ORACLE PROTECTION AND RECOVERY USING
VMWARE VSPHERE VIRTUAL VOLUMES ON
EMC VMAX3

- Simplified Oracle storage operations for virtualized Oracle environments
- Faster Oracle database snapshot creation and deletion
- Efficient Oracle Recovery Manager backup and recovery enabled by vSphere Virtual Volumes snapshots

EMC Solutions

Abstract
This solution guide describes the deployment of VMware vSphere Virtual Volumes on EMC® VMAX3™ to solve backup and recovery challenges for virtualized databases and deploying vSphere Virtual Volumes for OLTP applications using Oracle Database 12c.

December 2015
Chapter 1  Executive Summary .......................................................... 4
Business case .................................................................................... 5
Solution overview ............................................................................ 5
Key benefits ...................................................................................... 6
Document purpose ........................................................................... 7
Audience ......................................................................................... 7
We value your feedback!................................................................. 7

Chapter 2  Technology Overview ...................................................... 8
Solution architecture ........................................................................ 9
Key components ............................................................................... 10
Hardware resources .......................................................................... 10
Software resources .......................................................................... 11

Chapter 3  Testing and Validation .................................................... 12
Introduction ...................................................................................... 13
Use Case 1: Oracle Database backup using vSphere Virtual Volumes ... 13
Use Case 2: Oracle Database recovery using vSphere Virtual Volumes .... 20

Chapter 4  Conclusion ...................................................................... 28
Summary ......................................................................................... 29
Findings ........................................................................................... 30

Chapter 5  References ..................................................................... 31
References ....................................................................................... 32
Recommended reading ..................................................................... 33

Appendix A  Configuring vSphere Virtual Volumes on EMC VMAX3 ...... 35
Introduction ...................................................................................... 36
Configuration prerequisites ............................................................... 36
Configuring the storage solution ...................................................... 37

Appendix B  Deploying Oracle Database on vSphere Virtual Volumes ...... 45
Introduction ...................................................................................... 46
Selecting Oracle data types .............................................................. 46
Creating virtual machines on vSphere Virtual Volumes ..................... 48
Other deployment considerations for Oracle Database ...................... 50
Chapter 1: Executive Summary

This chapter presents the following topics:

**Business case** .................................................................................................................. 5

**Solution overview** ........................................................................................................... 5

**Key benefits** ....................................................................................................................... 6

**Document purpose** ............................................................................................................. 7

**Audience** ............................................................................................................................ 7

**We value your feedback!** .................................................................................................... 7
Business case

Today nearly 70 percent of Oracle customers virtualize their database environments, including in production (Source: Independent Oracle Users Group). However, traditional virtual data service features have consumed a relatively large portion of host-level CPU and memory resources, which can negatively affect database performance and increase data response times. Offloading these tasks to the storage has been a gap in virtual-machine-level capabilities within virtual interfaces such as VMware vSphere. VMware vSphere Virtual Volumes addresses this challenge.

VMware vSphere Virtual Volumes provides enhanced storage and policy-based management control (SPBM) in vSphere 6.0, empowering the virtual-machine administrator with more efficient control and use of underlying storage resource.

vSphere Virtual Volumes is different from the traditional volume-centric approach of providing services at the host level to an environment because the storage of vSphere Virtual Volumes is virtual-machine aware. This changes how shared storage is used in virtualized environments, enabling a more granular application on a per-virtual-machine basis.

vSphere Virtual Volumes provides many features for storage and virtual data administrators, including:

- Granular SPBM control for virtual-machine administrators
- Volume-clone capabilities that enable you to quickly deploy new virtual machines
- Data protection optimized for individual virtual machines using vSphere-based snapshots
- End-to-end detailed SAN-storage metrics provided to virtual-machine administrators at a per-disk level of granularity

EMC and VMware believe that vSphere Virtual Volumes will eventually replace traditional VMware Virtual Machine File System (VMFS) clustered file system or raw-device mapping (RDM) approaches to Oracle database infrastructure management.

Solution overview

EMC® VMAX3™ provides a complete and integrated data services platform for mission-critical Oracle block and file workloads. VMAX3 enables Oracle database administrators to easily provision resources for varying service level objectives (SLOs), and then scale up performance and scale out capacity, cost-effectively and without disruption.

For information about existing EMC solutions and documentation outlining the value of VMAX3 SLOs and software functionality, refer to Chapter 5: References.

This EMC solution is the first in a series that shows the value of using vSphere Virtual Volumes on the VMAX3 storage array. This solution focuses on addressing the challenging of database cloning and backup and recovery.
Chapter 1: Executive Summary

This solution comprises the following key components:

- VMware vSphere 6.0 featuring VMware vSphere Virtual Volumes
- EMC VMAX3
- Oracle Database 12c Enterprise Edition

We tested and validated two use cases for this solution:

- **Use Case 1**: Oracle Database backup using vSphere Virtual Volumes
- **Use Case 2**: Oracle Database recovery using vSphere Virtual Volumes

Testing and validation of this solution confirmed:

- Creating point-in-time copies of Oracle databases is more efficient with vSphere Virtual Volumes. The base virtual disk has the latest data, which avoids the need to create and manage a complex 'snapshot chain'.
- Cloning an Oracle virtual machine only requires making a snapshot delta on the VMAX3 storage array instead of creating a child delta disk, which saves capacity when protecting Oracle databases using snapshots.
- Snapshot-based Oracle database backup and recovery are as efficient with vSphere Virtual Volumes as with Oracle Recovery Manager. Also, it is faster and easier to create and delete snapshots using vSphere Virtual Volumes.

**Key benefits**

The combination of vSphere Virtual Volumes and VMAX3 in this solution provides the following key benefits for virtualized Oracle environments:

- vSphere Virtual Volumes simplifies storage operations by automating tasks and reducing the interdependencies between the vSphere administrator and the storage administrator. Provisioning is faster and change management is simpler, because the vSphere administrator can use a policy-driven operational model.
- vSphere Virtual Volumes virtualizes storage devices by abstracting physical hardware resources into logical pools of capacity (represented as Virtual Datastore in vSphere) for Oracle virtual machines. It enables array-based operations at the virtual disk level that can be precisely aligned to Oracle application boundaries.
- vSphere Virtual Volumes defines a new virtual disk container (virtual volume) that is independent of the underlying physical storage representation (LUN, file system, object, and so on). This enables vSphere administrators to run storage operations with virtual machine granularity and to provision native array-based data services such as snapshots and compression to individual Oracle database virtual machines.
- vSphere Virtual Volumes offers finer control at the virtual machine level, enabling Oracle database administrators to:
  - Match virtual machine storage requirements exactly as needed with class of service delivered per virtual machine.
Chapter 1: Executive Summary

- Create vSphere-based snapshots of Oracle database virtual machines instead of the entire LUN
- Trigger a backup or clone a database from a virtual machine with VMDK-level granularity, no longer getting VMDKs of other databases as part of the backup/clone, which requires more time

Document purpose

The primary focus of this solution guide is to show the value of vSphere Virtual Volumes and its effect on multiple areas: storage operations, service-level delivery, and resource utilization.

The use cases address critical concerns around performance, faster database backups using snapshots/cloning, and disaster recovery/integrity for Oracle Database 12c.

