

# **Dell® Reference Configuration for Large Oracle® Database Deployments on Dell EqualLogic™ Storage**

## **Database Solutions Engineering**

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## Executive Summary

Deployment of very large Oracle® databases, in the order of multiple terabytes, requires a lot of planning. Managing large and complex database environments that balance performance with growing database size is a key challenge for customers. Dell EqualLogic™ iSCSI storage arrays are designed to simplify the storage deployment and its patented peer-to-peer architecture helps to scale the performance with growing storage requirements.

This white paper provides a reference configuration for very large oracle online transaction processing (OLTP) deployments on multi-member Dell EqualLogic storage arrays. This paper also provides the best practices for configuring the hardware and software components of Dell EqualLogic storage arrays. These defined best practices were established based on the experiments performed by Dell engineers simulating OLTP database workload on Oracle databases deployed on Dell EqualLogic storage arrays.

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## Introduction

Planning the storage layout plays a critical role in Oracle database deployment. The storage should be configured to address the performance requirement for the application that uses the database. When the database size grows, however, one of the basic expectations from the storage underneath is that the storage sub-system should be able to scale, or sustain, the required performance. The complexity of the storage management usually grows with increasing database size. Hence, it is very important for customers to choose the storage arrays which can scale, or sustain, the required database performance, and that also have any required management software needed to simplify the data management.

Dell EqualLogic iSCSI storage arrays are built with patented peer-to-peer architecture, which can address the above customer pain point's very effectively. The storage arrays have built-in intelligence to perform data management by rebalancing data across storage arrays to avoid hot spots for the data blocks. The built-in intelligence spans the volumes across the members inside a storage pool, without user intervention, and ensures that the I/O operations are optimized across all the available members.

Oracle Automatic Storage Management (ASM) also helps in rebalancing Oracle I/O inside an Oracle ASM disk group. Oracle ASM virtualizes the database storage into disk groups, or a set of disk groups, and manages the database files automatically within a disk group. Data is spread evenly across all the disks in the disk group to optimize performance and available resource utilization. ASM has eliminated the need to manually tune the I/O performance of database files, and provides benefits for raw I/O with easy management of the file system. From previous work by Dell engineers<sup>1</sup>, it was observed that Oracle ASM load balancing complements Dell EqualLogic storage rebalancing and that database performance is increased when Oracle ASM is used with Dell EqualLogic storage arrays.

This whitepaper outlines how the Dell EqualLogic storage arrays can be used for deploying very large Oracle databases (multiple terabytes in size). Dell engineers have performed multiple performance runs to determine how Dell EqualLogic storage can scale up performance while increasing the storage capacity for increased database size. From these experiments, several configuration best practices are highlighted for very large database deployments with multiple Dell EqualLogic arrays. To achieve a cost effective solution, this whitepaper also highlights the usage of Dell EqualLogic PS iSCSI arrays with SATA drives to host the Oracle database components with low performance requirements, for example flash recovery area.

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<sup>1</sup> Performance Implications of running Oracle ASM with Dell EqualLogic™ PS series storage - [http://www.dell.com/downloads/global/solutions/Performance\\_Implications\\_Oracle\\_ASM.pdf?c=us&cs=555&l=en&s=biz](http://www.dell.com/downloads/global/solutions/Performance_Implications_Oracle_ASM.pdf?c=us&cs=555&l=en&s=biz)

## Dell Reference Configuration for Large Oracle OLTP Deployments on Dell EqualLogic Storage

### Dell Solutions for Oracle Database

Dell Solutions for Oracle database (10g and 11g) provides a tested and validated software and hardware bundle which is easy to deploy and easy to scale with Dell building blocks. The following advantages are also included with Dell solutions for Oracle databases.

- Dell Configurations for Oracle 10g and 11g – Backed up by in-depth testing of Oracle configurations for complex database deployments; documentation and tools that help simplify oracle database deployment.
- Dell Enterprise Support and Infrastructure Services for Oracle – Includes offerings for planning, deployment and maintenance of Dell solutions for Oracle database 10g and 11g.

For more information pertaining to Dell solutions for Oracle database, please visit [dell.com/oracle](http://dell.com/oracle).

### Dell EqualLogic Storage Systems Overview

It is extremely important to select a storage array for Oracle database deployments that can address the desired performance requirements, and should provide advanced storage features such as virtualization, snapshots, and replication.

Dell EqualLogic PS Series iSCSI storage arrays are built on patented peer storage architecture which helps expand storage capacity seamlessly (by adding the new PS member into a pool) without degrading performance. Performance scales up with this architecture because the new PS member comes with additional processing power to serve added data volume. Also, when additional arrays are added to the pool, the existing data is automatically redistributed across the pool to balance the I/O optimally. Hence, all arrays in a storage pool are designed to work together to provide disk capacity and evenly distribute the load.

