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# Expanding Oracle's Virtual Compute Appliance Using Oracle ZFS Storage Appliance

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## Introduction

Oracle's Virtual Compute Appliance is a converged infrastructure solution that combines preconfigured networking, servers, and storage into a convenient package that system administrators can easily deploy into an existing data center. Each Virtual Compute Appliance arrives in a single rack with up to 25 servers (compute nodes), as well as multiple InfiniBand and Ethernet switches. Virtual Compute Appliance has been designed to scale dynamically using built-in software automation to accommodate the expansion of its server and storage space. Combined with the virtualization power of Oracle VM, the Virtual Compute Appliance provides the perfect general-purpose solution for rapidly and easily bringing online a new rack into a cloud environment.

The existing storage within the Virtual Compute Appliance is a small Oracle ZFS Storage Appliance (the Oracle ZFS Storage ZS3-ES model), which is located in the bottom of the rack. It contains two clustered 1U controllers and a single disk tray supplied with twenty 900 GB SAS data drives. This design could be limiting for high-performance database workloads as well as for backup and recovery needs. To address these requirements, the Virtual Compute Appliance has been qualified for use with an additional external Oracle ZFS Storage Appliance. This document describes how to increase the storage capacity of the Virtual Compute Appliance by adding a new rack containing a larger Oracle ZFS Storage Appliance cluster.

## Why Use Oracle ZFS Storage Appliance with Oracle's Virtual Compute Appliance?

Oracle ZFS Storage Appliance is an ideal solution for storage expansion of the Virtual Compute Appliance. It has been coengineered with the Virtual Compute Appliance to maximize performance and efficiency while reducing deployment risk and total cost of ownership. As an engineered storage expansion, the Oracle ZFS Storage Appliance offers the following capabilities to Virtual Compute Appliance customers:

- » The Oracle ZFS Storage Appliance provides extremely high performance for applications and workloads deployed on the Virtual Compute Appliance. It is optimized for Input/Output Operations per Second (IOPS)–intensive workloads, such as OLTP databases, as well as for bandwidth-driven workloads including data warehousing, business intelligence analytics, and video processing. The Oracle ZFS Storage Appliance is powerful enough to run a diverse set of workloads concurrently by leveraging the Virtual Compute Appliance InfiniBand network.
- » The Oracle ZFS Storage Appliance provides high throughput for thousands of virtual machines (VMs). It is capable of booting 16,000 VMs in approximately seven minutes. It provides fast response time and low latency, which allows it to avoid VM boot storms, throughput congestion, hot spots, and I/O saturation.
- » The Oracle ZFS Storage Appliance also comes with superior storage analytics, which allow you to visualize and drill down into specific workloads to understand where congestion occurs and why. It can even allow you to examine and manage the storage aspects of Virtual Compute Appliance environments all the way down to the VM level.
- » The Oracle ZFS Storage Appliance provides scalable capacity for Virtual Compute Appliance customers. It is offered in multiple configurations to address different application needs and can expand up to 3.4 PB.
- » The Oracle ZFS Storage Appliance reduces risk by automating storage management using Oracle Enterprise Manager, so you have fewer storage systems to integrate and manage. It also lowers risk by providing leading fault-monitoring and self-healing capabilities, and by simplifying setup and management through its DTrace Analytics feature.
- » The Oracle ZFS Storage Appliance reduces complexity because its large DRAM and flash cache–based architecture is more efficient in serving the I/O from large virtualized environments. In addition, unique features such as its Hybrid Columnar Compression feature reduce the amount of storage needed for data warehouses built using Oracle Database. And, it enables you to lower total cost of ownership because you need fewer systems that cost less and are easier to manage.

The Oracle ZFS Storage Appliance is ideal for expanding Virtual Compute Appliance storage by utilizing the Oracle ZFS Storage Appliance intelligent caching capabilities. This provides the I/O performance of DRAM (1000x faster than flash) at the cost and scalability of a disk-based storage solution.

The following sections outline the steps required for expanding Oracle's Virtual Compute Appliance using the Oracle ZFS Storage Appliance. Either the Oracle ZFS Storage ZS3-4 or ZS3-2 can be utilized depending on the capacity demands of the environment.

### Cabling

The Virtual Compute Appliance currently supports external connectivity to an Oracle ZFS Storage Appliance cluster using InfiniBand for storage data traffic. Additional Ethernet connections should also be made between the Oracle ZFS Storage Appliance cluster and an Ethernet switch connected to a customer's network infrastructure. The two Oracle Switch ES1-24 switches located in U21 of the Virtual Compute Appliance should *not* be used for ZFS Storage Appliance connectivity.

## Management

The network management port on both Oracle ZFS Storage Appliance controllers should be connected to a customer-provided Ethernet switch. NET0 on both controllers should also be connected to this switch for a total of four connections.

