UPGRADE TO ORACLE DATABASE 12c WITH ORACLE MULTITENANT OPTION (PLUGGABLE DATABASE)

Enabled by EMC Symmetrix VMAX 40K and EMC TimeFinder/Clone

- Faster replication
- Efficient storage management with EMC Virtual Provisioning
- Nondisruptive to existing Oracle production infrastructure

EMC Solutions Group

Abstract

This white paper describes how to upgrade Oracle 11g database to Oracle 12c and, optionally, convert it to a new multitenant database architecture using EMC® TimeFinder®/Clone technology to accelerate the migration process. The virtualized OLTP environment is deployed on VMware vSphere 5.1 and resides on an EMC Symmetrix® VMAX® 40K storage system.

September 2013
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Executive summary

Business case

Oracle Database 12c (Oracle 12c) is the newest database technology from Oracle Corporation and contains more than 500 new features. Because Oracle Database 11g release 2 (Oracle 11gR2) will enter “Extended Support” on February 1, 2015, a number of customers are already examining their upgrade options.

One of the high-profile new features of Oracle 12c Enterprise Edition (EE) is the multitenant option. This option allows the creation of many pluggable databases (PDBs) within a single multitenant container database (CDB). The PDBs share resources provided by the CDB, such as memory, background processes, UNDO, REDO, and control files. This enables more databases to run on a single platform than was possible with the former Oracle 11gR2 architecture.

You should evaluate the impact of adopting this new Oracle technology into your current Oracle infrastructure before upgrading.

This white paper describes an Oracle 12c migration from an existing Oracle 11gR2 EE single-instance database using Automatic Storage Management (ASM) to an Oracle 12c EE single-instance database. The migration process includes conversion of the single-instance database to an Oracle 12c PDB deployed on an EMC® Symmetrix® VMAX® 40K storage array using VMware vSphere 5 as the virtualization technology. The conversion is accomplished using Oracle’s recommended My Oracle Support (MOS) migration document (see References).

EMC TimeFinder® replication technology accelerates this Oracle 12c migration. The replication is nondisruptive to the production database infrastructure because the provisioning of the database files for the migration of Oracle 11gR2 to Oracle 12c is executed on the VMAX 40K via TimeFinder/Clone technology. Because the copy is offloaded to the storage array, the TimeFinder process does not consume any database server resources such as CPUs or memory.

In summary, this Oracle 12c migration solution uses EMC technologies (VMAX 40K and TimeFinder) to allow nondisruptive replication of database files for the migration. After the Oracle 11g database is migrated and converted to an Oracle 12c PDB, the same EMC technology can replicate PDB databases to meet daily Oracle operational lifecycle needs for rapid on-demand cloning of Oracle 12c PDBs for use in production, development and test, patch, and other Oracle environments.

Solution overview

Every mission-critical system requires multiple copies of data for development, testing, backup offloading, reporting, data publishing, and more. With EMC Symmetrix VMAX using EMC TimeFinder/Clone technology, one or more Oracle database copies (either full volume TimeFinder Clones or space-efficient VP Snaps) can be created or restored in seconds, regardless of the database size.
The Oracle multitenant architecture offers operational flexibility for moving a PDB between multitenant CDBs by unplugging from one and plugging into the other. The multitenant architecture supports the following configurations:

- Single-tenant configuration—one PDB plugged into a CDB—is available at no extra cost in all editions.
- Multitenant option for up to 252 pluggable databases per CDB is available with Oracle 12c EE at an additional cost.

Figure 1 shows the workflow for upgrading to Oracle 12c and converting to a PDB within a multitenant environment. The detailed steps are shown in Testing and validation on page 17.

**Key benefits**

The solution enables the fast and easy replication of Oracle databases between hosts and virtual machines with the following benefits:

- Upgrading a cloned copy of the source database ensures that all application objects and grants are in place.
- The target devices are available immediately to the host upon activation of the TimeFinder copy session. You do not need to wait on slow host copy methods, such as RMAN duplicate, Oracle Data Pump export, or Golden Gate, to complete.
- Using TimeFinder/Clone technology avoids the cost of additional expensive licenses for products or features that create a host copy, such as Oracle Golden Gate.

- When Virtual Provisioning™ storage management is simplified and on the target device, storage is allocated as needed from the shared virtual pool of physical disks. Also, data is striped across all data devices in the virtual pool, balancing the workload across physical storage devices.

- Using Auto-Provisioning Groups simplifies the creation and mapping of storage for Oracle database environments.