In addition to unique peer architecture, the Dell EqualLogic PS storage arrays have several other built-in intelligence features that ensure the storage array performs optimally at all times with minimal user intervention. For example, when one volume is created inside a pool, Dell EqualLogic is intelligent enough to span the volume across the appropriate members to make sure that I/O activities occur optimally on the volume. The storage administrator does not have to think about the volume placement inside the pool. Dell EqualLogic storage arrays also monitor the performance for the volumes and, if required, the volume can be moved around across the members inside the pool for optimal performance.

The features discussed above help to deploy and optimize Oracle database deployment easier. The following sections provide more insight into planning a large Oracle deployment with Dell EqualLogic PS storages.

# Large Oracle Database Deployment with Multimember Dell EqualLogic Storage

When customers plan for very large oracle database, they should provide outmost importance to following couple of considerations:

- **Capacity**

When the database grows in size, the storage array should be expanded to accommodate the database. This can be very easily achieved by adding more disk space to existing storage arrays.

With Dell EqualLogic PS storage, the storage capacity is easily expanded by adding PS members either to an existing storage pool or to a new storage pool. Using multiple pools can help customers doing storage maintenance activities (e.g. firmware upgrade).

- **Performance**

When storage expands in capacity, it is critical that performance scales up and the applications using the database do not encounter any performance degradation.

Usually, when disk space is added (to expand the storage capacity) without adding any processing power, the storage controllers need to handle more data with the same processing power. With Dell EqualLogic's peer storage architecture, however, processing power is added when the storage capacity is expanded. Hence performance for Dell EqualLogic storage arrays scale up with the expansion of the storage capacity.

- **Manageability**

Typically, with increasing data size, manageability becomes a challenging task for the storage administrators. Data placement needs to be planned appropriately to maintain storage performance with increasing data size.

Dell EqualLogic storage arrays have several built-in intelligence features designed to handle data placement automatically to ensure optimum performance. Performance is also monitored over time to make sure it is optimal and, in the case of degraded performance, the storage arrays has the intelligence to move the volumes across the members inside the pool to remove hot spots. The rebalancing feature of Dell EqualLogic storage arrays redistributes the data within a pool each time the capacity is changed.

## Dell Reference Configuration for Large Oracle OLTP Deployments on Dell EqualLogic Storage

The following sections showcase the considerations described above, while deploying very large oracle database with multi-member (up to 6 members) Dell EqualLogic storage arrays. Engineering test results were analyzed to provide the configuration guidelines.

### ORION (Oracle I/O Numbers)

Orion is a tool for simulating the Oracle database disk subsystem characteristics. Orion is designed to simulate Oracle database I/O patterns such as OLTP, DSS, and mixed workloads. Orion supports several I/O workloads ranging from small random reads/writes, large sequential reads/writes, or a mix of small random and large sequential I/O workloads. In this study, the OLTP workload was simulated with a mix of small random reads and writes.

The small random I/O workload simulates the typical OLTP workload where most I/O operations are 8 KB in size. The performance in terms of number of I/O operations per second (IOPS) and I/O latency is the key criteria for comparing the performance of storage subsystems for OLTP workload.

### Test Methodology and Configuration

To measure the performance and scalability of multiple EqualLogic PS iSCSI storage arrays for different database I/O workloads, Dell engineers used the Oracle I/O Numbers Calibration tool (ORION).

For all of the tests, six Dell EqualLogic PS6000XV storage arrays with 15K RPM SAS disks were used. Each storage array used 14 disks in a RAID 10 configuration with two hot spare disks. Each storage array was configured with multiple redundant paths from the hosts (4-iSCSI ports). The PS6000XV storage arrays were configured to use the linux native device mapper for I/O load balancing. Multi bus round robin protocol was used for DM multipath and load balancing.

For the Dell EqualLogic PS iSCSI SAN configurations, two Dell Power Connect™ 6248 Gigabit Ethernet switches were used to connect the host servers to the storage subsystem to isolate the iSCSI traffic from other network traffic. Between the two Ethernet switches, a 10 GB/s Link Aggregation Group was configured to provide a high bandwidth, inter-switch network. For this testing configuration, network best practices guidelines were followed. Two Dell PowerEdge R710 servers with two Intel Xeon® X5560 quad-core 2.80 GHz CPU with 8 M cache and 32 GB memory were used in the test setup.

Orion tests were run using six PS6000XV arrays in three different configurations, as described in the previous section, and performance metrics were captured to evaluate the performance for a large OLTP database. The load level for each of the test was set to maximum of 1200 small outstanding I/Os. Each

of these test scenarios was executed with the number of raw volumes ranging from one to twelve, and the size of each volume being 400~600 GB. Each test simulated the effect of oracle ASM striping.

The table-1 summarizes the test configurations that were used for all the performance runs.

