



Sizing and Best Practices for Deploying Oracle Databases on Oracle VM using Dell EqualLogic Hybrid Arrays

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Feedback

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Executive summary

Oracle database applications, ranging from web-based e-commerce sites to accounting systems to customer support programs, are at the heart of many business functions. They are often deployed in a non-virtualized environment. For many customers, mission critical applications running on these databases have been in place for a long time, sometimes even preceding the virtualization era of the last decade.

To maintain the quality of service, traditionally these databases are overprovisioned – both for the server and storage infrastructures – to eliminate any potential performance bottlenecks. However, performance needs increase over time, and data generated by these applications can grow exponentially as well. Consequently, today database administrators face the challenge of scaling on demand and reducing deployment costs significantly.

Advances in virtualization technology, powerful servers, innovations in enterprise data storage and potential licensing cost savings are driving business leaders to evaluate moving Oracle databases into a virtualized environment today to lower their total cost of ownership.

Oracle virtualization has emerged as a key technology for optimizing database resources in a datacenter. Oracle VM helps in deploying applications while maximizing server and storage resources. It is a fully certified and supported virtualization platform for Oracle database applications. On the storage front, Dell EqualLogic hybrid arrays that automatically tier data between high-performing solid-state drives (SSDs) and capacity-oriented hard disk drives (HDDs) compliment this by optimizing and balancing performance and capacity needs of a demanding virtualized Oracle database environment. Oracle VM combined with EqualLogic PS Series hybrid arrays provide the best solution for customers looking to virtualize their Oracle database deployments.

This paper presents key guidelines and best practices for deploying Oracle VM solution using Dell EqualLogic iSCSI SAN hybrid storage arrays. The Oracle database I/O simulation tool, Oracle I/O Numbers (ORION), was used to demonstrate the efficiency of the Oracle virtualized solution deployed on an EqualLogic SAN compared to a physical server configuration.

The test results show that Oracle VM guests on EqualLogic hybrid arrays deliver the same kind of performance for OLTP database workloads compared to a physical server configuration. This paper also presents detailed best practices based on a set of storage I/O performance test results. Additionally, detailed guidelines and procedures for deploying the Oracle VM environment using EqualLogic SAN are also presented in the paper.



1 Introduction

Online transaction processing (OLTP) applications often need to deliver extremely fast response times and rapid access to data in high demand. Moreover, significant data growth over time in a typical OLTP system leads to high capacity requirements as well. While the OLTP data set size can grow exponentially, the active and frequently accessed data set size remains relatively small in comparison with the overall OLTP system size.

Storage infrastructure supporting OLTP platforms, like Oracle RAC, need to not only scale in performance and capacity non-disruptively, but also deliver the required high performance in an optimal, cost-effective way. EqualLogic hybrid arrays – combining solid-state drives (SSDs) and hard disk drives (HDDs) within a single chassis – are well suited for these OLTP environments. The scale-out, peer storage architecture of the EqualLogic PS Series allows organizations to start small and grow non-disruptively as the performance and capacity needs increase. Additionally, automated data tiering between SSDs and HDDs by the EqualLogic PS firmware deliver the high performance for the active data sets while optimally serving the capacity for the OLTP systems.

1.1 Objective

This paper presents the key guidelines and best practices for deploying Oracle VM with EqualLogic hybrid arrays. It also highlights some of the key configuration settings to achieve optimal performance and compares performance of virtualized and non-virtualized Oracle database solutions.

1.1.1 Audience

This paper is intended for system administrators, database administrators and storage architects interested in deploying Oracle virtualized database solutions on Red Hat Enterprise Linux using Dell EqualLogic PS Series SANs. It is assumed that the readers of this document have familiarity with Red Hat Enterprise Linux system administration, EqualLogic storage array configuration and Oracle VM installation and administration tasks.

1.2 Terminology

The following terms are used throughout this document.

Domain: A configurable set of resources such as memory, CPU, network and disk devices.

Dom0: The management domain that has complete access to all the hardware resources within the physical server. Each VM hosted on the server is completely managed by these domains.

DomU: A guest VM started by the OVM server that is completely managed by Dom0 of the VM server.

Server pool: A Logical group of one or more Oracle VM servers. This presents a unified view of the storage and server resources for the hosted virtual machines.



OCFS2: Oracle Cluster File System 2 is an open-source clustered file system developed by Oracle. Clusterware applications can leverage OCFS2 to achieve optimal performance and high availability.

OLTP I/O pattern: OLTP workloads tend to select a small number of rows at a time. These transfers happen anywhere in the data, and are each fairly small (typically between 8K and 64K). This causes the I/O pattern to be random in nature. The key metric in measuring performance of OLTP workloads is the number of I/Os per second (IOPS) that can be achieved while maintaining a healthy response time.

ORION: Oracle I/O Numbers (ORION) is a popular I/O simulation tool used to understand the I/O performance behavior of storage systems for Oracle databases. The tool and documentation is included as part of the Oracle 11g installation software.

SAN HQ: SAN Headquarters (SAN HQ) monitors one or more PS Series groups. The tool is a client/server application that runs on a Microsoft Windows system and uses simple network management protocol (SNMP) to query the groups. Much like a flight data recorder on an aircraft, SAN HQ collects data over time and stores it on the server for later retrieval and analysis. Client systems connect to the server to format and display the data in the SAN HQ GUI.



2 Product overview

2.1 EqualLogic hybrid storage array

EqualLogic hybrid arrays offer scalable, high-performance virtualized storage that is designed for reliability, manageability, and efficiency. EqualLogic SANs come with a range of efficiency features designed to enhance utilization and help reduce costs. For example, automated data tiering by EqualLogic PS Series firmware allows the hybrid arrays to effectively balance peak load capabilities and scale-out storage capacity requirements for Oracle database environments.

EqualLogic PS6210XS (and its predecessor, PS6110XS) hybrid arrays have 24 drives (seven high performance SSD drives and seventeen high capacity 10K rpm SAS hard disk drives) within a single chassis. The on-board intelligence of the EqualLogic firmware provides automatic tiering and balancing of stored data between the SSD and HDD tiers. Data tiering within the array creates a flexible and powerful balance between performance and responsiveness provided by the low latency SSD tier and the capacity provided by the HDD tier. As the working set of an Oracle database environment (frequently accessed data that needs fast access time) is a relatively small percentage of the total database capacity, the performance and capacity balance provided by the EqualLogic PS6210XS hybrid arrays is exceptionally well suited for Oracle database environments.

2.2 Oracle VM

Oracle VM is a server virtualization platform. It is based on the open source Xen hypervisor technology and fully supported for Oracle and non-Oracle environments. Oracle VM is proven to reduce operations and support costs while maximizing the efficiency of a datacenter.

Oracle VM consists of three key components:

Oracle VM Server: A managed virtualization platform comprised of a hypervisor which runs multiple virtual machines. More than one Oracle VM server is required to take advantage of clustering. The server is based on an updated version of Xen hypervisor technology that communicates with Oracle VM Manager and manages the virtual machines.

Oracle VM Manager: A single user-friendly interface for administration of servers and virtual machines. This helps in management and control of the entire virtualization environment. It is an Oracle Fusion Middleware application, based on the Oracle Weblogic Server application server and Oracle database.

Oracle VM agent: This component is part of the Oracle VM server. It is the communication channel between Oracle VM server and Oracle VM Manager for managing virtual machines.