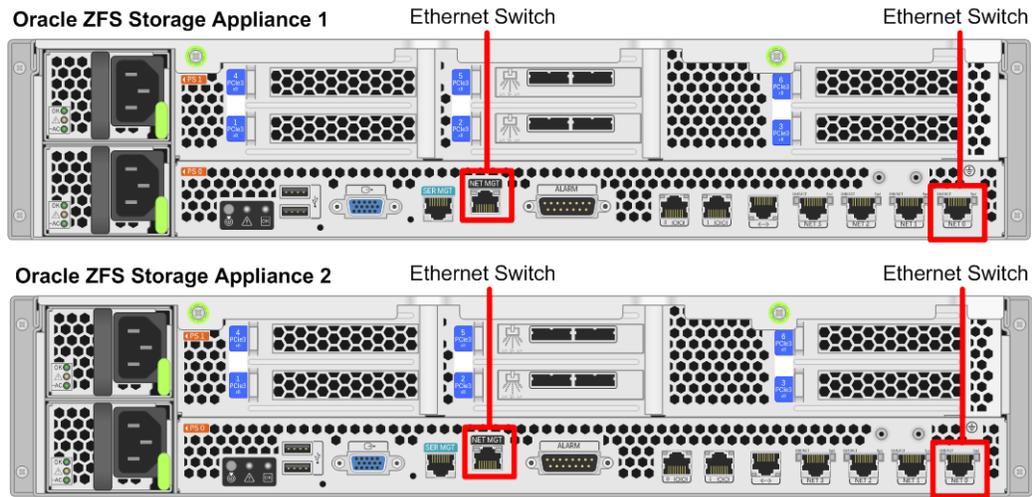


Figure 1. Connecting the Oracle ZFS Storage Appliance controllers

## InfiniBand

Four InfiniBand connections should be made between the two Oracle ZFS Storage Appliance controllers and two Oracle Fabric Interconnect F1-15 switches. These connections must be diversified to avoid a single point of failure. Figure 2 illustrates which ports should be utilized on the switches and their paths to the Oracle ZFS Storage Appliance controllers.

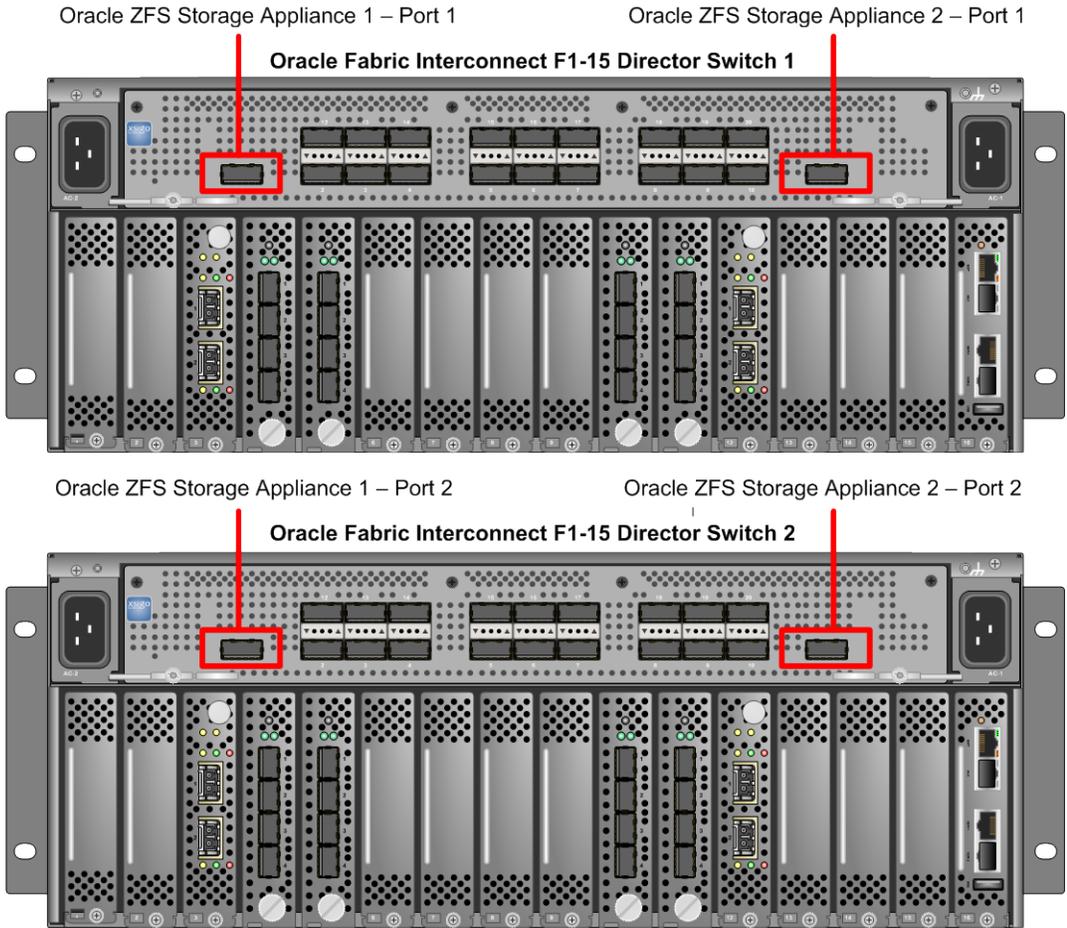


Figure 2. Connecting the Oracle Fabric Interconnect F1-15 switches

### External Oracle ZFS Storage Appliance Configuration

The Oracle ZFS Storage Appliance supports both an active/active and an active/passive cluster configuration. The configurations slightly differ in their network and storage layouts. An active/active configuration provides the highest performance, while an active/passive configuration provides the most stable and predictable environment during a storage failover event.

