
login as: opc
Authenticating with public key "rsa-key-20181119"
Last login: Tue Mar 12 11:20:04 2019 from 156.151.8.1
[opc@instance-vsc ~]$ sudo su
[root@instance-vsc opc]# virsh console vsc
Connected to domain vsc
Escape character is ^]

Login: admin
Password:

*A:vsc-ocip#
```

Configure VSC

Next, you configure the VSC itself. For details about the commands being used, see the VSP installation guide.

The VSC controller configuration has the following components:

- **Boot Options File (BOF)**: Contains the parameters needed to boot the device. Nuage Networks VSC uses a file named `bof.cfg` that's read on system boot and used for some basic, low-level system configuration needed to successfully boot the VSC.
- **Main configuration**: Contains the main configuration, such as LAG and BGP settings.

Perform Boot Options File Configuration

For this solution, we're using a single-disk installation in which all configuration and boot images are stored on the CF1 disk (user disk). Now we update the BOF file.

1. To navigate to the BOF context, enter `bof<Enter>`. The prompt indicates a change to the `bof` context.

```
*A:vsc-ocip# bof
*A:vsc-ocip>bof#
```

2. Assign the management IP address.

```
*A:vsc-ocip>bof# address 10.0.103.101/24 active
```

3. Configure the DNS servers.

```
*A:vsc-ocip>bof# primary-dns 10.5.0.50
```

Note: You can configure up to three DNS servers: primary, secondary, and tertiary.

4. Configure the DNS domain.

```
*A:vsc-ocip>bof# dns-domain sirlab.lab
```

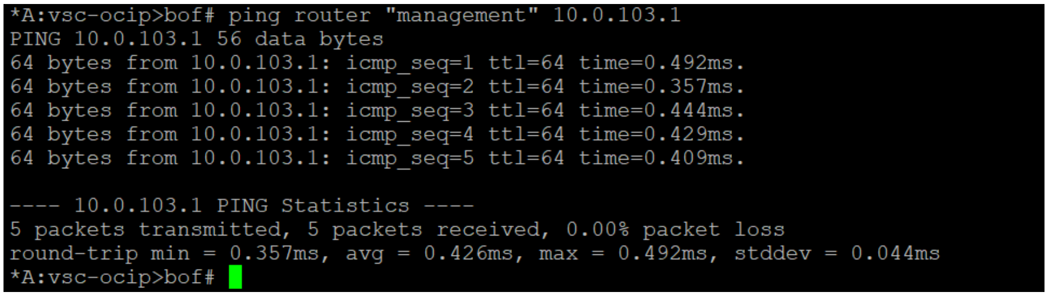
5. Configure static routes for the management IP network.

```
*A:vsc-ocip>bof# static-route 0.0.0.0/1 next-hop 10.0.103.1
*A:vsc-ocip>bof#128.0.0.0/1 next-hop 10.0.103.1
```

Note: The BOF configuration doesn't accept a static route of 0.0.0.0/0. If a default route is required, configure two static routes, 0.0.0.0/1 and 128.0.0.0/1, instead.

6. Verify connectivity against the management gateway.

```
*A:vsc-ocip>bof# ping router "management" 10.0.103.1
```



```
*A:vsc-ocip>bof# ping router "management" 10.0.103.1
PING 10.0.103.1 56 data bytes
64 bytes from 10.0.103.1: icmp_seq=1 ttl=64 time=0.492ms.
64 bytes from 10.0.103.1: icmp_seq=2 ttl=64 time=0.357ms.
64 bytes from 10.0.103.1: icmp_seq=3 ttl=64 time=0.444ms.
64 bytes from 10.0.103.1: icmp_seq=4 ttl=64 time=0.429ms.
64 bytes from 10.0.103.1: icmp_seq=5 ttl=64 time=0.409ms.

---- 10.0.103.1 PING Statistics ----
5 packets transmitted, 5 packets received, 0.00% packet loss
round-trip min = 0.357ms, avg = 0.426ms, max = 0.492ms, stddev = 0.044ms
*A:vsc-ocip>bof#
```

7. Ensure that the location of the primary configuration and the network setting are set correctly.

```
*A:vsc-ocip>bof# primary-config cf1:\config.cfg
*A:vsc-ocip>bof# autonegotiate
*A:vsc-ocip>bof# wait 3
```

Note: The system attempts to use the configuration specified in `primary-config`. If the specified file can't be located, the system automatically attempts to obtain the configuration from the location specified in `secondary-config` and then in `tertiary-config`.

8. Save the configuration to CF1.

```
*A:vsc-ocip>bof# save
```

9. Reboot the VSC to load the saved boot options.

```
*A:vsc-ocip>bof# exit
*A:vsc-ocip# admin reboot
WARNING: Configuration and/or Boot options may have changed since the last save. Are you sure
you want to reboot (y/n)? y
```

Perform the Main Configuration

In its most basic configuration, the VSC contains the following sections:

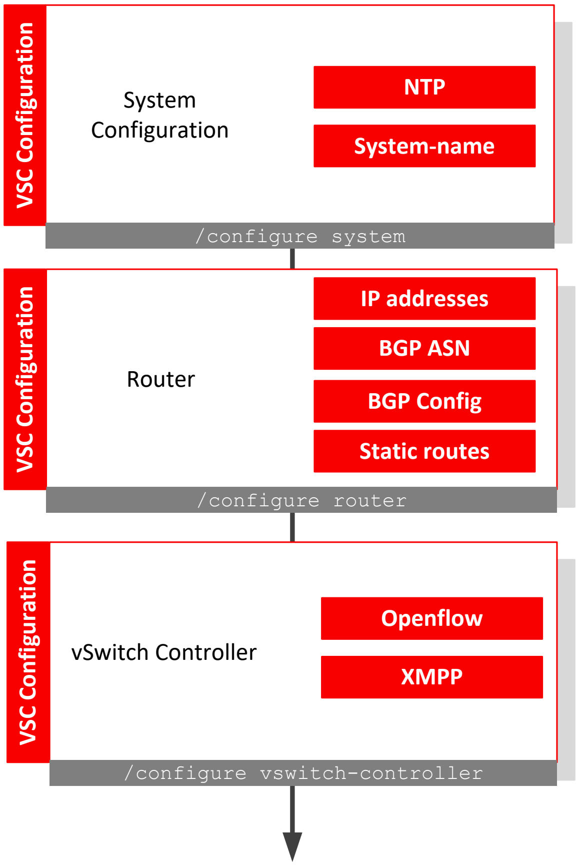


Figure 7: VSC Configuration Flow

System Configuration

This section covers the basic system information, such as system name, contact information, time zone, and NTP parameters to display the time according to your zone.

CONFIGURATION	PARAMETER
System name	vsc-ocip
Contact information	EMEA Cloud Pursuit Team
Location	40.5214579,-3.8913381
NTP server	10.5.0.50
Time zone	UTC

To configure the system parameters, run the following commands:

```
*A:vsc-ocip# configure system
*A:vsc-ocip>config>system# name vsc-ocip
*A:vsc-ocip>config>system# contact "EMEA Cloud Pursuit Team"
*A:vsc-ocip>config>system# location “40.5214579,-3.8913381”

*A:vsc-ocip>config>system# time
*A:vsc-ocip>config>system>time#ntp
*A:vsc-ocip>config>system>time>ntp# server 10.5.0.50
*A:vsc-ocip>config>system>time>ntp# no shutdown
*A:vsc-ocip>config>system>time>ntp# exit

*A:vsc-ocip>config>system>time# zone UTC
*A:vsc-ocip>config>system>time#
```

Router Configuration

This section covers the control interface, the ASN number, and the default route for the VSC.

CONFIGURATION	PARAMETER
Control IP address	10.0.104.101/24
ASN number	65005
Router ID	10.0.104.101
Route	Default route

To configure the router parameters, follow these steps:

1. Configure the system’s control interface and check the status:

```
*A:vsc-ocip# configure router
*A:vsc-ocip>config>router# interface “control” address 10.0.104.101/24
```

```
*A:vsc-ocip# show router interface

===============================================================================
Interface Table (Router: Base)
```

```
===============================================================================
Interface-Name                   Adm         Opr(v4/v6)  Mode    Port/SapId
   IP-Address                                                    PfxState
-------------------------------------------------------------------------------
control                          Up          Up/Down     Network A/2:0
   10.0.104.101/24                                               n/a
system                           Down        Down/Down   Network system
   -                                                             -
-------------------------------------------------------------------------------
Interfaces : 2
===============================================================================
*A:vsc-ocip#
```

2. Configure the BGP ASN used in the configuration.