Audience

The primary audience for this solution guide is storage and database administrators. Readers should have an understanding of Oracle databases and VMware vSphere virtual environments, and be familiar with EMC VMAX3.

We value your feedback!

EMC and the authors of this solution guide welcome your feedback on the solution and the solution documentation. Contact us at EMC.Solutions.Feedback@emc.com with your comments.

You can also post your feedback on the DBA Society community on the EMC Community Network and search for other EMC solutions for Oracle.

Authors: Mark Lin, Sam Lucido, Colleen Jones
This chapter presents the following topics:

- Solution architecture ................................................................. 9
- Key components ........................................................................... 10
- Hardware resources ..................................................................... 10
- Software resources ...................................................................... 11
Solution architecture

Introduction

This chapter describes the overall architecture and key components for this vSphere Virtual Volumes solution with VMAX3 and Oracle Database.

Solution architecture

Figure 1 shows the reference architecture of this solution.

Solution configuration

In this solution, we configured vSphere Virtual Volumes from both the storage system and the vSphere environment. From a storage perspective, the required components, such as the protocol endpoints, storage containers, and VMware vSphere API for Storage Awareness (VASA) provider, are installed and configured on the EMC VMAX3 storage array.

For configuration details, see Appendix A: Configuring vSphere Virtual Volumes on EMC VMAX3.
Chapter 2: Technology Overview

We followed the guidelines to set up the Oracle 12c database on the vSphere Virtual Volumes components. For details, see Appendix B: Deploying Oracle Database on vSphere Virtual Volumes.

The procedure for backing up and recovering an Oracle database on vSphere Virtual Volumes is validated in Use Case 2: Oracle Database recovery using vSphere Virtual Volumes.

For more information about Oracle database best practices, provisioning, and performance, refer to the recommended reading in Chapter 5: References.

**Key components**

**Overview**

This solution uses the following key components:

- VMware vSphere 6.0 including:
  - VMware vSphere Virtual Volumes
  - VMware vSphere API for Storage Awareness (VASA)
- EMC VMAX3
- Oracle Database 12c Enterprise Edition

**Hardware resources**

Table 1 lists the hardware resources used in the solution.

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Quantity</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage array</td>
<td>1</td>
<td>EMC VMAX3 200K:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Two engines (1 TB cache per engine)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 60 x 300 GB 15k Fibre Channel (FC) disks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 90 x 600 GB 10k FC disks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 90 x 2 TB 7.2k FC disks</td>
</tr>
<tr>
<td>Servers</td>
<td>2</td>
<td>- 20 x 2.999 GHz Intel Xeon physical CPU cores and 40 logical cores</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 512 GB memory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 2 x 10 GbE network interface cards (NICs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1 x 1 GbE network NICs</td>
</tr>
<tr>
<td>FC switches</td>
<td>2</td>
<td>8 GB/s FC</td>
</tr>
<tr>
<td>Ethernet switches</td>
<td>2</td>
<td>- 1 x 1 GbE/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1 x 10 GbE/s</td>
</tr>
</tbody>
</table>
Software resources

Table 2 lists the software resources used in this solution.

Table 2. Software resources

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC VMAX3 HYPERMAX OS</td>
<td>5977.691.684</td>
<td>Operating environment for VMAX3</td>
</tr>
<tr>
<td>EMC Solutions Enabler</td>
<td>T8.1.1.195</td>
<td>API between storage and other components</td>
</tr>
<tr>
<td>EMC Unisphere®</td>
<td>T8.1.1.8</td>
<td>VMAX3 management GUI</td>
</tr>
<tr>
<td>Oracle Enterprise Linux</td>
<td>7.1</td>
<td>Operating system for database servers</td>
</tr>
<tr>
<td>Oracle Database 12c</td>
<td>Enterprise Edition 12.1.0.2</td>
<td>Oracle Database software</td>
</tr>
<tr>
<td>EMC VASA Provider</td>
<td>2.0.0.559</td>
<td>A stand-alone component to help provision storage, such as EMC VMAX3, using vSphere Virtual Volumes</td>
</tr>
<tr>
<td>VMware vSphere</td>
<td>6.0</td>
<td>Hypervisor hosting all virtual machines</td>
</tr>
<tr>
<td>VMware vCenter</td>
<td>6.0</td>
<td>vSphere management server</td>
</tr>
<tr>
<td>Swingbench</td>
<td>2.5</td>
<td>Benchmarking tool</td>
</tr>
</tbody>
</table>
This chapter presents the following topics:

Introduction ........................................................................................................................................13

Use Case 1: Oracle Database backup using vSphere Virtual Volumes .........................13

Use Case 2: Oracle Database recovery using vSphere Virtual Volumes .....................20
Introduction

The test use cases described in this chapter address the following critical concerns related to transitioning to vSphere Virtual Volumes:

- Protection
- Backup and recovery

In Use Case 1, we used vSphere Virtual Volumes snapshots to protect and back up Oracle databases.

In Use Case 2, we recovered an Oracle database using a cloned vSphere Virtual Volumes snapshot.

Notes on test results

Benchmark results are highly dependent on workload, specific application requirements, and system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, do not use this workload as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

All performance data contained in this solution guide was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly.

EMC Corporation does not warrant or represent that a user can or will achieve similar performance expressed in transactions per minute.

Use Case 1: Oracle Database backup using vSphere Virtual Volumes

Introduction

To support an Oracle production system, Use Cases 1 and 2 address two fundamental areas: protecting the Oracle database, and aiding additional backup and recovery options by using vSphere Virtual Volumes snapshots to:

- **Create and delete Oracle database snapshots:** A snapshot provides a logical point-in-time view of the source virtual machine. We took snapshots of the Oracle databases in vSphere Virtual Volumes using vSphere and measured the time to delete snapshots after creation.

- **Back up Oracle databases:** We used vSphere Virtual Volumes snapshots to create a clone database on a different ESXi environment for the Recovery Manager backup. Recovery Manager performed a database backup without impacting the production server resources during the backup. The backup files were copied to the Oracle production database for future recovery purposes.

Test objectives

The test objectives for this use case were to:

- Show the process of cloning a database using snapshots to create crash-consistent copies of the database, and then use it as a backup server to perform an Oracle Recovery Manager backup
Chapter 3: Testing and Validation

- Show the use of multiple vSphere Virtual Volumes snapshots to create point-in-time copies of the source-database virtual machine, and measure the time to delete snapshots after creation

**Prerequisites**

Meet the following prerequisites before running this test:

- vSphere Virtual Volumes snapshots can be created for a specific virtual machine from the vSphere Web Client. The Snapshot Manager in vSphere Web Client provides operations for creating and managing virtual machine snapshots. However, to manage the snapshots more efficiently, we used VMware PowerCLI.

- Before running the VMware PowerCLI, install the following software in the test environment for scripting support:
  - VMware PowerCLI 6.0
  - Microsoft PowerShell 4.0
  - Microsoft Windows PowerShell Integrated Scripting Environment

- With the release of PowerCLI 6.0, the distribution model of cmdlets changed from snap-ins to modules. We imported modules into PowerShell using the `Import-Module` command.

**Test method**

This use case mainly focuses on vSphere Virtual Volumes snapshots and using the key technology components to meet the objectives of the Oracle database backup.

We used the following procedure to validate the backup test by implementing the Oracle database backup using snapshots. We performed the same test procedure separately on VMFS and vSphere Virtual Volumes.