- Symmetrix VMAX 40K provides validated and trusted multitenant storage environments.
Introduction

Purpose
This white paper describes a solution that upgrades an Oracle database 11g running on Oracle ASM to version 12c and, optionally, converts it to a PDB. This solution is enabled by TimeFinder/Clone technology as the replication mechanism in a VMware vSphere environment.

Scope
The scope of the white paper is to present the following:

- Introduction of the key enabling technologies
- Description of the solution architecture and design
- Description of the key components and processes
- Identification of the key business benefits of the solution

Audience
This white paper is intended for Oracle database administrators, VMware administrators, storage administrators, IT architects, and technical managers responsible for designing, creating, and managing Oracle databases, infrastructure, and data centers.

Terminology
This white paper includes the following terminology.

Table 1. Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDB</td>
<td>Container database</td>
</tr>
<tr>
<td>PDB</td>
<td>Pluggable database</td>
</tr>
<tr>
<td>VMDK</td>
<td>Virtual Machine Disk</td>
</tr>
<tr>
<td>PowerCLI</td>
<td>PowerShell interface for managing VMware vSphere</td>
</tr>
<tr>
<td>ASM</td>
<td>Automatic Storage Management</td>
</tr>
<tr>
<td>DBCA</td>
<td>Database Configuration Assistant</td>
</tr>
</tbody>
</table>
Key technology components

Overview

The key technology components used in this white paper are as follows:

- EMC Symmetrix VMAX
- EMC Solutions Enabler
- EMC Unisphere for VMAX
- VMware vSphere
- EMC PowerPath/VE
- Oracle Database 11g R2 Enterprise Edition
- Oracle Database 12c R1 Enterprise Edition
- EMC VMAX Storage Plug-In for Oracle Enterprise Manager 12c

EMC Symmetrix VMAX

The EMC Symmetrix VMAX 40K storage system delivers unmatched scalability and high availability for the enterprise while providing market-leading functionality to accelerate your transformation to the hybrid cloud. The EMC Quad Virtual Matrix Architecture™ is a unique way to build storage systems that transcend the physical constraints of all existing architectures by scaling system resources through common building blocks called EMC Symmetrix VMAX engines.

A single VMAX 40K engine provides the complete foundation for a high availability Symmetrix VMAX 40K system. Each VMAX 40K contains two Symmetrix VMAX 40K directors and redundant interfaces to the EMC Quad Virtual Matrix interconnect. Each Symmetrix VMAX 40K director consolidates front-end, global memory, and back-end functions, enabling direct memory access to data for optimized I/O operations.

VMAX 40K engines are interconnected by a set of multiple active fabrics that provide scalable performance and high availability. VMAX 40K engines can be added nondisruptively to provide linear scale-out of Symmetrix system resources. The Quad Virtual Matrix is designed to scale to dozens of engines, geographically dispersed throughout a data center, delivering unprecedented scale of infrastructure services under a single point of management.

TimeFinder/Clone

TimeFinder/Clone provides point-in-time copies of critical data that can be used for backups, decision support, data warehouse refreshes, or any other process that requires multi-application access to data. Each clone keeps its own copy of a source volume's information at the point in time that it was activated.

TimeFinder/Clone allows users to make copies of data simultaneously on multiple target devices from a single source device. It copies data from the source device and creates a physical backup copy called a clone. The data can be available to a target device’s host immediately upon activation of the TimeFinder copy session even if the copy process has not completed. The background copy process and host I/O, on the protected tracks on source devices, drive the copy process.
**EMC Solutions Enabler**
The EMC Solutions Enabler software provides your host system with an API shared library and a special command set that comprises the Symmetrix command line interface (SYMCLI) for use by storage administrators and systems engineers.

**EMC Unisphere for VMAX**
EMC Unisphere® for VMAX is an intuitive management interface that enables IT managers to maximize human resources by dramatically reducing the time required to provision, manage, and monitor Symmetrix storage assets. Unisphere delivers the simplification, flexibility, and automation that are key requirements to accelerate the transformation to the hybrid cloud.

Unisphere for VMAX release 1.6 builds on the initially delivered functionality for the VMAX Family and adds support for the configuration, management, and monitoring of older EMC Symmetrix DMX™ arrays as well as all new features in the latest EMC Enginuity™ release. For customers who frequently build up and tear down storage configurations, Unisphere for VMAX 1.6 makes reconfiguring an array even easier by reducing the number of steps required to delete and repurpose volumes.