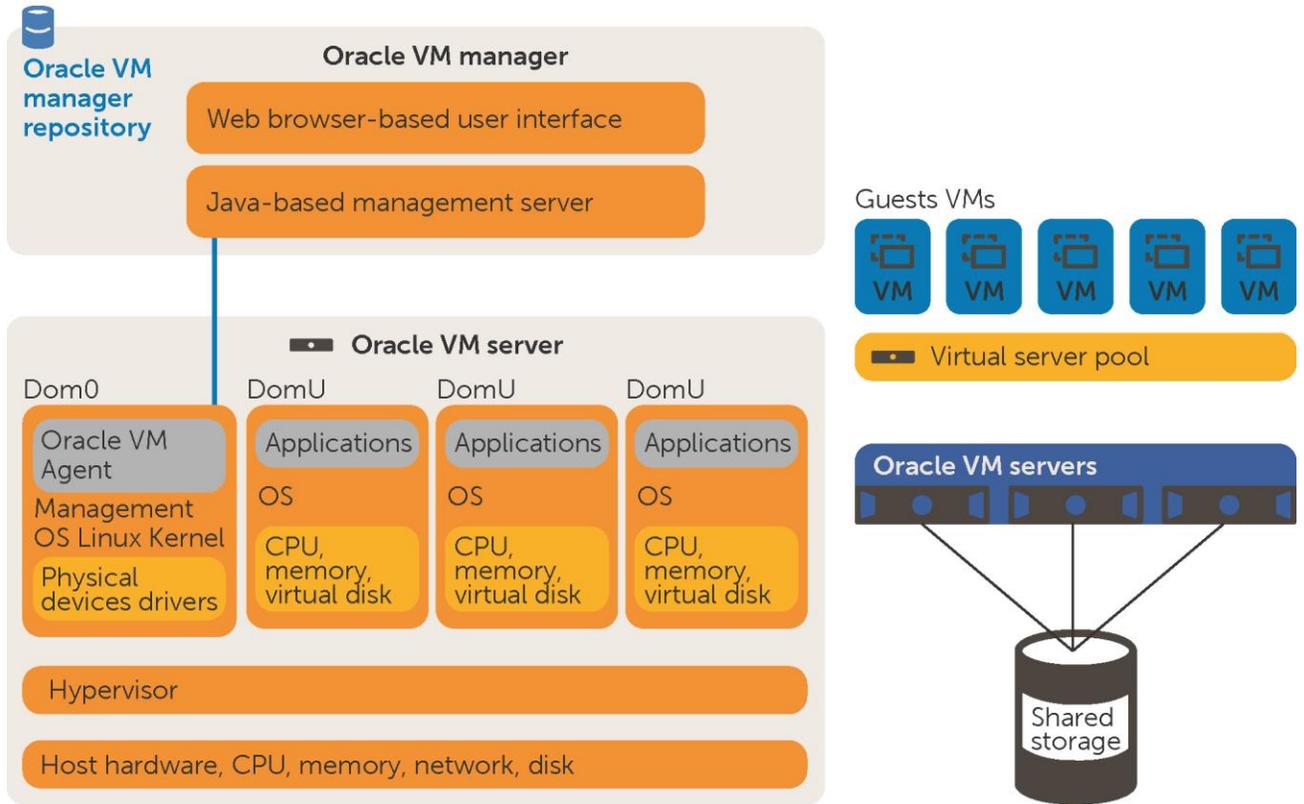


Figure 1 OVM technology overview

Oracle VM server is installed directly on the bare metal server hardware. Each Oracle VM server is comprised of a hypervisor and privileged domain (Dom0) that allows running multiple virtual machines. Multiple Oracle VM servers are grouped into server pools and this enables setting up High Availability (HA) to ensure that there are no disruptions to virtual machines. Every server in a server pool will have access to shared storage. The Oracle VM agent processes VM management requests and provides event notifications and configuration data to Oracle VM Manager. Oracle VM Manager uses an Oracle database or MySQL database as the management repository.



3 Oracle VM Solution deployment using EqualLogic SAN

This section presents a high-level overview of the steps involved in configuring OVM setup using EqualLogic SAN. Please refer to the Oracle Web site at http://docs.oracle.com/cd/E35328_01/E35330/html/index.html for detailed installation instructions.

Oracle VM deployment involves many components and some of the key configuration prerequisites before starting the installation are listed in the following section (Section 3.1).

3.1 General environment requirements

Deploying an Oracle VM solution requires an environment that includes:

- OVM configuration is theoretically possible with one Oracle VM server, but will not provide high availability features. At least two physical servers are recommended. Servers with 64 bit processor and at least 2GB of memory is recommended. The example in this paper uses two Dell PowerEdge R720 servers as OVM servers with clustering enabled in the solution.
- One dedicated physical server or a VM guest running Oracle Linux 5, update 6 or above required for configuring Oracle VM Manager.
- Multiple hostnames and IP addresses configured while deploying the OVM. The hostnames and IP subnets used to evaluate the solution in this paper are shown in section 3.6.
- At least two shared storage disks presented to the OVM servers. One of them is for the server pool file system (the clustered file system OCFS2) to take care of the cluster heartbeat, configuration and other cluster management functions. The other shared disk is required for a storage repository which will contain Oracle VM guest hard disk images and also store any other resources such as ISO files and VM templates.
- An Oracle VM Server 3 ISO image that is installed directly on the bare metal server hardware (Oracle VM servers). For the examples presented in this paper, two Dell PowerEdge R720 (12th Generation) servers were used to install this OVM server component.
- Oracle VM Manager 3 is an Oracle Fusion Middleware application and requires Oracle Linux 5.6 or later for installation. Oracle VM Manager also uses Oracle database as the management repository. In this paper, a dedicated physical server was used and Oracle Linux 6 update 4 installed as the OS. Also, Oracle 11.2.0.4 Enterprise Edition database was installed on this server to be used as management repository.

Sections 3.2 to 3.8 highlight the key configuration steps for deploying an OVM solution.

3.2 Build an Oracle VM server

Even though it is theoretically possible to deploy OVM solution with one server, it is highly recommended to have at least two Oracle VM servers configured as a server pool for ensuring high availability. Clustered server pools use a shared OCFS2 file system for managing cluster heartbeat and configuration.

- Two PowerEdge R720 servers were used in this solution to create a server pool.



- Download the ISO for Oracle VM from <https://edelivery.oracle.com/oraclevm>.
- Set a password for the root login to the server, Oracle VM Agent and hostname.
- Configure network for management. Select **eth0** as the interface to use for management of the server.
- Modify the memory size for **Dom0** for optimal performance. Refer to best practices recommendations in section 6.3.1 for details.
- Ensure that SNMP services are enabled permanently. This is required for monitoring OVM servers.

3.3 Build the management server

Oracle VM Manager is the administrative interface that provides an easy-to-use centralized management environment for configuration and controlling the entire Oracle virtualization environment. The entire stack including server, network and storage infrastructure can be managed by this single user interface. This is an Oracle Fusion Middleware application, based on the Oracle Weblogic application and Oracle database.

3.3.1 Install Oracle Linux on the management server

- One PowerEdge R810 server was used to install Oracle VM Manager.
- Make sure that the minimum hardware and software requirements are addressed and that the prerequisite packages are completely installed. For details, refer to the following Oracle document at http://docs.oracle.com/cd/E27300_01/E27308/html/vmiug-manager-requirements.html
- Download the Oracle Linux ISO from <https://edelivery.oracle.com/linux>. Install the Oracle Linux update 6 (64 Bit) or later on the physical server.
- Disable the firewall and open the required ports for Oracle VM Manager.

3.3.2 Install and configure Oracle VM Manager on the management server

- Create and mount an 8GB or larger file system (/u01) on the physical server.
- Oracle VM Manager uses an Oracle database or MySQL database as the management repository. The supported Oracle database repositories are:
 - Oracle Database, release 10.2.0.4 or greater
 - Oracle Database, release 11.1.0.7 or greater
 - Oracle Database, release 11.2.0.1 or greater
 - MySQL, Enterprise edition
- Oracle 11.2.0.4 Enterprise edition database was used as the management repository in this solution.
- Ensure that the prerequisites documented in the link http://docs.oracle.com/cd/E11882_01/install.112/e24321/pre_install.htm are installed before proceeding to the database installation.
- Install a single instance database. Note the global database name and database credentials required for the Oracle VM Manager installation.
- Download the Oracle VM Manager ISO file from <https://edelivery.oracle.com/oraclevm> and mount it on the server.



- Install the Oracle VM Manager Component using the **Custom** installation so that the management repository can be configured to use a previously installed database.
- Oracle VM Manager uses a VNC client to launch console sessions of Oracle VM guest machines. TigerVNC is a package included in Oracle Linux 6 and later, and this should be installed for accessing the virtual machines through VM Manager.
- The default port used to access the VM Manager is 7001; the user interface can be accessed with a browser. The URL for the interface will be similar to **Error! Hyperlink reference not valid.**

3.4 Build the Oracle VM server pool

Oracle VM Server pool is a logical collection of one or more Oracle VM servers. The servers within a pool share storage access. The VMs are placed on the servers based on the server CPU, memory and network utilization.

3.4.1 Discover the Oracle VM server

1. Click **Hardware** in the view pane of Oracle VM Manager.
2. Type in the IP addresses of the OVM servers and discover the servers.
3. Provide the Oracle VM Agent password and use the default port number 8899 to start Oracle VM agent.
4. Once the servers are discovered, they are added to the **Unassigned** server resources pool until a server pool is created and these servers are assigned to it.

3.5 Shared storage configuration

EqualLogic PS6210XS and PS6210E arrays can be used as the shared backend storage for Oracle VM servers. As mentioned in section 3.1, at least two shared storage disk volumes (one for server pool file system and one for storage repository to store VM hard disks, templates, ISOs etc.) should be used. Host the database volumes on the PS6210XS hybrid array and directly present it to the Oracle VM guest machines using guest iSCSI initiators. The server pool file system and shared storage repository can be hosted on PS6210E array and presented to all OVM servers. The detailed storage volume configuration used for validating this solution is documented in section 4.2.

3.5.1 Discover shared storage

1. Ensure iSCSI service is running on the Oracle VM servers.
2. Add iSCSI access to the volumes designated for the server pool file system and storage repository. Ensure that these volumes are presented to the OVM servers.
3. Select storage type as **iSCSI Storage Server** and the default storage plugin **Oracle Generic SCSI Plugin**.
4. Provide the EqualLogic Group IP and the default access port 3260 to discover the storage.



3.5.2 Present shared storage to servers

In the previous section, steps to register an iSCSI array with Oracle VM Manager were discussed, however, no connection has been established between the iSCSI array and OVM servers. The creation of access groups establishes iSCSI sessions between Oracle VM servers and the EqualLogic storage arrays.

1. Once the storage array is registered, a default access group is created under the iSCSI array.
2. Edit the Access Group settings and select the iSCSI initiators for all of the Oracle VM servers.
3. Once the initiators are selected, Oracle VM agents on the servers establish the iSCSI sessions by logging into a target array.
4. Refresh the UI to view all the volumes presented to the Oracle VM servers in the Volume Groups tab under the registered iSCSI array.