1. Ran the OLTP I/O test suite against the Oracle virtual database.
2. Created multiple snapshots of the Oracle virtual machine on the VMFS or vSphere Virtual Volumes data store during workload and monitored the test progress, including snapshot creation time.
3. Deleted the snapshots generated in the previous step and monitored the test progress, including snapshot deletion time.
4. Cloned a virtual machine from a vSphere Virtual Volumes snapshot as an Oracle database backup source.
5. Performed a Recovery Manager backup (full database backup) using cloned vSphere Virtual Volumes snapshots.

Note: In this use case, we wanted to show the advanced capabilities of vSphere Virtual Volumes by taking several snapshots and making clones from them. Often, you can make a clone directly from production, which streamlines the database provisioning process. vSphere offloads the clone activity to VMAX3, which makes database provisioning very quick.
In this test, we provisioned Oracle virtual machines as vSphere Virtual Volumes on VMAX3 storage containers. We created the storage containers using the virtual machine vSphere Virtual Volumes No Requirements storage policy, which enables the data store to determine the best placement strategy for storage objects. We used the following command to create a point-in-time snapshot on an Oracle virtual machine provisioned separately on vSphere Virtual Volumes or VFMS.

```
vSphere PowerCLI > Get-VM OracleVM | New-Snapshot -Name "FirstSnap" -Description "FirstSnap on OracleVM" -Quiesce
```

**Notes:**
- We used the PowerCLI New-Snapshot command with the -Quiesce option to capture a crash-consistent snapshot and stop the guest OS from writing to the virtual disk during the snapshot creation.
- For more information, refer to the Oracle document *Supported Backup, Restore and Recovery Operations using Third Party Snapshot Technologies (604682.1)*. You need an account to access this content.
- Oracle Recovery Manager provides enhanced support for crash-consistent snapshot copies. For more information, refer to the Oracle Help Center topic *Database Backup and Recovery User's Guide*, specifically Making User-Managed Database Backups and Performing User-Managed Database Flashback and Recovery.

For the test, we created five snapshots in five-minute increments for both the vSphere Virtual Volumes and VMFS environments. We ran a 30-minutes Swingbench user workload during the snapshot creation period.

We generated Figure 2 based on the snapshot creation and deletion period on both VMFS and vSphere Virtual Volumes. The results show that there was little difference between vSphere Virtual Volumes snapshot creation and VMFS snapshot creation. However, the time to delete vSphere Virtual Volumes snapshots was greatly reduced.

![Figure 2. Snapshot creation and deletion comparison: vSphere Virtual Volumes versus VMFS](image)
Traditionally, VMFS snapshots had long deletion times, especially with many snapshots, similar to what we used in this test. The time-consuming part of deleting VMFS snapshots is rolling up all the changes from the snapshots into the base VMDK file. The 155 minutes for VMFS snapshot removal was the time for vSphere to roll all the changes from five snapshots into the base VMDK file. This is a considerable task for an OLTP workload that changes large amounts of data.

For more information about VMFS snapshot best practices, refer to the VMware Knowledge Base (KB) topic *Best practices for virtual machine snapshots in the VMware environment (1025279)*.

vSphere Virtual Volume snapshots are more efficient. To create a snapshot, vSphere creates a snapshot delta file that is responsible for maintaining a point-in-time copy of the data. In this use case, five snapshots were created; therefore, vSphere created five point-in-time delta files. Removing the snapshots means removing the point-in-time delta files, which happens quickly and does not require any roll-up activity.

Using vSphere Virtual Volumes snapshots is more efficient than using VMFS snapshots.

Test results: Database backup using vSphere Virtual Volumes and cloning

Next, we tested the ability of vSphere Virtual Volumes to clone an Oracle virtual machine from a point-in-time snapshot. In our example, we cloned the virtual machine *OEL_V71v3*, as shown in Figure 3.

We created the clone from the snapshot of the Oracle virtual machine using PowerCLI and the following command:

```
New-VMFromSnapshot -SourceVM OEL_V71v3 -CloneName "v3_Clone01" -SnapshotName "FirstSnap" -Datastore "VVOL_fra"
```

![Figure 3. Creating a clone from a snapshot of an Oracle virtual machine](image)

You can view the cloned *v3_Clone01* of source virtual machine *OEL_V71v3* in the virtual machine inventory list in the vSphere Web Client, as shown in Figure 4.
Figure 4. Viewing a clone of an Oracle virtual machine in the vSphere Web Client

We created other cloned virtual machines using previously created vSphere Virtual Volumes snapshots, to make different point-in-time database copies.

EMC recommends that you set up a cloned virtual machine to be the backup server in a different ESXi environment. This greatly reduces any conflicts between CPU and I/O resources in the production environment. By offloading the backup process from the Oracle production virtual machine to a cloned virtual machine, you can improve performance on the production database and reduce the backup window.

**Note:** In the following procedure, we set up another grid infrastructure; however, it is common for database administrators to prepare a virtual machine with pre-installed Oracle GRID/Database executables as a backup server. After mounting the relevant database ASM disk groups, you can configure the server to run Recovery Manager to do the database backup.

To set up a dedicated backup server and then run the Oracle Recovery Manager backup, we used the following procedure:

1. Confirmed the cloned virtual machine was ready for backup.
2. Reconfigured the grid infrastructure on one server and changed the server name and IP.
   a. Deleted the current grid infrastructure configuration using the `roothas.pl` script as root user with the correct attributes. If the grid infrastructure was running, all resources were stopped automatically before deletion.
   b. Added cluster resources.
   c. Started another grid infrastructure resource such as Oracle Listener.

Adding an Oracle ASM instance is optional.
For more information, refer to the Oracle document *Reconfiguring & Recreating the 11g R2/12c R1 Restart/OHAS/SIHA Stack Configuration (Standalone) (DOC ID 1422517.1)*. You need an account to access this content.

**Note:** You can create the recovery catalog on another host to enable redundancy for the Recovery Manager repository stored in the control file of each target database. For more information, refer to the Oracle topic *Resync Catalog*.

3. Mounted but did not open the database on the cloned virtual machine. Ran the Oracle Recovery Manager command to back up the database, as shown in Figure 5.

```
[oracle@swingbench ~]$ rman catalog rman_db01/rman_db01@catdb
RMAN> connect target/oracle@vvol3_79
RMAN> backup incremental level 0 database;
Starting backup at 14-DEC-15
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=799 device type=DISK
channel ORA_DISK_1: starting incremental level 0 datafile backup set
input datafile file number=00002 name=+DATA/VVOL3/DATAFILE/soecopy
input datafile file number=00007 name=+DATA/VVOL3/DATAFILE/lops.294.897589953
input datafile file number=00004 name=+DATA/VVOL3/DATAFILE/undotbs1.276.895320649
input datafile file number=00005 name=+DATA/VVOL3/DATAFILE/example.285.895320649
input datafile file number=00003 name=+DATA/VVOL3/DATAFILE/sysaux.275.895320649
input datafile file number=00001 name=+DATA/VVOL3/DATAFILE/system.274.895320649
input datafile file number=00006 name=+DATA/VVOL3/DATAFILE/users.278.895320649
channel ORA_DISK_1: starting piece 1 at 14-DEC-15
channel ORA_DISK_1: finished piece 1 at 14-DEC-15
piece handle=+/FRA/VVOL3/BACKUPSET/2015_12_14/nncen0_tag20151214t175029_0.335.898451429 tag=TAG20151214T175029 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:50:16
Finished backup at 14-DEC-15
```

**Figure 5.** Backing up clone database using Oracle Recovery Manager

4. Copied the backup files to the Oracle production database for future recovery purposes, as shown in Figure 6 and Figure 7.
Chapter 3: Testing and Validation

Figure 6.  Copying Oracle backup files to the production database

Figure 7.  Viewing catalog backup files in the production database

Findings

Database backups using vSphere Virtual Volumes snapshots

We tested the impact of creating and removing VMFS snapshots versus vSphere Virtual Volumes snapshots. We also tested the creation of a database clone from a point-in-time snapshot.