**VMware vSphere**
VMware vSphere 5.1 abstracts applications and information from the complexity of underlying infrastructure by virtualizing server, storage, and networking hardware. This transformation creates fully functional virtual machines that run isolated and encapsulated operating systems and applications just like physical computers. Virtualizing hardware resources enables efficiencies by consolidating multiple applications on fewer physical servers.

**EMC PowerPath/VE**
EMC PowerPath®/VE for VMware vSphere delivers multipathing features that optimize VMware vSphere virtual environments. PowerPath/VE is installed as a kernel module on the VMware ESXi host and works as a multipathing plug-in (MPP) that provides enhanced path management and load-balancing capabilities for ESXi hosts.

**Oracle Database 11g R2 Enterprise Edition**
Oracle Database 11g EE delivers industry-leading performance, scalability, security, and reliability on a choice of clustered or single servers running Windows, Linux, or UNIX. It supports advanced features, either included or as extra-cost options, that are not available with Oracle Database 11g Standard Edition (SE). These include security features such as Virtual Private Database and data warehousing options such as partitioning and advanced analytics.

**Oracle Database 12c R1 Enterprise Edition**
Oracle 12c introduces the Oracle multitenant architecture, which simplifies the process of consolidating databases onto the cloud. Oracle 12c delivers all the benefits of managing many databases as one, yet it retains the data isolation and resource prioritization of a separate database.

**EMC VMAX Storage Plug-In for Oracle Enterprise Manager 12c**
The EMC VMAX Storage Plug-in for Oracle Enterprise Manager 12c delivers comprehensive availability, performance, and configuration information for EMC VMAX storage arrays. By combining EMC VMAX system monitoring solution for Oracle systems with Oracle Enterprise Manager 12c, customers can significantly reduce the complexity of managing and cost of applications that rely on EMC Symmetrix VMAX systems and Oracle technologies.
Application administrators can now consolidate all monitoring information in Oracle Enterprise Manager and perform comprehensive root cause analysis. Storage and database administrators can proactively monitor EMC VMAX systems, identify the impact of storage performance problems on end-user services, and better align their efforts with the Oracle database administrators and business needs.

Figure 2 shows a screenshot of the EMC VMAX Storage Plug-in for Oracle Enterprise Manager 12c with the performance tab for the EMC Symmetrix VMAX 40K used in this solution highlighted and magnified.

Figure 2. EMC VMAX Storage Plug-in for Oracle Enterprise Manager 12c
Solution architecture and design

EMC solutions are designed to reflect and validate real-world deployments. Figure 3 depicts the physical and logical architecture of the solution described in this white paper.

![High-level solution architecture diagram](image)

**Figure 3.** High-level solution architecture diagram

Use case description

The use case details the process of upgrading an Oracle 11g database running on Oracle ASM to version 12c and, optionally, converting it to a PDB. TimeFinder/Clone is the local replication mechanism in this VMware vSphere environment, with storage provided by an EMC Symmetrix VMAX system.
Table 2. Solution hardware environment

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Quantity</th>
<th>Configuration</th>
</tr>
</thead>
</table>
| Storage | 1        | Symmetrix VMAX 40K with Enginuity*:  
  - 8 engines  
  - 1280 x 300 GB FC drives  
  - 256 x 100 GB EFD drives |
| Servers for templates and virtual machines hosting Oracle Database | 3 | VMware ESXi: 2 x four-core CPUs, 128 GB RAM |
| Network switches | 2 | 10 Gb/s Ethernet |
| FC switches | 2 | 8 Gb/s FC |

*The EMC Symmetrix VMAX environment used in this solution is a shared multitenant environment hosting multiple projects.

Table 3. Solution software environment

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC Enginuity</td>
<td>5876.229.145</td>
<td>Operating environment for Symmetrix VMAX</td>
</tr>
<tr>
<td>EMC Solutions Enabler</td>
<td>7.6</td>
<td>Storage management software CLI</td>
</tr>
<tr>
<td>EMC Unisphere</td>
<td>T1.6.0.90</td>
<td>VMAX management software</td>
</tr>
<tr>
<td>EMC Virtual Storage Integrator (VSI)</td>
<td>5.4.1.8</td>
<td>VMware storage integration</td>
</tr>
<tr>
<td>EMC PowerPath/VE</td>
<td>5.8 (build 342)</td>
<td>Multipathing software</td>
</tr>
<tr>
<td>Red Hat Enterprise Linux</td>
<td>5.6</td>
<td>Operating system for all DBVM</td>
</tr>
<tr>
<td>VMware vSphere</td>
<td>5.1 Update 1</td>
<td>Hypervisor that hosts all virtual machines</td>
</tr>
<tr>
<td>VMware vSphere PowerCLI</td>
<td>5.1</td>
<td>Windows PowerShell interface for managing VMware vSphere</td>
</tr>
<tr>
<td>Oracle Database 11g</td>
<td>Enterprise Edition 11.2.0.3.6</td>
<td>Oracle database and cluster software</td>
</tr>
<tr>
<td>Oracle Database 12c</td>
<td>Enterprise Edition 12.1.0.1.0</td>
<td>Oracle database and cluster software</td>
</tr>
</tbody>
</table>
For the solution, we created two Oracle database environments for both 11g and 12c. Table 4 provides high-level details of the two database environments.

