Best Practices for using the Dell Storage Center with Oracle Real Application Clusters (RAC) on Solaris

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Executive summary

Oracle Real Application Clusters (RAC) on Oracle Solaris helps customers lower IT costs by enabling consolidation of databases onto a shared clustered database architecture. It also delivers higher reliability, availability, flexibility and scalability to business critical environments.

Oracle Solaris 11 provides improved database performance and scalability because it can scale up to tens of thousands of CPU cores and hundreds of terabytes of memory. The SPARC microprocessor is also specifically optimized for the Oracle database which makes one of the most high-performing database platforms.

The use of Dell Storage Center with this stack provides excellent integration options and allows the enterprise to further leverage the best features of Storage Center coupled with the best features of the Oracle vertically integrated software stack.
1 Overview

The scope of this paper outlines the implementation of Oracle Grid compute and RAC on a Solaris operating system, backed by a Dell Storage Center SC8000. Recommendations are also provided for the most effective integration with Storage Center volumes into this vertical solution to provide the most optimized experience.

Oracle Clusterware is an integral part of the Oracle Grid infrastructure (GI) which includes Oracle Automatic Storage Management (ASM), Oracle Automatic Storage Management Cluster File System (ACFS) and Oracle Automatic Storage management Dynamic Volume Manager (ADVM).

Flex ASM and Flex Cluster are outside the scope of this paper. For more information about this topic, refer to the document listed in Appendix A titled, “Oracle Grid Infrastructure Installation Guide 12c Release 1 (12.1) for Oracle Solaris”.

Due to the various methods that can be used to accomplish the tasks discussed, this paper is intended as a reference and starting point for system, storage and database administrators.
2 Setup

This section outlines and details the infrastructure, platform and connectivity for the environment used to write this paper. This paper is built on two Oracle SunFire T4-1 servers, running the Solaris 11.1 operating system and connected using Dell PowerConnect 5548 switches and a Cisco-based Fibre Channel fabric as illustrated in the diagram below.

![Diagram of Oracle Grid/RAC on Solaris]

**Note:** Each line to the respective Ethernet networks represents two physical cables.

Figure 1 Infrastructure diagram: Two-node Oracle RAC on Solaris with Storage Center

2.1 Fiber channel connectivity

Each SunFire T4-1 host is configured with a QLogic QLE 2562 8GB dual port HBA as shown below.

```bash
root@hadrian:/kernel/drv# fcinfo hba-port | egrep 'Model|Firmware|FCode|Serial|Driver|WWN'
HBA Port WWN: 21000024ff3ebd24
Model: 371-4325-02
Firmware Version: 5.6.4
FCode/BIOS Version: BIOS: 2.02; fcode: 2.03; EFI: 2.01;
```
2.1.1 Configuration

QLogic configuration is managed with the /kernel/drv/qlc.conf file (for Sun-QLogic branded host bus adapters) and /kernel/drv/qla2300.conf file (for QLogic branded host bus adapters) on each Solaris host. This section discusses certain key-value pairs contained within this file and makes recommendations as a starting point. However, it is also acknowledged that every application platform and environment can differ and will need to adapt this configuration accordingly to suit individual business environments.

execution-throttle

This parameter dictates the queue depth per LUN by the HBA firmware. This value defaults to 32 during installation. As a best practice, start by changing this value to 64, then evaluate, test and validate it to the needs of the environment for optimal performance. Setting this value too low may underutilize the bandwidth capacity; setting this value too high may potentially create unneeded command retries. Both scenarios may create latency and impact performance.

port-down-retry-count

This parameter dictates the number of command retries against a SCSI device that stops responding on
the Fibre Channel bus. This value defaults to eight during installation. Coupled with the **port-down-retry-delay** parameter below, it dictates how long the SCSI queue will attempt to issue command retries to this path before switching to an alternate path. As a best practice, leave this value at its default unless a change is needed for a specific performance tuned goal or application dictated requirements.

**port-down-retry-delay**

This parameter, used in conjunction with the **port-down-retry-count** parameter above, dictates how long the SCSI queue will attempt to issue command retries to this path before switching to an alternate path. This value defaults to two during installation. As a best practice, leave this value at its default, unless a change is needed for a specific performance tuned goal or application dictated requirements.

A Change to the configuration of these files requires a reboot of the Solaris host for the changes to be applied.

```bash
# cd /
  # touch reconfigure
  # reboot
```

## 2.2 Network connectivity

Each SunFire T4-1 host is configured with an onboard 1G quad port Ethernet adapter as shown below. The net0 and net1 interfaces are bonded with IPMP into the ipmp0 interface, while the net2 and net3 interfaces are bonded into the ipmp1 interface accordingly.

In this setup, ipmp0 is set up for the public network while ipmp1 is set up for the private cluster network. User sessions and system administrations are routed through the public network (ipmp0). Cluster interconnect traffic and cluster heartbeat are isolated on the private network (ipmp1).

```
root@hadrian:/kernel/drv# ipadm
NAME  CLASS/TYPE STATE UNDER ADDR
ipmp0  ipmp  ok  --  --
ipmp0/v4  static  ok  --  172.16.26.86/20
ipmp0/v4b  static  ok  --  172.16.26.84/20
ipmp1  ipmp  ok  --  --
ipmp1/v4  static  ok  --  10.10.26.86/24
lo0  loopback  ok  --  --
lo0/v4  static  ok  --  127.0.0.1/8
lo0/v6  static  ok  --  ::1/128
net0  ip  ok  ipmp0  --
net1  ip  ok  ipmp0  --
net2  ip  ok  ipmp1  --
net3  ip  ok  ipmp1  --
net10  ip  ok  --  --
net10/v4  static  ok  --  169.254.182.77/24

root@maximus:/etc/driver/drv# ipadm
NAME  CLASS/TYPE STATE UNDER ADDR
ipmp0  ipmp  ok  --  --
```
2.3 Storage Center connectivity

A single Dell Storage Center SC8000 is used in this scenario. The Storage Center runs SCOS 6.5.2 in Virtual port mode with both controllers zoned across two separate VSANs to each Solaris host. Both Solaris hosts are made part of a Server Cluster object.

The application-defined configuration of these interfaces is discussed in the section 3.7, “Configuring network” below.
Additionally, volumes are created and mapped to the Server Cluster object, as well as to individual hosts, where required.

![Storage Center volume view](image)

**Figure 3  Storage Center volume view**

### 2.4 SCSI/UNMAP Bug in Solaris 11.1

Solaris 11.1 currently presents a known issue with excessive calls to SCSI/UNMAP routines and is especially detrimental when used with flash-based storage. Oracle does not currently have a fix to this issue. At this time, it is recommended to disable this SCSI/UNMAP feature via the methods by following these instructions.

1. Edit the `/etc/system` file.
2. Insert the following line into the `set` clause within this file, "set zfs:zfs_unmap_ignore_size=0".
3. Save the file, exit from the editor session and reboot the Solaris host.

### 2.5 Installing Solaris 11.1

A text-based menu interface that guides the users step-by-step, makes the Solaris 11.1 installation simple. The following information is required during the installation process.

1. Select the default system language.
2. Select the disk for the Solaris 11.1 OS installation.
3. Decide the disk partition layout on the boot disk. The default is to use the whole disk and ZFS for all system files.
4. Configure the Network.
   a. Enter a unique server name.
b. Use the manual configuration option.
c. The server IP should be static and entered in the DNS servers.
d. Configure the DNS server IPS and search the domains.
e. Configure the additional name services if required.

5. Configure the time zone, date and time settings.
6. Configure the root user account.
3 Configuring Solaris for Oracle Grid Infrastructure and RAC

This section describes configuring the Solaris environment settings on each server for Oracle Grid Infrastructure and RAC installation.

3.1 Swap and tmp space requirement

Oracle recommends the following swap sizes based on the amount of memory installed in a server.

Table 1 Requirement for swap size

<table>
<thead>
<tr>
<th>RAM</th>
<th>Swap size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4GB – 16GB</td>
<td>Equal to the physical memory</td>
</tr>
<tr>
<td>Greater than 16GB</td>
<td>16GB</td>
</tr>
</tbody>
</table>

1. To check the current swap size, use:

```bash
# swap -l
```

```
swapfile       dev  swaplo  blocks   free
/dev/zvol/dsk/rpool/swap 285,2      16 33554416 33554416
```

2. To adjust the size of the swap device, disable the swap device, resize it, and then re-enable and reboot the server.

```bash
# swap -d /dev/zvol/dsk/rpool/swap
# zfs set volsize=16G rpool/swap
# swap -a /dev/zvol/dsk/rpool/swap
# init 6
```

Oracle requires a minimal of 1GB temporary space in /tmp for installation. In Solaris, /tmp is a tmpfs memory based file system and the space is allocated from the system swap resources using tmpfs.

3. To check the current tmp size, use:

```bash
# df -h /tmp
```

3.2 Configuring Storage Center volumes

This section provides information on creating and mapping Storage Center volumes with Dell Enterprise Manager and configuring multipathing on the servers.