HARDWARE AND SOFTWARE CONFIGURATIONS FOR BENCHMARK FACTORY TEST	
Server	<p>Two Dell PowerEdge R610 servers with:</p> <ul style="list-style-type: none"> <li>• One Intel® Xeon® X5560 quad-core 2.80 GHz CPU with 8M cache, 6.40 GT/s QPI and TURBO and HT mode enabled.</li> <li>• 16 GB of RAM with 2GB DIMMs respectively.</li> <li>• Four 1Gb Broadcom NetXtreme II NIC ports for iSCSI traffic</li> </ul>
External Storage	<p>Dell™ EqualLogic™ PS6000XV</p> <ul style="list-style-type: none"> <li>• RAID 10 with 2 spare disks in each member</li> <li>• 15K RPM SAS disks in PS6000XV</li> <li>• Firmware: 4.1.4 (R91505)</li> </ul> <p>Dell™ EqualLogic™ PS6000E</p> <ul style="list-style-type: none"> <li>• RAID 5 with 2 spare disks</li> <li>• 7.2K RPM SATA II drives 500GB</li> </ul>
Volume Configuration	<ul style="list-style-type: none"> <li>• One to Twelve volumes of 400GB ~ 600GB.</li> <li>• One volume of 2 TB for Flash Recovery area.</li> </ul>
OS and Device Driver	<p>Red Hat Enterprise Linux 5 Update 3</p> <ul style="list-style-type: none"> <li>• Open iSCSI initiator iscsi-initiator-utils-6.2.0.868-0.18.el5</li> <li>• Device Mapper multipath driver device-mapper-multipath-0.4.7-23.el5</li> </ul>
Storage Network	<p>Two stacked Dell Power Connect 6248 Gigabit Ethernet switches for iSCSI SAN</p>
Test Software	<ul style="list-style-type: none"> <li>• Orion 11.1.7.0</li> </ul>

**Table 1- Orion Test Configuration.**



## Dell Reference Configuration for Large Oracle OLTP Deployments on Dell EqualLogic Storage

OLTP workload (with 70% reads and 30% writes) was used to simulate with Orion and storage subsystem was stressed with the same. Load level is expressed in terms of the number of outstanding asynchronous I/Os. The number of outstanding asynchronous I/Os was increased to increase the OLTP workload level.

### Test Scenarios

To evaluate the performance of large oracle database deployments with Dell EqualLogic storages, Dell engineers configured six Dell EqualLogic storage arrays as follow:

- 1 Storage pool – All six members in one single storage pool
- 2 Storage pools – Three members in each storage pool
- 3 storage pools – Two members in each storage pool

The following scenarios were chosen to demonstrate the flexibility available when configuring Dell EqualLogic storages. The intent of these experiments was to showcase that Dell EqualLogic can deliver the same level of performance with any of the configurations.

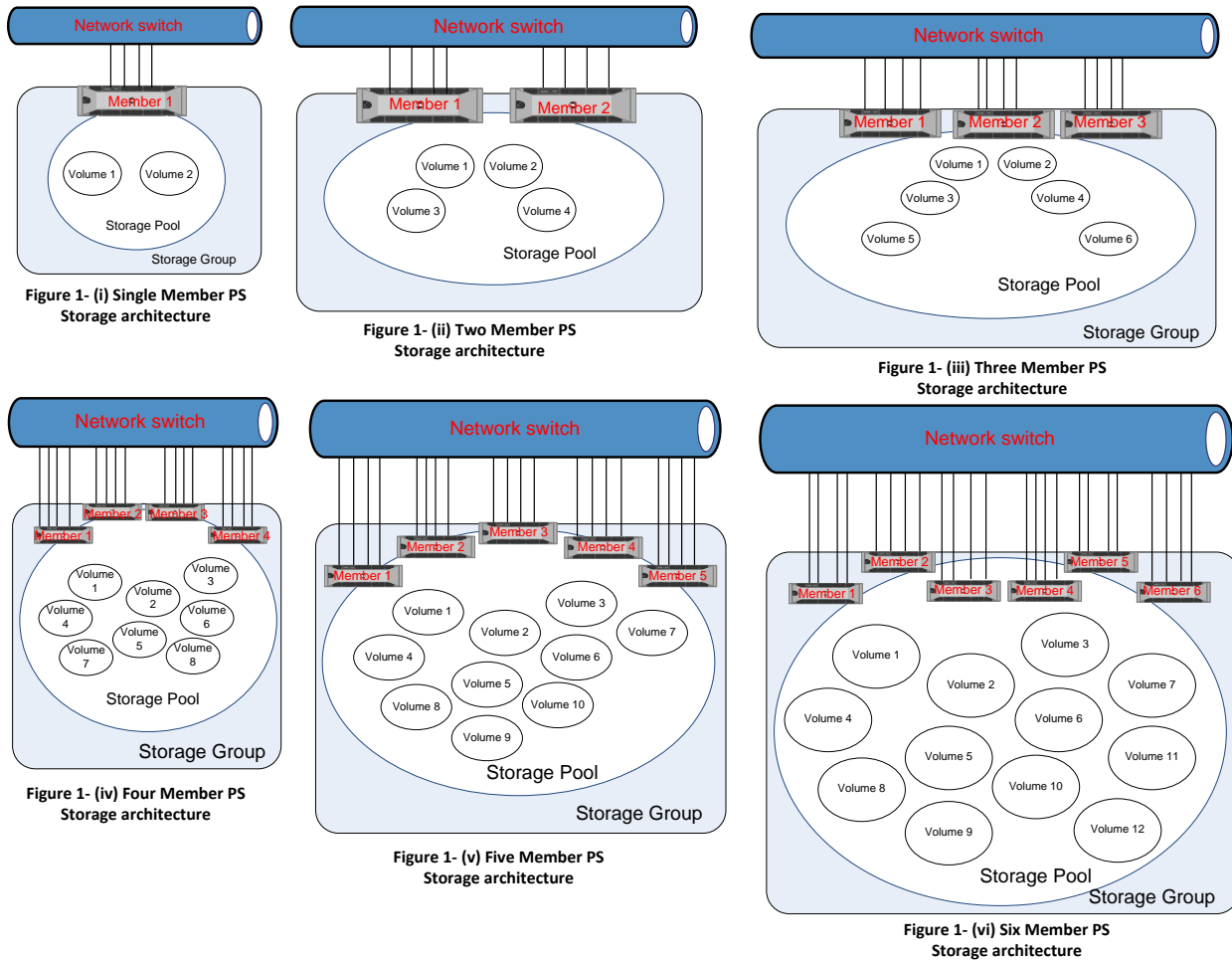
#### Configuration 1 [Single storage pool]