```
*A:vsc-ocip>config>router#autonomous-system 65005
```

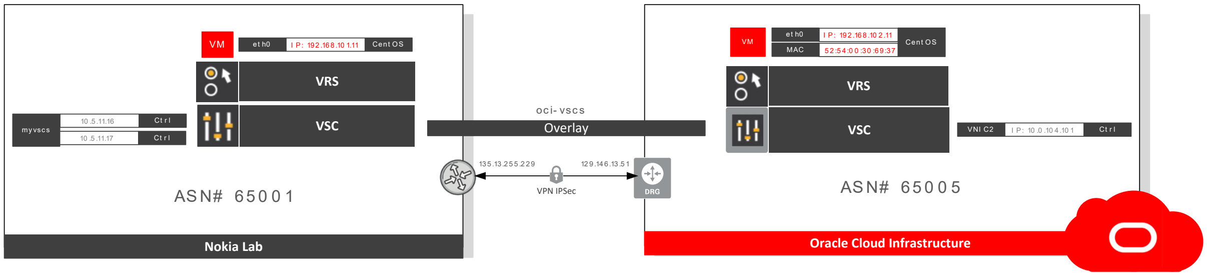
3. Configure the router ID for the virtual router.

```
*A:vsc-ocip>config>router# router-id 10.0.104.101
```

4. Configure the default route.

```
*A:vsc-ocip>config>router# static-route 0.0.0.0/0 next-hop 10.0.104.1
```

Multiprotocol border gateway protocol (MP-BGP) is used for distribution of MAC/IP reachability information for VMs between VSCs. Establish connectivity between the two environments.



CONFIGURATION	PARAMETER
BGP group	myvscs
BGP peer ASN	65001
BGP neighbors	10.5.11.16, 10.5.11.17
Multihop	TTL value: 5
Connect attempts	2
Peer tracking	Enabled
Rapid withdrawal	Enabled

5. Run the following commands:

```
*A:vsc-ocip>config>router# bgp
*A:vsc-ocip>config>router>bgp# connect-retry 2
*A:vsc-ocip>config>router>bgp# enable-peer-tracking
*A:vsc-ocip>config>router>bgp# rapid-withdrawal
*A:vsc-ocip>config>router>bgp# group “myvscs”
```

```
       *A:vsc-ocip>config>router>bgp>group$ family evpn
       *A:vsc-ocip>config>router>bgp>group$ type external
       *A:vsc-ocip>config>router>bgp>group$ multihop 5
       *A:vsc-ocip>config>router>bgp>group$ peer-as 65001
       *A:vsc-ocip>config>router>bgp>group$ neighbor 10.5.11.16
       *A:vsc-ocip>config>router>bgp>group$ neighbor 10.5.11.17
       *A:vsc-ocip>config>router>bgp>group$ exit
       *A:vsc-ocip>config>router>bgp# no shutdown
       *A:vsc-ocip>config>router>bgp# exit
```

Note: For other configuration parameters, see “Appendix C: Virtualized Services Controller Configuration File.”

vSwitch Configuration

To make the VSC act as the SDN controller, configure the following lines:

```
*A:vsc-ocip>config# vswitch-controller
*A:vsc-ocip>config>vswitch-controller# xmpp-server "vsc-ocip@xmpp.sirlab.lab”
*A:vsc-ocip>config>vswitch-controller# exit
```

When you configure XMPP, VSC initiates an ejabberd connection to the VSD server's FQDN. This connection is required to download policy information for new VMs or to receive policy updates. OpenFlow, on the other hand, is required to start listening to any incoming OpenFlow connection from VRS.

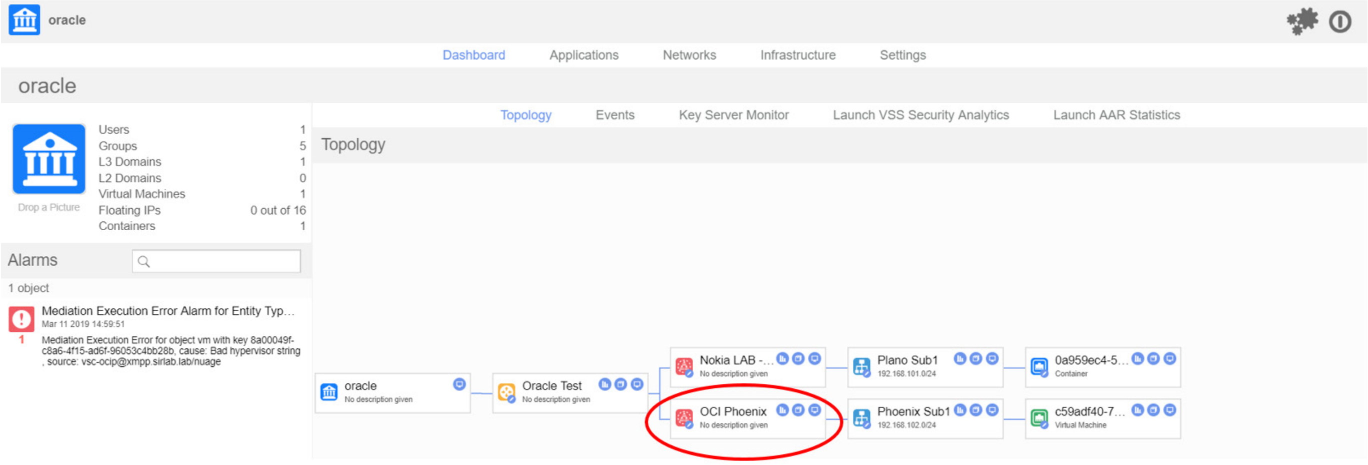
The XMPP server automatically creates the user for the VSC with the specified username.

```
*A:vsc-ocip# show vswitch-controller xmpp-server detail

=========================================================================
XMPP Server Table
=========================================================================
XMPP FQDN          : xmpp.sirlab.lab
XMPP User Name     : vsc-ocip
Last changed since : 0d 03:44:33
State              : Functional
IQ Tx.             : 123                IQ Rx.             : 123
IQ Error           : 0                  IQ Timed Out       : 0
IQ Min. Rtt        : 20                 IQ Max. Rtt        : 120
IQ Ack Rcvd.       : 123
Nuage Updates Rcvd.: 2                  VSD Updates Rcvd.  : 688
Nuage Msg Tx.      : 98                 Nuage Msg Rx.      : 98
Nuage Msg Ack. Rx. : 98                 Nuage Msg Error    : 0
Nuage Msg Min. Rtt : 30                 Nuage Msg Max. Rtt : 120
Nuage Sub Tx.      : 4                  Nuage UnSub Tx.    : 0
Nuage Msg Timed Out: 0
Encryption Type    : none

=========================================================================
*A:vsc-ocip#
```

Test connectivity to the VSD.