3.2.1 Creating and mapping Storage Center volumes

Dell Enterprise Manager is a central management console that monitors, manages and analyzes one or many Storage Centers. For additional information, see Appendix A, “Additional resources”.

1. Login to the Enterprise Manager client
2. Navigate to and select the Storage Center in the left pane.

![Dell Storage Center](image)

3. Create volume
   a. Click the **Storage** tab on top.
   b. Navigate to the **Volumes** view in the tree hierarchy.
   c. In this setup, the volume folder **oracle-on-solaris** has been created to contain the volumes for the servers.
   d. Right click the volume folder or **Volumes** at the top of the tree.
   e. Select **Create Volume**.

![Volume Creation](image)

4. Define the volume details.
   a. Enter a volume name.
   b. Enter the volume size (see section 4 for more information).
   c. Select the folder where the volume will be placed.
   d. Select Replay Profiles (see section 4 for more information).
e. Select the server(s).
f. Accept the other default settings.

3.2.2 Scanning for new volumes
After volumes are created and mapped to the servers, use the following procedures to make the volumes available on the servers.

1. Login to each server as root.
2. Run fcinfo to determine the HBA ports to scan and cfgadm to scan for new volumes. The following snippet simplifies the procedure to look for and scan all available HBA ports.

```bash
# fcinfo hba-port|awk -F/ '/OS Device/ {print $NF}('|while read c
do
cfgadm -o force_update -c configure $c
done
```

3. Verify the volumes with the format command. The new volumes should show up in the output.

```bash
# format
```

4. Verify the volumes with the luxadm probe command.

```bash
# luxadm probe
```
3.2.3 Configuring Solaris I/O Multipathing (mpxio)

The Solaris I/O multipathing features enable multipathing access to the SAN volumes. Multipathing is recommended as it provides high availability for storage devices in the event of one or more SAN paths failure. Multipathing enabled devices have persistent device names that maintain across system reboots. Multipathing is disabled by default for FC devices on SPARC based systems but is enabled by default on x86 based system.

Use the following procedures to enable and configure multipathing features. Perform the steps as root user.

1. Verify that the multipathing software package is installed.
   
   ```
   # pkg info system/storage/multipath-utilities
   
   If it is not installed, do so with the command:
   
   # pkg install system/storage/multipath-utilities
   ```

2. Enable multipathing.

   ```
   # stmsboot -e
   ```

   **Note:** This requires a system reboot for the setting to take effect.

3. Reboot the system.

4. After reboot, enable device multipathing for all FC devices.

   ```
   Edit /etc/driver/drv_fp.conf
   
   mpxio-disable="no"
   ```

5. Rescan the volumes.

   ```
   # fcinfo hba-port|awk -F '/OS Device/ {print $NF}'|while read c
   do
     cfgadm -o force_update -c configure $c
   done
   ```

6. Validate multipathing using the following sequence of commands.

   a. `format` command

   Multipathing devices have /scsi_vhci at the beginning of the device paths. The multipathing device names also contain the Storage Center device id.

   ```
   # format
   
   Searching for disks...done
   ```

   AVAILABLE DISK SELECTIONS:
   
   ```
   0. c0t5000c50048697f5fd0 <SUN300G cyl 46873 alt 2 hd 20 sec 625> solaris
   /scsi_vhci/disk@g5000c50048697f5f
   /dev/chassis//SYS/HDD0/disk
   ```
1. c0t6000D31000006500000000000000017E7d0 <COMPELNT-Compellent Vol-0605-250.00GB>
   /scsi_vhci/ssd@g6000d3100000650000000000000000017e7
2. c0t6000D31000006500000000000000017EEd0 <COMPELNT-Compellent Vol-0605 cyl 31966 alt 2 hd 4 sec 164>
   /scsi_vhci/ssd@g6000d3100000650000000000000000017ee
3. c0t6000D31000006500000000000000017EFd0 <COMPELNT-Compellent Vol-0605 cyl 44556 alt 2 hd 255 sec 189>
   /scsi_vhci/ssd@g6000d3100000650000000000000000017ef
4. c0t6000D31000006500000000000000017F0d0 <COMPELNT-Compellent Vol-0605 cyl 63935 alt 2 hd 32 sec 205>
   /scsi_vhci/ssd@g6000d3100000650000000000000000017f0

b. luxadm probe command

Each multipathing device should have a single logical path. If multipathing is not enabled on the
device, multiple logical paths are displayed for the same device.

# luxadm probe
No Network Array enclosures found in /dev/es

Found Fibre Channel device(s):
   Node WWN:5000d31000006501  Device Type:Disk device
   Logical Path:/dev/rdsk/c0t6000D31000006500000000000000017E7d0s2
   Node WWN:5000d31000006501  Device Type:Disk device
   Logical Path:/dev/rdsk/c0t6000D31000006500000000000000017EEd0s2
   Node WWN:5000d31000006501  Device Type:Disk device
   Logical Path:/dev/rdsk/c0t6000D31000006500000000000000017EFd0s2
   Node WWN:5000d31000006502  Device Type:Disk device
   Logical Path:/dev/rdsk/c0t6000D31000006500000000000000017F0d0s2

C. mpathadm list LU command

The command shows the total number of paths for each device.

# mpathadm list LU
   /dev/rdsk/c0t5000C50048697F5Fd0s2
      Total Path Count: 1
      Operational Path Count: 1
   /dev/rdsk/c0t6000D31000006500000000000000017EEd0s2
      Total Path Count: 4
      Operational Path Count: 4
   /dev/rdsk/c0t6000D31000006500000000000000017EFd0s2
      Total Path Count: 4
      Operational Path Count: 4
   /dev/rdsk/c0t6000D31000006500000000000000017E7d0s2
      Total Path Count: 4
      Operational Path Count: 4
   /dev/rdsk/c0t6000D31000006500000000000000017F0d0s2
      Total Path Count: 4
d. **stmsboot –L command**

The command shows the relationship between non multipathing device names to multipathing device names.

```
# stmsboot -L
non-STMS device name STMS device name
--------------------------------------------------------------
/dev/rdsk/c6t5000D31000006511d3 /dev/rdsk/c0t6000D310000065000000000000000017ECd0
/dev/rdsk/c6t5000D31000006511d1 /dev/rdsk/c0t6000D310000065000000000000000017EAd0
/dev/rdsk/c6t5000D31000006512d3 /dev/rdsk/c0t6000D310000065000000000000000017ECd0
/dev/rdsk/c6t5000D31000006512d1 /dev/rdsk/c0t6000D310000065000000000000000017EAd0
/dev/rdsk/c6t5000D31000006505d2 /dev/rdsk/c0t6000D310000065000000000000000017EBd0
/dev/rdsk/c6t5000D31000006506d2 /dev/rdsk/c0t6000D310000065000000000000000017EBd0
/dev/rdsk/c7t5000D31000006508d2 /dev/rdsk/c0t6000D310000065000000000000000017EBd0
/dev/rdsk/c7t5000D31000006513d3 /dev/rdsk/c0t6000D310000065000000000000000017ECd0
/dev/rdsk/c7t5000D31000006513d1 /dev/rdsk/c0t6000D310000065000000000000000017EAd0
/dev/rdsk/c7t5000D31000006514d3 /dev/rdsk/c0t6000D310000065000000000000000017ECd0
/dev/rdsk/c7t5000D31000006514d1 /dev/rdsk/c0t6000D310000065000000000000000017EAd0
/dev/rdsk/c7t5000D31000006507d2 /dev/rdsk/c0t6000D310000065000000000000000017EBd0
```

### 3.3 Creating file systems with ZFS

ZFS is the default file system type on Solaris. It is a transactional file system and offers many advantages over traditional file systems. Since it is a transactional file system, the file system state is always consistent on a disk. The file system can never be corrupted through power loss or system crash. More information on ZFS can be found in Appendix A, “Additional resources”.

**Table 2** Oracle Grid Infrastructure Home and Database Home file systems

<table>
<thead>
<tr>
<th>Usage</th>
<th>File System</th>
<th>Size in GB</th>
<th>Storage Center Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle Grid Infrastructure Home</td>
<td>/u01/app/12.1.0/grid</td>
<td>100</td>
<td>One 250GB Volume</td>
</tr>
<tr>
<td>Oracle Grid Infrastructure Base</td>
<td>/u01/app/grid</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Oracle RDBMS Base and Home</td>
<td>/u01/app/oracle/</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Oracle root filesystem</td>
<td>/u01</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

1. To create ZFS file systems:

   ```
   # zpool create oracle $disk
   # zfs set mountpoint=/u01 oracle
   # zfs create -o mountpoint=/u01/app/12.1.0 oracle/gridhome
   # zfs create -o mountpoint=/u01/app/grid oracle/grid
   # zfs create -o mountpoint=/u01/app/oracle oracle/oracle
   ```
2. To set quota and reservation on ZFS file systems:

   # zfs set refquota=20G oracle
   # zfs set refreservation=20G oracle

   # zfs set refquota=20G oracle/gridbase
   # zfs set refreservation=20G oracle/gridbase

   # zfs set refquota=100G oracle/oracle
   # zfs set refreservation=100G oracle/oracle
   # zfs set refquota=100G oracle/gridhome
   # zfs set refreservation=100G oracle/gridhome

3. Verify the ZFS file systems settings.

   # zfs list -t all -r oracle
   # df -h

### 3.4 Creating users and groups for Grid Infrastructure and Oracle Database Home

The following users and groups must be created if they do not already exist on the systems.