<table>
<thead>
<tr>
<th>Virtual machine name</th>
<th>Database unique name</th>
<th>Database version</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEL-11g</td>
<td>prod</td>
<td>11.2.0.3.6</td>
</tr>
<tr>
<td>OEL-12c</td>
<td>cdb12c</td>
<td>12.1.0.1.0</td>
</tr>
</tbody>
</table>

Virtual machines OEL-11g and OEL-12c and the VMDK holding the OS and Oracle binaries reside on one of the three shared datastores, PDB-OSBIN-DS1 – 3, used to deploy virtual machines and templates and accessible to all three ESXi servers.

Within the virtual machine, the Oracle database uses separate datastores mapped and dedicated to its Oracle ASM disk groups for DATA, REDO, and Fast Recovery Area (FRA), which can be then cloned separately from and independent of the virtual machine. This is illustrated in Figure 4.

**Figure 4. Mapping of ESXi hosts and virtual machines to datastore**

On the target ESXi host, the replicated database is made available as a TimeFinder/Clone. See Table 5 for the mapping of ASM disk groups to datastores that are deployed on striped metavolumes of thin-provisioned devices bound to a single virtual pool consisting of FC devices only, using RAID 1 protection. Metavolumes are used to create volumes greater than the maximum size of 240 GB for a standard thin device in Symmetrix VMAX. Best practice is for FRA devices to be bound to virtual pools using RAID 6 SATA where available.
Table 5. Mapping ASM disk groups to datastores

<table>
<thead>
<tr>
<th>Database</th>
<th>Datastore</th>
<th>Number of VMDK</th>
<th>Size (GB)</th>
<th>ASM disk group</th>
</tr>
</thead>
<tbody>
<tr>
<td>prod (11g)</td>
<td>PDB-ProdDB-DS</td>
<td>5</td>
<td>20</td>
<td>ORA_DATA</td>
</tr>
<tr>
<td></td>
<td>PDB-ProdRED01-DS</td>
<td>3</td>
<td>10</td>
<td>ORA_REDO</td>
</tr>
<tr>
<td></td>
<td>PDB-ProdRED02-DS</td>
<td>3</td>
<td>10</td>
<td>ORA_REDO_M</td>
</tr>
<tr>
<td></td>
<td>PDB-ProdFRA-DS</td>
<td>4</td>
<td>50</td>
<td>ORA_FRA</td>
</tr>
<tr>
<td>cdb12c (CDB)</td>
<td>PDB-CDB-DATA-DS</td>
<td>2</td>
<td>10</td>
<td>CDB_DATA</td>
</tr>
<tr>
<td></td>
<td>PDB-CDB-RED01</td>
<td>3</td>
<td>10</td>
<td>CDB_REDO</td>
</tr>
<tr>
<td></td>
<td>PDB-CDB-RED01</td>
<td>3</td>
<td>10</td>
<td>CDB_REDO_M</td>
</tr>
<tr>
<td></td>
<td>PDB-CDB-FRA-DS</td>
<td>2</td>
<td>50</td>
<td>CDB_FRA</td>
</tr>
<tr>
<td>Prod (PDB)</td>
<td>PDB-ProdDB-DS**</td>
<td>5</td>
<td>20</td>
<td>ORA_DATA</td>
</tr>
</tbody>
</table>

** This is a cloned datastore. After the PDB conversion process is completed, the cloned target devices for PDB-ProdRED01-DS, PDB-ProdRED02-DS, and PDB-ProdFRA-DS can be released. Online and archived redo as well as undo are provided by the CDB and not the individual PDBs.