In this configuration, one storage pool was created and all six members were added to the pool one by one. The following steps were used to evaluate the performance with a single storage pool configuration.

1. Single Dell EqualLogic PS6000XV storage array (member 1) was used to create a storage pool. Two 400 GB volumes (volume 1, volume 2) were created in the storage pool and added to oracle ASM disk group. See Figure 1-(i).
2. Second Dell EqualLogic PS6000XV storage array (member 2) was added to the same storage pool. Two more 400 GB volumes (volume 3, volume 4) were created in the storage pool and added to oracle ASM disk group. See Figure 1-(ii).
3. Third Dell EqualLogic PS6000XV storage array (member 3) was added to the same storage pool. Two more volumes (volume 5, volume 6) were created in the storage pool and added to oracle ASM disk group. See Figure 1-(iii).
4. Fourth Dell EqualLogic PS6000XV storage array (member 4) was added to the same storage pool. Two more volumes (volume 7, volume 8) were created and added to oracle ASM disk group. See Figure 1-(iv).
5. Fifth Dell EqualLogic PS6000XV storage array (member 5) was added to the same storage pool. Two more volumes (volume 9, volume10) were created and added to oracle ASM disk group. See Figure 1-(v)

- As a last step, the sixth Dell EqualLogic PS6000XV storage array (member 6) was added to storage pool and two more volumes (volume 11, volume 12) were created in the storage pool and added to oracle ASM disk group as illustrated in figure 1-(vi) below. , totaling 6 arrays in the storage pool.

At the end of this configuration the storage pool contained a total of six arrays and twelve volumes.



**Figure 1- Single storage pool-six member PS Storage configuration**

Another important aspect to be noted here is that while creating the volumes inside the pool, Dell EqualLogic storage array handled the spanning of the volume across the members. Dell EqualLogic storage array has built-in intelligence to handle the data placement for optimal performance. It is a best practice to let the storage array handle the volume spanning rather than the storage administrator forcing the volume to span across the members. For all of these configurations the database flash recovery area was created on Dell EqualLogic PS6000E storage array.

## Dell Reference Configuration for Large Oracle OLTP Deployments on Dell EqualLogic Storage

### Results and Analysis

By performing this experiment, the storage capacity was increased every time one new member was added to the pool. For example, in the first configuration 14 disks were used for hosting the database, where as in the second configuration 28 (2x14) disks were used for hosting the database.

The six configurations were stressed with OLTP workload (simulated by Orion) as explained in the previous section. The IOPS per disk were calculated for each configuration and analysis was performed to determine whether the storage could scale up with the capacity expansion.

In Figure 2, the X-axis represents the outstanding asynchronous I/Os and the Y-axis represents the normalized IOPS per disk and the number of disks in the configuration.