Reviewing the tests together, we confirmed that vSphere Virtual Volumes snapshots are more efficient than VMFS snapshots while providing the same level of protection and backup capabilities.

After database administrators create snapshots, they can move databases to different SLO levels using vSphere Virtual Volumes on VMAX3. The greater efficiencies in vSphere Virtual Volumes combined with VMAX3 SLOs provide an ideal performance consolidation platform for Oracle databases.
Chapter 3: Testing and Validation

**Database backups using vSphere Virtual Volumes and cloning**

When moving to a new virtual storage model, consider how using vSphere Virtual Volumes affects your database backup process. The goal of this test was to show two key points:

- An Oracle database can be backed up on vSphere Virtual Volumes
- Minimal changes are required to current backup procedures

Our testing showed that there were no issues with doing an Oracle database backup on vSphere Virtual Volumes using Oracle Recovery Manager.

The backup procedure we used to clone the virtual machine and back up the database can be used for both VMFS data stores and vSphere Virtual Volumes with minimal changes. For example, the only required changes are to the PowerCLI script and the server name and IP, based on which database is being backed up.

Every database administrator team backs up databases differently. EMC recommends reviewing and testing backups with vSphere Virtual Volumes. Our testing shows that vSphere Virtual Volumes have minimal to no impact on how databases are backed up.

**Use Case 2: Oracle Database recovery using vSphere Virtual Volumes**

**Introduction**

This use case tests Oracle database recovery using vSphere Virtual Volumes. Backups are based on the vSphere Virtual Volumes snapshots created in Use Case 1, and backup and recovery operations are implemented using Oracle Recovery Manager.

This use case shows the availability and resilience of the vSphere Virtual Volumes architecture by showing the data integrity during Oracle instance failure and Oracle virtual-machine failure.

**Test objectives**

The test objectives for this use case were to:

- Perform a complete Oracle database recovery using vSphere Virtual Volumes snapshots. After restoring the Oracle virtual machine from vSphere Virtual Volumes in a backup environment, we copied the Oracle datafiles back to the production environment and recovered to the last committed transaction.
- Verify database integrity by killing Oracle processes to simulate an instance failure and show an Oracle instance recovery.
- Verify database integrity by suddenly powering off the Oracle virtual machine while Oracle transactions are running and show an Oracle instance recovery.

**Test method**

We tested the following scenarios:

- Oracle lost datafile recovery using vSphere Virtual Volumes
- Oracle instance failure and recovery on vSphere Virtual Volumes
- Oracle virtual machine failure and recovery on vSphere Virtual Volumes
Oracle lost datafile recovery using vSphere Virtual Volumes

This section describes a database protection and disaster recovery test for an Oracle production database deployed on vSphere Virtual Volumes. A vSphere Virtual Volumes snapshot provides an easy way to recover Oracle datafiles from physical corruption or deletion. This provides the best data protection if an unexpected datafile failure or unplanned outage makes the data in Oracle Database unavailable.

To simulate the recovery of lost Oracle datafiles, we used the following procedure:

1. Simulated the loss of a datafile from the production database, as shown in Figure 8.

   ![Figure 8. Lost datafile in Oracle database](image)

   Figure 8. Lost datafile in Oracle database

2. Enabled access to point-in-time image from the vSphere Virtual Volumes snapshot/clone in backup environment.

3. Restored and recovered the datafile from the cloned database, as shown in Figure 9.
Chapter 3: Testing and Validation

Figure 9. Copying the missing datafile from the cloned database

4. Verified the recovered datafile were accessible and working, as shown in Figure 10.

Figure 10. Recovering the datafile using cloned database file
Similarly, to simulate the recovery of all lost Oracle datafiles, we used the following procedure:

5. Simulated the loss of all datafiles from the production database, as shown in Figure 11.

```
[grid@ool71v3 ~]$ [grid@ool71v3 ~]$ asmcmd
ASMCD> cd /DATA/VVOL3/DATAFILE
ASMCD> ls
EXAMPLE.285.895077775
SYSAUX.278.895077649
SYSTEM.276.895077683
UNDOTBS1.274.895077729
USERS.275.895077729
soecopy
ASMCD> rm -f *
ASMCD> ls
ASMCD> pwd
+DATA/VVOL3/DATAFILE
ASMCD>
```

**Figure 11.** Simulating all datafiles lost from the production database

6. Restored all lost datafiles from the copied backup file and from the cloned database, as shown in Figure 12.

```
RMAN> restore database;
Starting restore at 15-DEC-15
using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=386 device type=DISK
channel ORA_DISK_1: starting datafile backup set restore
channel ORA_DISK_1: specifying datafile[s] to restore from backup set
channel ORA_DISK_1: restoring datafile 00001 to /DATA/VVOL3/DATAFILE/system.274.895320649
channel ORA_DISK_1: restoring datafile 00002 to /DATA/VVOL3/DATAFILE/sysoecopy
channel ORA_DISK_1: restoring datafile 00003 to /DATA/VVOL3/DATAFILE/sysaux.275.895320649
channel ORA_DISK_1: restoring datafile 00004 to /DATA/VVOL3/DATAFILE/undotbs1.276.895320649
channel ORA_DISK_1: restoring datafile 00005 to /DATA/VVOL3/DATAFILE/example.285.895320649
channel ORA_DISK_1: restoring datafile 00006 to /DATA/VVOL3/DATAFILE/users.278.895320649
channel ORA_DISK_1: restoring datafile 00007 to /DATA/VVOL3/DATAFILE/iops.294.897509953
channel ORA_DISK_1: reading from backup piece +FRA/full_bak
channel ORA_DISK_1: piece handle=-FRA/full_bak tag=TAG28151214T175829
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore completes, elapsed time: 01:07:35
Finished restore at 15-DEC-15
```

**Figure 12.** Restoring all lost datafiles from the copied backup
Chapter 3: Testing and Validation

7. Recovered all lost datafiles and performed a complete database recovery, as shown in shown Figure 13.

```
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore complete, elapsed time: 01:07:35
Finished restore at 15-DEC-15

RMAN> recover database;
Starting recover at 15-DEC-15
using channel ORA_DISK_1
starting media recovery
media recovery complete, elapsed time: 00:00:52
Finished recover at 15-DEC-15
RMAN> alter database open;
Statement processed
RMAN>
```

**Figure 13. Recovering the Oracle database using backup files**

**Oracle instance failure and recovery on vSphere Virtual Volumes**

We manually killed the Oracle Instance by running the command `Kill -9 <Oracle SMON process id>` to simulate an Oracle instance failure.