Prior to starting the upgrade process, we created the Oracle CDB “cdb12c” on the virtual machine “OEL-12c.” This virtual machine was deployed from a VMware virtual machine template. Figure 5 shows the output from the Database Configuration Assistant (DBCA).
Upgrade to Oracle Database 12c with Oracle Multitenant Option (Pluggable Database) with Oracle Multitenant Option (Pluggable Database) Enabled by EMC Symmetrix VMAX 40K and EMC TimeFinder/Clone

Figure 5. Database Configuration Assistant – Create Database Summary
Testing and validation

This section describes the testing performed to validate this solution. It follows the process flow outlined in Figure 1 on page 6.

Clone database

A clone can be taken when the Oracle database is in one of the following states:

- Shut down or mounted but not open (offline)
- In hot backup mode (online)
- Open and crash-consistent at the point of the split

With EMC TimeFinder, the Enginuity Consistency Assist (ECA) feature is used to perform consistent splits between the source and target device pairs, even when the database is online and not in hot backup mode. Consistent splits also maintain dependent write-order consistency on the target devices.

To test this solution we created a restartable replica, where the clone is equivalent to the state a database would be in after a power failure. We performed a crash recovery using REDO from the online logs, as follows:

1. Create target devices for the clone.
2. Create a Symmetrix Device Group and populate it with the source and associated target devices.
3. Create and activate the TimeFinder/Clone.
4. Use Auto-Provisioning Groups to configure access for the target host to the cloned target devices.

Create target devices for the clone

Figure 6 shows how to create each of the thin target devices for the associated source.

```bash
#DATA Device
symconfigure -sid 000195701221 -cmd "configure 1 devices copying dev 1B69 overriding config= BCV+TDEV;" commit -nop

#REDO Devices
symconfigure -sid 000195701221 -cmd "configure 1 devices copying dev 1BFC overriding config= BCV+TDEV;" commit -nop
symconfigure -sid 000195701221 -cmd "configure 1 devices copying dev 1C1D overriding config= BCV+TDEV;" commit -nop

#FRA Device
symconfigure -sid 000195701221 -cmd "configure 1 devices copying dev 1D45 overriding config= BCV+TDEV;" commit -nop
```

Figure 6. Create the target devices by copying the source devices
Create a Symmetrix Device Group

Several options are available, depending on your environment and expertise, for creating a Symmetrix Device Group and populating it with the source and associated target devices. Figure 7 shows a sample of how to create a new Device Group.

```
symdg  create PDB-11g-FULL1  
#For Data
symld -g PDB-11g-FULL1 -sid 000195701221 add dev 1B69  
symbcv -g PDB-11g-FULL1 -sid 000195701221 associate dev 2092  

#For REDO
symld -g PDB-11g-FULL1 -sid 000195701221 add dev 1BFC  
symbcv -g PDB-11g-FULL1 -sid 000195701221 associate dev 20C3  

symld -g PDB-11g-FULL1 -sid 000195701221 add dev 1C1D  
symbcv -g PDB-11g-FULL1 -sid 000195701221 associate dev 20E4  
#For FRA
symld -g PDB-11g-FULL1 -sid 000195701221 add dev 1D45  
symbcv -g PDB-11g-FULL1 -sid 000195701221 associate dev 2105
```

**Figure 7. Add the source and target devices to the new Device Group**

Create and activate the TimeFinder/Clone

The clone can now be created and activated as shown in Figure 8.

```
symclone -g PDB-11g-FULL1 -sid 000195701221 -noprompt create
symclone -g PDB-11g-FULL1 -sid 000195701221 -noprompt -consistent activate
```

**Figure 8. Create and Activate the TimeFinder/Clone**

If this is not the first TimeFinder/Clone for the source devices, then the `symclone` command must contain the concurrent flag, as shown in Figure 9.

```
symclone -g PDB-11g-FULL2 -sid 000195701221 -noprompt create -concurrent
symclone -g PDB-11g-FULL2 -sid 000195701221 -noprompt -consistent activate
```

**Figure 9. Create and Activate the TimeFinder/Clone when there are multiple targets**

Whenever TimeFinder is used to clone an ASM Disk Group, consistency technology should be used (consistent flag) even if hot backup mode is used at the database level. Hot backup mode does not protect ASM metadata writes.

Auto-provision target devices

The next step is to enable access for the target ESXi host to the target devices. With Auto-Provisioning Groups, the mapping of devices for Oracle database environments becomes faster and easier. You can easily group devices, HBA ports, and storage ports to create a masking view that defines the exact relationship between host LUNs and the connected storage.