```
*A:vsc-ocip# show vswitch-controller vsd detail

=========================================================================
VSD Server Table
=========================================================================
VSD User Name       : cna@xmpp.sirlab.lab/vsd1
Uptime              : 9d 14:38:09
Status              : available
Nuage Msg Tx.       : 1467              Nuage Msg Rx.       : 1467
Nuage Msg Ack. Rx. : 1467              Nuage Msg Error     : 0
Nuage Msg TimedOut : 0                 Nuage Msg MinRtt    : 40
Nuage Msg MaxRtt    : 11080

VSD User Name       : cna@xmpp.sirlab.lab/vsd3
Uptime              : 9d 14:38:14
Status              : available
Nuage Msg Tx.       : 1546              Nuage Msg Rx.       : 1546
Nuage Msg Ack. Rx. : 1546              Nuage Msg Error     : 0
Nuage Msg TimedOut : 0                 Nuage Msg MinRtt    : 40
Nuage Msg MaxRtt    : 1040

VSD User Name       : cna@xmpp.sirlab.lab/vsd2
Uptime              : 9d 14:38:33
Status              : available
Nuage Msg Tx.       : 2298              Nuage Msg Rx.       : 2298
Nuage Msg Ack. Rx. : 2298              Nuage Msg Error     : 0
Nuage Msg TimedOut : 0                 Nuage Msg MinRtt    : 40
Nuage Msg MaxRtt    : 13100

========================================================================
*A:vsc-ocip#
```

From the VSD dashboard:



Users	1
Groups	5
L3 Domains	1
L2 Domains	0
Virtual Machines	1
Floating IPs	0 out of 16
Containers	1

1 object

1 Mediation Execution Error Alarm for Entity Typ…
Mar 11 2019 14:59:51
Mediation Execution Error for object vm with key 8a00049f-c8a6-4f15-ad6f-96053c4bb28b, cause: Bad hypervisor string , source: vsc-ocip@xmpp.sirlab.lab/nuage

Figure 8: VSC View from VSD

Installing Virtual Routing and Switching

Virtual Routing and Switching (VRS) is responsible for L2/L3 forwarding and supports a range of L2 and L3 encapsulations methods, from VLAN up to VxLAN and GRE, that allow communication with external endpoints.

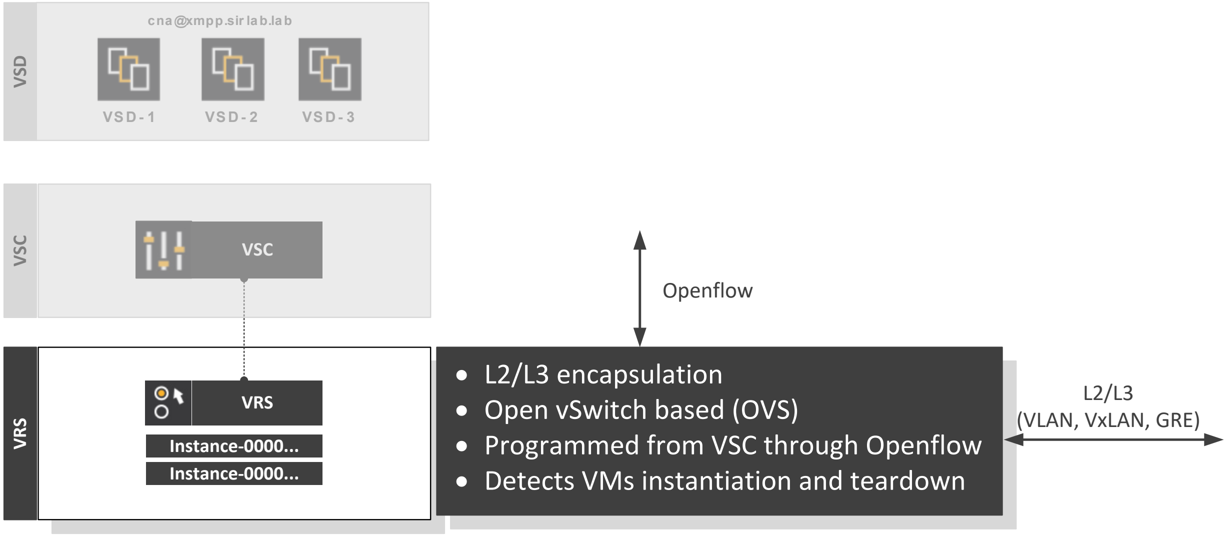


Figure 9: VRS Component

This is the final step of the installation. The following steps (and flow) provide guidance during the deployment.

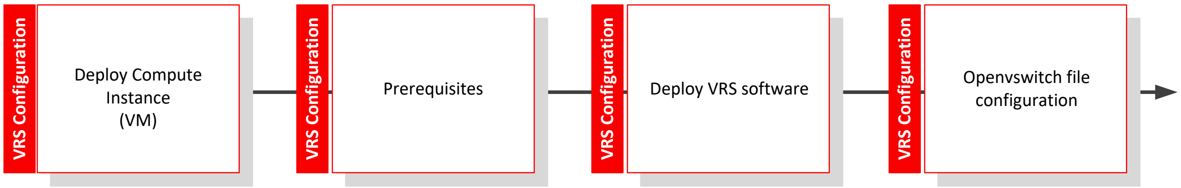


Figure 10: VRS Installation Flow

Prerequisites

Before installing VRS, ensure that the following dependencies are met on the target host:

- Packages required by VRS:
  - Python twisted library
  - Perl JSON library
  - vconfig package
- Other software:
  - KVM
  - libvirt

Note: The CentOS 7 image, which is certified to run VRS, is also required.

Install VRS

1. To deploy a compute instance, from the navigation menu in the Oracle Cloud Console, select **Compute** and then select **Instances**.
2. Click **Create instance**.
3. Provide a name for the instance (for example, **Instance-VRS**) and select an availability domain (**AD 3**).
4. Click **Change image** and select **CentOS 7**.
5. Click **Change shape**, select **Virtual machine**, select **VM.Standard2.2**, and then click **Select shape**.
6. In the **Networking** section, select the VCN and the subnet (**mgt-plain**).
7. In the **Add SSH keys** section, upload an SSH public key file or paste the SSH key in the text box.
8. Click **Create**.

   After some minutes, the instance deployed.

9. After the VM is running, log in to the instance and install or update the repos from the “Prerequisites” section.

   ```
   [root@instance-vrs opc]#  yum install libvirt
   [root@instance-vrs opc]#  yum install qemu-kvm
   ```

   Warning: Always check the list of supported kernels in the Nuage Networks release notes. Any system update (yum update) can lead into an unsupported operating system version.

10. Check the kernel that’s running.

    ```
    [root@instance-vrs opc]# uname -r
    3.10.0-957.1.3.el7.x86_64
    ```

11. Each supported operating system has a VRS `.tar.gz` file. Copy the VRS software file to the destination host.

    ```
    [root@instance-vrs opc]# mkdir nuage
    [root@instance-vrs opc]# cd /home/opc/nuage
    [root@instance-vrs nuage]# scp admin@source_host :/share/nfs/nuage/5.3.3/nuage-VRS- 5.3.3-
    128.tar.gz ./ nuage-VRS- 5.3.3-128.tar.gz
    ```

12. Untar the Nuage VRS software file on the host.

    ```
    [root@instance-vrs nuage]#  tar xzvf nuage-VRS- 5.3.3-128.tar.gz
    ```

13. Install the `nuage-openvswitch` package and the `nuage-bgp` package.

    ```
    [root@instance-vrs nuage]# yum localinstall nuage-openvswitch- 5.3.3-128.el7.x86_64.rpm
    [root@instance-vrs nuage]# yum localinstall nuage-bgp- 5.3.3-128.el7.x86_64.rpm
    ```

14. Verify that the package has been installed.

    ```
    [root@instance-vrs nuage]# yum list installed | grep nuage
    nuage-metadata-agent.x86_64                 5.3.3-128.el7                  installed
    nuage-openvswitch.x86_64                    5.3.3-128.el7                  installed
    ```

15. Edit `/etc/default/openvswitch` to set the personality, the platform (KVM), and the controller IP address.

    ```
    # PERSONALITY: vrs/vrs-g/vrs-b/nsg/nsg-br/nsg-duc/vdf/vdf-g/none (default: vrs)
    PERSONALITY=vrs

    # PLATFORM: kvm/xen/esx-i/lxc. Only apply when in VRS personality.
    ```

```
# lxc and kvm can exist at the same time as a , separated list like so:
# PLATFORM: "kvm, lxc"
PLATFORM="kvm"

# ACTIVE_CONTROLLER: Primary controller IP. Only valid IP addresses will be
# accepted. To delete the controller comment out the ACTIVE_CONTROLLER
# variable below
ACTIVE_CONTROLLER=10.0.104.101
#
```

16. Restart the VRS.