Table 3  OS users and groups for Oracle Grid Infrastructure and Database Home

<table>
<thead>
<tr>
<th>Users</th>
<th>Description</th>
<th>Primary group and secondary groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>grid</td>
<td>Oracle Grid Infrastructure owner</td>
<td>oinstall, dba</td>
</tr>
<tr>
<td>oracle</td>
<td>Oracle Database Home owner</td>
<td>oinstall, dba</td>
</tr>
</tbody>
</table>

The Oracle Grid Infrastructure and Oracle Database owners can be the same or different users. Oracle recommends separating the Grid Infrastructure owner from the Oracle Database software owner.

The grid user and oracle users should have the Oracle central inventory group, oinstall as their primary group. Members of this group are granted permission to write to the Oracle central inventory directory, Oracle Cluster home directories and OCR keys. Members of this group are also granted permission to manage the Clusterware resources and databases such as starting and stopping resources, updating resources and configuration.

### Note: The grid and oracle users must have the same central inventory group as their primary group. If an Oracle software owner has a different central inventory group, the central inventory may get corrupted.

1. Create oracle users home directories.

   # mkdir /u01/app/ghome
   # mkdir /u01/app/orahome
2. Create the groups.

   `# groupadd -g 54321 oinstall
   # groupadd -g 54322 dba`

3. Create the users.

   `# useradd -u 54321 -g oinstall -G dba grid -d /u01/app/ghome
   # useradd -u 54322 -g oinstall -G dba oracle -d /u01/app/orahome`

4. Set passwords.

   `# passwd grid
   # passwd oracle`

5. Set ownerships and permissions on the Oracle file systems.

   `# chown -R grid:oinstall /u01
   # chown -R oracle:oinstall /u01/app/oracle
   # chown -R oracle:oinstall /u01/app/orahome
   # chmod -R 775 /u01
   # chown oracle:oinstall /u01/app/ghome
   # chmod 750 /u01/app/ghome
   # chmod 750 /u01/app/orahome`

3.5 Creating SSH connectivity for the GI and Oracle users

During Oracle installation, the runInstaller OUI uses SSH to run commands and copy files to the other nodes. SSH connectivity must be set up between all cluster nodes so that they do not prompt for a password.

The runInstaller OUI can configure passwordless SSH connectivity automatically. The following conditions must be met for the automatic configuration to work.

1. All stty commands, or commands that generate output to the terminal, must be removed from the Oracle installation user profiles and hidden files.

2. Enable runInstaller OUI to locate the ssh-keygen command and SSH public keys. The OUI searches them in /usr/local/etc and /usr/local/bin but on Solaris, they are located in different directories.

   `# ln -s /etc/ssh /usr/local/etc
   # ln -s /usr/bin /usr/local/bin`

3.5.1 Configuring SSH connectivity manually

Passwordless SSH connectivity can be setup by the OUI but it might not work in all situations depending on the user environment. This section provides information on how to manually set up passwordless SSH connectivity if the OUI fails or manual configuration is preferred.
1. Login as the Oracle installation user.

2. Generate the SSH private key and public key.

   $ ssh-keygen -b 2048 -t dsa
   Generating public/private dsa key pair.
   Enter file in which to save the key (/u01/app/orahome/.ssh/id_dsa):
   Enter passphrase (empty for no passphrase): (Enter)
   Enter same passphrase again: (Enter)
   Saving the key failed: /u01/app/orahome/.ssh/id_dsa.

3. Copy the public key content of /u01/app/orahome/.ssh/id_dsa.pub to a temporary centralized authorized_keys file.

   Example: a temporary authorized_keys file is created on node one in /tmp.

4. Repeat steps 1 through 3 for the same Oracle installation user on all cluster nodes. Copy the public key contents only to the temporary /tmp/authorized_keys on node one. If there are 3 cluster nodes, there should be three lines in the file.

5. Copy the temporary centralized /tmp/authorized_keys file to the permanent location.

   For example:
   a. Steps 1 through 4 were performed for the grid user.
   b. A temporary centralized /tmp/authorized_keys file has been created on node one for the grid user.
   c. Copy /tmp/authorized_keys file on node one to the grid user SSH directory on each cluster node.

   $ chmod 644 /tmp/authorized_keys

   $ for h in node1 node2 node3
do
   $ scp -p /tmp/authorized_keys $h:/u01/app/ghome/.ssh
done

6. Test passwordless SSH setup. Answer yes to accept the node to the known host file. This must be done so that the installation will not encounter error.

   # for h in node1 node2 node3 node1-priv node2-priv node3-priv
do
   ssh $h uname -a
done

   For example:
   # ssh hadrian uname -a
   The authenticity of host 'hadrian (::1)' can't be established.
   Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'hadrian' (RSA) to the list of known hosts.
SunOS hadrian 5.11 11.1 sun4v sparc sun4v

7. Repeat steps 1 through 6 for different Oracle installation users.

3.5.2 Disable X11 forwarding
Oracle recommends turning off X11 forwarding during the installation because it might cause the installation to fail. Configure the .sshconfig file for each Oracle installation user.

```
$ echo "Host * ForwardX11 no" >> ~/.sshconfig
```

3.5.3 Disable terminal output
If the Oracle installation user .bashrc, .cshrc or other hidden files contain terminal output commands, they will cause makefile and other installation errors. As a best practice, temporarily remove these terminal commands or modify the commands in these hidden files to suppress STDOUT and STDERR outputs.

The following commands provide an example for suppressing stty output in the hidden files.

For Bourne, Bash, or Korn shell:

```
if [ -t 0 ]; then
  stty intr ^C
fi
```

For C shell:

```
test -t 0
if ($status == 0) then
  stty intr ^C
endif
```

3.6 Resource management with project
With Oracle Solaris 11.x, system resources can be allocated for applications like Grid Infrastructure and databases by using resource management functionality. Shared memory, semaphores and shell limits are adjusted and allocated by creating projects and assigning default projects to the Oracle users.

3.6.1 Shared memory and semaphore resource requirement for Oracle
The application resources shown in the following table are minimum values required for successful installation.

<table>
<thead>
<tr>
<th>Resource control parameters</th>
<th>Resource control minimum value</th>
<th>Description</th>
</tr>
</thead>
</table>

|                      |                               |             |

Table 4 Requirements for Oracle resources
<table>
<thead>
<tr>
<th>Resource Control parameters</th>
<th>Resource control value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>process.max-file-descriptor</td>
<td>Basic: 65536 (at least 1024)</td>
<td>Maximum open file descriptors.</td>
</tr>
<tr>
<td></td>
<td>Privileged: 65536 (at least 65536)</td>
<td></td>
</tr>
<tr>
<td>process.max-stack-size</td>
<td>Basic: 10MB (at least 10MB)</td>
<td>Maximum stack memory segment available.</td>
</tr>
<tr>
<td></td>
<td>Privileged: 32MB (at most 32M)</td>
<td></td>
</tr>
<tr>
<td>process.max-core-size</td>
<td>Basic: large value (unlimited)</td>
<td>Maximum core file size.</td>
</tr>
<tr>
<td></td>
<td>Privileged: large value (unlimited)</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The basic setting is the same as the soft limit within ulimit. The priv setting is the same as the hard limit within ulimit.

### 3.6.3 Modifying resource control project values

Use the following procedure to check and modify the values based on the previous sections.

1. To check the current values of resource control, log in as the user and execute the commands:
   ```bash
   # id -p
   # prtctl $$
   ```

2. Create a user resource control project.
   a. Execute the following commands as root user. The projadd command creates the user resource control projects and updates the /etc/project file.
   ```bash
   # projadd user.oracle
   # projadd user.grid
   ```
b. Update the user resource control project settings permanently.

Example:

```shell
# projmod -sK "project.max-shm-memory=(priv,8321499136,deny)" user.grid
# projmod -sK "process.max-file-descriptor=(basic,65536,deny)" user.grid
# projmod -sK "process.max-stack-size=(basic,10M,deny)" user.grid
# projmod -sK "project.max-shm-memory=(priv,8321499136,deny)" user.oracle
# projmod -sK "process.max-file-descriptor=(basic,65536,deny)" user.oracle
# projmod -sK "process.max-stack-size=(basic,10M,deny)" user.oracle
```

**Note:** Make sure all the resource control parameters and shell limits are set for each resource control project.

c. Check syntax in `/etc/project` file.

```shell
# projmod -n
```

### 3.7 Configuring network

This section provides information on network and IP requirements for Oracle Grid Infrastructure, Clusterware and Oracle RAC. Proper configuration and meeting the minimal requirements for networking are both crucial for a successful deployment of Oracle Grid Infrastructure.

#### 3.7.1 Network requirement for Oracle Grid Infrastructure

Oracle Grid Infrastructure and Clusterware require at least one public network and one private network. If flex ASM is used, either an additional private network can be configured to isolate the ASM traffic or a single private network can be shared with both ASM and Clusterware.