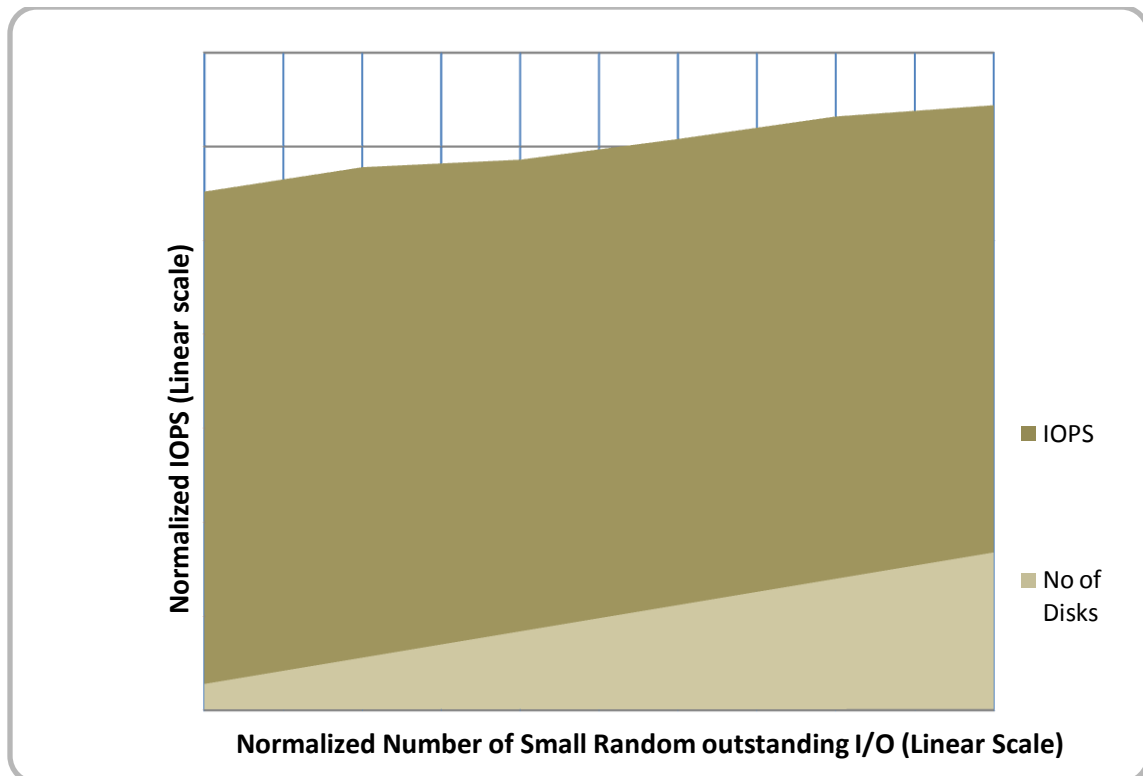


Figure 2 – IOPS per disk for a single storage pool-six member configuration

As we can observe for the given OLTP workload, that the Dell EqualLogic storage could scale while expanding the storage capacity by adding new members to the storage pool. IOPS per disk were sustained as we added more arrays, or disks, to the storage pool. Hence, it can be concluded that the Dell EqualLogic storage array can scale up, and the disk IOPS can be sustained with increasing data size with a single pool configuration.

**Configuration 2 [Two storage pools]**

In this configuration, two storage pools were created and six members were distributed in these two storage pools. The following steps were used for evaluating the performance with a two storage pool configuration.

1. Three Dell EqualLogic PS6000XV storage arrays (member 1, member 2, and member 3) were used to create a Storage Pool 1. A single 600 GB storage volume (volume 1) was created in the storage pool and was added to oracle ASM disk group. See Figure 3-(i).
2. A second storage pool (Storage Pool 2) was then created and three Dell EqualLogic storage arrays (member4, member 5, and member 6) were added to the Storage Pool 2. Another 600 GB volume (volume 2) was created in Storage Pool 2 and was added to oracle ASM disk group. See Figure 3-(ii).

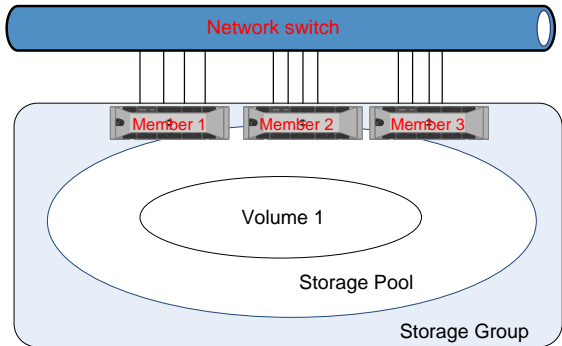


Figure 3 - (i) Single pool with three members

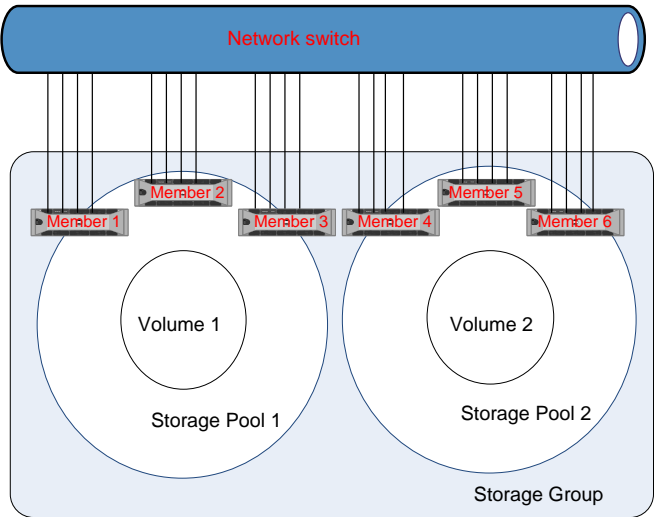


Figure 3 - (ii) Two pools with three members each

**Figure 3 – Two storage pool-six member configurations**

Similar to the earlier test case, Dell EqualLogic storage array was allowed to manage the volume spanning across different members. In this case volume 1 spanned across members 1, 2 and 3 and