```
[root@instance-vrs opc]# service openvswitch restart
```

17. Verify that the VRS is up and connected to the VSC controller.

```
[root@instance-vrs opc]# ovs-vsctl show
66870816-6a7c-4f30-b341-68f56eaef19c
    Bridge "alubr0"
        Controller "ctrl1"
            target: "tcp:10.0.104.101:6633"
            role: master
            is_connected: true
        Port svc-pat-tap
            Interface svc-pat-tap
                type: internal
        Port "svc-rl-tap1"
            Interface "svc-rl-tap1"
        Port "vnet0"
            Interface "vnet0"
        Port nuage-bgp
            Interface nuage-bgp
                type: internal
        Port svc-spat-tap
            Interface svc-spat-tap
                type: internal
        Port "svc-rl-tap2"
            Interface "svc-rl-tap2"
        Port "alubr0"
            Interface "alubr0"
                type: internal
    ovs_version: "5.3.3-128-nuage"
    other_config: {acl-non-tcp-timeout="180", acl-tcp-timeout="3600", connid-type="", connid-
val="", connobj-limit="320000", control-cos="7", control-dscp="56", controller-less-
duration="", "disable-dhcp4"=no, dual-vtep=no, flow-collection="true", flow-limit="200000",
fp-ports="", head-less-duration="", nat-traversal-enabled=no, network-namespace=default, nw-
uplink="ens4f0", openflow_audit_timer="180", personality=vrs, platform=kvm, revertive-
controller=no, revertive-timer="300", stats-
collector="10.5.0.11:39090,10.5.0.12:39090,10.5.0.13:39090", stats-collector-type=ip, stats-
enable="true", sticky-ecmp-timeout="0", syslog-dest=localhost, syslog-dest-port="514", sysmon-
timer="3600", tcp-mss="0", vdf_uplink="", vport-init-stateful-timer="300", vss-stats-
interval="30"}
[root@instance-vrs opc]#
```

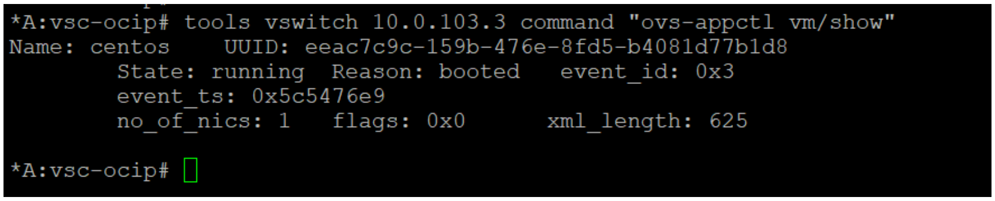
18. Confirm connectivity from VSC to VRS.

```
*A:vsc-ocip# show vswitch-controller vswitches

=====================================================================
VSwitch Table
=====================================================================
---------------------------------------------------------------------
Legend: * -> Primary Controller ! -> NSG in Graceful Restart
---------------------------------------------------------------------
Vswitch-Instance     Personality  Uptime             Num VM/Host/Bridge/Cont
                                                     Num Resolved
---------------------------------------------------------------------
*va-10.0.103.3/1     VRS          37d 21:08:39       1/0/0/0
                                                     1/0/0/0
---------------------------------------------------------------------
No. of virtual switches: 1
---------------------------------------------------------------------
=====================================================================
*A:vsc-ocip#
```

You can query VRS directly from VSCs by sending a specific shell command down the VRS, capturing the output, and displaying it on the controller.

19. List the VMs behind the VRS.

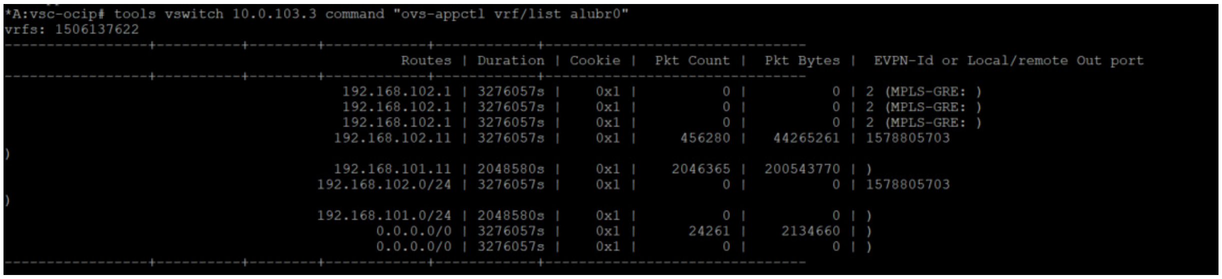
```
*A:vsc-ocip# tools vswitch 10.0.103.3 command "ovs-appctl vm/show"
```



```
*A:vsc-ocip# tools vswitch 10.0.103.3 command "ovs-appctl vm/show"
Name: centos    UUID: eeac7c9c-159b-476e-8fd5-b4081d77b1d8
        State: running  Reason: booted   event_id: 0x3
        event_ts: 0x5c5476e9
        no_of_nics: 1   flags: 0x0      xml_length: 625

*A:vsc-ocip#
```

20. You can even check the routing table configured in the VRS.

```
*A:vsc-ocip# tools vswitch 10.0.103.3 command "ovs-appctl vrf/list alubr0"
```