To simulate an Oracle instance failure and recover it, we used the following procedure:

1. Opened the database on the Oracle virtual machine deployed on vSphere Virtual Volumes.
2. Ran the Swingbench workload against the Oracle instance.
3. Ran the command `Kill -9 <Oracle SMON process id>` to failure the Oracle instance.
4. Manually restarted the Oracle instance, and then monitored the Oracle alert log for warning and recovery messages.
5. Verified that the Oracle instance was recovered, as shown in Figure 14 and Figure 15.
Oracle virtual machine failure and recovery on vSphere Virtual Volumes

To simulate an Oracle virtual machine unplanned shut down and recovery, we used the following procedure:

1. Opened the database on the Oracle virtual machine deployed on vSphere Virtual Volumes.

2. Ran the Swingbench workload against the Oracle instance.
3. Powered off the Oracle virtual machine through the vSphere Web Client.

4. Powered on the Oracle virtual machine, and then checked the virtual machine and database statuses, as shown in Figure 16 and Figure 17.

Figure 16. Powering off the Oracle virtual machine during workload

Figure 17. Verifying Oracle instance recovery after Oracle virtual machine power off
Findings

Our tests validated that the Oracle recovery process remained unchanged when we did a recovery using vSphere Virtual Volumes.

- In the first test, we recovered a datafile or all datafiles from a cloned copy of the database. The Oracle database performed a media recovery and open normally.
- In the second test, we purposely failed the Oracle instance. We opened the database and make a cache recovery.
- In the third test, we shut down the virtual machine while the database was running a Swingbench workload. When we restarted the virtual machine, we started up the database and verified the failure recovery.

In all three recovery tests, the database was consistently and quickly recovered without any complexities or abnormalities. Database administrators want to minimize unplanned downtime. Our tests show that moving to vSphere Virtual Volumes does not lengthen or complicate an Oracle database recovery.
Chapter 4: Conclusion

This chapter presents the following topics:

Summary ........................................................................................................................................... 29
Findings ............................................................................................................................................. 30
Summary

Our testing shows that using VMware vSphere Virtual Volumes on EMC VMAX3 enables more elasticity, mobility, and protection for virtualized Oracle database environments.

**Snapshot workloads**

vSphere Virtual Volumes snapshots imposed no performance penalties. You can create vSphere Virtual Volume snapshots knowing that there is little to no impact on production performance. VMAX3 SLOs monitor storage performance and automatically move blocks to ensure response times stay within the range of the SLOs. Using vSphere snapshots with VMAX3 SLOs automates response-time management and minimizes or eliminates any storage-based database tuning.

**Snapshot creation and removal**

Snapshot creation times were the same for vSphere Virtual Volumes and VMFS. However, vSphere Virtual Volumes was exceptionally quick for snapshot removal. The role of the vSphere administrator is becoming increasingly important as companies invest in hybrid-storage solutions, such as VMAX3, to enable database as a service and the cloud. Our testing shows that accelerating database lifecycle management using vSphere snapshots works flawlessly on VMAX3. Using vSphere Virtual Volumes on VMAX3 means faster provisioning and deletion of databases, and more granular placement of databases.

vSphere Virtual Volumes is more efficient for snapshot removal, which can save you minutes or even hours depending on the number of snapshots, and minimizes any impact to production.

**Database backup and recovery**

Our tests confirm that you can back up or recover an Oracle database equally quickly using vSphere Virtual Volumes or VMFS data store.

vSphere Virtual Volumes does not affect or complicate database backups and recoveries. There is no additional risk to a database recovery based on the methods we tested.

**Service level objectives**

VMAX3 SLOs together with vSphere Virtual Volumes offer database administrators a powerful combination. Database administrators can select the best performance level for a database. If requirements change, they can dynamically move the database to a different level. VMAX3 SLOs combined with the granularity of vSphere Virtual Volumes provide granularity and automates storage performance management. We found that using vSphere Virtual Volumes with VMAX3 SLO can save you up to 85 percent of the storage management and tuning normally required with traditional arrays, as shown in Figure 18.
Findings

Advantages of VMware vSphere Virtual Volumes on EMC VMAX3

In this solution guide, we have shown that there are no obstacles to prevent you from using vSphere Virtual Volumes for a virtualized Oracle environment. VMAX3 enables you to take advantages of the features of vSphere Virtual Volumes:

- **Automation of storage SLO at scale**
  Use vSphere Virtual Volumes with VMAX3 SLOs to manage consolidation and database performance. The SLOs (Diamond, Platinum, Gold, Silver, Bronze, and Optimized) enable you to intelligently place databases over a wide range of performance tiers.

- **Simple change management using policies**
  Instead of moving databases, you can change the SLO in the policy attached to vSphere Virtual Volumes. Depending on the policy change, a database non-disruptively moves to the correct SLO tier.

- **Finer control of storage SLO**
  Match the virtual machine storage requirements to the SLO delivered per virtual machine and to any VMAX3 SLO tier.

- **Effective monitoring and troubleshooting**
  vSphere Virtual Volumes enables you to monitor individual virtual-machine performance and storage-performance metrics. This provides easier storage-performance analysis and faster remediation times. For example, you can easily view a database's storage performance and determine if moving the database to another SLO tier is required.

- **Safeguarding your existing investment**
  vSphere Virtual Volumes already integrates with products and tools such as VMware vRealize Automation, PowerCLI, and OpenStack. EMC predicts that vSphere Virtual Volumes will gain more functionality and integration with other products over time.
Chapter 5 References

This chapter presents the following topics:

References ........................................................................................................................................... 32

Recommended reading ...................................................................................................................... 33
Chapter 5: References

References

**EMC documentation**

The following documentation on the EMC.com website provides additional and relevant information. Access to these documents depends on your login credentials. If you do not have access to a document, contact your EMC representative.

- *Deployment Best Practice for Oracle Database with VMAX3 Service Level Objective Management White Paper*
- *EMC VMAX3 All-Flash Storage for Mission-Critical Oracle Databases White Paper*
- *EMC VMAX3 Service Level Objectives and SnapVX for Oracle RAC 12c White Paper*
- *EMC VMAX3 Family with HYPERMAX OS Product Guide*
- *Implementing VMware vSphere Storage API for Storage Awareness with Symmetrix Storage Arrays White Paper*
- *Oracle Database Backup and Recovery with VMAX3 White Paper*

**VMware documentation**

For more information about vSphere 6 and about vSphere Virtual Volumes, refer to the VMware vSphere 6 Documentation information hub and the vSphere > vSphere Virtual Volumes feature page respectively on the VMware website, and to the following documentation:

- *Best practices for virtual machine snapshots in the VMware environment (1025279)* (VMware KB topic)
- *Understanding Virtual Volumes in VMware vSphere 6.0 (2113013)* VMware KB topic
- *vSphere Storage APIs - Storage Awareness FAQ (2004098)* (VMware KB topic)
- *VMware What’s New: vSphere Virtual Volumes*
- *VMware vSphere Virtual Volumes Solutions Overview*
- *VMware vSphere Virtual Volumes Getting Started Guide*

**Oracle documentation**

For more information about Oracle 12c, refer to the Oracle Database 12c information hub on Oracle and to the following online documentation. You may need an Oracle account to access some of the documentation.