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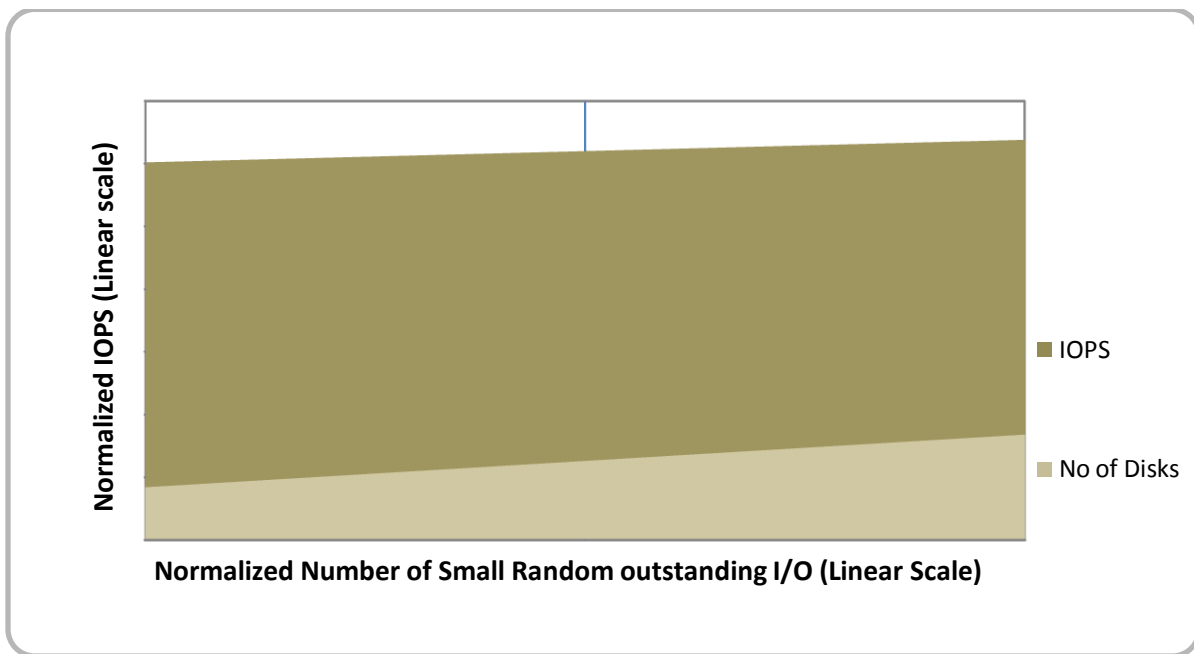
volume 2 spanned across members 4, 5 and 6. For all of these configurations the database flash recovery area was created on Dell EqualLogic PS6000E storage array.

### Results and Analysis

By performing this experiment, the storage capacity was increased by adding another storage pool to an existing deployment. The first configuration has 42 (3x14) disks for hosting the database, where as the second configuration has 84 (6x14) disks hosting the database.

Both configurations were stressed with OLTP workload (simulated by Orion) as explained in an earlier section. The IOPS per disk were calculated for each of the configuration and analysis was performed to determine whether the storage could scale up with the capacity expansion.

In Figure 4, the X-axis represents the outstanding asynchronous I/Os and the Y-axis represents the normalized IOPS per disk and the number of disks in the configuration.



**Figure 4 – IOPS per disk for a two storage pool-six member configurations**

As we can observe that for the given OLTP workload, the Dell EqualLogic storage could scale while expanding the storage capacity by adding new storage pool to the existing storage pool. IOPS per disk were sustained as we added more arrays, or disks, to a new storage pool. Hence, it can be concluded

that the Dell EqualLogic storage array can scale up, and the disk IOPS can be sustained with increasing data size with a two storage pool configuration.

### Configuration 3 [Three storage pool]

In this configuration, three storage pools were created and six members were distributed in these three storage pools. The following steps were used for evaluating the performance with a three storage pool configuration.

1. Two EqualLogic PS6000XV storage arrays (member 1, member 2) were used to create a storage pool. A single 400 GB storage volume (volume 1) was created in the Storage Pool 1 and was added to oracle ASM disk group. See Figure 5-(i).
2. Two more EqualLogic PS6000XV storage arrays (member 3, member 4) were added to a second storage pool (Storage Pool 2) and were added to oracle ASM disk group. Another 400 GB volume (volume 2) was created in Storage Pool 2. See Figure 5-(ii).
3. As a final step, two more EqualLogic PS6000XV storage arrays (member 5, member 6) were added to third storage pool (Storage Pool 3). Another 400 GB volume (volume 3) was created in Storage Pool 3 and was added to oracle ASM disk group. See Figure 5-(iii).