3.6 Network configuration

The networking infrastructure in Oracle VM environment includes various components:

- Management network for Oracle VM servers
- Network for communication between Oracle VM servers and Oracle VM Manager
- Network between Oracle VM servers and shared storage system
- Network for VM to VM communication
- Management network for virtual machines

3.6.1 Network assignment

The high-level overview of the network configuration including different Ethernet devices and subnets used as part of this solution are described below.

Table 1 Network configuration overview

Hostname	Purpose	Network
Ovmmanager	Physical server or VM guest running Oracle Linux 5.6 or later and where Oracle VM Manager component will be installed	Management subnet (eth0)
OVM Server Pool	Virtual IP used to manage the OVM server pool	Management subnet (eth0)
ovmserver1	Management IP for the Oracle VM server	Management subnet (eth0)
ovmserver2	Management IP for the Oracle VM server	Management subnet (eth0)
ovmserver1-eth1	IP assigned to a second network device to connect Oracle VM guest machines	Public subnet (eth1)
ovmserver2-eth1	IP assigned to a second network device to connect Oracle VM guest machines	Public subnet (eth1)



Hostname	Purpose	Network
ovmdb1	Oracle VM Guest residing on server ovmsvr1	Public subnet (eth1)
ovmdb2	Oracle VM Guest residing on server ovmsvr2	Public subnet (eth1)
SANiSCSI1	IP assigned to each OVM servers for dedicated SAN connectivity	SAN subnet (eth9)
SANiSCSI2	IP assigned to each OVM servers for dedicated SAN connectivity	SAN subnet (eth11)

- A network port on each Oracle VM server is automatically designated as the management interface during the installation. By default, the same port is enabled for **Live Migrate** and **Cluster Heartbeat** functionality as well.
- Once the management network is in place, create two more networks dedicated for storage connectivity. Configure at least two network interfaces for multipath to achieve optimal performance and high availability.
- As a best practice, create a network dedicated for VM to VM communication.

3.6.2 Create a virtual MAC addresses

With the network is configured as described, create a pool of virtual Ethernet MAC addresses so that the same can be assigned to guest VMs. VNICs should be created before creating a virtual machine that has the ability to connect to the network. This step is only required when additional VNICs are needed, not each time a virtual machine is created.

The VNICs can be automatically generated using the **AutoFill** feature available in the **Networking** tab of Oracle Virtual Manager.

3.7 Create a server pool

A server pool is a logical collection of multiple servers. The server resources such as CPU and memory are pooled together logically and presented to virtual machines as needed. The server pools have access to shared storage. Virtual machines are stored on the shared storage and placed on one of the Oracle VM servers to balance the workload of the server pool.

1. Create a server pool by specifying the pool name and a virtual IP (On the same subnet as the management IPs of Oracle VM servers).
2. A shared storage disk should have already been presented to the Oracle VM servers as a server pool file system. Select this disk as the storage location during installation.
3. During the server pool creation, the specified file system is formatted and presented as an OCFS2 file system.
4. Ensure that the password used to access the Oracle VM agent is the same on all servers.



5. Select all Oracle VM servers and add them to the newly created server pool. The Oracle VM servers to move from the unassigned folder to the specified server pool name where they can be viewed.

3.7.1 Create a storage repository

A storage repository is where Oracle VM resources such as VM hard disks, templates, ISOs and other image files are stored.

1. Create the storage repository and present it to the OVM servers. A shared storage disk is presented to all Oracle VM servers for storing VM resources such as hard disks, templates and ISOs. The example presented in this paper uses a 300GB volume for this purpose.
2. Create a new repository by selecting the shared storage disk presented to the OVM servers.
3. Present the new storage repository to all the Oracle VM servers.
4. Resources, such as ISOs, can be added to the storage repository.

3.8 Oracle VM guest creation

This is the final step of creating guest virtual machines. The virtual machines can be created using either the readymade OVM templates or an ISO image.

1. Install RHEL 6.3 OS on the VMs by importing the ISO images under the storage repository.
2. During creation, specify the amount of memory and processors to be allocated for the VM.
3. Add at least one NIC from the network designated for the Oracle VM server to VM communication.
4. Create a virtual disk on the storage repository to use as the VM hard disk.
5. Mount the ISO and complete the OS installation.
6. Ensure that the Virtual Machine is enabled in the **Network Channels** options to add networks to the virtual machine.
7. Add VNICs on the virtual machines for dedicated SAN connectivity.
8. Start the VM and verify network settings.



4 Test solution infrastructure

At least two OVM servers are required in a server pool for it to achieve high availability. Each Oracle VM server hosted a VM, and RHEL 6.3 was installed on the guest VMs. If any OVM server fails, the VM will migrate to the other server using the live migration capability. Section 4.1 illustrates the logical OVM test configuration that can be used to evaluate the solution using an EqualLogic SAN. Section 4.2 describes the volume layout on the EqualLogic SAN used for validating this solution.

Please refer to [Appendix A](#) for details on hardware and software components used for validating the solution.

4.1 Physical system configuration

The following diagram shows the logical test configuration used for validating the OVM solution.

The test configuration in the following diagram shows EqualLogic PS6110XS and PS6110E arrays for the backend SAN; the actual tests were executed on a PS6110 platform. However, all the guidelines and best practices mentioned in this paper additionally serve the newer PS6210 platform in general, and specifically the PS6210XS hybrid arrays.



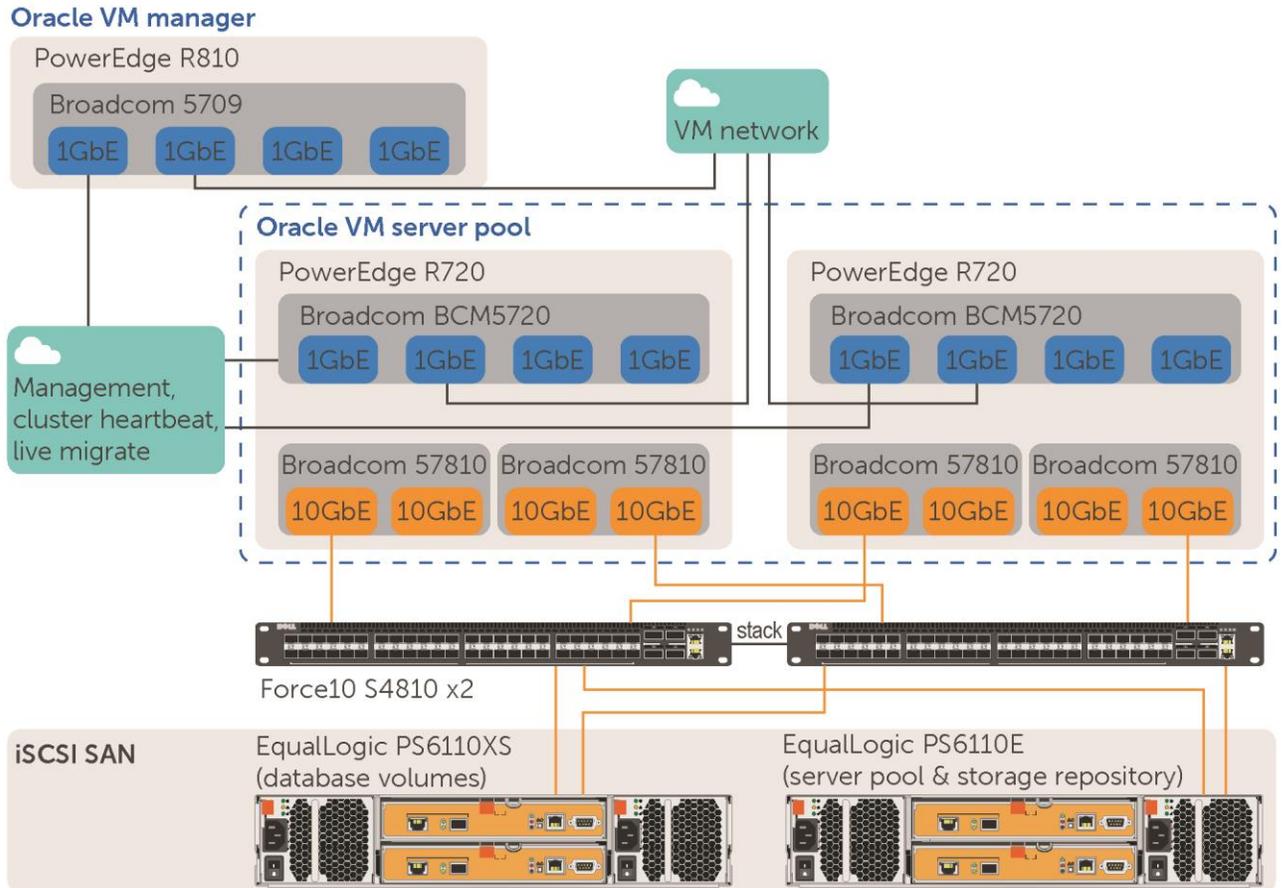


Figure 2 OVM test configuration showing LAN and iSCSI SAN connectivity

4.2 Storage configuration

The EqualLogic hybrid array was used to host all database volumes and a high-capacity/low cost PS6110E array was used to host server pool file system and storage repository. The EqualLogic arrays were in different pools and two virtual machines (OVMDB1 and OVMDB2) were used for validating this solution. Each VM was residing on a separate Oracle VM server, and a separate set of EqualLogic volumes were presented to both of these virtual machines as shown in Table 1.