```
*A:vsc-ocip# tools vswitch 10.0.103.3 command "ovs-appctl vrf/list alubr0"
vrfs: 1506137622
-------------------+------------+---------+--------------+--------------+---------------------------
                                    Routes | Duration | Cookie |  Pkt Count |  Pkt Bytes |  EVPN-Id or Local/remote Out port
-------------------+------------+---------+--------------+--------------+---------------------------
                             192.168.102.1 | 3276057s |    0x1 |          0 |          0 | 2 (MPLS-GRE: )
                             192.168.102.1 | 3276057s |    0x1 |          0 |          0 | 2 (MPLS-GRE: )
                             192.168.102.1 | 3276057s |    0x1 |          0 |          0 | 2 (MPLS-GRE: )
                            192.168.102.11 | 3276057s |    0x1 |     456280 |   44265261 | 1578805703
)
                            192.168.101.11 | 2048580s |    0x1 |    2046365 |  200543770 | )
                          192.168.102.0/24 | 3276057s |    0x1 |          0 |          0 | 1578805703
)
                          192.168.101.0/24 | 2048580s |    0x1 |          0 |          0 | )
                                 0.0.0.0/0 | 3276057s |    0x1 |      24261 |    2134660 | )
                                 0.0.0.0/0 | 3276057s |    0x1 |          0 |          0 | )
-------------------+------------+---------+--------------+--------------+---------------------------
```

Nuage Networks SDN Tests

The following image shows the network architecture used throughout this paper. VMs are launched using Docker and CentOS, depending on the environment (Nokia Lab or OCI).

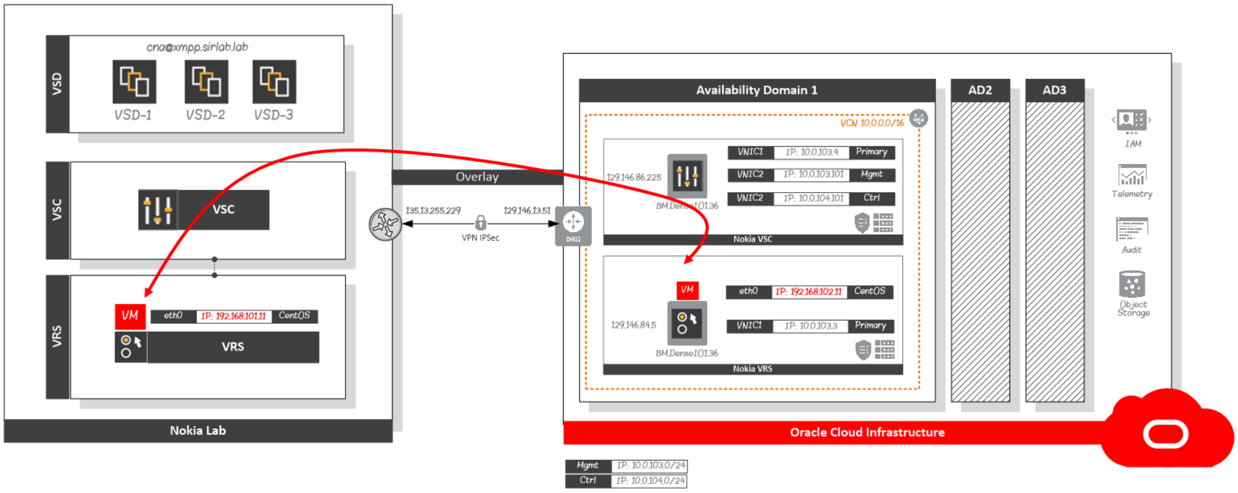
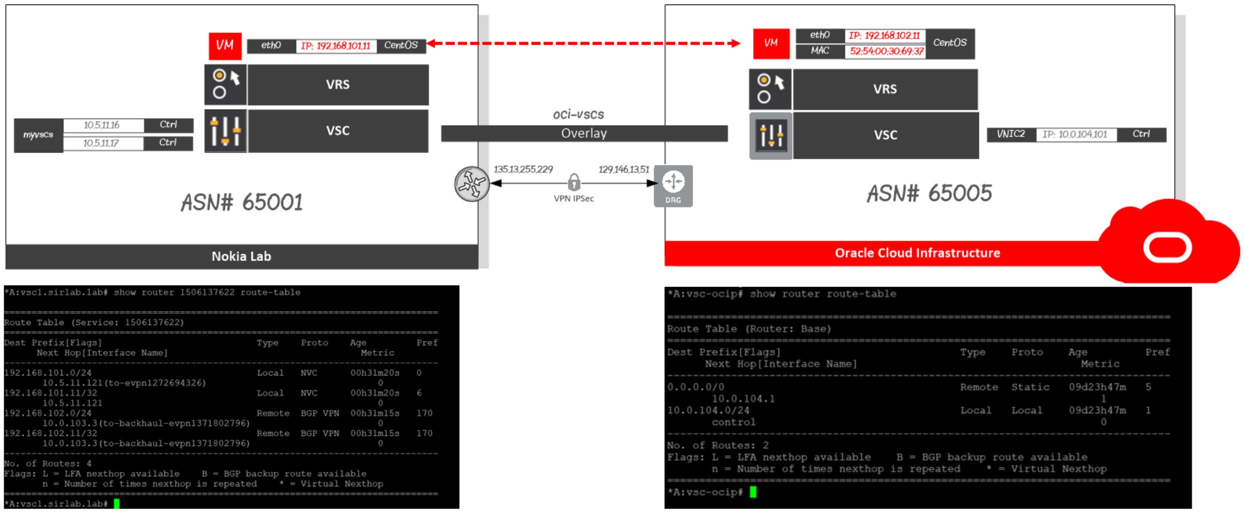


Figure 11: End-to-End Communication

For this paper, communications between both sites required encryption. IPSec tunnels are configured in the solution. This configuration can add some performance degradation because an overlay network is deployed to carry Ethernet traffic over an existing IP network. Although you can run connectivity between both sites without using IPSec tunnels, we recommend securing communications.

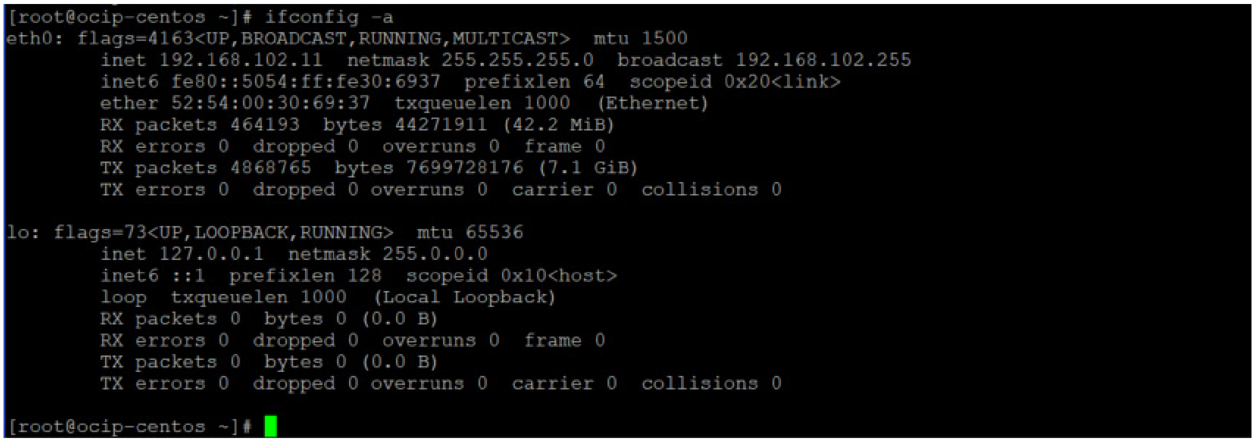


```
*A:vscl.sirlab.lab# show router 1506137622 route-table

===============================================================================
Route Table (Service: 1506137622)
===============================================================================
Dest Prefix[Flags]                              Type    Proto     Age        Pref
      Next Hop[Interface Name]                                      Metric
-------------------------------------------------------------------------------
192.168.101.0/24                                Local   NVC       00h31m20s  0
       10.5.11.121(to-evpn1272694326)                                 0
192.168.101.11/32                               Local   NVC       00h31m20s  6
       10.5.11.121                                                    0
192.168.102.0/24                                Remote  BGP VPN   00h31m15s  170
       10.0.103.3(to-backhaul-evpn1371802796)                         0
192.168.102.11/32                               Remote  BGP VPN   00h31m15s  170
       10.0.103.3(to-backhaul-evpn1371802796)                         0
-------------------------------------------------------------------------------
No. of Routes: 4
Flags: L = LFA nexthop available    B = BGP backup route available
       n = Number of times nexthop is repeated    * = Virtual Nexthop
===============================================================================
*A:vscl.sirlab.lab#
```