You can create a masking view by following a wizard in Unisphere for VMAX, as shown in Figure 10.
You can also enable access for the target ESXi host to the target devices by using the SYMCLI command `symaccess` to create the Storage Groups, Port Group, Initiator Group, and Masking View, as shown in Figure 11.

```
symaccess -sid 000195701221 -type storage devs 2092,20C3,20E4,2105 -name PDB-11G-FULL1 create
```

**Figure 11. Using symaccess to create the storage group PDB-11G-FULL1**

---

**Mount the cloned VMFS datastores**

vSphere sees the cloned datastores as snapshot LUNs. These datastores can be mounted directly to the target host. If they are presented back to the source host, the datastores must be resignatured (given a new unique ID) before the snapshot LUNs are mounted. The vSphere Client automatically handles this task, or it can be accomplished via a simple CLI command.

Use the vSphere Client as shown in Figure 12 to mount cloned datastores.
Figure 12. vSphere Client Storage Configuration screen

The cloned datastores also can be mounted with **Esxcli** commands, as shown in Figure 13. You can run the command directly on the server or call it from PowerCLI with the **Get-Esxcli** command.

```
esxcli storage core adapter rescan --all
evmkfstools -V
esxcli storage vmfs snapshot mount -l PDB-ProdFRA-DS
esxcli storage vmfs snapshot mount -l PDB-ProdRED02-DS
esxcli storage vmfs snapshot mount -l PDB-ProdRED01-DS
esxcli storage vmfs snapshot mount -l PDB-ProdDB-DS
```

Figure 13. Mount the cloned VMFS datastores

**Assign the VMDKs to the target virtual machine**

You can add VMDK to the virtual machine using the vSphere Client or the command line. In this solution, we added multiple VMDKs from the cloned datastore, using a simple PowerCLI script as shown in Figure 14.
Connect-VIServer -server x.x.x.x -user root -password xxxxxx

$esxihost="<ESXiTargetHostIP>"

Get-VMHostStorage -vmhost $esxihost -rescanallhba
Get-VMHostStorage -VMHost $esxihost -refresh

$vml="OEL5_12c"

$DS1=get-datastore -VMHost $esxihost | where-object {$_.Name -like "PDB-ProdDB-DS"}
$a1=$DS1.Name
New-HardDisk -VM $vml -DiskPath "[$a1] OEL6_11g/OEL6_11g.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a1] OEL6_11g/OEL6_11g_1.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a1] OEL6_11g/OEL6_11g_2.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a1] OEL6_11g/OEL6_11g_3.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a1] OEL6_11g/OEL6_11g_5.vmdk"

$DS2=get-datastore -VMHost $esxihost | where-object {$_.Name -like "PDB-ProdREDO1-DS"}
$a2=$DS2.Name
New-HardDisk -VM $vml -DiskPath "[$a2] OEL6_11g/OEL6_11g.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a2] OEL6_11g/OEL6_11g_1.vmdk"

$DS3=get-datastore -VMHost $esxihost | where-object {$_.Name -like "PDB-ProdREDO2-DS"}
$a3=$DS3.Name
New-HardDisk -VM $vml -DiskPath "[$a3] OEL6_11g/OEL6_11g.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a3] OEL6_11g/OEL6_11g_1.vmdk"

$DS4=get-datastore -VMHost $esxihost | where-object {$_.Name -like "PDB-ProdFRA-DS"}
$a4=$DS4.Name
New-HardDisk -VM $vml -DiskPath "[$a4] OEL6_11g/OEL6_11g.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a4] OEL6_11g/OEL6_11g_1.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a4] OEL6_11g/OEL6_11g_2.vmdk"
New-HardDisk -VM $vml -DiskPath "[$a4] OEL6_11g/OEL6_11g_3.vmdk"

Figure 14. Example of PowerCLI script for adding existing VMDKs to a target virtual machine

Scan for VMDK and Oracle ASM disks

Log in as root to the guest OS on the virtual machine, and dynamically scan for new disks as shown in Figure 15.

```bash
for i in `ls -ld /sys/class/scsi_host/host*/scan`
do echo "- - -" > $i
done
```

Figure 15. Dynamically scan for new disks

Then, using oracleasm, scan for new ASM disks, as shown in Figure 16.
Upgrade and convert database

Upgrade database to 12c

The database was manually upgraded following the process outlined in the My Oracle Support Document *Complete Checklist for Manual Upgrades to Oracle Database 12c Release 1 (12.1) (Doc ID 1503653.1)*.