<table>
<thead>
<tr>
<th>Network</th>
<th>Physical network adapters on each node</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Public Network</td>
<td>One minimal. Two is recommended for high availability</td>
<td>Client access</td>
</tr>
<tr>
<td>One Private Network</td>
<td>One minimal. Two is recommended for high availability</td>
<td>Clusterware communication</td>
</tr>
<tr>
<td>One ASM Private Network (optional)</td>
<td>One minimal. Two is recommended for high availability</td>
<td>ASM traffic if flex ASM is used and a dedicated network is desired</td>
</tr>
</tbody>
</table>

- All public and private interface names must be the same on all nodes.
- All public interfaces must be on the same network.
• All private interfaces must be on a different network subnet from the public network.
• For redundant Interconnect usage, each private interface can be on a different subnet, but each cluster node must have an interface on each private network subnet.
• For the public network, each interface must support TCP/IP.
• For the private network, each interface must support UDP.
• UDP is the default protocol for Oracle RAC.
• TCP is the interconnect protocol for Oracle Clusterware.
• ARP and UDP must work properly across all the public and private interfaces.
• Multicasting is required on the private interconnect at a minimum. The Oracle mDNS daemon uses it to communicate with other nodes in the cluster.
• Multicast communication across routers is not required.

3.7.2 IP addresses requirement
To setup Oracle Grid Infrastructure, multiple IP addresses must be secured for the cluster and cluster nodes.

For flex ASM and flex Cluster setup, Oracle GNS and DNS delegation must be set up for a subdomain to the Oracle GNS. Setting up flex ASM and flex Cluster is not covered in this paper. For more information about this topic, refer to "Oracle Grid Infrastructure Installation Guide 12c Release 1 (12.1) for Oracle Solaris" listed in Appendix A.

For standard cluster configuration, the following IP names and addresses must be configured in DNS before installation. The IP names must conform to the RFC 952 standard.

Table 7 IP name and address requirements for standard cluster type

<table>
<thead>
<tr>
<th>IP names</th>
<th>IP addresses</th>
<th>Network</th>
<th>Example</th>
</tr>
</thead>
</table>
| SCAN name                       | Three static IP addresses associated with the same SCAN name in DNS          | Public  | # nslookup clustorasol-scan
|                                 | Name: clustorasol-scan.techsol.beer.town
|                                 | Address: 172.16.26.73
|                                 | Name: clustorasol-scan.techsol.beer.town
|                                 | Address: 172.16.26.75
|                                 | Name: clustorasol-scan.techsol.beer.town
|                                 | Address: 172.16.26.74 |
| A virtual IP name for each cluster node | A static virtual IP address for each cluster node. | Public  | # Nslookup Hadrian-Vip; Nslookup Maximus-Vip
|                                 | Name: hadrian-vip.techsol.beer.town
|                                 | Address: 172.16.26.84
|                                 | Name: maximus-vip.techsol.beer.town
|                                 | Address: 172.16.26.85 |
### Network Auto-Magic (NWAM)

NWAM is designed to automate and simplify network configuration on Solaris. However, NWAM does not currently support the use of IPMP and therefore manual network configuration mode must be set within NWAM.

1. **Enable DefaultFixed NCP**
   
   `# netadm enable -p ncp DefaultFixed`

2. **Verify that the network/physical:default service has restarted and is online**
   
   `# svc -xv network/physical:default`
   
   ```
   svc:/network/physical:default (physical network interface configuration)
   State: **online** since June 10, 2014 01:55:16 PM CDT
   See: man -M /usr/share/man -s 1M dladm
   See: man -M /usr/share/man -s 1M ipadm
   See: man -M /usr/share/man -s 5 nwam
   See: /var/svc/log/network-physical:default.log
   Impact: None.
   ```

3. **Verify the DefaultFixed NCP is online**

   `# netadm list`

   ```
   TYPE PROFILE    STATE
   ncp  Automatic  disabled
   **ncp** DefaultFixed  online
   loc  Automatic  offline
   ```
3.7.4 Disable DHCP
To set up IPMP on the public interfaces, the IPMP group member interfaces must be free from DHCP control. The IPMP procedure will fail when a DHCP-controlled interface is being added to the IPMP interface.

To turn off DHCP, execute `sysconfig configure`. The command will walk through a series of system configuration screens. At the network IP configuration screen, select manual mode.

3.7.5 IP Network Multipathing (IPMP)
IPMP is a network multipathing feature on Solaris that provides high availability and load balancing for network interface cards. Two or more interface cards can be configured in an IPMP group for each network type.

Oracle also recommends using the Redundant Interconnect Usage feature to provide high availability for the private network. However, IPMP can also be used. For more information on the Redundant Interconnect Usage feature, refer to “Oracle Grid Infrastructure Installation Guide 12c Release 1 (12.1) for Oracle Solaris” listed in Appendix A.

Before configuring IPMP, ensure that NWAM is in manual network configuration mode.

In this example, two private network interfaces, net2 and net3, are configured with IPMP.

1. Verify that each interface in the IPMP group has a unique MAC address.
   
   ```bash
   # dladm show-linkprop -p mac-address
   ```
   
   - If multiple interfaces have the same MAC address, manually reconfigure the interfaces so that all interfaces have unique MAC addresses.
   
   ```bash
   # dladm set-linkprop -p mac-address=xx:xx:xx:xx:xx net0
   # reboot
   ```

   **Note:** Reboot the system before continuing.

2. All interfaces in the same IPMP group must have the same STREAMS modules configured in the same order. Use the following command to verify the STREAMS modules on the interfaces. Consult the Oracle Solaris Networking Administration Guide for more information.

   ```bash
   # ifconfig net2 modlist
   0 ip
   1 igb
   # ifconfig net3 modlist
   0 ip
   ```
1 igb

3. Create net2 and net3 interfaces.

   # ipadm create-ip net2
   # ipadm create-ip net3
   # ipadm show-if

   +-----------------+-----------------+-----------------+-----------------+-----------------+
   | IFNAME | CLASS  | STATE | ACTIVE | OVER |
   +-----------------+-----------------+-----------------+-----------------+-----------------+
   | lo0      | loopback | ok     | yes    | -- |
   | net0     | ip       | ok     | yes    | -- |
   | net2     | ip       | down   | no     | -- |
   | net3     | ip       | down   | no     | -- |
   | net6     | ip       | ok     | yes    | -- |

4. Create an IPMP interface and add net2 and net3 to it.

   # ipadm create-ipmp ipmp1
   # ipadm add-ipmp -i net2 -i net3 ipmp1

5. Create an IP address on the IPMP interface.

   # ipadm create-addr -T static -a 10.10.26.88/24 ipmp1

6. **Optional**: Set net2 as a standby interface. By default, IPMP will load balance across all active interfaces.

   # ipadm set-ifprop -p standby=on -m ip net2

7. If the transitive-probing feature is used, enable it with SMF.

   # svccfg -s svc:/network/ipmp setprop config/transitive-probing=true
   # svcadm refresh svc:/network/ipmp:default
   # svcs -lv svc:/network/ipmp | egrep transitive-probing

   config/transitive-probing (boolean) = true

8. Configure IPMP group system-wide settings in the /etc/default/mpathd file. The default behavior of IPMP group failover can be modified in this file.

   FAILURE_DETECTION_TIME - default is 10 seconds
   FAILBACK - default is yes
   TRACK_INTERFACES_ONLY_WITH_GROUPS - default is yes

9. Restart the in.pathd daemon.

   # pkill -HUP in.mpathd

10. Enable the ARP protocol on interfaces.

    # ipadm set-ifprop -p arp=on -m ipv4 net2
3.7.6 Configuring ephemeral ports for TCP and UDP

The Oracle installation requires the following settings for TCP and UDP ephemeral ports.

1. Configuring TCP and UDP ports.

   - # ipadm set-prop -p smallest_anon_port=9000 tcp
   - # ipadm set-prop -p smallest_anon_port=9000 udp
   - # ipadm set-prop -p largest_anon_port=65500 tcp
   - # ipadm set-prop -p largest_anon_port=65500 udp

2. Verify the port settings.

   - # ipadm show-prop tcp | egrep "anon_port|DEFAULT"

<table>
<thead>
<tr>
<th>PROTO PROPERTY</th>
<th>PERM</th>
<th>CURRENT</th>
<th>PERSISTENT</th>
<th>DEFAULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>tcp</td>
<td>rw</td>
<td>65500</td>
<td>65500</td>
<td>65535</td>
</tr>
<tr>
<td>tcp</td>
<td>rw</td>
<td>9000</td>
<td>9000</td>
<td>32768</td>
</tr>
</tbody>
</table>

   - # ipadm show-prop udp|egrep "anon_port|DEFAULT"

<table>
<thead>
<tr>
<th>PROTO PROPERTY</th>
<th>PERM</th>
<th>CURRENT</th>
<th>PERSISTENT</th>
<th>DEFAULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>udp</td>
<td>rw</td>
<td>65500</td>
<td>65500</td>
<td>65535</td>
</tr>
<tr>
<td>udp</td>
<td>rw</td>
<td>9000</td>
<td>9000</td>
<td>1024-655500</td>
</tr>
</tbody>
</table>

3.7.7 Configuring DNS client and name resolution

With Solaris version 10 and above, the DNS client configuration and name resolution configuration are configured with the SMF facility.