#### Oracle Integrated Lights Out Manager (Oracle ILOM) Configuration

On both controllers, a serial connection must be made to the RJ-45 serial management port. Serial access should use the following settings:

- » 9600 baud rate
- » 8N1: Eight data bits, no parity, one stop bit
- » No flow control, no hardware control, no software control

Once a connection has been established, log in to the console on each Oracle ZFS Storage Appliance controller using username `root` and password `changeme`. Next, use the following commands to set up the Oracle ILOM network interfaces:

```
-> cd /SP/network
```

```
-> set pendingipaddress=192.168.150.100
```

**Note:** This is an example IP address. Virtual Compute Appliance customers should provision an address within their own network for this connection.

```
-> set pendingipnetmask=255.255.255.0
```

```
-> set pendingipgateway=192.168.150.1
```

**Note:** This is an example gateway. Virtual Compute Appliance customers should provide their own gateway address.

```
-> set commitpending=true
```

After completion, ping each Oracle ILOM interface using any compute node on the Virtual Compute Appliance to verify the interfaces are working correctly.

## Management Interfaces

1. Log in to the Oracle ZFS Storage Appliance console through Oracle ILOM.

The default username is `root` and password is `changeme`.

2. Before clustering can be setup, reset each Oracle ZFS Storage Appliance controller to its factory conditions. On each controller, issue the following command from the CLI:

```
ZFS:> maintenance system factoryreset
```

3. After both controllers have rebooted, log in to the console of Oracle ZFS Storage Appliance Controller 1 and enter a new password in the Setup screen. Do not enter networking information now; it will be entered later.

4. Create a VNIC for each controller:

```
ZFS:maintenance system setup net> datalinks
datalinks> vnic
datalinks> set links=ixgbe0
```

**Note:** Use `ixgbe0` for an Oracle ZFS Storage ZS3-2 controller or `igb0` for an Oracle ZFS Storage ZS3-4 controller.

```
datalinks> commit
datalinks> vnic
datalinks> set links=ixgbe0
datalinks> commit
```

5. Create the management interface for each VNIC:

```
ZFS:maintenance system setup net datalinks> cd ..
net> interfaces
interfaces> ip
ip> set links=vnic1
ip> set v4addrs=ip_address_zfs_1/subnet_mask
```

```
Example: set v4addrs=192.168.150.100/24

ip> commit
interfaces> ip
ip> set links=vnic2
ip> set v4addrs=ip_address_zfs_2/subnet_mask
ip> commit
```

6. Destroy any system-created interfaces:

```
interfaces> destroy ixgbe0
```

**Note:** Use `ixgbe0` for an Oracle ZFS Storage ZS3-2 controller or `igb0` for an Oracle ZFS Storage ZS3-4 controller.

7. Create default routes for both management interfaces using a customer-supplied gateway address:

```
ZFS:maintenance system setup net interfaces> cd ..
net> routing
routing> create
routing> set destination=0.0.0.0
routing> set mask=0
routing> set gateway=gateway_ip_address
routing> set interface=vnic1
routing> set family=IPv4
routing> commit
routing> create
routing> set destination=0.0.0.0
routing> set mask=0
routing> set gateway=gateway_ip_address
routing> set interface=vnic2
routing> set family=IPv4
routing> commit
routing> done
net> done
```

8. Set up DNS using a customer-supplied DNS server:

```
dns> set domain=domain_name
dns> set servers=dns_ip_address
dns> done
```

9. Set up NTP using a customer-supplied NTP server:

```
ntp> set servers=ntp_ip_address
ntp> commit
ntp> done
```

10. Set up any needed AD, LDAP, or NIS server, or else type the following command:

```
directory> done
```

11. Bypass the storage setup for now:

```
storage> done
```

12. Set up 'Phone Home' for Oracle Support:

```
support> scrk
scrk> set soa_id=oracle_support_username
scrk> set soa_password=password
scrk> done
```

### 13. Configure clustering:

```
ZFS:> configuration cluster setup
cabling> done
identity> set nodename=zfs_2_hostname
identity> set password=changeme
identity> done
```

### 14. Assign the second VNIC to the second Oracle ZFS Storage Appliance controller:

```
ZFS:configuration cluster> resources
resources> select net/vnic2
net/vnic2> set owner=zfs_2_hostname
net/vnic2> commit
resources> commit
```

15. If an active/active cluster configuration is desired, type Y at the prompt to failback—otherwise choose N.

## Data Interfaces

The storage data interfaces should be created using InfiniBand ports `ibp0` and `ibp1` on the Oracle ZFS Storage Appliance. The network layout will differ based on the cluster configuration chosen in the previous section.