4.2.1 EqualLogic Hybrid array

The Oracle OLTP database I/O simulation was performed on these volumes using ORION. The volumes presented to the two Oracle VM guest machines (OVMDB1 and OVMDB2) are shown in Table 2.

Table 2 EqualLogic volume Oracle configuration

PS6110XS	
OVMDB1	OVMDB2
<ul style="list-style-type: none">• VM1DB1 (250GB)• VM1DB2 (250GB)• VM1DB3 (250GB)• VM1DB4 (250GB)• VM1DB5 (250GB)• VM1DB6 (250GB)	<ul style="list-style-type: none">• VM2DB1 (250GB)• VM2DB2 (250GB)• VM2DB3 (250GB)• VM2DB4 (250GB)• VM2DB5 (250GB)• VM2DB6 (250GB)

In addition, the volumes designated for the Oracle VM server pool file system and storage repository were presented to the Oracle VM servers from the EqualLogic PS6110E array.

Table 3 EqualLogic PS6110E

PS6110E	
ServerPool (20 GB)	Clustered file system required for Oracle VM Clustering
Storagerepovol (300 GB)	Resources to build Oracle virtual machines.



5 I/O profiling study

Typical OLTP database transactions are represented by 8K I/O blocks, with a mix of 90% read and 10% writes. A series of tests were executed to simulate I/O characteristics of OLTP database transactions on both physical and virtualized server configurations.

5.1 Test methodology

The ORION test was executed on both physical and Oracle VM server configurations using the same exact parameters so that the results are comparable. Simulations with Oracle OLTP database 8K I/O block requests (of 90% read and 10% write) were executed on a physical server to get a baseline. The same test was repeated with exact I/O characteristics on Oracle VM guest machines to evaluate the performance difference.

The EqualLogic storage volumes were presented to the OS as block I/O devices using guest software iSCSI initiators. ORION was installed on the operating system (Red Hat Enterprise Linux in this case) and used to simulate Oracle OLTP database transactions. EqualLogic HIT/Linux was installed on the guest VMs to manage multipathing.

The tests listed in the table below were executed with an 8K I/O block size and at specified queue depths (number of outstanding I/Os) to determine the maximum IOPS the storage array would sustain within the 20 ms latency (read and write latencies were measured separately).

The results of the tests in Table 4 are illustrated in sections 5.5 and 5.6.

Table 4 Test parameters: I/O workload studies

Configuration parameters	
EqualLogic SAN	One PS6110XS (7x 400GB SSDs & 17 x 600GB 10K SAS drives)
RAID type	RAID 6 (Accelerated)
I/O mix	8K 90% Read / 10% Write
I/O tool	Oracle I/O Numbers (ORION)
Test configuration #1 (Non-Virtualized Server)	6 x 250GB Volumes Queue Depth: 120 OS: RHEL 6.3
Test configuration #2 (OVM - Virtualized Server)	
VM #1 : ovmdb1	3 x 250GB Volumes Queue Depth: 60 OS: RHEL 6.3
VM #2 : ovmdb2	3 x 250GB Volumes Queue Depth: 60 OS: RHEL 6.3



5.2 Measurement and monitoring

Detailed performance metrics were captured from storage and operating system layers using the tools listed below.

- ORION
Total IOPS and average latency as part of ORION standard test results were captured.
- EqualLogic SAN HeadQuarters (SAN HQ)
EqualLogic storage array statistics for various objects including network, disk, I/O performance, and I/O capacity were captured. A dedicated server was used to run this tool.
- Oracle OSwatcher Black Box(OSWbb)
This utility was used to capture detailed operating system statistics such as vmstat, iostat and netstat at regular intervals while executing the tests.

5.3 Test criteria

During the study, the test configuration maintained the following criteria:

- The storage array disk access latencies (read and write) remained below 20 ms per volume.
- The database server CPU utilization remained below an 80% average.
- TCP retransmits on the storage network remained below 0.5%.

5.4 ORION (non-virtualized servers)

ORION tests were executed on a physical server and the simulated I/O access was random in nature. Six volumes, each with a 250GB capacity, were used. The EqualLogic-aware multipathing utility Linux HIT was installed to manage multipathing to storage from this server.

Many simultaneous I/O requests were simulated on the storage array by setting the queue depth to 120.

As shown in Figure 3, this test on the array produced approximately 6,750 IOPS for an 8K block size. a 90/10 read/write mix, and the disk latency stayed within the 20 ms limit for both read and write IOPS measured separately.



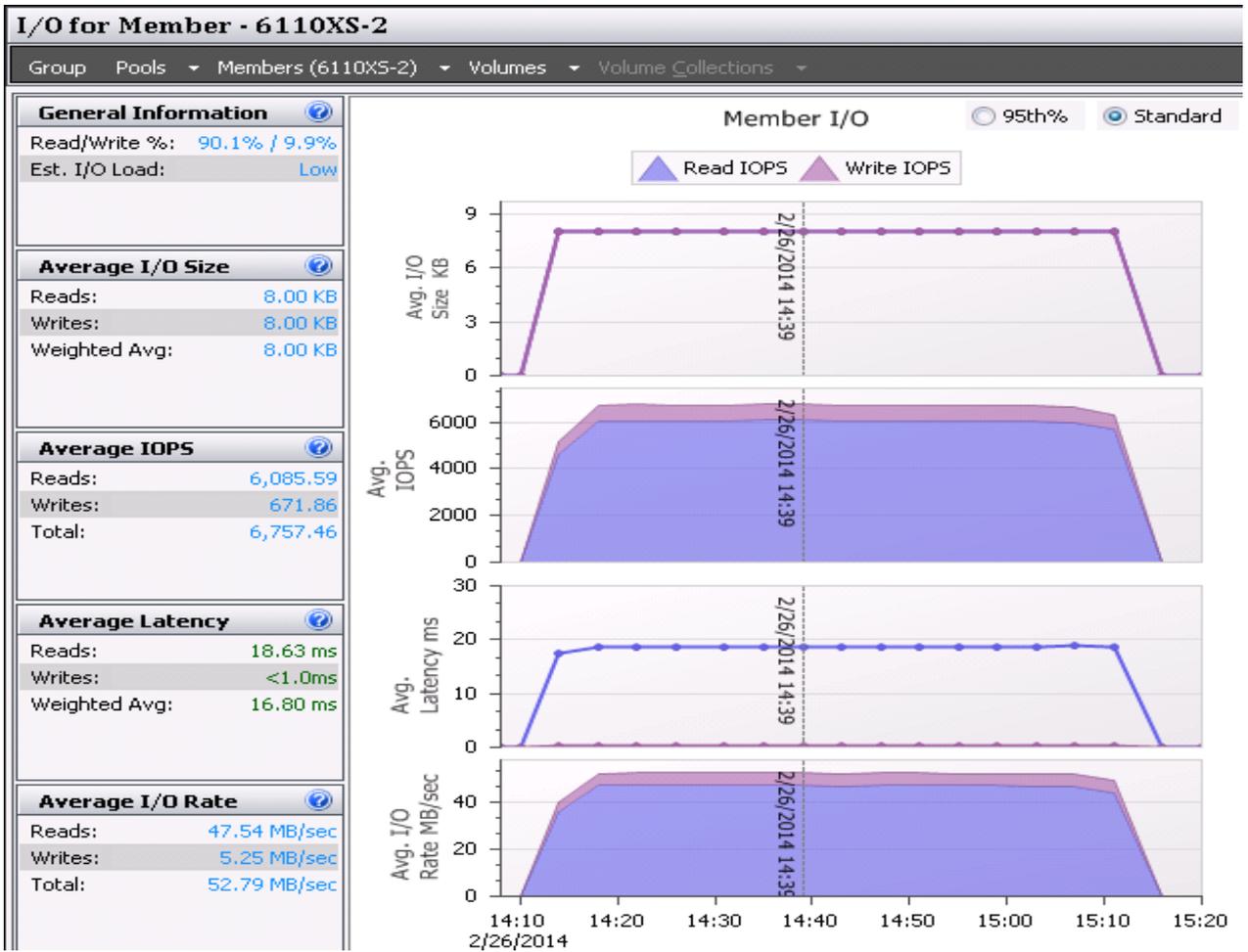


Figure 3 ORION IOPS for the non-virtualized server configuration on PS6110XS



5.5 ORION (virtualized servers)

These ORION tests were executed with the same I/O characteristics described in the previous section with the exception that the test was executed simultaneously on two Oracle virtual guest machines instead of the physical server. Because two VMs were used to simulate the I/O, three volumes of 250GB were presented to each VM. A queue depth of 60 was used so that the results would be comparable to the I/O test executed on physical server.