1. Configure /etc/resolv.conf:

   - # svccfg -s svc:/network/dns/client setprop config/search='("domain1" "domain2")'
   - # svccfg -s svc:/network/dns/client setprop config/nameserver=net_address:
     "(xxx.xxx.xxx.xxx yyy.yyy.yyy.yyy)"
   - # svcadm refresh svc:/network/dns/client
   - # svcs -lv svc:/network/dns/client | egrep "config/nameserver|config/search"
   - config/nameserver (net_address) = xxx.xxx.xxx.xxx yyy.yyy.yyy.yyy
   - config/search (astring) = "domain1 domain2"
2. Configure `/etc/switch.conf`:

```bash
# svccfg -s svc:/system/name-service/switch setprop config/default = astring: "files"
# svccfg -s name-service/switch setprop config/host = astring: '("files dns")'
# svcadm refresh svc:/system/name-service/switch
# svcs -lv svc:/system/name-service/switch|egrep "config/default|config/host"
```

cfg/default (astring) = files

3. **Configuring NTP service**

All cluster nodes should synchronize the time from the same time source. If the time on the nodes are out of sync, it will result in unpredictable issues such as cluster installation failure or node reboots periodically. Oracle version 11gR2 and above supports the use of vendor time synchronization daemon (ntpd) or Oracle Cluster Time Synchronization daemon (ctssd) to synchronize time on the cluster nodes. ctssd can detect whether ntpd is configured. If ntpd is not configured, ctssd will run in active mode and will only synchronize time among the cluster nodes. If ntpd is configured, ctssd will run in observer mode which will only detect time gap but will not adjust the time. If time is synchronized to an external time source, such as corporate time server, ntpd must be configured. The same synchronization method should be used on all cluster nodes.

To configure the Network Time Protocol (NTP) service, use the following steps.

**Note:** Slewing must be enabled for the ntp service to prevent a cluster node reboot issue due to a leap second.

1. Copy a configuration template if the configuration does not exist.
   ```bash
   # cd /etc/inet
   # cp ntp.client ntp.conf
   ```

2. Add the time server information to the configuration file.
   ```bash
   server xxx.xxx.xxx.xxx
   ```
   Replace `xxx.xxx.xxx.xxx` with the time server IP address.

3. Modify the NTP attributes.
   ```bash
   # echo "slewalways yes" >> /etc/inet/ntp.conf
   # echo "disable pll" >> /etc/inet/ntp.conf
   # svccfg -s svc:/network/ntp:default setprop config/slew_always = true
   # svcadm refresh ntp
   ```

4. Perform a one-time manual time sync.
   ```bash
   # svcadm disable ntp
   # ntpdate xxx.xxx.xxx.xxx
   # svcadm enable ntp
   ```
Replace xxx.xxx.xxx.xxx with the time server IP address.
4 Configuring Storage for ASM

There are considerations and guidelines when creating volumes for ASM. This section discusses these considerations and guidelines.

Dell Enterprise Manager is a management console for managing Dell Storage Center and other Dell Compellent products. It is used to create volumes, map volumes to the servers, and perform tasks related to the Storage Center.

---

**Figure 4** Oracle Database on ASM disk groups and Storage Center volumes. Oracle binaries on ZFS file systems and Storage Center volumes
4.1 Creating volumes for ASM

Determine how many volumes and the size of the volumes based on their specific usage. The following table provides an example of different usage types for ASM. Users should determine the actual volume size based on the business and application requirements.

Table 8  ASM and Storage Center volume examples

<table>
<thead>
<tr>
<th>Usage</th>
<th>ASM disk group</th>
<th>Size in GB</th>
<th>Dell Storage Center Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Infrastructure Voting and OCR disks</td>
<td>GIDG</td>
<td>10</td>
<td>1 x 100GB volume</td>
</tr>
<tr>
<td>Database Data disk group</td>
<td>DATADG</td>
<td>1000</td>
<td>2 x 500GB volumes</td>
</tr>
<tr>
<td>Database Archivelog disk group</td>
<td>FRADG</td>
<td>200</td>
<td>1 x 200GB volume</td>
</tr>
</tbody>
</table>

At least one volume is required for the Oracle Grid Infrastructure voting and OCR disk during the Oracle Grid Infrastructure installation. The volume must be created and mapped to all the cluster nodes before Grid Infrastructure installation can begin.

One or more volumes can be used for a single Oracle RAC database. The volumes must be created and mapped to all the cluster nodes before the Oracle RDBMS installation can begin.

As a best practice, create ASM disk groups based on the usage type:

- One for the Oracle Grid Infrastructure
- One for an Oracle RAC database that contains the data files
- One for the same Oracle RAC database that contains the archive logs

A database can have multiple ASM disk groups but an ASM disk group should only contain files from one database.

If there is more than one Oracle RAC database on the same cluster nodes, create separate disk groups in pairs (one data and one archivelog disk group) for each RAC database. See Figure 4 above.

4.2 Choosing a volume size

Dell Storage Center allows users to choose the optimal size of a volume. There is no performance difference within the storage array for different volume sizes.

For ASM disk groups, Oracle recommends using the same size volumes within a disk group. For example, to create volumes for an ASM disk group of 1TB, a single 1TB volume, two 500GB volumes or four 250GB volumes can be used.

Thin Provisioning, or Dynamic Capacity, allows space to be allocated to the servers and ASM without actually taking up the full capacity of a volume. A Storage Center volume is thin provisioned by default. The actual disk space is not used until the data is written to the volume.
For Oracle databases, data file space is pre-allocated when creating tablespaces. To take advantage of the thin provisioning feature, create smaller data files and enable the Oracle autoextend feature on the data files so that additional extents are allocated when needed.

**Note:** Enable the autoextend feature on Oracle data files to allow thin provisioning.

To monitor the space used by a volume, go to the volume summary view in the Enterprise Manager.

For example: The Storage Center volume named “fravol” is configured with 200 GB of space. The active space is only 1.78 GB and total space used is 3.56 GB. The active space represents the Oracle data on a volume. Since the volume space is on RAID 10 level, the total space used is twice of the active space.

![Storage Center volume size and thin provisioning](image)

**Figure 5** Storage Center volume size and thin provisioning

### 4.3 Consideration for ASM disk group expansion

Another consideration of choosing a volume size is that with Oracle ASM, it is very easy and safe to expand or reduce the capacity of an ASM disk group by adding new volumes or removing existing volumes. ASM performs the addition and reduction of volumes online without downtime to the application and database.

**Note:** As a best practice, add or remove volumes to expand or reduce an ASM disk group.

When expanding an ASM disk group, a volume with the same size is recommended. Therefore, ASM disk group expands by the size of a volume incrementally.

If an ASM disk group consists of a single large volume, it might not be ideal in some environments where a smaller incremental growth is desired. Therefore, choose a volume size that is more suitable for future incremental growth during the initial creation of the ASM disk group.

For example, create a 1TB ASM disk group by using four 250GB volumes initially. In the future when additional capacity is needed, an increment of 250GB volumes can be added to the ASM disk group.

**Note:** Consider a volume is a minimum size an ASM disk group can grow or reduce by.
4.4 Choosing Storage profiles for ASM volumes

With traditional storage systems, a disk volume is tied to a specific type of disk and performance level and it is very difficult to redistribute the data to lower cost disks when the data becomes less frequently accessed.

A Storage Center volume is a virtual disk that can span across multiple storage tiers. Storage Center guarantees that all active writes go to the fastest disks at RAID 10 performance level. With its advanced data progression algorithm, data that has not been accessed for a certain period of time gets redistributed to the lower cost disks at RAID 5 or RAID 6 performance levels. This is to reduce cost and save disk consumption from the higher cost disks.

Storage Profiles determine how data is distributed and moved most effectively within Storage Center. By default, the following profiles are available within the Storage Center. Custom Storage Profiles can also be created if standard profiles are not sufficient.

To maximize flexibility and cost-savings benefits, choose Storage Profiles that move data across all storage tiers.

For example: These Storage Profiles are good starting points and are generally good for all types Oracle files.

- Flash Optimized with Progression (Tier 1 to All Tiers)
- Recommended (All Tiers)

If more specific placement of data is desired, choose different Storage Profiles that move data across certain storage tiers or within a single storage tier.

For example: Oracle data and online redo logs volumes on Tier 1 while Oracle archive logs volumes on Tier 2 or Tier 3. Oracle binaries volumes might work well Tier 2 or Tier 3

- Flash only with Progression (Tier 1 to Tier 2)
- Write Intensive (Tier 1)
- High Priority (Tier 1)
- Medium Priority (Tier 2)
- Low Priority (Tier 3)

Storage Profiles can be changed at any time if the initial profile does not fit the need or the requirement has changed over time.