### Active/Passive Cluster

#### 1. On the active controller, create datalinks for `ibp0` and `ibp1`:

```
datalinks> device
device> set links=ibp0
device> commit
datalinks> device
device> set links=ibp1
device> commit
```

#### 2. Create a partition key of `ffff` for each InfiniBand device:

```
datalinks> partition
partition> set links=ibp0
partition> set pkey=ffff
partition> set linkmode=cm
partition> commit
datalinks> partition
partition> set links=ibp1
partition> set pkey=ffff
partition> set linkmode=cm
partition> commit
```

#### 3. Create an interface on each datalink:

```
ZFS:configuration net datalinks> cd ..
net> interfaces
interfaces> ip
ip> set links=pffff_ibp0
ip> set v4addrs=0.0.0.0/8
ip> commit
interfaces> ip
ip> set links=pffff_ibp1
ip> set v4addrs=0.0.0.0/8
ip> commit
```

4. Build an IPMP group using both interfaces with two virtual IP addresses:

```
ZFS:configuration net interfaces> ipmp
ipmp> set links=pffff_ibp0,pffff_ibp1
ipmp> set v4addrs=192.168.40.242/24,192.168.40.243/24
ipmp> commit
```

#### Active/Active Cluster

1. Create a datalink for `ibp0` on Oracle ZFS Storage Appliance Controller 1 and `ibp1` on Oracle ZFS Storage Appliance Controller 2:

```
ZFS1: configuration net datalinks> device
device> set links=ibp0
device> commit
ZFS2: configuration net datalinks> device
device> set links=ibp1
device> commit
```

2. Create a partition key of `ffff` for each InfiniBand device:

```
ZFS1: configuration net datalinks> partition
partition> set links=ibp0
partition> set pkey=ffff
partition> set linkmode=cm
partition> commit
ZFS2: configuration net datalinks> partition
partition> set links=ibp1
partition> set pkey=ffff
partition> set linkmode=cm
partition> commit
```

3. Create an interface on each datalink:

```
ZFS1:configuration net datalinks> cd ..
net> interfaces
interfaces> ip
ip> set links=pffff_ibp0
ip> set v4addrs=192.168.40.242/24
ip> commit
ZFS2:configuration net interfaces> ip
ip> set links=pffff_ibp1
ip> set v4addrs=192.168.40.243/24
ip> commit
```

#### Pool Setup

Regardless of the cluster configuration, the following storage pool configuration should be used when creating new pools inside of Configuration → Storage:

- » Mirrored or RAIDZ1 storage data profile
  - » Choose mirrored for high-performance workloads, such as Oracle Database or Oracle VM.
  - » Choose RAIDZ1 for streaming or backup workloads, such as the Oracle Recovery Manager.
- » Striped write log devices
- » Striped read cache
- » Single pool for active/passive configurations
- » Two pools for active/active configurations, one per controller

## NFS

Oracle VM requires either the NFS or iSCSI for protocol connectivity. Only one protocol should be chosen. The following steps outline the NFS configuration on the Oracle ZFS Storage Appliance. Refer to the next section if iSCSI is more desirable.

1. Create a project called "VCA":

```
ZFS:> shares project VCA
```

2. Set the default user and group to root:

```
VCA> set default_group=root
VCA> set default_user=root
```

3. Ensure root access is available to all the Virtual Compute Appliance subnets:

```
VCA> set
sharenfs="sec=sys,rw=@192.168.4.0/24:@192.168.40.0/24,root=@192.168.4.0/24:@192.168.40.0/24"
VCA> commit
```

4. Create a sample share to be imported to Oracle VM:

```
ZFS:> shares select VCA
VCA> filesystem testshare
VCA> commit
```

5. Create any additional NFS shares needed to expand Oracle VM's storage capacity.
6. Repeat this procedure for the second controller if an active/active cluster configuration is being used.

## iSCSI

Each compute node on the Virtual Compute Appliance has an IQN identifier that must be manually added to the Oracle ZFS Storage Appliance.

1. Extract the IQN from a root shell on a Virtual Compute Appliance compute node:

```
# cat /etc/iscsi/initiatorname.iscsi
InitiatorName=iqn.1988-12.com.oracle:974da248268c
```

2. Add the IQN to Oracle ZFS Storage Appliance Controller 1:

```
ZFS:> configuration san iscsi initiators
initiators> create
initiator-000> set alias=vca_computenode_hostname
initiator-000> set initiator=iqn.1988-12.com.oracle:974da248268c
```

**Note:** Use the IQN value discovered on the compute node. This is just an example IQN.

```
initiator-000> commit
```

3. Repeat the steps above for every compute node.
4. Create an initiator group and add all the IQNs:

```
initiators> groups
groups> create
group-000> set name=VCA
group-000> set initiators=iqn.1,iqn.2,iqn.3,iqn.4
```