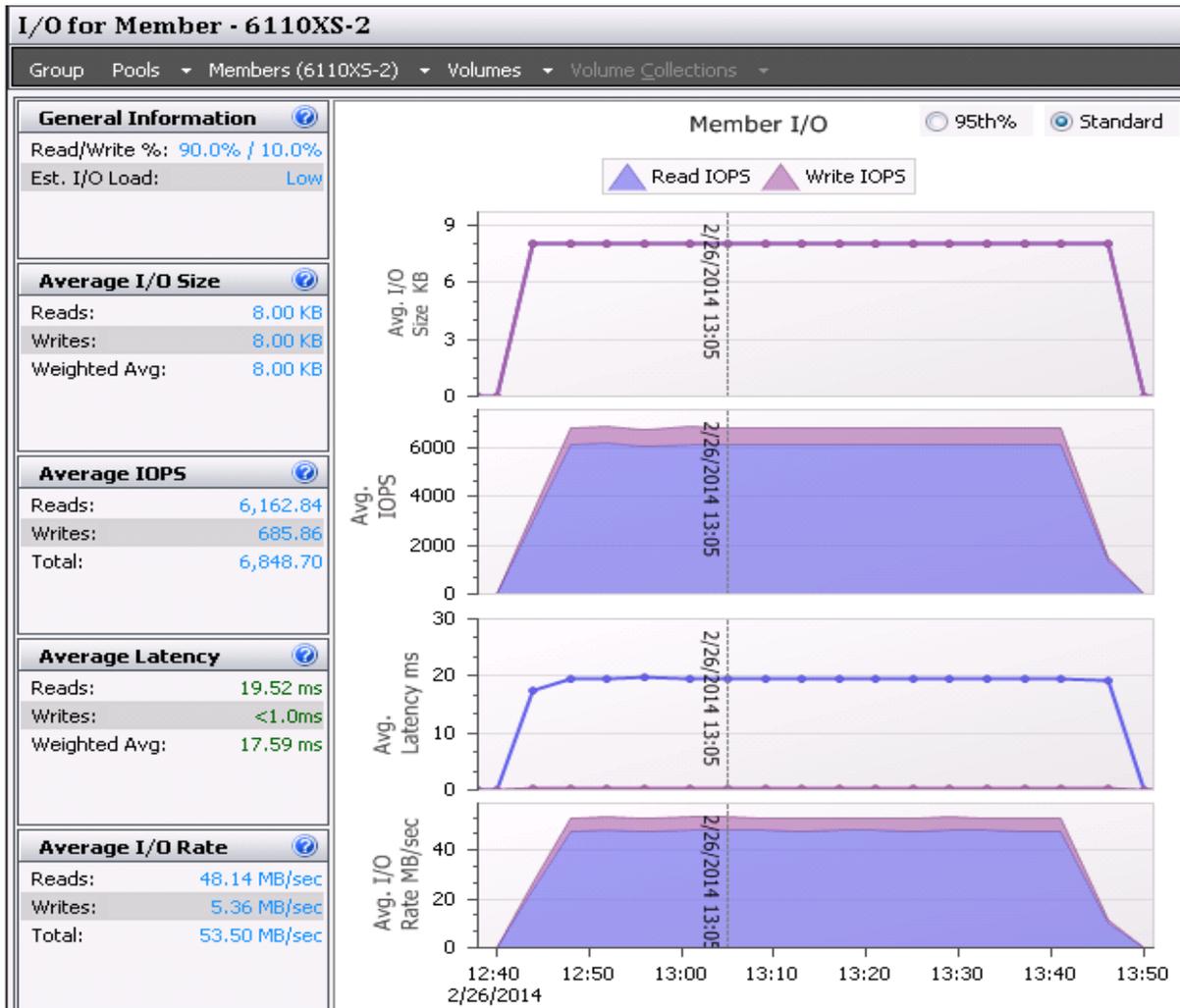


Figure 4 ORION IOPS for virtualized server configuration on PS6110XS

The peak IOPS was around 6850 IOPS which is close to the previous test configuration. The disk latency was within 20 ms for both read and write IOPS measured separately.



5.6 Summary

The test results described in sections 5.4 and 5.5 clearly prove that virtualization did not have an impact on the I/O performance. Approximately 6800 IOPS was observed on both physical and virtualized configurations.

These tests were used to compare Oracle database I/O performance between physical and Oracle VM virtualized server configurations. The EqualLogic PS6110XS hybrid array was used in the test setup. Same conclusions will be reached using the newer PS6210XS hybrid arrays. However, the actual performance numbers from the newer PS6210XS arrays are significantly higher than the PS6110XS arrays. See more details at: http://i.dell.com/sites/doccontent/shared-content/data-sheets/en/Documents/OLTP_PS6210XS_vs_PS6110XS_12_2013.pdf

IOPS : Non-Virtualized vs Virtualized

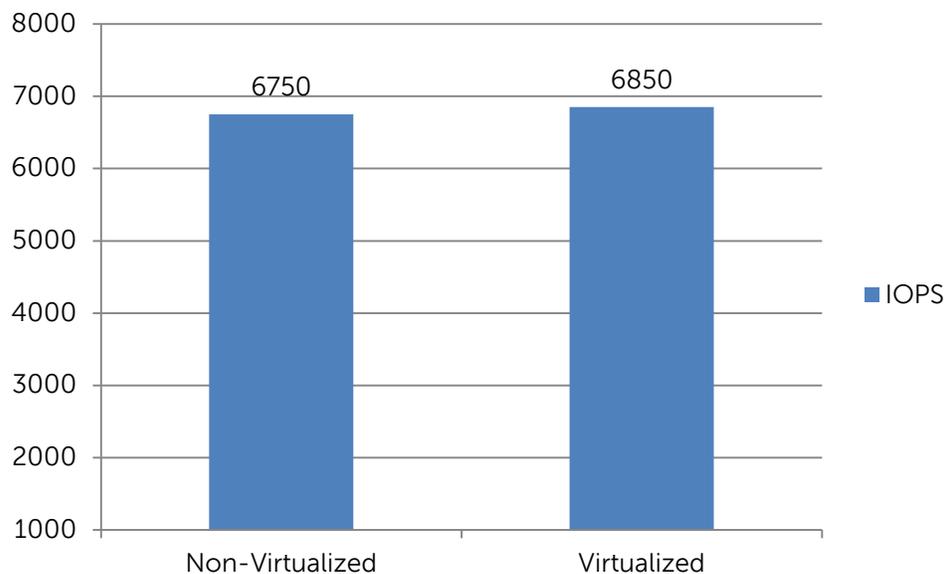


Figure 5 ORION IOPS for virtualized and non-virtualized server configurations on PS6110XS

The I/O characteristics simulated on these two configurations were similar. The I/O was simulated from two virtual machines in the virtualized configurations where the queue depth was set to 60. The queue depth was set to 120 in the single physical server configuration. So effectively, the amount of I/O, read/write mix and block size were exactly similar, and the results are comparable.

These results demonstrate that there is no impact to the performance because of virtualizing the Oracle database on an OVM environment.



6 Best practice recommendations

6.1 Storage

The backend shared storage configuration is one of the key factors for deploying an OVM solution. In addition to the volumes needed for hosting the database and applications, a minimum of two shared storage volumes are required for OVM deployment. The additional volumes required for setting up an OVM environment are for the server pool file system and the storage repository.

Server pool file system volume

A dedicated volume of 12 to 14GB is required for a cluster heartbeat, configuration and other cluster management operations. This volume will be formatted as an OCFS2 shared file system during configuration of the server pools.

In this test environment, very minimal I/O activity was observed on these volumes for most of the time. A slight increase in I/O is expected on a server pool file system only during I/O activity such as cloning or live migration.

Storage repository volume

A larger dedicated volume is required to store the Oracle guest VM hard disk images and all other storage resources such as ISOs and VM templates.

Similar to the server pool file system, minimal I/O was observed on this volume except for some higher I/O activity during the VM boot operations. When both VMs were simultaneously restarted, there was a spike of up to 3300 IOPS for a few seconds. The increase in IOPS during the VM boot operation is shown in the SAN-HQ (Live View of PS6110E array I/O) chart below.