Storage Tiering and Data Progression are transparent to Oracle ASM and databases. No configuration within Oracle is necessary to take advantage of these advanced features.

For example: Recent sales records in the sales table resides in Tier 1 storage while older sales records is moved to lower Tier 3 storage as seen in Figure 6.
An ASM disk on Storage Center virtual volume

Sales records in a sales history table

<table>
<thead>
<tr>
<th>Date</th>
<th>First</th>
<th>Last</th>
<th>Store #</th>
<th>Address</th>
<th>Phone #</th>
<th>Amt</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>John</td>
<td>Smith</td>
<td>100</td>
<td>xxxxxxx</td>
<td>xxxxxxx</td>
<td>$10.00</td>
</tr>
<tr>
<td>2000</td>
<td>John</td>
<td>Doe</td>
<td>200</td>
<td>xxxxxxx</td>
<td>xxxxxxx</td>
<td>$20.00</td>
</tr>
</tbody>
</table>

When data becomes active again, Data Progression moves it to higher performance storage tier over time.

To monitor the Storage Tiers of a volume, go to the volume statistics view in the Enterprise Manager.

Data Progression moves less active data to the lower storage tier over time.

Figure 6  Storage Tiering and Data Progression for an ASM volume on Storage Center

Figure 7  Storage Tiers information on a Storage Center volume
4.5 Choosing Replay profiles for ASM volumes

Data Instant Replay is a Storage Center feature that allows making space-efficient, point-in-time copies of one or more Storage Center volumes called Replays. A Replay profile is a set of rules and schedules that defines when Replays should be taken on a specific volume.

To create Replays that preserve the data integrity of an Oracle database, all Storage Center volumes used by the same Oracle database must be configured in the same Consistent Replay profile.

Here are some considerations for creating and applying Replay profiles for ASM volumes.

- Create a separate Consistent Replay profile for each Oracle database.
- Create a separate Replay profile for OCR and voting disks. It can be a standard Replay profile if only a single volume is used. Otherwise, it will have to be a Consistent Replay profile.
- Apply a Consistent Replay profile for a database to all volumes used by that same database.
- All volumes should have at least one Replay scheduled per day with a retention of 48 hours or longer.
- New volumes need the same Consistent Replay profile as the rest of the database.
- For Storage Center version 6.x, the maximum number of volumes for a single Consistent Replay profile is 40.
- When creating Replays on a running database, the database must be put in hot backup mode first.
- With the Storage Center Command Line tool, creating Replays for an Oracle database can be scripted and automated along with the execution of the Oracle tasks (such as taking a database in and out of hot backup mode).

The following example shows a Consistent Replays profile with one-time schedule and two volumes configured with the same profile.

![Figure 8](image-url) A Consistent Replays profile for a Oracle RAC database
5 Installing Oracle Grid Infrastructure with runInstaller

This section provides information on using the installer for Oracle Grid Infrastructure.

5.1 Verify Oracle Grid Home file systems

The software is installed in the Oracle Grid Home. Both Oracle Grid Home and Oracle Grid Base file systems need to be created before the installation begins.

Please refer to Section 3.5 for creating the required ZFS file systems.

On each cluster node, verify that /u01/app/grid and /u01/app/12.1.0 file systems are mounted with proper permission and ownership.

5.2 Installing Oracle Grid Infrastructure

The Oracle installer, runInstaller, is used to install the Oracle Grid Infrastructure software and configure the cluster in the same session. The installer goes through the configuration information and requirements step by step to verify the prerequisites are met before the installation begins.

1. Log on to the first cluster node as the Oracle RDBMS software owner. In this setup example, it is “oracle”.

   # ssh -X oracle@$server

2. Navigate to the installation software directory.

   # cd /stage/software/oracle/12c_solaris_sparc/grid

3. Invoke the runInstaller utility.

   # ./runInstaller


   a. Make sure the prerequisite tasks in Section 3 have been completed successfully.
   b. Choose the advanced installation that allows more storage and networking options during the installation. It also allows the cluster name to be different from the SCAN name.
   c. During the installation, create an ASM disk group dedicated for the OCR and voting disks and other Grid Infrastructure files.
   d. Select External Redundancy for the ASM disk group since Storage Center already provides hardware RAID protection.
5.3 Verify Grid Infrastructure services on all cluster nodes

After the installation, execute the following steps to confirm the Grid Infrastructure services are running.

1. Log on to one of the cluster nodes as the Grid Infrastructure Home owner.
2. Set the Oracle environment.

   $ . oraenv

3. Enter the corresponding ASM SID on the local server (for example, +ASM1).
4. Use crsctl to check cluster health and resource status.
   a. Run `crsctl check crs` on each cluster node. All services should be online.

   $ crsctl check crs
   CRS-4638: Oracle High Availability Services is online
   CRS-4537: Cluster Ready Services is online
   CRS-4529: Cluster Synchronization Services is online
   CRS-4533: Event Manager is online

   b. Run `crsctl stat res -t` on one cluster node. All resources should have ONLINE status.

   $ crsctl stat res -t
   
<table>
<thead>
<tr>
<th>Name</th>
<th>Target</th>
<th>State</th>
<th>Server</th>
<th>State details</th>
</tr>
</thead>
<tbody>
<tr>
<td>ora.CLUSTORASOL.dg</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.DATADG.dg</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.FRADG.dg</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.LISTENER.lsnr</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.asm</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>Started,STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>Started,STABLE</td>
</tr>
<tr>
<td>ora.net1.network</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.ons</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
</tbody>
</table>
### Cluster Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Status</th>
<th>State</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>ora.LISTENER_SCAN1.lsnr</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.LISTENER_SCAN2.lsnr</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.LISTENER_SCAN3.lsnr</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.MGMTLSNR</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>10.10.26.86,STABLE</td>
</tr>
<tr>
<td>ora.cvu</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.hadrian.vip</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.maximus.vip</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.mgmt.db</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.oc4j</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.orcl.db</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>Open,STABLE</td>
</tr>
<tr>
<td>ora.scan1.vip</td>
<td>ONLINE</td>
<td>maximus</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.scan2.vip</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
<tr>
<td>ora.scan3.vip</td>
<td>ONLINE</td>
<td>hadrian</td>
<td>STABLE</td>
</tr>
</tbody>
</table>
6 Installing Oracle RDBMS software and creating RAC database
This section will provide the steps to install an Oracle RAC database on Storage Center volumes.

6.1 Verify Oracle Home file systems
The Oracle installer will install the software in the Oracle Home. The Oracle Home and Oracle Base file systems need to be created before the installation begins.

Please refer to Section 3.5 for creating the required ZFS file systems.

On each cluster node, verify that /u01/app/oracle file system is mounted with proper permission and ownership.

6.2 Create ASM disk groups for the RAC database
asmca (Oracle ASM configuration Assistant) is a graphical user interface tool that support creating and configuring ASM disk groups. The following section shows the Create Disk Group screen in asmca.

The disk group should use external redundancy. The Storage Center provides hardware RAID to protect the volume; it is not necessary to use software redundancy in ASM.

6.2.1 Using asmca utility to create and mount disk group
The asmca graphical user interface is shown below. After creating a new disk group, it is automatically mounted on all cluster nodes.

1. Log on as the grid user.
2. Set up the DISPLAY environment variable.
3. Set up the Oracle environment variables.
4. Launch asmca and enter a Disk Group name.
5. Choose External Redundancy.
6. Choose the Storage Center volume for the disk group.
6.2.2 Using a sql statement to create and mount disk groups

If a sql statement is preferred and used to create a disk group, use the following steps.

7. Log on to one cluster node as the Grid Infrastructure owner. In this setup example, the GI owner is “grid”.
8. Set the oracle environment.
   
   `$ . oraenv`

9. Enter the correct ASM SID on that server (for example, +ASM1).
10. Invoke sqlplus.
    
    `$ sqlplus / as sysasm`

11. Create a disk group.
    
    ```
    SQLPLUS > create diskgroup FRADG external redundancy disk \
    '/dev/rdsk/c0t6000D3100000650000000000000017F0d0s6' ;
    ```

    - Repeat the command for each disk group.

**Note:** External redundancy should be used with Storage Center volumes.
12. Exit `sqlplus`.

   SQLPLUS > exit

13. Mount and activate the newly created disk groups.

   $ sructl start diskgroup -g FRADG

   • Repeat the command for other disk groups

6.3 Installing Oracle RDBMS software and creating a RAC database

The Oracle runInstaller is used to install the RDBMS software and to create a RAC database in the same session. It can also install just the RDBMS software without creating a database. To create a database later on, the dbca utility is used. In this paper, both RDBMS software and a RAC database are installed with runInstaller.

1. Log on to the first cluster node as the Oracle RDBMS software owner. In this setup example, it is "oracle".
2. Navigate to the installation software directory.

   $ cd /stage/software/oracle/12c_solaris_sparc/database

3. Invoke the `runInstaller` utility

   $ ./runInstaller


   a. Make sure that the prerequisite tasks in Section 3 have been completed successfully.
   b. In Oracle, the default database block size is 8 KB. In Storage Center, the default page size is 2 MB. Users might want to experiment using a bigger database block size that might improve the I/O performance by reducing IOPS and increasing data transfer throughput.