**Note:** Use the Tab key to add each IQN value added in Step 3 and Step 4.

```
group-000> commit
```

## Active/Passive Cluster

1. Create an iSCSI target:

```
ZFS:> configuration san iscsi targets
targets> create
targets> set alias=VCA
targets> set interfaces=ipmp0
targets> commit
```

2. Create an iSCSI target group with the previously created iSCSI target:

```
targets> groups
groups> create
group-000> set name=VCA
group-000> set targets=iqn_initiator_string
```

**Note:** The IQN value can be discovered using the Tab key with tabbed completion.

```
group-000> commit
```

## Active/Active Cluster

1. Create an iSCSI target on Oracle ZFS Storage Appliance Controller 1:

```
ZFS1:> configuration san iscsi targets
targets> create
target-000> set alias=VCA-1
target-000> set interfaces=ibp0
target-000> commit
```

2. Create an iSCSI target group with the previously created iSCSI target:

```
targets> groups
groups> create
group-000> set name=VCA-1
group-000> set targets=iqn_initiator_string
```

**Note:** The IQN value can be discovered using the Tab key with tabbed completion.

```
group-000> commit
```

3. Create an iSCSI target on Oracle ZFS Storage Appliance Controller 2:

```
ZFS2:> configuration san iscsi targets
targets> create
target-000> set alias=VCA-2
target-000> set interfaces=ibp1
target-000> commit
```

4. Create an iSCSI target group with the previously created iSCSI target:

```
targets> groups
groups> create
group-000> set name=VCA-2
group-000> set targets=iqn_initiator_string
```

**Note:** The IQN value can be discovered using the Tab key with tabbed completion.

```
group-000> commit
```

After creating the initiator and target groups, a Virtual Compute Appliance project and LUNs should be added for Oracle VM to access.

1. Create a project called "VCA":

```
ZFS:> shares project VCA
VCA> commit
```

2. Create a sample LUN to be imported to Oracle VM:

```
ZFS:> shares select VCA
VCA> lun testlun
VCA/testlun> set initiatorgroup=VCA
VCA/testlun> set targetgroup=VCA
```

**Note:** Use VCA-1 or VCA-2 if an active/active cluster configuration is being used.

```
VCA/testlun> set volsize=1T
VCA/testlun> commit
```

3. Create any additional LUNs needed to expand Oracle VM's storage capacity.

## Oracle VM Configuration

Oracle VM Manager can be accessed by logging into <https://manager-vip:7002/ovm/console>, where *manager-vip* is the virtual IP address of the Oracle VM management console.

### NFS

1. Select the **Storage** tab.



Figure 3. Selecting the Storage tab

2. Click the **Discover File Server** icon.



Figure 4. Clicking the Discover File Server icon

3. In the window that opens, input the following and click **Next**:

**Name:** zfssa\_1  
**Access Host (IP) Address:** 192.168.40.242

The screenshot shows the 'Discover a File Server' window. On the left, a navigation pane includes 'File Server Parameters', 'Add Admin Servers', 'Select Refresh Servers', and 'Select File Systems'. The main area contains the following fields:

- Storage Plug-in: Oracle Generic Network File System (dropdown)
- Name: zfssa\_1 (text input)
- Access Host (IP) Address: 192.168.40.242 (text input)
- Admin Host: (empty text input)
- Admin Username: (empty text input)
- Admin Password: (empty text input)
- Uniform Exports:
- Description: (empty text area)

'Cancel' and 'Next' buttons are located at the bottom right.

Figure 5. Entering a name and IP address

4. Move all of the Virtual Compute Appliance compute nodes from the **Available Admin Server(s)** section to the **Selected Admin Server(s)** section. Click **Next**.

The screenshot shows the 'Discover a File Server' window at the 'Add Admin Servers' step. The main area contains the following elements:

- Instruction: 'Select the Server(s) that can be used for administrative access to this File Server. Required when using a Network File System in a clustered Server Pool.'
- Available Admin Server(s): (empty list)
- Selected Admin Server(s):
  - brmv01 cn07
  - brmv01 cn08
  - brmv01 cn09
  - brmv01 cn10
- Navigation buttons: '>', '<<', '<', and '<<<'.
- 'Previous', 'Cancel', and 'Next' buttons at the bottom right.

Figure 6. Selecting the servers that can be used for administrative access

5. Click **Next** at the 'Select Refresh Servers' screen. The Virtual Compute Appliance compute nodes do not need to be added.
6. Select the test share presented.