- *Oracle Grid Infrastructure Installation Guide 12c Release 1 (12.1) for Linux*
- *Oracle Database Installation Guide 12c Release 1(12.1) for Linux*
- *Reconfiguring & Recreating the 11g R2/12c R1 Restart/OHAS/SIHA Stack Configuration (Standalone) (Doc ID 1422517.1)*
- *Supported Backup, Restore and Recovery Operations Using Third Party Snapshot Technologies (Doc ID 604682.1)*
Recommended reading

EMC has a library of solutions to assist you with best practices and deployment details for supporting Oracle databases on VMAX3. We particularly recommend the following white papers.

**Deployment Best Practice for Oracle Database with VMAX3 Service Level Objective Management**

The *Deployment Best Practice for Oracle Database with VMAX3 Service Level Objective Management White Paper* reviews storage design principles for Oracle on VMAX3. The granularity offered by vSphere Virtual Volumes enables you to place the datafiles and redo logs across different SLO tiers.

Use Case 1 in our solution testing shows how the transactions per minute (TPM) and db_file_sequential read times improved when we moved an OLTP workload from Bronze through all the SLO tiers to Platinum. Response times increased by five times and response times decreased by five times when we moved the OLTP workload to Platinum.

Although our testing was done in a physical environment, vSphere Virtual Volumes would be ideal to replicate the storage architecture. In our test, all datafiles resided on their respective tiers, but throughout the performance tests, the online redo logs always remained on the Bronze tier.

For best practices and supporting tests to show how Oracle databases can be optimized on VMAX3, refer to the *Deployment Best Practice for Oracle Database with VMAX3 Service Level Objective Management White Paper*.

**EMC VMAX3 Service Level Objectives and SnapVX for Oracle RAC 12c**

The *EMC VMAX3 Service Level Objectives and SnapVX for Oracle RAC 12c White Paper* shows mixed database workloads running on VMAX3. The paper presents findings that prove the hybrid storage platform is best for accelerating all kinds of workloads.

The white paper also explores the VMAX Data Storage Analyzer, which enables you to cache database objects to further improve performance.

A key finding from that paper is that a combined data warehouse and OLTP workload does not impact each other’s performance. VMAX3 can balance both database workloads to remain within the Gold SLO performance tier.

For more information about managing mixed database workloads on VMAX3, refer to the *EMC VMAX3 Service Level Objectives and SnapVX for Oracle RAC 12c White Paper*.

**EMC VMAX3 All-Flash Storage for Mission-Critical Oracle Databases**

Most VMAX3 hybrid storage arrays ship with flash, but they can also be configured as all-flash. The *EMC VMAX3 All-Flash Storage for Mission-Critical Oracle Databases White Paper* is unique because it tests Oracle OLTP workloads on an all-flash VMAX3.

In the first OLTP workload test, only two percent of the VMAX3 cache was used, which means that the flash drives serviced all read miss requests. In that configuration, the database drove 145,000 IOPS with 1 ms response times.
In the second OLTP workload test, 40 percent of the VMAX3 cache was used, which increased the read hit rate. This had a profound effect, because the IOPS increased to 200,140, and the response times decreased to sub-millisecond performance.

For more information about the VMAX3 all-flash configuration, refer to the *EMC VMAX3 All-Flash Storage for Mission-Critical Oracle Databases White Paper.*
Appendix A  Configuring vSphere Virtual Volumes on EMC VMAX3

This appendix presents the following topics:

Introduction ......................................................................................................................36
Configuration prerequisites ..............................................................................................36
Configuring the storage solution ....................................................................................37
Appendix A: Configuring vSphere Virtual Volumes on EMC VMAX3

Introduction

This appendix describes how we installed and configured vSphere Virtual Volumes on the VMAX3 storage array. The configuration of vSphere Virtual Volumes requires that both the storage system and the vSphere environment are prepared correctly.

The procedure for configuring the vSphere Virtual Volumes components on the storage system varies based on the vendor implementation and can differ based on the array brand and model.

For detailed information on the procedures required to configure the vSphere Virtual Volumes required components, refer to the storage system’s documentation or contact your EMC storage vendor.

Configuration prerequisites

You must meet the following requirements before you can enable vSphere Virtual Volumes.

Storage

The storage system must be compatible with vSphere Virtual Volumes and able to integrate with vSphere 6.0 using VASA 2.0.

A storage vendor provider must be available. If the vendor provider is not available as part of the storage system, deploy a vendor provider appliance.

Configure the protocol endpoints, storage containers, and storage profiles on the storage system.

vSphere

Follow the guidelines to set up the storage solution that is used: FC, NFS, FCoE, or iSCSI.

Synchronize the time of all storage components with vCenter Server and all ESXi hosts. VMware recommends that you use network time protocol (NTP) for the synchronization.

To configure vSphere Virtual Volumes, use the following procedure to complete the component tasks in the correct sequence:

1. Install VASA Provider 2.0 for VMAX3.
2. Configure the storage resources.
3. Register the storage provider.
4. Create the virtual data stores for vSphere Virtual Volumes.
5. Map storage capabilities to the virtual-machine storage policies.

These procedures are described in detail in the following sections.
Configuring the storage solution

EMC VASA Provider 2.0 for VMAX3 is a stand-alone component that is installed on ESXi 5.5 or ESXi 6.0 as a virtual appliance (vApp). This serves as an orchestration layer to help you provision vSphere Virtual Volumes based storage from VMAX3.

VASA Provider needs access to gatekeeper devices on the back-end VMAX3 and access to a LUN that is used for placing the VASA Provider database. You can do this configuration using vApp Manager.

Install VASA Provider as a vApp, as shown in Figure 19.

![Figure 19. Installing the VASA Provider vApp](image)

Your system must meet the following VASA Provider vApp requirements:

- ESXi and vCenter run with vSphere 6.0 builds
- One vCPU
- 1 GB memory
- Two virtual NICs (vNICs)
- 21 GB of storage space on ESXi: 2 VMDKs
- One 4 GB tdev for the VASA database
- Minimum of two gatekeepers
- FC connection between ESXi and VMAX3
After VASA Provider is installed, vApp Manager provides a URL so you can register the provider with VMware vCenter. You can access vApp Manager using the URL: https://<vApp-host-name>:5480/SE.

**Note:** One VASA Provider instance supports one VMAX3 array in the current release.

For more information about installing VASA Provider, refer to the *VASA Provider 2.0 (beta) for VMAX3 Installation Guide and Release Notes.*

By using a VASA API, the storage system is aware of the virtual volumes and their association with the relevant virtual machine. In this solution, VMAX3 is preconfigured with data pools and a storage resource pool. Create the host devices and make them visible to the hosts through device masking.

**Note:** Zoning at the switch sets the physical connectivity that device masking defines more closely. Set the zoning in advance between the host initiators and the storage ports that are used for device-masking tasks.

### Configuring the storage resources

### Creating host devices and device-masking components

You can create devices in the following ways:

- Using Unisphere for VMAX3 UI
- Using Solutions Enabler CLI

To use device masking to make the devices visible to the hosts:

1. Create an initiator group.
   - The initiator group is the list of host HBA port WWNs to which the devices are visible.
2. Create a storage group.
   - Storage groups are used for both EMC Fully Automated Storage Tiering (FAST®) SLO management and storage provisioning.
3. Create a port group.
   - A port group is the group of VMAX3 front-end ports where the host devices are mapped and visible.
4. Create a masking view.
   - The masking view brings together a combination of initiator groups, storage groups, and port groups.