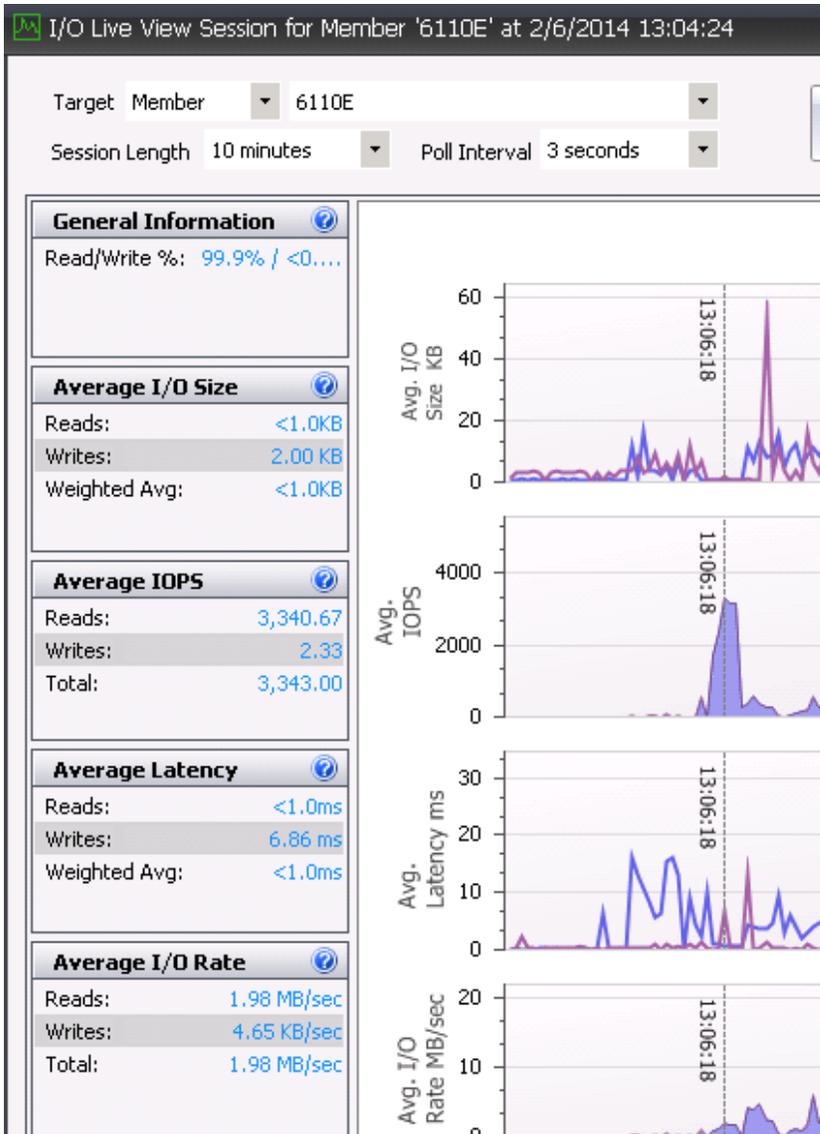


Figure 6 Storage IOPS during VM boot operation

Based on the above I/O characteristics, it is evident that the server pool file system and storage repositories do not need to be provisioned on high performing storage arrays. We recommend hosting the server pool file system and storage repository on an EqualLogic PS6210E array. These arrays can cater to the high capacity requirement of storage repository as well as minimal I/O activity with reduced cost.

The volumes hosting the Oracle database should be hosted on an EqualLogic PS6210XS array for optimal database performance.



6.2 Network configuration

6.2.1 EqualLogic networking

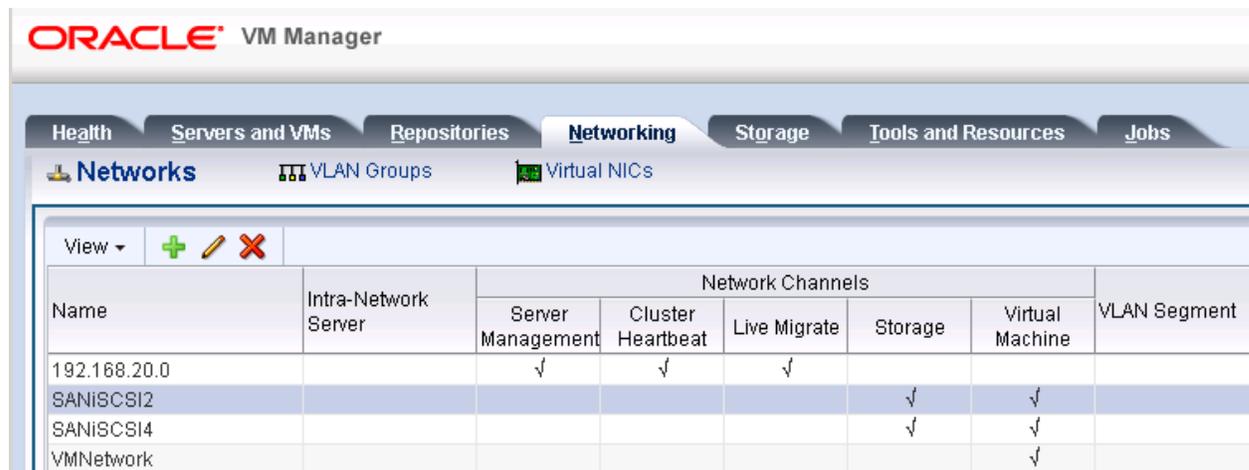
General EqualLogic network recommendations are listed below.

- Design separate network infrastructures to isolate the LAN traffic from the SAN traffic (iSCSI).
- Design redundant SAN component architectures for the NICs on the servers and switches for the storage network including both the server blade chassis switches and external switches.
- Make sure that the server NIC ports and storage NIC ports are connected so that any single component failure in the SAN will not disable access to any storage array volumes.
- Enable flow control on both the server NICs and switch ports connecting to the server and storage ports.
- Enable jumbo frames on the server ports and switch ports.
- On iSCSI SAN switches, spanning tree should be disabled on switch ports connecting to end devices like server and storage ports. The Portfast setting should be enabled in the switch configuration for these ports.

Note: General recommendations for EqualLogic PS Series array network configuration and performance is provided in the *EqualLogic Configuration Guide* at <http://en.community.dell.com/dell-groups/dtcmmedia/m/mediagallery/19852516/download.aspx>.

6.2.2 OVM network subnet configuration

It is recommended to have at least two dedicated network ports for SAN connectivity and another dedicated network port for VM to VM communication. In addition, a single network port or preferably two interfaces bonded together can be shared for management, cluster heartbeat and live migration as long as there is not much VM movement across the servers. Figure 7 shows the networks defined while validating the solution.



The screenshot shows the Oracle VM Manager interface with the 'Networking' tab selected. Below the navigation tabs, there are options for 'Networks', 'VLAN Groups', and 'Virtual NICs'. A table displays the network configuration details.

Name	Intra-Network Server	Network Channels					VLAN Segment
		Server Management	Cluster Heartbeat	Live Migrate	Storage	Virtual Machine	
192.168.20.0		√	√	√			
SANISCSI2					√	√	
SANISCSI4					√	√	
VMNetwork						√	

Figure 7 Oracle VM Network subnet configuration



6.2.3 VM manager network channel settings

Ensure that the storage networks are assigned to both **Virtual Machine** and **Storage** network channels. The **Virtual Machine** channel must be enabled in order to add a storage vNIC to guest VM.

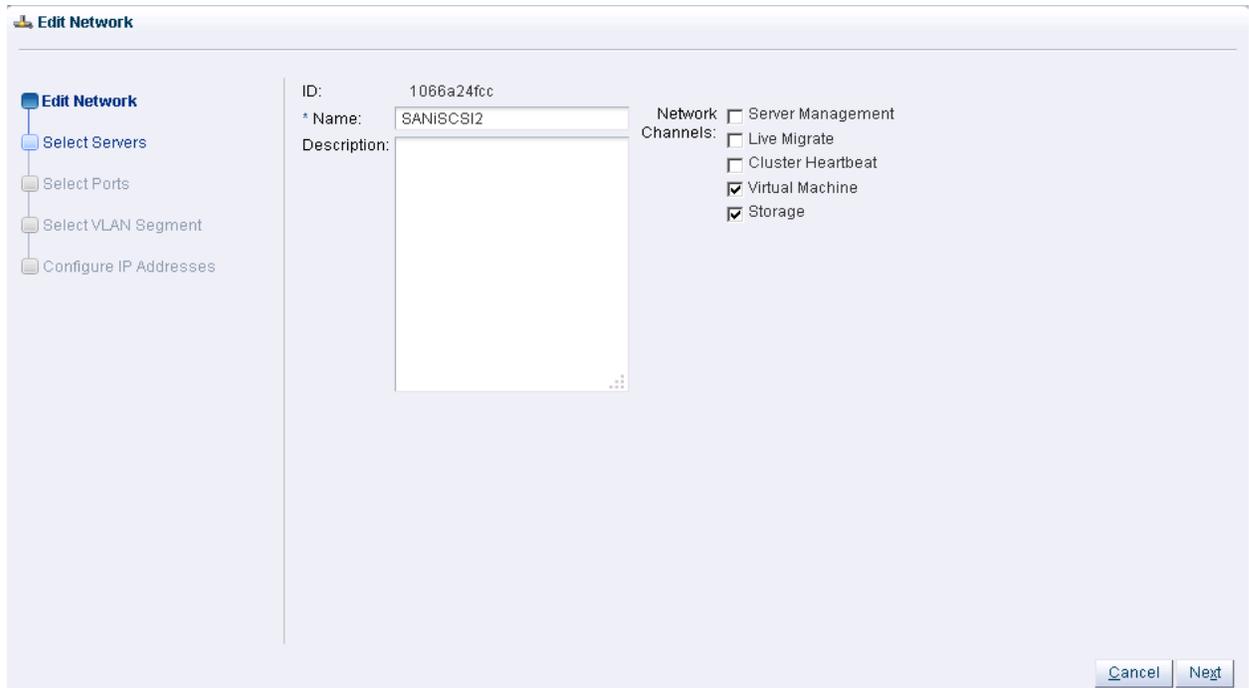


Figure 8 Network channel settings for OVM storage network

6.2.4 OVM guest MPIO settings

To enable advanced MPIO functionality, the EqualLogic HIT/Linux was installed on the OVM guest machines. The default connection parameters of two iSCSI sessions per volume slice on an array and a maximum of six iSCSI sessions for the entire volume were used. The default load balancing policy and I/Os per path were used for the MPIO. The utility **eqltune**, installed as part of the HIT/Linux package, was executed and the OS parameter recommendations from the utility that were adhered to.