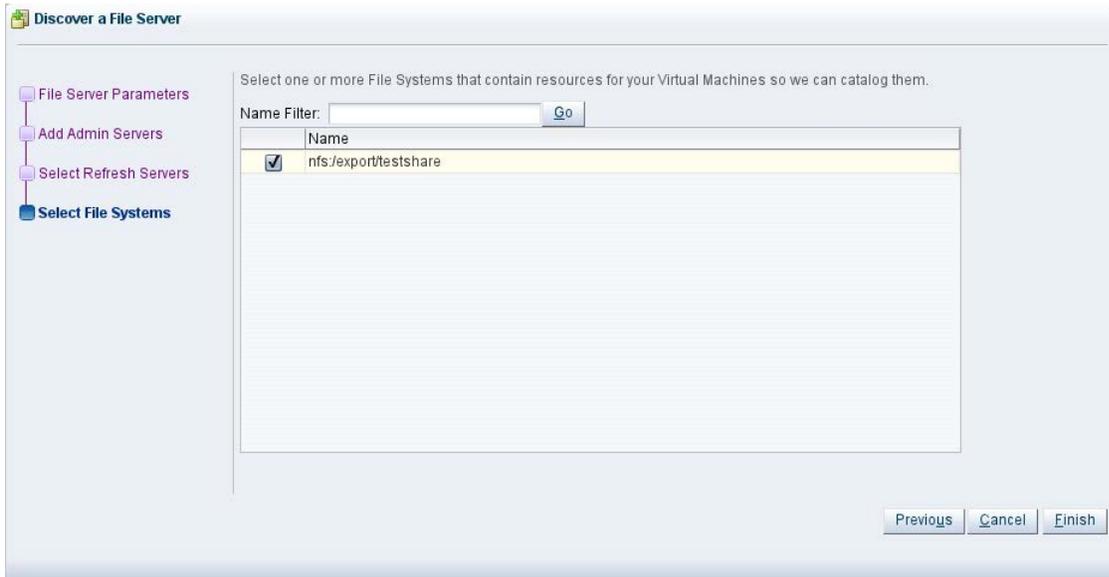


Figure 7. Selecting the test share

7. Click **Finish** to complete.
8. Repeat these steps for Oracle ZFS Storage Appliance Controller 2 if an active/active cluster configuration is being used. Step 3 should use the IP address 192.168.40.243.

The Oracle ZFS Storage Appliance should now be found in the File Server directory tree. Its shares can be added as a new storage repository for Oracle VM.

## iSCSI

1. Select the **Storage** tab.



Figure 8. Selecting the Storage tab

2. Click the **Discover SAN Server** icon.



Figure 9. Clicking the Discover SAN Server icon

3. Enter the Oracle ZFS Storage Appliance controller's hostname in the **Name** field and set **Storage Type** to iSCSI Storage Server. Click **Next**.

The screenshot shows a configuration window titled "Discover SAN Server". On the left is a vertical sidebar with five items: "Discover SAN Server" (selected), "Access Information (if required)", "Set Storage Name (if required)", "Add Admin Servers", and "Manage Access Group". The main area contains the following fields:

- Name:** A text input field containing "zfssa\_1".
- Description:** A large empty text area.
- Storage Type:** A dropdown menu showing "iSCSI Storage Server".
- Storage Plug-in:** A dropdown menu showing "Oracle Generic SCSI Plugin".
- Plug-in Private Data:** An empty text input field.
- Admin Host:** An empty text input field.
- Admin Username:** An empty text input field.
- Admin Password:** An empty text input field.

At the bottom right of the window are two buttons: "Cancel" and "Next".