```
*A:vsc-ocip# show router route-table

===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix[Flags]                              Type    Proto     Age        Pref
      Next Hop[Interface Name]                                      Metric
-------------------------------------------------------------------------------
0.0.0.0/0                                       Remote  Static    09d23h47m  5
       10.0.104.1                                                   1
10.0.104.0/24                                   Local   Local     09d23h47m  1
       control                                                      0
-------------------------------------------------------------------------------
No. of Routes: 2
Flags: L = LFA nexthop available    B = BGP backup route available
       n = Number of times nexthop is repeated    * = Virtual Nexthop
===============================================================================
*A:vsc-ocip#
```

Figure 12: Routing Tables

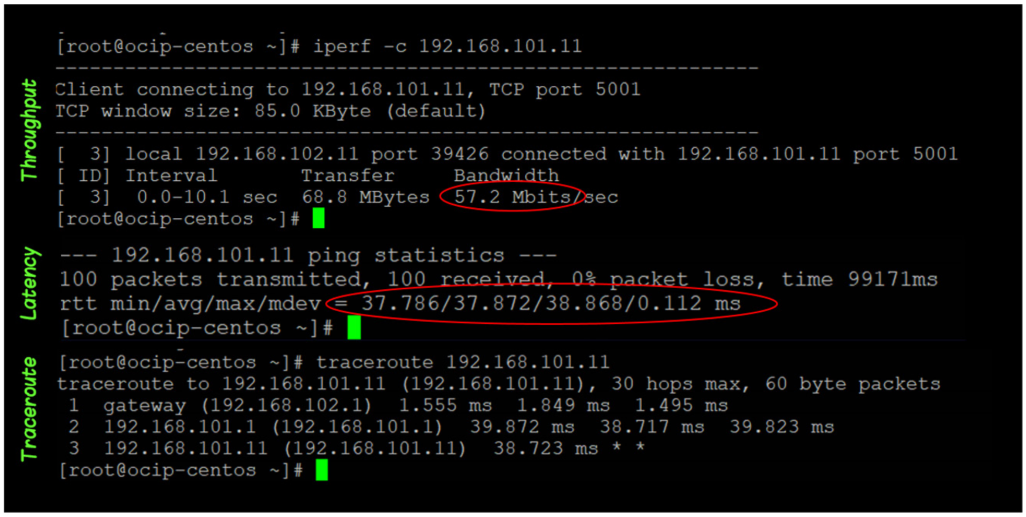
The following image shows CentOS VM network configuration in OCI.



```
[root@ocip-centos ~]# ifconfig -a
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.102.11  netmask 255.255.255.0  broadcast 192.168.102.255
        inet6 fe80::5054:ff:fe30:6937  prefixlen 64  scopeid 0x20<link>
        ether 52:54:00:30:69:37  txqueuelen 1000  (Ethernet)
        RX packets 464193  bytes 44271911 (42.2 MiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 4868765  bytes 7699728176 (7.1 GiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

[root@ocip-centos ~]#
```

Figure 13: CentOS VM Network Configuration

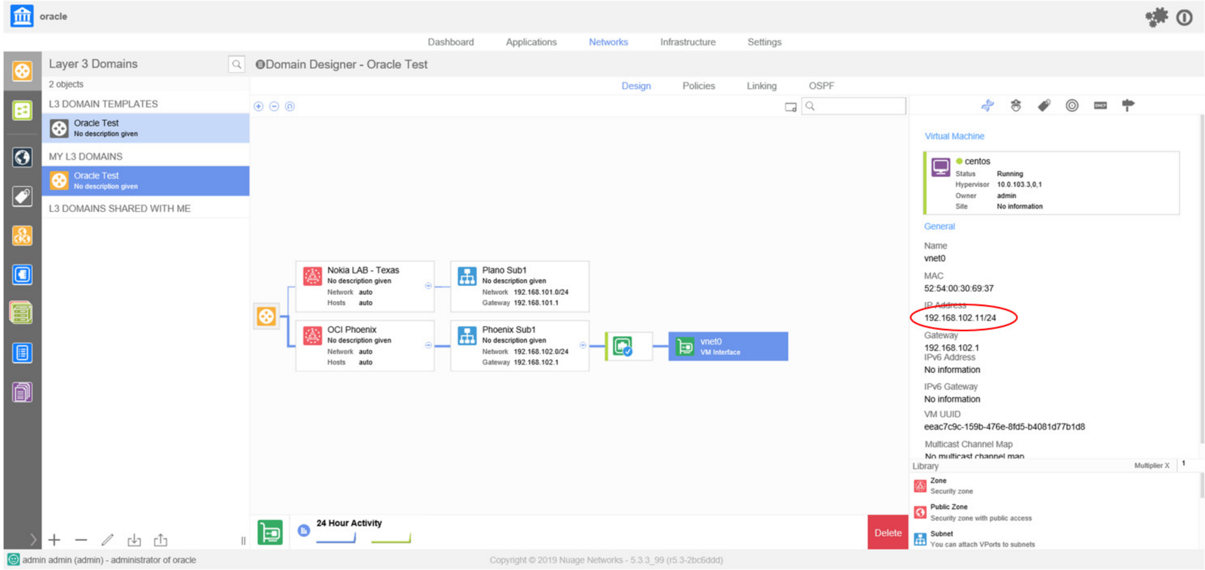
Testing network performance for speed and bandwidth is essential for both production and nonproduction environments. The following image shows the results for some of the tests run in the network.



```
[root@ocip-centos ~]# iperf -c 192.168.101.11
------------------------------------------------------------
Client connecting to 192.168.101.11, TCP port 5001
TCP window size: 85.0 KByte (default)
------------------------------------------------------------
[  3] local 192.168.102.11 port 39426 connected with 192.168.101.11 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.1 sec  68.8 MBytes  57.2 Mbits/sec
[root@ocip-centos ~]#

--- 192.168.101.11 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 99171ms
rtt min/avg/max/mdev = 37.786/37.872/38.868/0.112 ms
[root@ocip-centos ~]#

[root@ocip-centos ~]# traceroute 192.168.101.11
traceroute to 192.168.101.11 (192.168.101.11), 30 hops max, 60 byte packets
 1  gateway (192.168.102.1)  1.555 ms  1.849 ms  1.495 ms
 2  192.168.101.1 (192.168.101.1)  39.872 ms  38.717 ms  39.823 ms
 3  192.168.101.11 (192.168.101.11)  38.723 ms * *
[root@ocip-centos ~]#
```

Figure 14: Network Performance

Last, check that from the policy engine (VSD), you have control over the different VSCs deployed in OCI. The following figure shows how to manage from a single console all the controllers deployed in your environments, whether they're on-premises or in the cloud.



Oracle Test
No description given

Oracle Test
No description given

Nokia LAB - Texas
No description given
Network auto
Hosts auto

Plano Sub1
No description given
Network 192.168.101.0/24
Gateway 192.168.101.1

OCI Phoenix
No description given
Network auto
Hosts auto

Phoenix Sub1
No description given
Network 192.168.102.0/24
Gateway 192.168.102.1

vnet0
VM Interface

Virtual Machine

centos
Status Running
Hypervisor 10.0.103.3,0,1
Owner admin
Site No information

General

Name
vnet0

MAC
52:54:00:30:69:37

IP Address
192.168.102.11/24

Gateway
192.168.102.1
IPv6 Address
No information

IPv6 Gateway
No information

VM UUID
eeac7c9c-159b-476e-8fd5-b4081d77b1d8

Multicast Channel Map
No multicast channel map

Zone
Security zone

Public Zone
Security zone with public access

Subnet
You can attach VPorts to subnets

admin admin (admin) - administrator of oracle

Copyright © 2019 Nuage Networks - 5.3.3_99 (r5.3-2bc6ddd)

Figure 15: VSD Layer 3 Domain

Appendix A: Attach Secondary VNICs in OCI

You can add secondary VNICs by using the Oracle Cloud Console.

1. From the navigation menu, select **Compute** and then select **Instances**.
2. Click the name of the instance (in this case, **Instance-VSC**) to view its details.
3. Under **Resources**, click **Attached VNICs**.
4. Click **Create VNIC**.
5. Provide the following information:
   - **Name**: vf-mgt-nic
   - **Virtual cloud network**: VCN
   - **Subnet**: mgt-plain
   - **Private IP address**: 10.0.103.101

   Leave the rest of the entries blank.
6. Repeat the preceding steps to add the second VNIC with the following information:
   - **Name**: vf-ctl-nic
   - **Virtual cloud network**: VCN
   - **Subnet**: ctl-plain
   - **Private IP address**: 10.0.104.101

7. Create a directory and download the `secondary_vnic_all_configure.sh` script. Connect to the instance by using SSH and run the following commands:

```
mkdir /opt/secondary_vnic
cd /opt/secondary_vnic
wget
https://docs.cloud.oracle.com/iaas/Content/Resources/Assets/secondary_vnic_all_configure.sh
chmod u+x secondary_vnic_all_configure.sh
```

8. Create the unit file.