Details and configuration information on EqualLogic HIT/Linux are available in the technical report, *EqualLogic Integration: Installation and Configuration for Host Integration Tools for Linux* at <http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/20219945.aspx>.

6.2.5 OVM server multipathing

Configure Linux native multipathing on OVM servers for optimal performance and high availability.

Reference *Deploying Red Hat Enterprise Linux, CentOS and Oracle Linux Server with Dell EqualLogic PS Series Arrays*

<http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19861422.aspx> for the native



multipath configuration procedure. Before proceeding to the multipath configuration, the following tasks should be completed on the OVM servers.

As mentioned in section 6.2.2, for a network port to be assigned to an Oracle VM guest machine, the same virtual network channel needs to be enabled on Oracle VM manager. In this test setup, **eth9** and **eth11** were the two network interfaces dedicated for SAN connectivity on OVM servers. Once the virtual network channel was enabled for these interfaces, new aliases were created on the OVM servers as shown below.

```
[root@ovms2 ~]# ifconfig -a | more
105b4d757c Link encap:Ethernet HWaddr 00:10:18:DD:CB:02
    inet addr:172.168.20.27 Bcast:172.168.20.255 Mask:255.255.255.0
    UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
    RX packets:701 errors:0 dropped:0 overruns:0 frame:0
    TX packets:12 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:0
    RX bytes:48265 (47.1 KiB) TX bytes:952 (952.0 b)

[root@ovms2 ~]# ifconfig eth11
eth11 Link encap:Ethernet HWaddr 00:10:18:DD:CB:02
    UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
    RX packets:1910 errors:0 dropped:56 overruns:0 frame:0
    TX packets:788 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1000
    RX bytes:761472 (743.6 KiB) TX bytes:68272 (66.6 KiB)
    Interrupt:53 Memory:d4800000-d4ffffff
```

The output shows that the MAC address for **eth11** and the new alias **105b4d757c** are the same. In addition, the IP addresses assigned through the OVM Manager were assigned to the aliases and not the devices such as eth9 or eth11. Similarly, new aliases were created for other storage network interfaces. These aliases need to be used instead of the actual Ethernet device names while configuring the multipaths. Before configuring multipaths, create an iSCSI interface for each NIC and map them to the corresponding Ethernet devices.

In the test solution, Ethernet devices eth9 and eth11 were dedicated for SAN connectivity. The iSCSI interfaces were created using the commands shown below.

```
[root@ovmsserver1 ~]# iscsiadm -m iface -I ieth9 --op=new
New interface ieth9 added
[root@ovmsserver1 ~]# iscsiadm -m iface -I ieth11 --op=new
New interface ieth11 added
```

Mapping for the iSCSI interfaces to actual Ethernet NICs was created using the following commands. Note the alias names were used instead of the actual Ethernet device names.

```
[root@ovmsserver1 ~]# iscsiadm -m iface -I ieth9 --op=update -n
iface.net_ifacename -v 1066a24fcc
```



```
ieth9 updated.  
[root@ovmserver1 ~]# iscsiadm -m iface -I ieth11 --op=update -n  
iface.net_ifacename -v 105b4d757c  
ieth11 updated.
```

The interface mapping with the Ethernet NICs was verified using the command below.

```
[root@ovmserver1 ~]# iscsiadm -m iface  
default tcp,<empty>,<empty>,<empty>,<empty>  
bnx2i.00:10:18:dc:6b:23 bnx2i,00:10:18:dc:6b:23,<empty>,<empty>,<empty>  
ieth11 tcp,<empty>,<empty>,105b4d757c,<empty>  
bnx2i.00:10:18:dc:6b:21 bnx2i,00:10:18:dc:6b:21,<empty>,<empty>,<empty>  
ieth9 tcp,<empty>,<empty>,1066a24fcc,<empty>
```

The output shows that the aliases created automatically on OVM servers were used to create mapping between iSCSI interfaces and the Ethernet NICs. The iSCSI targets were discovered using the new interfaces with the following command.

```
iscsiadm -m discovery -t st -p <EqualLogic Group IP> -I ieth9 -I ieth11
```

Verifying that the aliases were created on the OVM servers and that the interfaces were created and mapped with the aliases before discovering iSCSI targets is an important step.

Device-Mapper Settings

Device mapper multipath enables multiple I/O paths between OVM servers and EqualLogic arrays to provide high availability and performance. Oracle VM server recognizes the multipath devices using WWIDs. It is important to make sure that the **user_friendly_names** parameter is set to **no** in the multipath file.

```
defaults {  
  vendor "EQLOGIC"  
  product "100E-00"  
  path_grouping_policy multibus  
  getuid_callout "/sbin/scsi_id -g -u -s /block/%n"  
  features "1 queue_if_no_path"  
  path_checker readsector0  
  failback immediate  
  rr_min_io 10  
  rr_weight priorities  
  user_friendly_names no  
}
```

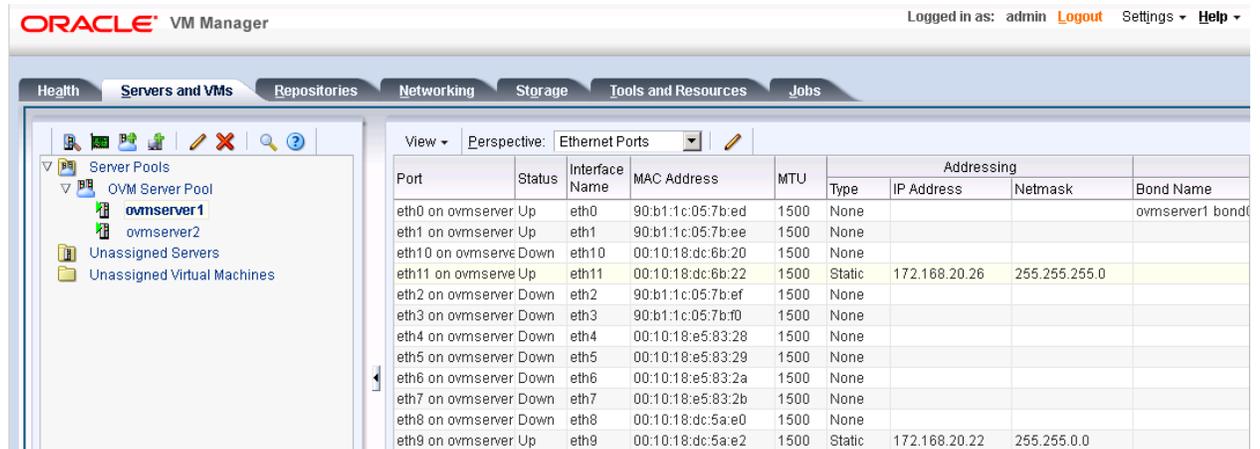


6.2.6 Jumbo frames on OVM servers

Jumbo frames are fully supported on Oracle VM servers and highly recommended for all network interfaces used when connecting to EqualLogic storage. Jumbo frames enable the transfer of larger packet sizes, resulting in better performance.

To configure the Jumbo frames settings for SAN interfaces on the OVM:

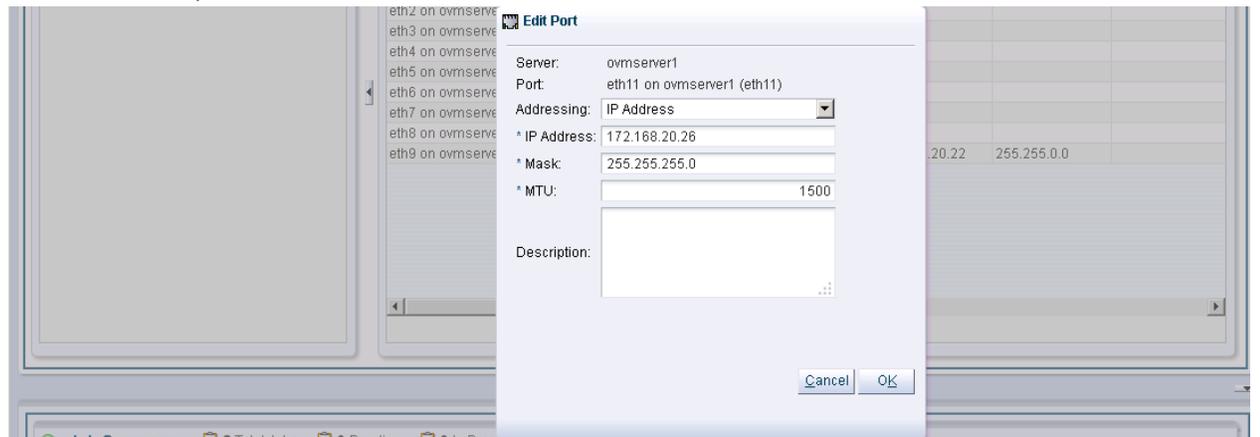
1. In Oracle VM Manager, open the **Servers and VMs** tab and then click on the OVM server. Select **Ethernet Ports** in the **Perspective** drop-down menu.