Figure 10. Entering the Oracle ZFS Storage Appliance controller's hostname

4. Enter IP address 192.168.40.242 in the **Access Host** field and click **OK**.

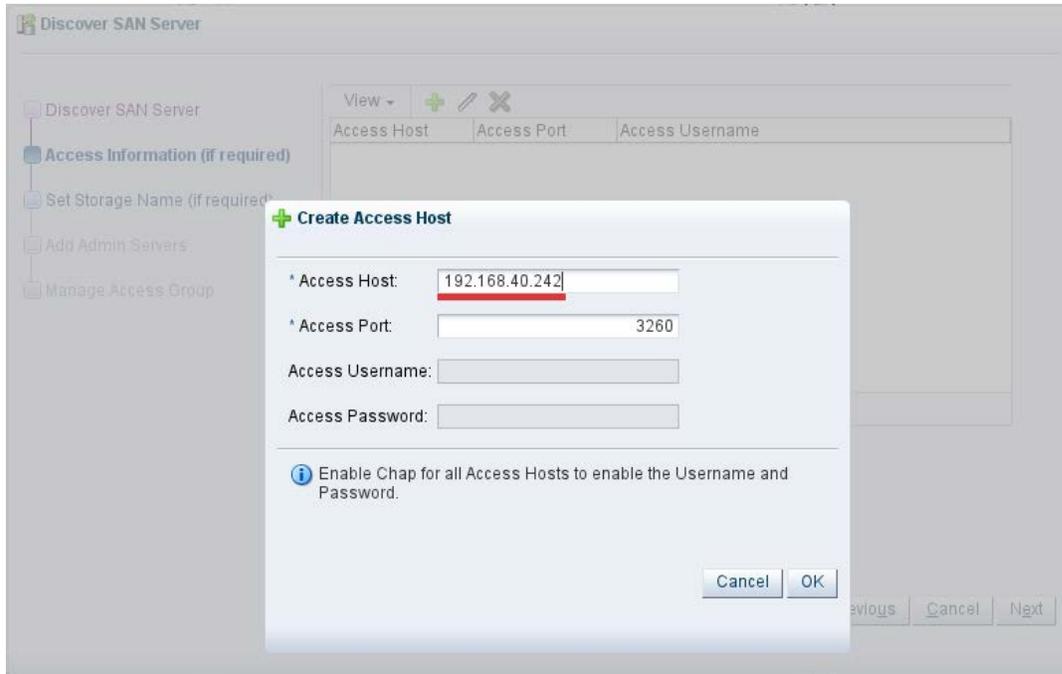


Figure 11. Entering the IP address

5. Move all of the Virtual Compute Appliance compute nodes from the **Available Server(s)** section to the **Selected Server(s)** section. Click **Next**.