```
# vi /etc/systemd/system/secondary_vnic_all_configure.service
```

9. Paste the following lines into the file:

```
     [Unit]
     Description=Add the secondary VNIC at boot
     After=basic.target
     [Service]
     Type=oneshot
     ExecStart=/opt/secondary_vnic/secondary_vnic_all_configure.sh -c
     [Install]
     WantedBy=default.target
```

10. Enable the unit file.

```
    # chmod 664 /etc/systemd/system/secondary_vnic_all_configure.service
    # systemctl enable /etc/systemd/system/secondary_vnic_all_configure.service
    # systemctl list-unit-files|egrep secondary_vnic_all_configure.service
```

11. Reboot the instance by clicking the Reboot button on the instance details page in the Oracle Cloud Console.

12. Confirm that the second VNIC is automatically configured:

```
# uptime; ip address
```

Appendix B: Virtualized Services Controller BOF File

```
*A:vsc-ocip# show bof
=============================================================================
BOF (Memory)
=============================================================================
    primary-image         cf1:\timos\cpm.tim
    primary-config        cf1:\config.cfg
    address               10.0.103.101/24 active
    primary-dns           10.5.0.50
    dns-domain            sirlab.lab
    static-route          0.0.0.0/1 next-hop 10.0.103.1
    static-route          128.0.0.0/1 next-hop 10.0.103.1
    autonegotiate
    duplex                full
    speed                 100
    wait                  3
    persist               off
    no li-local-save
    no li-separate
    no fips-140-2
    console-speed         115200
```

```
=============================================================================
*A:vsc-ocip#
```

Appendix C: Virtualized Services Controller Configuration File

For the main configuration, type `admin display-config`.

```
*A:vsc-ocip# admin display-config
# TiMOS-DC-C-5.3.3-100 cpm/i386 NUAGE VSC Copyright (c) 2000-2018 Nokia.
# All rights reserved. All use subject to applicable license agreements.
# Built on Wed Oct 31 13:42:50 PDT 2018 [d429da] by builder in /rel5.3-DC/release/panos/main

# Generated MON MAR 11 13:40:49 2019 UTC

exit all
configure
#--------------------------------------------------
echo "System Configuration"
#--------------------------------------------------
        name "vsc-ocip"
        contact "EMEA Cloud Pursuit Team"
        location "40.5214579,-3.8913381b"
        snmp
        exit
        time
            ntp
                ntp-server
                server 10.5.0.50
                no shutdown
            exit
            sntp
                shutdown
            exit
            zone UTC
        exit
        thresholds
            rmon
            exit
        exit
#--------------------------------------------------
echo "System Security Configuration"
#--------------------------------------------------
    system
        security
            user "admin"
                password "L8PI6XXQN0W1jz.nZ92v2E" hash2
                access console
                console
                    member "administrative"
                exit
            exit
        exit
    exit
#--------------------------------------------------
echo "Log Configuration"
#--------------------------------------------------
```

```
    log
    exit
#--------------------------------------------------
echo "System Security Cpm Hw Filters and PKI Configuration"
#--------------------------------------------------
    system
        security
        exit
    exit
#--------------------------------------------------
echo "QoS Policy Configuration"
#--------------------------------------------------
    qos
    exit
#--------------------------------------------------
echo "Card Configuration"
#--------------------------------------------------
#--------------------------------------------------
echo "Service Configuration"
#--------------------------------------------------
    service
    exit
#--------------------------------------------------
echo "LAG Configuration"
#--------------------------------------------------
    lag 98
        description "Multichassis interconnect LAG"
        encap-type dot1q
        qos
        exit
        lacp active administrative-key 36864
        no shutdown
    exit
#--------------------------------------------------
echo "Management Router Configuration"
#--------------------------------------------------
    router management
    exit

#--------------------------------------------------
echo "Router (Network Side) Configuration"
#--------------------------------------------------
    router
        interface "control"
            address 10.0.104.101/24
            no shutdown
        exit
        interface "system"
            shutdown
        exit
        vxlan
        exit
        autonomous-system 65005
        router-id 10.0.104.101
#--------------------------------------------------
```

```
echo "Static Route Configuration"
#--------------------------------------------------
        static-route 0.0.0.0/0 next-hop 10.0.104.1
#--------------------------------------------------
echo "Web Portal Protocol Configuration"
#--------------------------------------------------
    exit

#--------------------------------------------------
echo "Service Configuration"
#--------------------------------------------------
    service
        customer 1 create
            description "Default customer"
        exit
    exit
#--------------------------------------------------
echo "Router (Service Side) Configuration"
#--------------------------------------------------
    router
#--------------------------------------------------
echo "BGP Configuration"
#--------------------------------------------------
        bgp
            connect-retry 2
            enable-peer-tracking
            rapid-withdrawal
            rapid-update evpn
            group "myvscs"
                family evpn
                type external
                multihop 5
                peer-as 65001
                neighbor 10.5.11.16
                exit
                neighbor 10.5.11.17
                exit
            exit
            no shutdown
        exit
    exit

#--------------------------------------------------
echo "System Time NTP Configuration"
#--------------------------------------------------
    system
        time
            ntp
            exit
        exit
    exit
#--------------------------------------------------
echo "Virtual Switch Controller Configuration"
#--------------------------------------------------
    vswitch-controller
```

```
        xmpp-server "vsc-ocip@xmpp.sirlab.lab"
        open-flow
        exit
        xmpp
        exit
        ovsdb
        exit
        init
        exit
    exit

exit all

# Finished MON MAR 11 13:41:04 2019 UTC
*A:vsc-ocip#
```

Appendix D: Virtual Routing and Switching Configuration File

```
[root@instance-vrs opc]# cat /etc/default/openvswitch
### Configuration options for openvswitch

# Copyright (C) 2009, 2010, 2011 Nicira, Inc.

# FORCE_COREFILES: If 'yes' then core files will be enabled.
# FORCE_COREFILES=yes

# OVSDB_SERVER_PRIORITY: "nice" priority at which to run ovsdb-server.
#
# OVSDB_SERVER_PRIORITY=-10

# VSWITCHD_PRIORITY: "nice" priority at which to run ovs-vswitchd.
# VSWITCHD_PRIORITY=-10

# VSWITCHD_MLOCKALL: Whether to pass ovs-vswitchd the --mlockall option.
#     This option should be set to "yes" or "no".  The default is "yes".
#     Enabling this option can avoid networking interruptions due to
#     system memory pressure in extraordinary situations, such as multiple
#     concurrent VM import operations.
# VSWITCHD_MLOCKALL=yes

# OVS_CTL_OPTS: Extra options to pass to ovs-ctl.  This is, for example,
# a suitable place to specify --ovs-vswitchd-wrapper=valgrind.
# OVS_CTL_OPTS=
# DELETE_BRIDGES: Delete the previously existing ones, default is "no".
# DELETE_BRIDGES=no

# PERSONALITY: vrs/vrs-g/vrs-b/nsg/nsg-br/nsg-duc/vdf/vdf-g/none (default: vrs)
PERSONALITY=vrs

# UUID: uuid assigned to nsg
UUID=

# CPE_ID: 4 byte id assigned to nsg
CPE_ID=
# DATAPATH_ID: Datapath id of the nsg
DATAPATH_ID=

# UPLINK_ID: uplink id assigned to nsg
UPLINK_ID=

# NETWORK_UPLINK_INTF: uplink interface of the host
NETWORK_UPLINK_INTF=ens4f0
# NETWORK_NAMESPACE: namespace to create pat interfaces, iptables & route rules
NETWORK_NAMESPACE=