Port	Status	Interface Name	MAC Address	MTU	Addressing			
					Type	IP Address	Netmask	Bond Name
eth0 on ovmserver	Up	eth0	90:b1:1c:05:7b:ed	1500	None			ovmserver1 bond0
eth1 on ovmserver	Up	eth1	90:b1:1c:05:7b:ee	1500	None			
eth10 on ovmserver	Down	eth10	00:10:18:dc:6b:20	1500	None			
eth11 on ovmserver	Up	eth11	00:10:18:dc:6b:22	1500	Static	172.168.20.26	255.255.255.0	
eth2 on ovmserver	Down	eth2	90:b1:1c:05:7b:ef	1500	None			
eth3 on ovmserver	Down	eth3	90:b1:1c:05:7b:f0	1500	None			
eth4 on ovmserver	Down	eth4	00:10:18:e5:83:28	1500	None			
eth5 on ovmserver	Down	eth5	00:10:18:e5:83:29	1500	None			
eth6 on ovmserver	Down	eth6	00:10:18:e5:83:2a	1500	None			
eth7 on ovmserver	Down	eth7	00:10:18:e5:83:2b	1500	None			
eth8 on ovmserver	Down	eth8	00:10:18:dc:5a:e0	1500	None			
eth9 on ovmserver	Up	eth9	00:10:18:dc:5a:e2	1500	Static	172.168.20.22	255.255.0.0	

2. Change the MTU for the storage connectivity interfaces to 9000. MTU is set to 1500 by default. In the above screen shot, **eth9** and **eth11** interfaces are used for storage connectivity.

- a. Select the specific interface and click **Edit**.



- b. Modify the MTU value to 9000 and click **OK**.
- c. Verify that the values were modified successfully.

6.3 Oracle VM server settings

6.3.1 Changing the Dom0 memory size

The domain zero (or Dom0) is a small footprint Linux kernel, but the key component of an Oracle VM server. It is responsible for managing complete server resources such as CPUs, memory, network devices etc. Each guest VM or DomU is started and completely managed by Dom0. If this memory is not enough, then there may be performance issues in environments consisting of a large number of virtual machines.

Use the following formula to calculate the optimal setting for Dom0 to have sufficient allocated memory.

$$\text{dom0_mem} = 502 + \text{int}(\text{physical_mem} * 0.0205)$$

The **dom0_mem** parameter can be modified in the `/boot/grub/grub.conf` file on Oracle VM servers.

6.3.2 SCSI Disk timeout

The SCSI disk timeout value on the OVM server should be set to 60 seconds. This prevents the path to storage from being disrupted during a transient event like controller failover. List the devices being used on the system with the **multipath -ll** command as shown below.

```
[root@ovmserver1 ~]# multipath -ll
36019cb61a2ede3c2352bd524c501b070 dm-1 EQLOGIC,100E-00
size=20G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=1 status=active
  |- 11:0:0:0 sdb 8:16 active ready running
  `- 12:0:0:0 sdc 8:32 active ready running

36019cb61f25dea73c52c95da51ba17d9 dm-0 EQLOGIC,100E-00
size=300G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=1 status=active
  |- 13:0:0:0 sdd 8:48 active ready running
  `- 14:0:0:0 sde 8:64 active ready running
```

As you can see from the output the, sdb, sdc, sdd and sde devices are discovered on this server.

Verify that the default disk timeout setting for SCSI devices using the following commands that show the SCSI disk timeout value for device **/sdb**.

```
[root@ovmserver1 ~]# cat /sys/block/sdb/device/timeout
60
```

6.3.3 Reverse path filtering

Reverse path filtering is a mechanism used to verify that a receiving packet source is routable. To enable source validation of the packets received by multiple interfaces, the **rp_filter** value should be set to 2.



```
[root@ovmserver1 ~]# cat /proc/sys/net/ipv4/conf/default/rp_filter
2
```

In this test setup, two NICs on each server were dedicated for SAN connectivity. Setting the **rp_filter** to 2 helped to ensure that the source packets were accepted. This works even if the source address is routable using either interface.



7 Conclusion

Many customers today are still running Oracle production databases on physical servers with underutilized resources. They are reluctant to virtualize their databases. This is because of key challenges around determining the right virtualization as well as storage platforms that can scale and support the highly critical Oracle database applications.

Oracle VM combined with EqualLogic PS Series hybrid arrays provide the best solution for customers looking to virtualize their Oracle database deployments because:

- Oracle VM is a scalable x86 server virtualization platform designed from the ground up for excellent manageability and ease-of-use.
- EqualLogic PS Series hybrid arrays compliment this by optimizing and balancing performance and capacity needs of a demanding virtualized Oracle database environment.
- Oracle VM is a virtualization platform which is fully supported and certified by Oracle.
- The database I/O simulation tests in this paper demonstrate that there is no difference in database performance on Oracle VM virtualized servers compared to physical servers.

Optimal database performance can be achieved when the applicable best practices laid out in this paper are followed. It must be ensured that the entire ecosystem, including server resources and network switches, are sized and configured appropriately to meet the workload performance requirements. Also, ensure that the operating system and databases are configured with the optimal settings and design recommendations that are mentioned in this paper.



A Solution components

This section contains an overview of the configurations used throughout the testing described in this document.

Table 5 Test configuration hardware components

Solution Configuration - Hardware Components:		Description
Oracle VM servers	<ul style="list-style-type: none"> • 2 x Dell PowerEdge R720 servers: <ul style="list-style-type: none"> ○ Broadcom 5719 Quad port 1Gig NIC ○ Broadcom 57810 Dual port 10Gig NIC 	Two R720 servers to be part of the Oracle VM server pool. 1 x 1Gig NIC (B5720) will be used for Management, Cluster heartbeat and Live migration. 1 x 1Gig NIC (B5720) will be used for VM to VM communication. 2 x 10Gig NICs (B57810) will be used for iSCSI SAN connectivity.
Physical database server	<ul style="list-style-type: none"> • 1 x Dell PowerEdge R720 servers: <ul style="list-style-type: none"> ○ Broadcom 5719 Quad port 1Gig NIC ○ Broadcom 57810 Dual port 10Gig NIC 	One R720 servers used for comparing I/O performance on physical and OVM configuration. 1 x 1Gig NIC (B5720) will be used for Management 2 x 10Gig NICs (B57810) will be used for iSCSI SAN connectivity.
Oracle VM Manager	<ul style="list-style-type: none"> • 1 Dell PowerEdge R810 server: <ul style="list-style-type: none"> ○ Broadcom 5709 Quad port 1Gig NIC 	Centralized management application for controlling the entire OVM stack including OVM servers, storage resources and guest VMs.
Infra Management	<ul style="list-style-type: none"> • 1 Dell PowerEdge R810 server: <ul style="list-style-type: none"> ○ Broadcom 5709 Quad port 1Gig NIC 	Management server for the entire infrastructure. EQL Manager and SAN HQ
Network	<ul style="list-style-type: none"> • 2 x Dell Force10 S4810 switches • Firmware: 9.1.0.0 	Two switches stacked together for iSCSI SAN connectivity.
Storage	<ul style="list-style-type: none"> • 1 x Dell EqualLogic PS6110XS: <ul style="list-style-type: none"> ○ 7x 400GB SSDs & 17 x 600GB 10K SAS ○ Firmware: 6.2.1 ○ RAID 6 accelerated • 1 x Dell EqualLogic PS6110E: <ul style="list-style-type: none"> ○ 24 x 2TB SATA ○ Firmware: 6.2.1 ○ RAID 50 	Backend storage for Oracle database volumes. Backend storage for server pool file system and storage repository (OVM guest hard disk, ISOs, Templates etc).



Table 6 Test Configuration - Software Components

Test Configuration - Software Components	
Oracle VM Servers	<ul style="list-style-type: none"> • 2 x Oracle VM server 3.2.6 • Server pool file system and storage repository presented from PS6110E. • Native multipathing.
Oracle VM Manager	<ul style="list-style-type: none"> • Oracle Linux 6.4 • Oracle 11.2.0.4 Enterprise Edition – Management repository
Oracle VM guest machines	<p>2 x Oracle VM guest machines were used (ORION I/O simulation executed on these two machines)</p> <ul style="list-style-type: none"> • RHEL 6.3 • Database volumes presented using guest iSCSI initiators. • VM hard disk presented through OVM server. • HIT/Linux installed for managing multipaths
Monitoring Tools	<ul style="list-style-type: none"> • EqualLogic SAN Headquarters version 2.6.0 • Oracle OS Watcher utility (installed on database servers)



Additional resources

Support.dell.com is focused on meeting your needs with proven services and support.

DellTechCenter.com is an IT Community where you can connect with Dell Customers and Dell employees for the purpose of sharing knowledge, best practices, and information about Dell products and your installations.

Referenced or recommended Dell publications:

- Dell EqualLogic Configuration Guide:
<http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19852516/download.aspx>

Referenced or recommended Oracle publications:

- Oracle VM generic information:
<http://www.oracle.com/technetwork/server-storage/vm/overview/index.html>
- Oracle VM 3.2.1 Documentation:
http://docs.oracle.com/cd/E35328_01/index.html

For EqualLogic best practices white papers, reference architectures, and sizing guidelines for enterprise applications and SANs, refer to Storage Infrastructure and Solutions Team Publications at:

- <http://dell.to/sM4hJT>