6.4 Verify the database home and services on all cluster nodes

After the installation, execute the following steps to confirm the database home and services are running.

1. Log on to one of the cluster nodes as the Oracle Home owner.
2. Set the Oracle environment.

   $ . oraenv

3. Enter the corresponding database SID on the local server (for example, orcl).
4. Use `sructl` to check the database status.

   $ sructl status db -d orcl
   Instance orcl1 is running on node maximus
Instance orcl2 is running on node hadrian

5. **Use the opatch utility to verify the Oracle Home on each cluster node.**

   $ ./opatch lsinventory
   Oracle Interim Patch Installer version 12.1.0.1.0
   Copyright (c) 2012, Oracle Corporation. All rights reserved.

   Oracle Home       : /u01/app/oracle/product/12.1.0/dbhome_1
   Central Inventory : /u01/app/oraInventory
                      from /u01/app/oracle/product/12.1.0/dbhome_1/oraInst.loc
   OPatch version    : 12.1.0.1.0
   OUI version       : 12.1.0.1.0
   Log file location : /u01/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/opatch2014-07-03_22-47-07PM_1.log

   Lsinventory Output file location : /u01/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/lsinv/lsinventory2014-07-03_22-47-07PM.txt

   -----------------------------------------------------------------------------------------------
   Installed Top-level Products (1):
   Oracle Database 12c 12.1.0.1.0
   There are 1 products installed in this Oracle Home.

   There are no Interim patches installed in this Oracle Home.

   Rac system comprising of multiple nodes
     Local node = maximus
     Remote node = hadrian

   -----------------------------------------------------------------------------------------------

   OPatch succeeded.
7 Using Replay with Oracle ASM
Replays take up a very small amount of space as data blocks are not copied but they are frozen instead. Any new writes then take up new data blocks.

7.1 Replay use cases
- Backup and recovery:
  - Create Replays on database volumes periodically. View volumes can then be created from Replays and mounted on a backup server. Backup processes run against the View volumes without impacting the source database.
  - Use Replays as disk-based backups. Since Replays take up very little space and can be created quickly, it is a cost-effective and space-efficient way to keep multiple versions of a database on a disk.
  - Recovering from disks is much faster than recovering from tapes.
  - Create an on-demand Replay before performing major database changes. If the changes fail, the database can be rolled quickly from a Replay.

- Creating separate copies of a database:
  - Use Replays to clone a production database for developing and testing new codes, testing or bug fixes.
  - A cloned database is less than a full size copy of the source database.
  - Creating Replays takes a few in minutes, and shortens the time to spin up new development databases significantly.

- Refresh multiple databases from a single source:
  Multiple database environments can base on the same source. They can be reset to the same baseline easily and quickly.

7.2 Create a clone database from Replays
This section describes the procedure to create a clone database from Replays.

1. Log on to Enterprise Manager.
2. Navigate to the Storage Center’s Storage view.
3. Select the volume where the Replays are created and navigate to the Replays view.
4. If the most recent data is needed, create an on-demand Replay by choosing Create Replay on the contextual menu. If the volume belongs to a Consistent Replay Profile with other volumes in it, it will prompt to also create Replay for all the volumes in the same Consistent Replay Profile.

Note: the database must be put in hot-backup mode before creating a Replay
5. Select the Replays of interest and choose **Create Volume from Replay** on the contextual menu. See Figure 10.

6. The new View volume is now displayed on the left pane under the **Volumes** folder.

7. Select the new View volume and choose **Map Volume to Server** on the contextual menu.

8. Repeat the above steps for each volume of the database.

9. Log on to the server(s). Scan for the new volumes, configure multipathing and permissions. See Section 3 for details.

10. Launch asmca or log on using **sqlplus** and mount the ASM disk groups. Since these are the exact replicas of the source volumes, they have the same ASM disk group names and disk names.

11. Open the database and allow access to users.

Figure 10  Create a volume from Replay
8 Replication with Oracle ASM

The replication process duplicates volumes from one Storage Center to another Storage Center. The Storage Centers are usually at different sites but they can also be at the same location.

The replication process replicates data using Replays on a block level. Only the blocks that have changed since the last Replay are copied to the remote volumes.

For information on how to set up connections between Storage Centers and the replication process, please refer to “Dell Enterprise Manager 2014 R2 Administrator’s Guide” listed in Appendix A.

8.1 Replication uses with Oracle

The replication process can be implemented for different business needs.

- Business Disaster Recovery
  
  Use replication to duplicate business critical databases to a remote disaster recovery site.

- Duplicating databases for testing and development
  
  Use replication to duplicate a database to remote sites where testing and development teams can work on a copy of the source database.

- Set up an Oracle Data Guard database
  
  Use replication to duplicate a production database and set up an Oracle Data Guard database with the copy.

  Oracle Data Guard is a software based replication technology and is dependent on network stability and bandwidth to keep up with the log transfers between the primary and remote sites.

  Storage Center replication is a hardware-based block level replication. It can be set up on a Fibre Channel network and serves as a back up to the primary site in addition to the Oracle Data Guard database. If the Oracle Data Guard database fails behind getting updates from the primary site, it can be quickly reinstated from the replication copy.
8.2 Asynchronous replication

With asynchronous replication, data is written to the primary site and control is returned to the servers without having to wait for the writes to complete to the remote site.

Asynchronous replication does not have the latency impact that synchronous replication does, nor does it guarantee the writes to the remote site. Data loss might happen if the primary Storage Center fails.

Data is transferred to the remote site whenever Replays are created and only the blocks changed since the last Replay are transferred. The Replay interval schedule is defined in the Replay policy.

To transfer data to the remote site in near real time, select the Replicate the Active Replay feature. However, Oracle ASM and databases replicated using the Active Replay might fail to come up on the remote site because of inconsistent data. Therefore, it is recommended to adjust the Replay schedule to create Consistent Replays more frequently.

8.3 Synchronous replication

With synchronous replication, data is written to both the primary site and the remote site before control is returned to the servers. The application latency includes the write latency to the remote site.

The network that connects the primary and remote sites must be designed to meet the business needs, application latency requirements, and user response time expectations.
### 8.3.1 High consistency mode

Synchronous High Consistency mode is designed to ensure that both the primary and remote volumes are in sync at all time. If the writes fail to reach the remote site for any reason, replication stops and the primary volumes become inaccessible to the servers.

High Consistency mode provides the maximum level of data protection between the primary and remote sites.

### 8.3.2 High availability mode

Synchronous High Availability mode writes to both primary and remote sites but the primary volumes continue to be accessible when the remote site becomes unavailable.

### 8.4 Replication requirements and considerations for Oracle ASM

- Requires two Storage Centers connected to each other using Fibre Channel, iSCSI or both.
- Replication relies on Replay profile configured on the volumes.
- Volumes used for the same Oracle database must be configured in the same Consistent Replay profile, regardless of how many ASM disk groups are configured.
- Choose synchronous replication for maximum data protection, or asynchronous replication and enable deduplication to conserve bandwidth and avoid causing high latency to the Oracle database.
- Similar server hardware is available and configured at the remote sites.
- The same version of Oracle Grid Infrastructure, Clusterware and Oracle database software should be installed and configured on the servers at the remote sites.
- A Quality of Service (QoS) policy can be defined to specify a link speed and the amount of bandwidth allowed for replications.
A Additional resources

Dell Compellent Storage Center System Manager Version 6.5 Administrator’s Guide
http://kc.compellent.com/Published%20Documents/680-019-016.pdf

Dell Enterprise Manager 2014 R2 Administrator’s Guide
http://kc.compellent.com/Knowledge%20Center%20Documents/680-017-021.pdf

SC8000 Connectivity Guide

Dell Compellent Storage Center 6.5 Command Utility (CompCU) Administrator’s Guide

Oracle Solaris 11.1 Information Library – Contains all Solaris related manuals and documentation
http://docs.oracle.com/cd/E26502_01/

Installing Oracle Solaris 11.1. Systems

Oracle Solaris 11.1 Administration: Devices and File Systems

Oracle Solaris 11.1 Administration: ZFS File Systems

Oracle Solaris 11.1 Administration: SAN Configuration and Multipathing

Oracle Solaris 11.1 Administration: Configuring and Administering Oracle Solaris 11.1. Network

Oracle Grid Infrastructure Installation Guide 12c Release 1 (12.1) for Oracle Solaris
http://docs.oracle.com/cd/E16655_01/install.121/e17890/toc.htm

Oracle Database Quick Installation Guide 12c Release 1 (12.1) for Oracle Solaris on SPARC (64-Bit)
http://docs.oracle.com/cd/E16655_01/install.121/e17756/toc.htm

Oracle Database Installation Guide 12c Release 1 (12.1) for Oracle Solaris
http://docs.oracle.com/cd/E16655_01/install.121/e17752/title.htm
B  Configuration details

This section describes the testing component configuration details. This includes the physical and software components such as servers, network switches, Storage Center, software and firmware versions.