To upgrade to Oracle 12c:

1. Start up the Oracle Database 11g and run the version 12c pre-upgrade script: `preupgrd.sql` (requires file `utluppkg.sql`). Then run any required fix scripts.
2. Run the Oracle command-line upgrade utility, `catctl.pl`, which enables parallel processing during the upgrade to version 12c. See Figure 17 for the full command script and flags.
3. Run the post-upgrade actions script `catuppst.sql`.
4. Recompile any invalid objects within the database.
Upgrade to Oracle Database 12c with Oracle Multitenant Pluggable Database Option

Figure 17. Key steps in the manual upgrade to Oracle 12c
Generate a PDB manifest file

The PDB conversion of the newly upgraded Oracle 12c database, “prod,” follows the process described in the My Oracle Support Document *How to migrate an existing pre12c database (non-CDB) to 12c CDB database* (Doc ID 1564657.1).

Before converting a non-container Oracle 12c Database to a PDB, you must generate a manifest file for it. Run `dbms_pdb.describe`, as shown in Figure 18, to generate the manifest file. Figure 18 also shows sample output from the PDB manifest file.

```sql
SQL> exec dbms_pdb.describe(pdb_descr_file=>'/home/oracle/prodnon_noncdb.xml');
PL/SQL procedure successfully completed.

SQL> ! cat /home/oracle/prod_noncdb.xml
<?xml version="1.0" encoding="UTF-8"?>
<PDB>
  <pdbname>prod</pdbname>
  <cid>0</cid>
  <byteorder>1</byteorder>
  <vsn>202375168</vsn>
  <dbid>235758810</dbid>
  <xdbid>235758810</xdbid>
  <guid>E4EC6302F77A393CE043FE4F6E0AF79A</guid>
  <uscnbas>2974831</uscnbas>
  <uscnwrp>0</uscnwrp>
  <rdba>4304080</rdba>
  . . .
  . . .
  . . .
  <parameters>
    <parameter>processes=1000</parameter>
    <parameter>sga_target=1107296256</parameter>
    <parameter>db_block_size=8192</parameter>
    <parameter>compatible=12.1.0.0.0</parameter>
    <parameter>recyclebin=OFF</parameter>
    <parameter>pls_sql_warnings=D_DISABLE:ALL</parameter>
    <parameter>result_cache_max_size=2883584</parameter>
    <parameter>open_cursors=300</parameter>
    <parameter>optimizer_mode=ALL_ROWS</parameter>
    <parameter>query_rewrite_enabled=TRUE</parameter>
    <parameter>pga_aggregate_target=190840832</parameter>
    <parameter>optimizer_dynamic_sampling=2</parameter>
    <parameter>skip_usable_indexes=TRUE</parameter>
  </parameters>
  <tzvers>
    <tzver>primary version:14</tzver>
    <tzver>secondary version:0</tzver>
  </tzvers>
  <walletkey>0</walletkey>
</PDB>
```

Figure 18. Generate a pluggable database manifest file for the non-container database
Create a pluggable database

Create a new pluggable database using the previously generated PDB manifest file. As this solution uses replication on the storage array to copy and present the datafiles and tempfiles, no host copy methods were required. The “NOCOPY” and “TEMPFILE REUSE” options are used in the key pluggable database statement shown in Figure 19.

```
SQL> CREATE PLUGGABLE DATABASE prodpdb USING '/home/oracle/prod_noncdb.xml'
   2 NOMCOPY
   3 TEMPFILE REUSE;
Pluggable database created.
SQL> alter pluggable database prodpdb open;
Warning: PDB altered with errors.
SQL> select CON_ID, NAME, OPEN_MODE from V$PDBS;
CON_ID   NAME     OPEN_MODE
---------- ----------------------- -------
 2 PDB$SEED  READ ONLY
 3 PRODPDB  READ WRITE
SQL> alter pluggable database prodpdb close;
Pluggable database altered.
```

Figure 19. Create pluggable database prodpdb using the generated XML file

Convert PDB data dictionary

To finish the process of converting the PDB “prodpdb,” clean up superfluous data held in the pluggable database’s data dictionary from its original version as a non-container database, as shown in Figure 20. This is recommended in a production environment and is necessary if you need to upgrade the container database at a later time.

```
SQL> @?/rdbms/admin/noncdb_to_pdb.sql
SQL> alter pluggable database prodpdb close;
Pluggable database altered.
SQL> alter pluggable database prodpdb open;
SQL>
Pluggable database altered.
SQL> select CON_ID, NAME, OPEN_MODE from V$PDBS;
   CON_ID   NAME     OPEN_MODE
----------- ----------------------- -------
 2 PDB$SEED  READ ONLY
 3 PRODPDB  READ WRITE
```