Device masking helps you control access to storage. For example, you can share storage ports across many servers, but only the masking view determines which server has access to the devices and storage ports.

### Creating protocol endpoints and storage containers

After you complete device masking, create the protocol endpoint and storage container for vSphere Virtual Volumes from the dashboard in Unisphere, as shown in Figure 20.
Appendix A: Configuring vSphere Virtual Volumes on EMC VMAX3

Figure 20. Unisphere for VMAX: vSphere Virtual Volumes dashboard

Create a protocol endpoint to make a data path from the virtual machines to their respective virtual volumes on demand. Add the protocol endpoint to the masking view by clicking Provision PE to Host, as shown in Figure 21, and then select the host group/port group.

Figure 21. Creating a protocol endpoint in the dashboard
You must rescan the ESXi storage for the masking view to be discoverable by the ESXi Server.

**Note:** One protocol endpoint per ESXi server is supported in the current release.

Provide a name and description for the storage container. Assign capability profiles to the storage container. For example, we used **Bronze** for the SLO and **OLTP** for the workload, as shown in Figure 22.

![Figure 22. Creating a storage container in the dashboard](image)

**Registering the storage provider**

After you have created a storage container in vSphere, you can create a virtual data store for vSphere Virtual Volumes. Establish a communication link between the vCenter Server instance and the storage system.

To register a new storage provider:

1. Browse to **vCenter Server** in the vSphere Web Client.
2. Select **Manage**, and then select **Storage Provider**.
3. Verify that a VASA Provider appliance is deployed and obtain its credentials from the storage administrator, as shown in Figure 23.
Appendix A: Configuring vSphere Virtual Volumes on EMC VMAX3

Creating the virtual data stores for vSphere Virtual Volumes

To create a virtual data store for vSphere, Virtual Volumes, use the New Datastore wizard in the vSphere Web Client:

1. Select the host in the vSphere inventory.
2. Right-click and browse to the storage menu.
3. Click New Datastore.
4. Type a data store name.
   a. Ensure that the name is not a duplicate of another data store name in the vCenter Server instance inventory.
   b. If you mount the same data store on multiple hosts, the name of the data store must be the same across all the hosts.
5. Select VVOL as the virtual data store type, as shown in Figure 24.

![Figure 23. Registering a storage provider in vCenter](sandbox-vcenter.gso.lab.emc.com - New Storage Provider)

![Figure 24. Creating a data store in the vSphere Web Client](New Datastore)

6. From the list of storage containers, select a backing storage container.
7. Click Next to view the configuration options, and then click Finish to view the list of data stores, as shown in Figure 25.
After you create the virtual data stores, you can mount them onto other hosts using the **Mount Datastore to Additional Hosts** wizard in the vSphere Web Client, as shown, in Figure 26.
After you configure all the vSphere Virtual Volumes components, define the storage requirements and storage service for the virtual machines and their virtual disks.

To stratify the virtual machines service requirements, create virtual-machine storage policies in the vSphere Web Client, as shown in Figure 27.

Mapping storage capabilities to virtual-machine storage policies

To create the virtual-machine storage policies:

1. In the vSphere Web Client, select **VM Storage Policies**, as shown in Figure 27.
2. Click the **Create a New Storage Policy** icon.
3. Select the vCenter instance.
4. Type a name and description for the storage policy.
5. In the **Rule-Set 1** window, select the vendor provider for the storage system that is registered with vSphere from the **Rules based on data services** list box, as shown in Figure 28.
Figure 28. Creating a new virtual-machine storage policy

6. Review the list of data stores that match the **VM StoragePolicy**, and then click **Next**.

7. Verify the **VM Storage Policy** configuration settings, and then click **Finish**.

Ensure that the storage containers meet the requirements set in the virtual-machine storage policy and that they appear on the list of compatible data stores.

The virtual-machine storage policy should have now been added to the list and can be applied to virtual machines and its virtual disks.

**Note:** A virtual data store does not need to satisfy all the rule sets defined within the virtual-machine storage policy. A virtual data store must satisfy at least one rule set, and all rules within that set.
Appendix B  Deploying Oracle Database on vSphere Virtual Volumes

This appendix presents the following topics:

- **Introduction** .................................................................................................................. 46
- **Selecting Oracle data types** ............................................................................................ 46
- **Creating virtual machines on vSphere Virtual Volumes** ............................................... 48
- **Other deployment considerations for Oracle Database** ............................................... 50
Appendix B: Deploying Oracle Database on vSphere Virtual Volumes

Introduction

This appendix describes the tasks for deploying the virtualized Oracle Database 12c database onto virtual data stores for vSphere Virtual Volumes. When the tasks are complete, Oracle servers are set up on virtual machines with all the database files, using the data stores designed for the vSphere Virtual Volumes infrastructure. The database files include data files, control files, online redo files, voting disk files, Oracle Clusterware (CRS) files, and so on.

This appendix also provides guidelines for various Oracle data types and the selection of SLOs to achieve a specific database performance on VMAX3. With FAST and SLO management, VMAX3 provides the right amount of resources to each environment, and modifies the environment as business priorities or performance needs change over time.

Selecting Oracle data types

For this solution, we used the Oracle data types listed in Table 3.

<table>
<thead>
<tr>
<th>Virtual machine hard disk/SCSI controller</th>
<th>Storage container</th>
<th>VMDK</th>
<th>Contains</th>
<th>SLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Disk 1 SCSI (0:0)</td>
<td>ORACLE_VVOL_OS</td>
<td>[ORACLE_VVOL_OS]</td>
<td>+OS (ASM Disk Group)</td>
<td>Bronze SLO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>naa.600009700BB96B 571679002600000010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/Oracle-VVOL.vmdk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Disk 2 SCSI (0:1)</td>
<td>ORACLE_VVOL_OS</td>
<td>[ORACLE_VVOL_OS]</td>
<td>+OS (ASM Disk Group)</td>
<td>Bronze SLO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>naa.600009700BB96B 571679002600000010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/Oracle-VVOL_1.vmdk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Disk 3 SCSI (1:0)</td>
<td>ORACLE_VVOL_DATA</td>
<td>[ORACLE_VVOL_DATA]</td>
<td>+DATA (ASM Disk Group)</td>
<td>Bronze SLO (Gold SLO recommended)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>naa.600009700BB96B 571679002600000010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/Oracle-VVOL.vmdk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Disk 4 SCSI (2:0)</td>
<td>ORACLE_VVOL_REDO</td>
<td>[ORACLE_VVOL_REDO]</td>
<td>+REDO (ASM Disk Group)</td>
<td>Bronze SLO (Gold SLO recommended)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>naa.600009700BB96B 571679002600000018</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/Oracle-VVOL.vmdk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Disk 5 SCSI (3:0)</td>
<td>ORACLE_VVOL_FRA</td>
<td>[ORACLE_VVOL_FRA]</td>
<td>+FRA (ASM Disk Group)</td>
<td>Bronze SLO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>naa.600009700BB96B 571679002600000018</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/Oracle-VVOL.vmdk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
With vSphere Virtual Volumes, VMware offers a model in which an individual Oracle virtual machine and its disks, rather than LUNs, become a unit of storage management for a storage system.