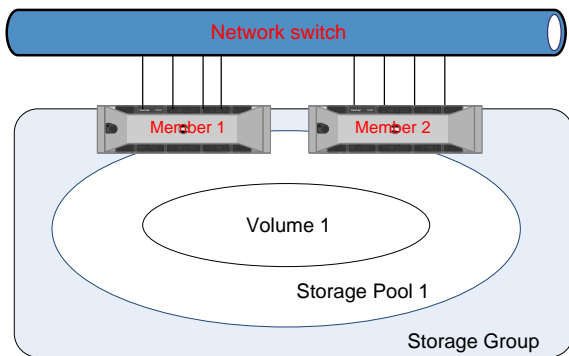


Figure 5 - (i) Single Pool with two Members

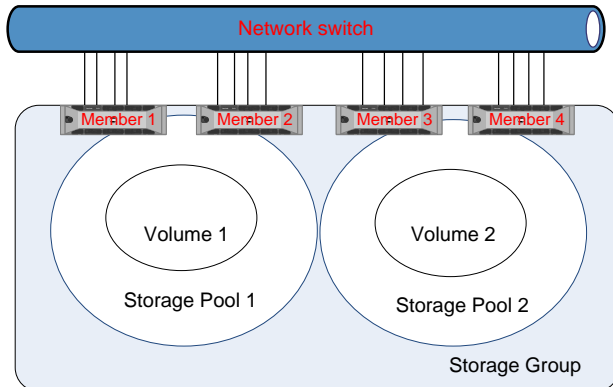


Figure 5 - (ii) Two Pools with two Members each

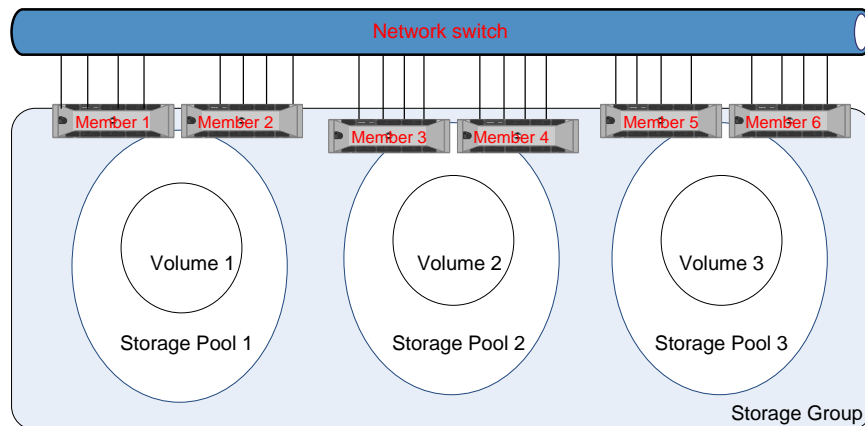


Figure 5 - (iii) Three Pools with two Members each

Figure 5- Three storage pool-six member configuration

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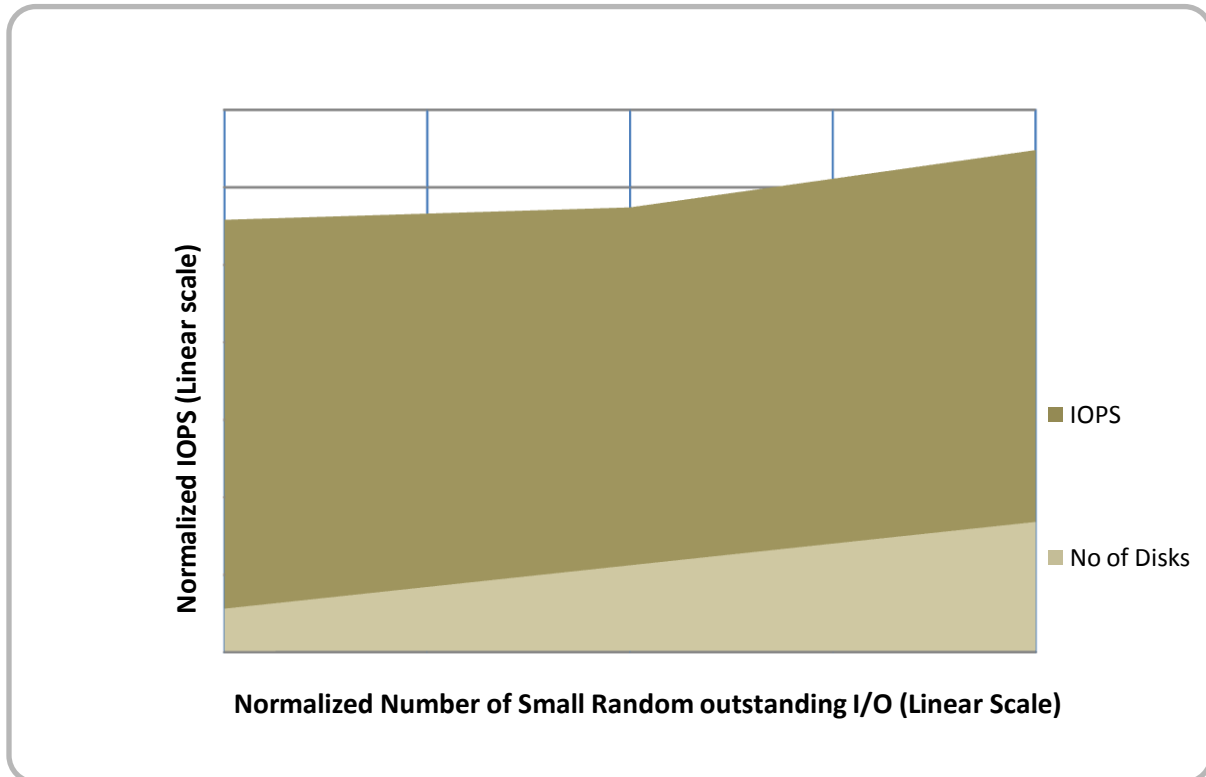
Similar to earlier test cases, Dell EqualLogic storage array was allowed to manage the volume spanning across different members. In this case volume 1 spanned across members 1 and 2, volume 2 spanned across the members 3 and 4, and the volume 3 spanned across members 5 and 6. For all of these configurations the database flash recovery area was created on Dell EqualLogic PS6000E storage array.