Figure 20. Converting PDB prodpdb using the generated XML file
Automate startup of PDB with event trigger

PDBs are mounted only when the CDB is opened. To open the PDBs automatically along with the CDB and have them ready for use, use an “after startup” trigger, as shown in Figure 21, to open all PDBs.

```sql
create or replace trigger Sys.After_Startup_CDB after startup on database begin
  execute immediate 'alter pluggable database all open';
end
After_Startup_CDB;
/
```

Figure 21. Create trigger statement to automatically open all pluggable databases
Conclusion

Summary

Oracle 12c is the latest version of Oracle's flagship database technology. It delivers a number of new features including the multitenant option. The multitenant architecture supports the following configurations:

- Single tenant configuration—one PDB plugged into a CDB—is available at no extra cost in all editions.
- Multitenant option for up to 252 pluggable databases per CDB is an additional-cost option of Oracle 12cEE.

With Oracle Database 11g release 2 scheduled to enter “Extended Support” on February 1, 2015, a number of customers are examining their upgrade options.

Oracle states that the easiest way to move up to Oracle 12c is to upgrade your existing database using either Database Upgrade Assistant (DBUA) or the command-line upgrade scripts. These options are preferred over host-based copying, which Oracle considers slower and more complex.

For customers with a non-trivial Oracle Database estate to be upgraded to version 12c, a process based around command-line upgrades offers a repeatable, streamlined solution with the option to script or automate the process with a workflow product such as VMware vCenter Orchestrator.

Using EMC Symmetrix VMAX and TimeFinder/Clone technology to replicate your database environment has a number of advantages over either upgrading your existing database or using a slow host-based copy method:

- It is non-disruptive to the source (existing database), and you can make multiple copies for test or upgrade.
- The target devices are available immediately to the host upon activation of the TimeFinder copy session, without the need to wait for a host copy to complete.
- Because the copy is offloaded to the storage array, the TimeFinder process does not consume any valuable database server resources.
- After the upgrade of the cloned database has completed, the database can be converted to a PDB and run in multitenant CDB without consuming any valuable database server cycles.
References

**Product documentation**
For additional information, see the following product documents:
- *EMC Solutions Enabler Symmetrix TimeFinder Family CLI 7.6 Product Guide*
- *EMC Solutions Enabler 7.6 Installation Guide*
- *EMC Solutions Enabler 7.6 Release Notes*
- *EMC Solutions Enabler Symmetrix CLI 7.6 Command Reference*
- *EMC VMAX Plug-in for Oracle Enterprise Manager 12c Deployment Guide*
- *VMware vSphere PowerCLI Cmdlets Reference version 5.1*
- *Oracle Database Administrator's Guide* for Oracle Database 12c Release 1 (12.1)

**White papers and technical notes**
For additional information, see the following documents:
- *EMC Symmetrix VMAX Using EMC SRDF/TimeFinder and Oracle Database 10g/11g*
- *EMC Symmetrix VMAX Using EMC SRDF/TimeFinder and Oracle 11g*
- *Implementing Symmetrix Virtual Provisioning with VMware vSphere*
- *Using EMC Symmetrix Storage in VMware vSphere Environments* (TechBook)
- *Storage Pool Management Feature in EMC Virtual Storage Integrator* (TechBook)
- *Deploying Oracle Database 11 on EMC Symmetrix VMAX 10K*
- From VMware: *Oracle Databases on VMware: Best Practices Guide*
- From Oracle: *Upgrading to Oracle Database 12c*

**Other documentation**
For additional information, see the following documents:
- My Oracle Support website:
  - Database Server Upgrade/Downgrade Compatibility Matrix (Doc ID 551141.1)
  - How to migrate an existing pre12c database (nonCDB) to 12c CDB database (Doc ID 1564657.1)
  - Complete Checklist for Manual Upgrades to Oracle Database 12c Release 1 (12.1) (Doc ID 1503653.1)
  - Complete Checklist for Upgrading to Oracle Database 12c Release 1 using DBUA (Doc ID 1516557.1)
  - Supported Backup, Restore and Recovery Operations using Third Party Snapshot Technologies (Doc ID 604683.1)
  - Backup and Recovery Scenarios (Doc ID 94114.1)
- VMware website:
  - vSphere handling of LUNs detected as snapshot LUNs (Knowledgebase article 1011387)