In this solution, we created four vSphere Virtual Volumes storage containers on the array for Oracle datafiles, redo log files, FRA files, and OS/cluster files. In general, EMC recommends that you separate the following data types for mission-critical databases into distinct datastores/storage containers:

- **+DATA**: Minimum of one disk group for data and control files. Large databases may use more disk groups for datafiles, based on business needs, retention policy, and so on. Each disk group can have its own vSphere Virtual Volumes datastore/storage container.

- **+REDO**: Online redo logs. A single ASM disk group has its own vSphere Virtual Volumes datastore/storage container. EMC recommends that you separate data from logs for performance reasons, but also so that a restore of the datafile devices does not over-write the redo logs during backup and recovery.

- **+FRA**: Archive or flashback logs that have their own vSphere Virtual Volumes datastore/storage container.

- **+OS**: OS files and Oracle database software binary files that have their own vSphere Virtual Volumes datastore/storage container. When storage replications are used, those files also must be replicated.

- **+GRID** (optional): Typically keeps Oracle cluster configuration files when Oracle ASM is required and configured. In this solution, we deployed the cluster configuration files onto a +OS vSphere Virtual Volumes data store. In a single-instance Oracle environment, do not separate cluster configuration files from other files.

---

**Note**: When Oracle RAC is installed, EMC recommends that you use a separate vSphere Virtual Volumes data store for the Oracle cluster configuration files and quorum devices. EMC also recommends only for this disk group to use Normal, or High ASM redundancy (double or triple ASM mirroring). All other disk groups should normally use External redundancy, leveraging capacity saving and VMAX RAID protection.
EMC recommends using Gold SLO for database datafiles and redo log files, while other files can use Bronze SLO. In this solution, as shown in Table 3 on page 46, the Bronze SLO fit our OLTP test performance needs. You can assign different SLOs to different Oracle data types to provide the right amount of resources to meet each file’s performance needs.

VMAX3 SLO provides a range of allowed I/O latency that FAST works to maintain between different storage groups/storage containers.

For more information about SLOs, refer to the Deployment Best Practice for Oracle Database with VMAX Service Level Objective Management White Paper.

Creating virtual machines on vSphere Virtual Volumes

When the vSphere infrastructure and the storage systems are ready, and you have configured and defined their respective polices and capabilities, deploy Oracle virtual machines onto virtual data stores for vSphere Virtual Volumes.

To create a virtual machine and deploy it onto the virtual data store for vSphere Virtual Volumes:

1. Select any virtual-machine parent object (data center, cluster, host, or resource pool) in the vSphere inventory.
2. Right-click any of the objects listed and select New Virtual Machine.
3. When the New Virtual Machine wizard opens, select Create a new Virtual Machine and click Next.
4. Type a name and select a location for the virtual machine, and then click Next.
5. Select the computer resource for the new-virtual-machine deployment operation and click Next.
6. Select a virtual-machine storage policy to configure the virtual machine storage requirements for a virtual data store.
7. Select the compatible data store that meets the storage requirements for the chosen policy, as shown in Figure 29, and click Next.
Appendix B: Deploying Oracle Database on vSphere Virtual Volumes

8. Select the host compatibility for the Virtual Machine and click **Next**.

9. Select the **Guest OS Family** and **Guest OS version** to be installed on the virtual machine and click **Next**.

10. Customize the virtual machine hardware as required, and then click **Next**.

11. Review the virtual machine configuration, including the selected **VM Storage Policy**, and then click **Finish**, as shown in Figure 30.

![Figure 29. Selecting storage](image)

Figure 29. Selecting storage

![Figure 30. Reviewing the virtual machine configuration](image)

Figure 30. Reviewing the virtual machine configuration
Other deployment considerations for Oracle Database

**ASM and database striping considerations**

Oracle ASM natively stripes its content across the ASM members (storage devices). ASM uses two types of striping.

The first, which is the default for most Oracle data types, is *coarse striping*. It allocates capacity across ASM disk groups of nine members using a round-robin format, with a 1 MB default allocation unit or stripe depth. You can size an ASM allocation unit from 1 MB (default) up to 64 MB.

The second type of ASM striping is *fine-grain striping*. It is used only for the control files. Fine-grain striping divides the ASM disk groups into eight members, allocates an allocation unit on each. It then stripes the newly created data at 128 KB across the eight members until each member’s allocation unit is full.

Typically, ASM default behavior is adequate for most workloads. However, when Oracle databases expect a high update rate, this generates numerous redo logs. EMC recommends setting the redo logs ASM template10 to fine-grain rather than coarse to create better concurrency. To change the database redo logs template, run the following command on the ASM disk group holding the logs:

```
SQL> ALTER DISKGROUP <REDO_DG> ALTER TEMPLATE onlinelog ATTRIBUTES (FINE);
```

**Partition alignment considerations for X86-based platforms**

ASM requires at least one partition on each host LUN. Some operating systems (such as Solaris) also require at least one partition for user data. Due to a legacy BIOS architecture, by default, x86-based operating systems tend to create partitions with an offset of 63 blocks, or 63 * 512 bytes = 31.5 KB. This offset is not aligned with the VMAX3 track boundary (128 KB). As a result, I/Os crossing track boundaries may be requested in two operations, causing unnecessary overhead and a potential for performance problems.

The sample shown in Figure 31 shows the use of the fdisk command.
Figure 31. Sample of fdisk command data

Note: EMC recommends that you align the host partition of VMAX3 devices to an offset of at least 1 MB (2,048 blocks). Use the Linux parted command or the expert mode in fdisk command to move the partition offset.

Optimizing Oracle parameters

Multiple changes in Oracle parameters are required to ensure the best performance of Oracle Database when used with vSphere Virtual Volumes and VMAX3. These parameter changes are outlined in the Deployment Best Practices for Oracle Database with VMAX Service Level Objective Management White Paper.
Optimization best practices include:

- **Automatic Shared Memory Management (ASMM)** is a standard method of dynamically managing memory in an Oracle database and has been available since Oracle Database 10g. EMC recommends that you implement ASMM to automate the management of the Oracle shared memory structures. To implement this feature, set the following initialization parameters:
  - SGA_TARGET set to a non-zero value
  - STATISTICS_LEVEL=TYPICAL (or ALL)

- **HugePages** is crucial for faster Oracle database performance on Linux if you have a large RAM and SGA. If the combined database SGAs are large (more than 8 GB), configure HugePages.

  **Note:** Do not use Oracle Automatic Memory Management, which is incompatible with HugePages. If you want to use Linux HugePages, ensure that both MEMORY_TARGET and MEMORY_MAX_TARGET initialization parameters are not set.

- **Set DISKASYNCHIO=TRUE:** The default value for this asynchronous I/O for Oracle Database 12c is true.

- **Set FILESYSTEMIO_OPTIONS=SETALL:** This enables both direct I/O and asynchronous I/O.
  - Direct I/O is a feature available in the file system that delivers data directly to the application without caching in the file system buffer cache.
  - With asynchronous I/O, processing continues while the I/O request is submitted and processed. This enables asynchronous I/O to bypass some of the performance bottlenecks associated with I/O operations.