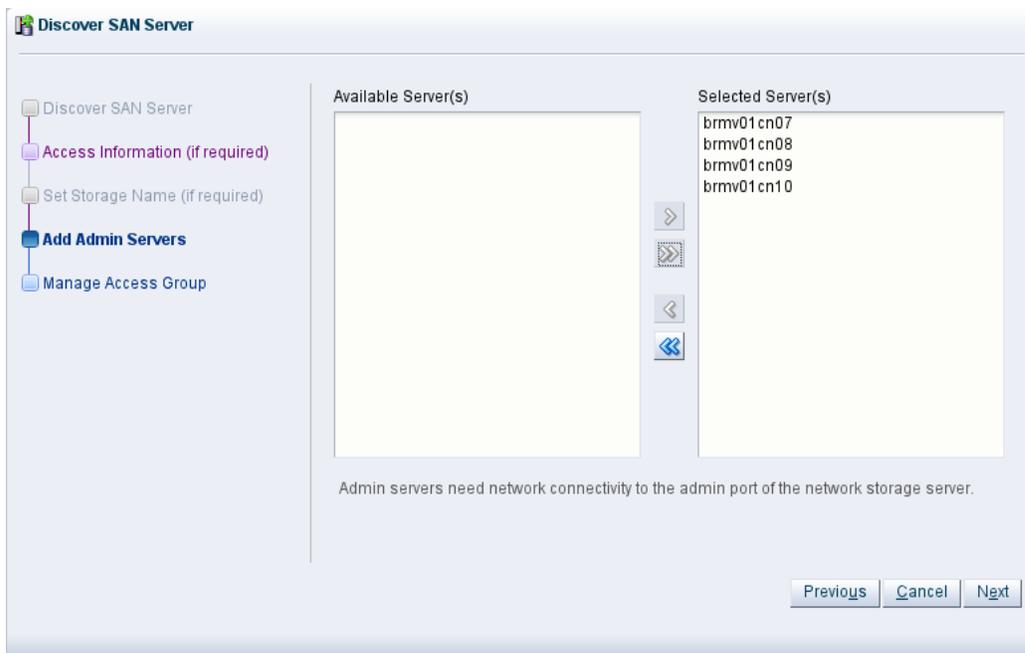


Figure 12. Moving the compute nodes to the Selected Server(s) section

6. Click the **Edit Access Group** icon (pencil) to edit the selected “Default access group.”

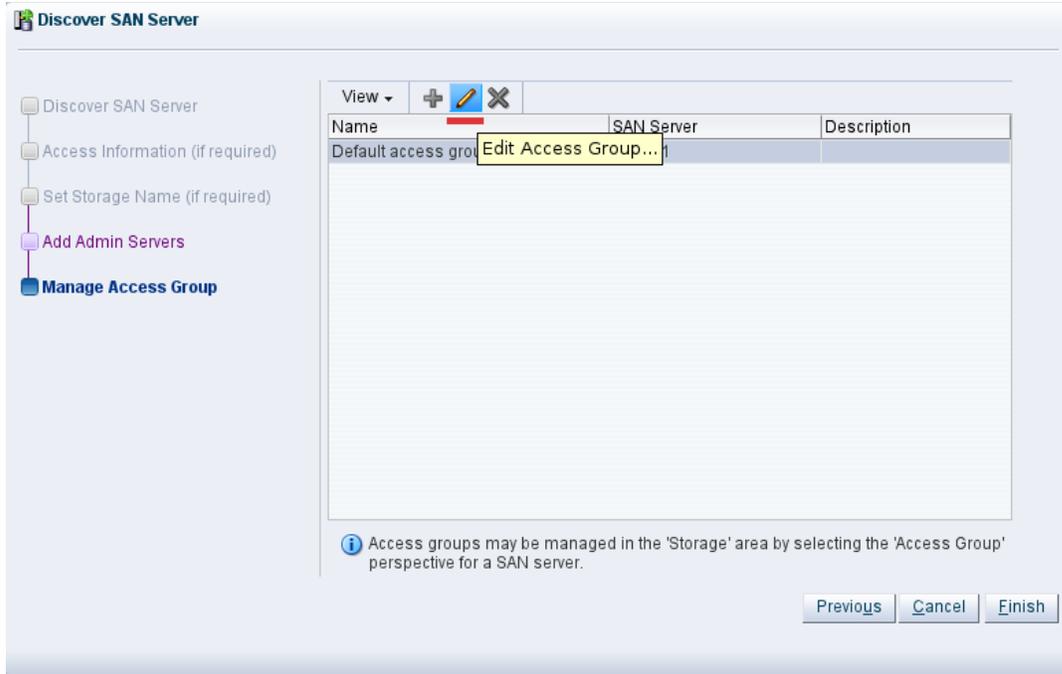


Figure 13. Clicking the Edit Access Group icon

7. Click the **Storage Initiators** tab and move all initiators from the **Available Storage Initiators** section to the **Selected Storage Initiators** section. Click **OK**.

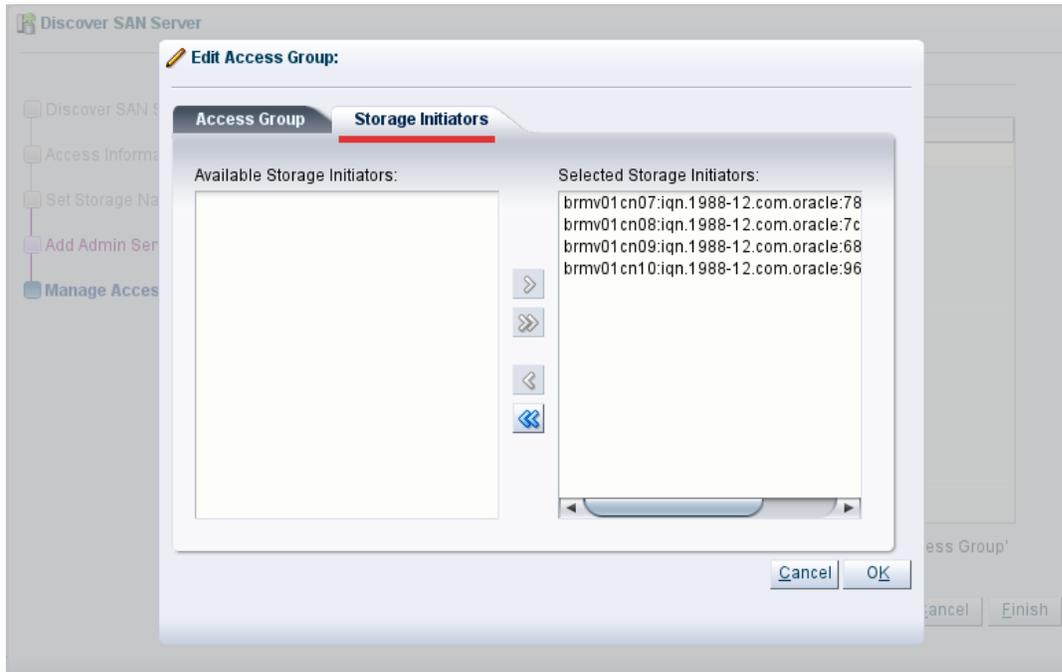


Figure 14. Moving the initiators to the Selected Storage Initiators section

8. Click **Finish** to complete.
9. Repeat these steps for Oracle ZFS Storage Appliance Controller 2 if an active/active cluster configuration is being used. Step 3 should use the IP address 192.168.40.243.

The Oracle ZFS Storage Appliance should now be found in the SAN Server directory tree. Its LUNs can be added as a new storage repository for Oracle VM.

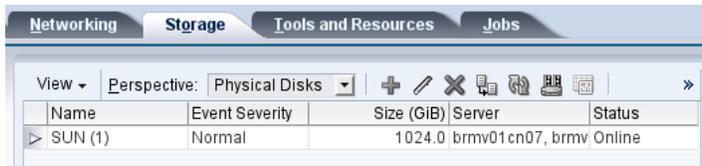


Figure 15. The Oracle ZFS Storage Appliance in the SAN Server directory tree

## Additional Use Cases

The Oracle ZFS Storage Appliance can also be used for general-purpose storage with Oracle VM. Table 1 documents the connectivity options and protocols for this integration. Please note that the guest virtual machines of Oracle VM cannot use Oracle ZFS Storage Appliance for general NFS with IP over InfiniBand (IPoIB). This use case should be implemented using 10 GbE.

**TABLE 1: GENERAL-PURPOSE CONNECTIVITY FOR ORACLE VM**

Connectivity	Protocol	Oracle VM Hypervisor (dom0)	Oracle VM Guests (domU)
Storage IP over InfiniBand (IPoIB) network	NFS	Yes	No
Storage IP over InfiniBand (IPoIB) network	iSCSI	Yes	No
Public 10 GbE network	NFS	No*	Yes
Public 10 GbE network	iSCSI	No*	Yes

\* It is planned that future support in the software will allow compute nodes to use customer-supplied IP addresses.



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