# VDF_UPLINK: Adds intf to use as uplink for vdf for creating vlan interfaces
VDF_UPLINK=

#
# VRSG_PEER_IP: Applies only when in GateWay mode
# VRSG_PEER_IP=0.0.0.0

# PLATFORM: kvm/xen/esx-i/lxc. Only apply when in VRS personality.
# lxc and kvm can exist at the same time as a , separated list like so:
# PLATFORM: "kvm, lxc"
PLATFORM="kvm"

# DEFAULT_BRIDGE: Nuage managed bridge
DEFAULT_BRIDGE=alubr0

# BRIDGE_MTU: Configurable bridge MTU
#BRIDGE_MTU=

# MCAST_UNDERLAY_TX_INTF: mcast tx interface
#MCAST_UNDERLAY_TX_INTF=

# GW_HB_BRIDGE: Name of the gateway heartbeat bridge
GW_HB_BRIDGE=

# GW_HB_VLAN: vlan for heart beat exchange in gateways
GW_HB_VLAN=

# GW_HB_TIMEOUT: timeout for heart beat exchange in gateways in milliseconds
GW_HB_TIMEOUT=2000

# MGMT_ETH: Comma separated names of management Ethernet interfaces
MGMT_ETH=

# UPLINK_ETH: Comma separated names of Ethernet interfaces used for uplink
UPLINK_ETH=

# GW_PEER_DATAPATH_ID: Datapath ID of peer gateway to which access resiliency
# will be established
GW_PEER_DATAPATH_ID=

# GW_ROLE: Specify role of a gateway.
# Set to "master" if all access link ports of the gateway should act as
# a master in a resilient setup, "backup" if it should act as a backup.
GW_ROLE="backup"
```

```
#Sample Mcast Underlay interface and range configuration
# MCAST_UNDERLAY_INTF_1: mcast interface
#MCAST_UNDERLAY_INTF_1=

# MCAST_UNDERLAY_INTF_RANGE_1: mcast interface range
#MCAST_UNDERLAY_INTF_RANGE_1=

# CONNID_TYPE: This could be set to type uuid or string
# CONNID_TYPE=

# CONNID_VAL: This could be a uuid value or a string
# CONNID_VAL=

# CLIENT_KEY_PATH: SSL client key file path
# CLIENT_KEY_PATH=

# CLIENT_CERT_PATH: SSL client certificate file path
# CLIENT_CERT_PATH=

# CA_CERT_PATH: CA certificate file path
# CA_CERT_PATH=

# CONN_TYPE: ssl or tcp
CONN_TYPE=tcp

# ACTIVE_CONTROLLER: Primary controller IP. Only valid IP addresses will be
# accepted. To delete the controller comment out the ACTIVE_CONTROLLER
# variable below
ACTIVE_CONTROLLER=10.0.104.101
#
# STANDBY_CONTROLLER: Secondary controller IP. Only valid IP addresses
# will be accepted. To delete the controller comment out the STANDBY_CONTROLLER
# variable below
# STANDBY_CONTROLLER=
#
# NUAGE_MONITOR_PRIORITY:
# NUAGE_MONITOR_PRIORITY= -10
#
# VM_MONITOR_PRIORITY:
# VM_MONITOR_PRIORITY= -10
#
# MANAGEMENT_INTERFACE: Management interface (example: eth0)
# MANAGEMENT_INTERFACE=eth0

# DHCP_RELAY_ADDRESS: IP Address of the DHCP relay server
#DHCP_RELAY_ADDRESS=

# STATS_COLLECTOR_ADDRESS: IP or FQDN of the STATS relay server (applicable only for NSG)
# STATS_COLLECTOR_ADDRESS=

# STATS_COLLECTOR_TYPE: IP or FQDN (default: FQDN) (applicable only for NSG)
# STATS_COLLECTOR_TYPE=

# STATS_COLLECTOR_PORT: ssl port of the STATS relay server (applicable only for NSG)
# STATS_COLLECTOR_PORT=
#
# DB_FILE: OVSDB file location (default: /etc/openvswitch)
# DB_FILE=

# FLOW_EVICTION_THRESHOLD: Number of flows at which eviction from
# kernel flow table will be triggered (default : 2500)
#FLOW_EVICTION_THRESHOLD=

# DATAPATH_SYNC_TIMEOUT: Datapath flow stats sync timeout
# specified in milliseconds (default: 1000)
#DATAPATH_SYNC_TIMEOUT=

# DATAPATH_FLOW_IDLE_TIMEOUT : Datapath flow idle timeout
# specified in milliseconds (default: 5000)
#DATAPATH_FLOW_IDLE_TIMEOUT=

# SKB_LRO_MOD_ENABLED: enable or disable LRO modification in skb for
# improving performance. Allowed values: 'yes' or 'no'
SKB_LRO_MOD_ENABLED=no

# PROBE_INTERVAL : Configurable openflow echo timer
# specified in milliseconds (default: 5000)
#PROBE_INTERVAL=
#
# DEFAULT_LOG_LEVEL: default log level at openvswitch start
# DEFAULT_LOG_LEVEL=any:file:dbg
DEFAULT_LOG_LEVEL=

# REVERTIVE_CONTROLLER: Revertive behavior of VRS (default : no)
REVERTIVE_CONTROLLER=no

# REVERTIVE_TIMER: Revert timer for the revertive behavior of VRS (default: 300 seconds)
# Valid range : 10 - 7200 seconds
REVERTIVE_TIMER=300

# CONTROLLER_LESS_DURATION : Controller-less duration of VRS (applicable only for NSG)
# (default is 3600 seconds. Valid Range: 3600 seconds(1 hr) - 86400 seconds(24 hr))
# -1 indicates infinite duration
#CONTROLLER_LESS_DURATION=3600

# Service IPV4 subnet for kubernetes
K8S_SERVICE_IPV4_SUBNET=0.0.0.0/8
# Pod IPV4 subnet for kubernetes
K8S_POD_NETWORK_CIDR=0.0.0.0/8

# FP_PORTS: List of fast-path ports to be recognized as Network ports (applicable only for Advanced
VRS)
#FP_PORTS=

# DUAL_VTEP_VRS: VRS supports dual-uplinks (default:no) (applicable only for DC environments)
#DUAL_VTEP_VRS=

# DISABLE_DHCP4: VRS will not act as dhcp server (default:no) (applicable only
# for DC environments)
```

```
#DISABLE_DHCP4=

# UPLINK1: Uplink 1 name (applicable only when DUAL_VTEP_VRS is enabled)
#UPLINK1=

# Controller configuration (applicable only when DUAL_VTEP_VRS is enabled)
# UPLINK1_ACTIVE_CONTROLLER: Active controller of Uplink 1 (applicable only when DUAL_VTEP_VRS is
enabled)
#UPLINK1_ACTIVE_CONTROLLER=

# UPLINK1_STANDBY_CONTROLLER: Standby controller of Uplink 1 (applicable only when DUAL_VTEP_VRS is
enabled)
#UPLINK1_STANDBY_CONTROLLER=

# UPLINK1_UNDERLAY_ID: Underlay ID of Uplink 1 (applicable only when DUAL_VTEP_VRS is enabled)
#UPLINK1_UNDERLAY_ID=

# UPLINK2: Uplink 2 name (applicable only when DUAL_VTEP_VRS is enabled)
#UPLINK2=

# UPLINK2_ACTIVE_CONTROLLER: Active controller of Uplink 2 (applicable only when DUAL_VTEP_VRS is
enabled)
#UPLINK2_ACTIVE_CONTROLLER=

# UPLINK2_STANDBY_CONTROLLER: Standby controller of Uplink 2 (applicable only when DUAL_VTEP_VRS is
enabled)
#UPLINK2_STANDBY_CONTROLLER=

# UPLINK2_UNDERLAY_ID: Underlay ID of Uplink 2 (applicable only when DUAL_VTEP_VRS is enabled)
#UPLINK2_UNDERLAY_ID=
[root@instance-vrs opc]#
```

Resources

- Nuage Networks VSP 5.3.3 Release Notes
- Nuage Networks VSP 5.3.3 Installation Guide

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