B.1  Hardware components

Table 9  Hardware configuration detail

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>Oracle SunFire T4-1</td>
</tr>
<tr>
<td>BIOS/Driver version</td>
<td>• Driver Version = 8.04.00.04.06.3-k-debug</td>
</tr>
<tr>
<td></td>
<td>• BIOS Version = 3.00</td>
</tr>
<tr>
<td>Firmware version</td>
<td>Firmware Version = 5.06.05 (90d5)</td>
</tr>
<tr>
<td>Switch</td>
<td>Dell PowerConnect 5500 Series</td>
</tr>
<tr>
<td>Storage</td>
<td>• Dell Storage Center 8000 with dual controllers</td>
</tr>
<tr>
<td></td>
<td>• SCOS 6.5.2</td>
</tr>
<tr>
<td>Tier 1</td>
<td>• 12 x 170 GB SLC drives</td>
</tr>
<tr>
<td></td>
<td>• 1 enclosure</td>
</tr>
<tr>
<td>Tier 2</td>
<td>• 12 x 1.46 TB MLC drives</td>
</tr>
<tr>
<td></td>
<td>• 1 enclosure</td>
</tr>
<tr>
<td>Tier 3</td>
<td>• 16 x 370 GB 10K drives</td>
</tr>
<tr>
<td></td>
<td>• 1 enclosures</td>
</tr>
<tr>
<td>FC Adapter</td>
<td>QLogic QLE 2562 8GB dual port HBA</td>
</tr>
</tbody>
</table>

B.2  Software components

Table 10  Software component detail

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database</td>
<td>• Oracle Clusterware 12.1.0</td>
</tr>
<tr>
<td></td>
<td>• Oracle RAC 12.1.0</td>
</tr>
<tr>
<td>Operating system</td>
<td>• Solaris 11.1</td>
</tr>
<tr>
<td></td>
<td>• MPXIO</td>
</tr>
<tr>
<td>Dell Compellent Enterprise Manager</td>
<td>Enterprise Manager 2014 R2</td>
</tr>
<tr>
<td>Storage Center OS</td>
<td>SCOS 6.5.2 Virtual Port Mode</td>
</tr>
</tbody>
</table>
Step-by-step Oracle Grid Infrastructure installation

Software updates
The installer can download the latest recommended updates such as PatchSet Updates (PSUs) and other patches if the user chooses to do so.

As a best practice, let the installer download and apply the latest PSUs and patches during the installation. This option requires internet access to the Oracle support website and a valid Oracle Support credential.

Installation option
Oracle Grid Infrastructure is installed and configured for a two-node cluster.

Cluster type
In this setup example, a standard cluster is configured.

Installation type
An advanced installation provides more configuration options (such as storage choices and networking options).

Product languages
By default, the installer selects English as the default language. Select additional languages from the Available languages pane.

Grid plug and play information
Specify the Cluster name, SCAN Name and SCAN port.

The typical installation automatically matches the cluster name to the scan name and there is no option to change the cluster name. Beware that the cluster name has a length limitation of eight characters.

The advanced installation allows users to specify a different cluster name than the scan name.

GNS is required if Flex cluster type is selected in the earlier screen.
Cluster node information
The local node where the runInstaller is invoked is added by default.

Click Add to include the other nodes in the cluster.

A virtual hostname must be specified for each cluster node.

SSH connectivity without a password can be configured automatically. Click SSH connectivity and provide additional information for the setup.

Specify network interface usage
The installer automatically detects the existing network interfaces on the server and then populates the Subnet and Use for fields. The information populated by the installer is not always accurate and requires users to verify and update accordingly.

In this setup, with standard cluster type, a public interface and a private interface are configured.

Grid Infrastructure management repository option
If this optional step is selected, a separate management repository database is created.

The management repository is named “-MGMTDB” and it has /u01/app/12.1.0/grid as its ORACLE HOME.

Storage option information
In this setup example, the standard ASM option is chosen.
Create ASM disk group
Specify the disk group name for OR and voting disk files. Select a meaningful name that represents the types of files stored in the disk group.

For example, use the CLUSTER NAME for the disk group name.

Select **External** redundancy since Storage Center already provides hardware RAID protection.

Select the Storage Center volume(s) for the disk group.

Specify ASM password
In this setup, both sys and asmsnmp are configured to use the same password.

They can also be set to different passwords.

Privileged operating system groups
In this setup, the default of dba and oinstall groups are used.

Installation location
The Oracle Base is set to `/u01/app/grid` and Grid Home is set to `/u01/app/12.1.0/grid`.

These file systems should exist with ownership and permission properly configured.

Create inventory
Specify the location for the Oracle software inventory. `/u01/app/oraInventory` is the default. The directory is created if it does not exist. Both Oracle Home owner and Grid Home owner must have the oraInventory Group, oainstall, as their primary group.
Root script execution configuration
The root.sh script must be run on each cluster node to complete the installation. The script can be automatically executed if proper root credentials or sudo privilege is provided.

Perform prerequisite checks
The installer will execute the cluvfy or runcluvfy utility to verify all prerequisites are met.

It will report any issues and offer an explanation of what needs to be fixed in the next screen.

It also offers to fix the issues automatically. However, it does not resolve all issues all the time. User intervention might be needed to correct some of the issues.

Summary
Verify the information is correct. Click **Edit** to modify the information.

It is also recommended to save a response file for this configuration. A response file can be used to quickly fill in the information for the next installation.

A response file is in text format so it can be modified with any text editor and is convenient for customizing the configuration data.

Click **Install** to start the installation.
Install product
The installation begins and the progress status is displayed.

The duration of the installation depends on the server hardware and the number of cluster nodes. In this setup, it took approximately 45 minutes to complete a two-node cluster installation.

Execute root scripts
When it is time to execute the root scripts, it will prompt for confirmation before the execution.

If there is no root credential or if the sudo privilege was provided in the configuration, manual execution on each cluster node is prompted.

Configure Oracle Grid Infrastructure
The installer continues with the configuration on all cluster nodes.

Finish
The installation completes. Click Close to exit the installer.
Step-by-step Oracle database software installation and database creation

Software updates
The installer can download the latest recommended updates such as PatchSet Updates (PSUs) and other patches as needed. As a best practice, let the installer download and apply the latest PSUs and patches during the installation. This option requires internet access to the Oracle support website and a valid Oracle Support credential.

Installation option
In this setup example, the Oracle RDBMS software is installed, and then a RAC database created and configured in a single step.

System class
Choose the appropriate class for the systems.

Database installation option
Choose the type of database installation. In this setup example, RAC database is selected.

Cluster database type
Choose the appropriate type of cluster database. In this setup example, Admin managed is used.
Node selection
Select the cluster nodes for the RAC database.

The Oracle RDBMS software is installed and a RAC database instance configured on the selected nodes.

It can also check SSH connectivity between the selected nodes.

Product languages
By default, the installer selects English as the default language. Select additional languages from the Available languages pane.

Database edition
Select the appropriate database edition.

Installation location
The Oracle base is set to /u01/app/oracle and Oracle Home is set to /u01/app/oracle/product/12.1.0/dbhome_1. Properly set ownership and permission for these file systems.

Configuration type
Select the database configuration type.
**Database identifiers**
Specify the Global database name and Oracle SID.

Specify whether this is a container database or a standard database.

**Database configuration options**
Adjust the memory settings accordingly based on the server capacity and the number of expected configured databases on the server.

**Database configuration options**
If multiple languages are required in the database, select Unicode or different character sets under the Character sets tab.

**Database storage options**
Specify Oracle ASM to be used.
Management options
If Oracle Enterprise Manager 12c Cloud Control is available in your environment and is used to centrally manage all databases, the installer can register the new database in Oracle Enterprise Manager.

As an option, Registration with the OEM can be done separately after the database has been created.

Recovery options
The Fast Recovery Area is recommended for quick database recovery. If it is selected, it will require the storage location for the fast recovery area files.

Use a dedicated disk group. In this setup example, the FRA disk group is FRADG.

ASM disk group
Select the appropriate data disk group for the database. The system, sysaux, temp, undo and users tablespaces are created in this disk group.

In this setup example, DATADG is selected.

Schema passwords
Specify the passwords for the main database schemas.

Privileged operating system groups
Assign an existing dba operating system group to the various database groups.
**Perform prerequisite checks**
The installer will execute the cluvfy or runcluvfy utility to verify all prerequisites are met.
It will report any issues and offer explanation what needs to be fixed in the next screen.
It also offers to fix the issues automatically. However, it does not resolve all issues all the time. User intervention might be needed to correct some of the issues.

**Summary**
Verify the information is correct. Click edit to modify the information.
As a best practice, save a response file for this configuration. A response file can be used to quickly fill in the information for the next installation.
A response file is in text format so it can be modified with any text editor. It offers great convenience to customize the configuration data.
Click Install to start the installation.

**Execute root scripts**
When prompted, log on to each cluster node using the root credential or sudo privilege and run the script specified by the installer.
Execute the script on one node at a time. After the script is run on all nodes, the software installation is complete.
**Database Configuration Assistant**

The configuration assistant creates a database instance on each node and completes the configuration.