### Results and Analysis

By performing this experiment, the storage capacity was increased by adding multiple storage pools to an existing deployment. The first configuration has 28 (2x14) disks for hosting the database, where as the second and third configurations have 56 (4x14) and 84 (6x14) disks used for hosting the database respectively.

The three configurations were stressed with OLTP workload (simulated by Orion) as explained in an earlier section. The IOPS per disk were calculated for each of the configurations and analysis was performed to determine whether the storage could scale up with the capacity expansion.

In Figure 6, the X-axis represents the outstanding asynchronous I/Os and the Y-axis represents the normalized IOPS per disk and the number of disks in the configuration.



### Figure 6 – IOPS per disk for a three storage pool-six member configuration

As we can observe that for the given OLTP workload, the Dell EqualLogic storage could scale while expanding the storage capacity by having multiple storage pools. IOPS per disk were sustained as we added more arrays, or disks, to a new storage pool. Hence, it can be concluded that the Dell EqualLogic storage array can scale up, and the disk IOPS can be sustained with increasing data size with a three storage pool configuration.

## Conclusion

The test results from the previous sections demonstrated that Dell EqualLogic PS storage array is a great choice for large oracle database deployment. Customers can choose to start with a minimal number of storage arrays and follow the pay-as-you-go approach. When the database size grows, more storage arrays can be added to the existing deployment without worrying about the performance degradation. Dell EqualLogic PS array's unique peer architecture can scale the performance with increasing storage capacity. Also, Dell EqualLogic PS arrays are equipped with several built-in intelligence features which require no manual intervention for data placement and managing hot spots inside the storage pool. Another key take away from the experimentations is that customers have the flexibility to configure the Dell EqualLogic storage arrays with multiple storage pools. Creating multiple storage pools helps in performing storage maintenance, because it adds more granularities to the storage configuration and the storage arrays can be isolated easily.

Based on the experimentation results, the best practices for deploying large oracle databases can be summarized as follows:

- While creating volumes, allow the Dell EqualLogic PS storage arrays to manage the volume placement across available members inside the storage pool. Do not force the volume to span across members to perform hot spot management manually.
- Create volumes with small sizes (size of around 400 ~ 600 GB) because having smaller size volumes simplifies storage maintenance. Do not create volumes of more than 2 TB, as ASM does not support disk size over 2 TB. Oracle errors out with the ORA-15018 and ORA-15099 errors if you try to add disks of more than 2 TB to the ASM disk group. Please refer to Metalink Notes: 6453944.8, 736891.1 for more details.
- Create multiple volumes in a storage pool and add them to oracle ASM to take advantage of both Dell EqualLogic and Oracle ASM load balancing.
- Number of storage pools and number of members inside the pool should be decided keeping array maintenance in mind. The larger the number of storage pools, the easier it is to isolate the members for storage maintenance. As it was discovered during testing, Dell EqualLogic storage arrays scale up with storage expansion regardless of the number of storage pools.



## Dell Reference Configuration for Large Oracle OLTP Deployments on Dell EqualLogic Storage

To summarize all findings, Dell EqualLogic storage arrays simplify the storage deployment for large Oracle databases. Because Dell EqualLogic storage arrays come with both SAS and SATA disk support, it makes a good choice for deploying Oracle database in a tiered storage environment, where the low performance components (like flash recovery area) can be placed on SATA arrays and application data can be placed on the SAS arrays.

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