



Red Hat Reference Architecture Series

Deploying Oracle RAC 11g R2 Database on Red Hat Enterprise Linux 6

Best Practices

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1 Executive Summary

IT organizations face challenges of optimizing Oracle database environments to keep up with the ever increasing workload demands and evolving security risks. This reference architecture provides a step-by-step deployment procedure with the latest best practices to install and configure an Oracle Real Application Clusters (RAC) Database 11g Release (11.2.0.3) with Oracle Automatic Storage Management (ASM). It is suited for system, storage, and database administrators deploying Oracle RAC Database 11g Release 2 (11.2.0.3) on Red Hat Enterprise Linux 6. It is intended to provide a Red Hat | Oracle reference architecture that focuses on the following tasks:

- Deploying Oracle Grid Infrastructure 11g R2 (11.2.0.3)
- Deploying Oracle RAC Database 11g R2 (11.2.0.3) with shared SAN disks
- Using Oracle ASM disks with *udev* rules
- Using Oracle ASM disks with Oracle ASMLib (RHEL 6.4 and above)
- Enabling the Oracle RAC Database 11gR2 environment with *SELinux*



2 Reference Architecture Environment

This section focuses on the components used during the deployment of Oracle RAC Database 11g Release 2 (11.2.0.3) with Oracle Automatic Storage Management (ASM) on Red Hat Enterprise Linux 6.4 x86_64 in this reference architecture.

2.1 Reference Architecture Overview

A pictorial representation of the environment used in this reference architecture is shown in the following **Figure 2.1.1: Reference Architecture Overview**.

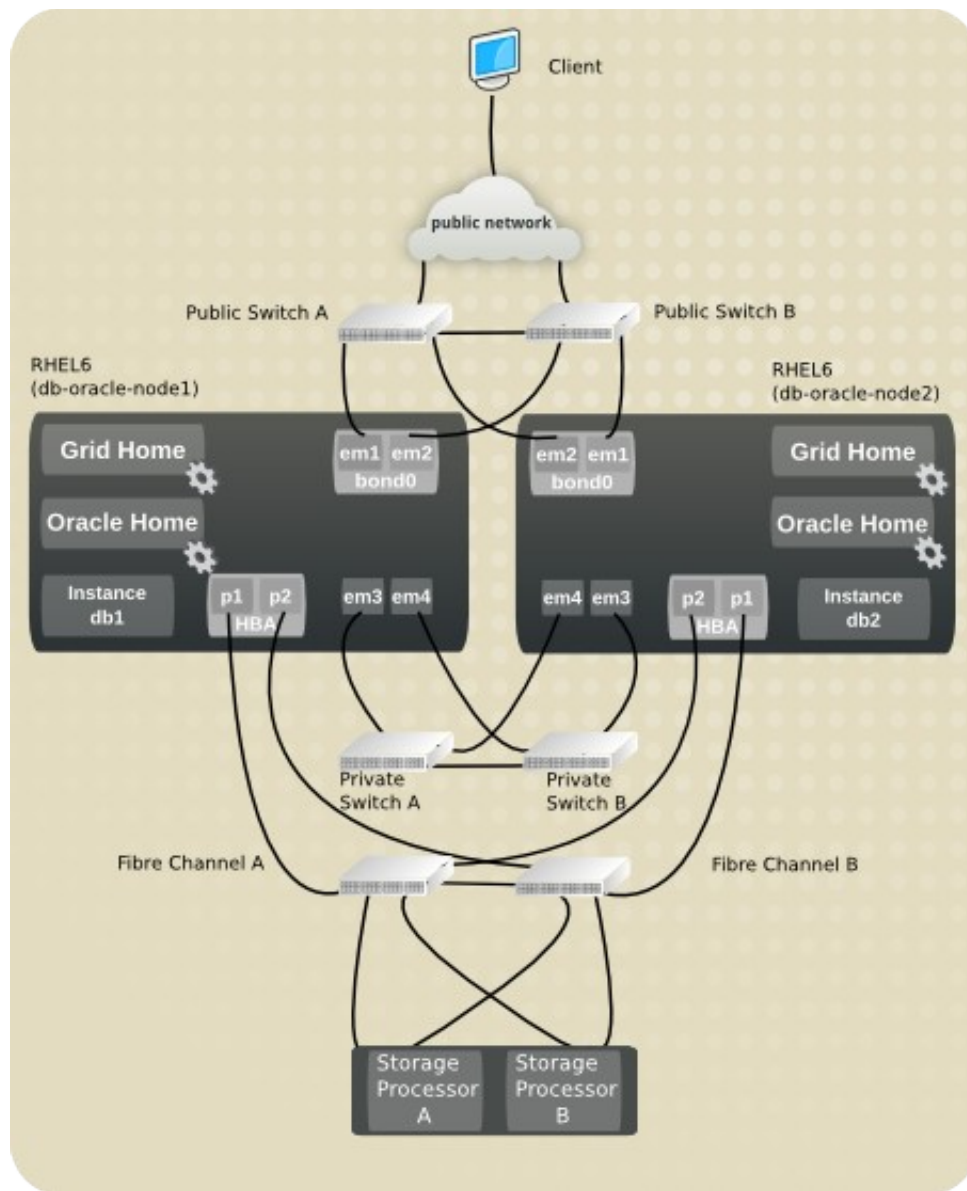


Figure 2.1.1: Reference Architecture Overview



2.2 Network Topology

The network topology used in this reference architecture consists of two public switches using link aggregation to connect the two switches together (*Public Switch A* and *Public Switch B*), creating a single logical switch. Ethernet device *em1* on the server connects to *Public Switch A*, while Ethernet device *em2* on the server connects to *Public Switch B*. Ethernet devices *em1* and *em2* are bonded together as a bond device, *bond0*, providing high availability for the public network traffic. Ethernet device *em3* on each server connects to *Private Switch A*, while Ethernet device *em4* on each server connects to *Private Switch B*. Ethernet devices *em3* and *em4* take advantage of Oracle's Highly Available Internet Protocol (HAIP) for Oracle's private interconnect. HAIP can load balance Ethernet traffic for up to four Ethernet devices. Due to the use of Oracle's HAIP, no bond device is created for the private Ethernet devices *em3* and *em4* on each node within the Oracle RAC Database 11.2.0.3 cluster. **Figure 2.2.1: Network Topology** shows the pictorial representation of the network topology.

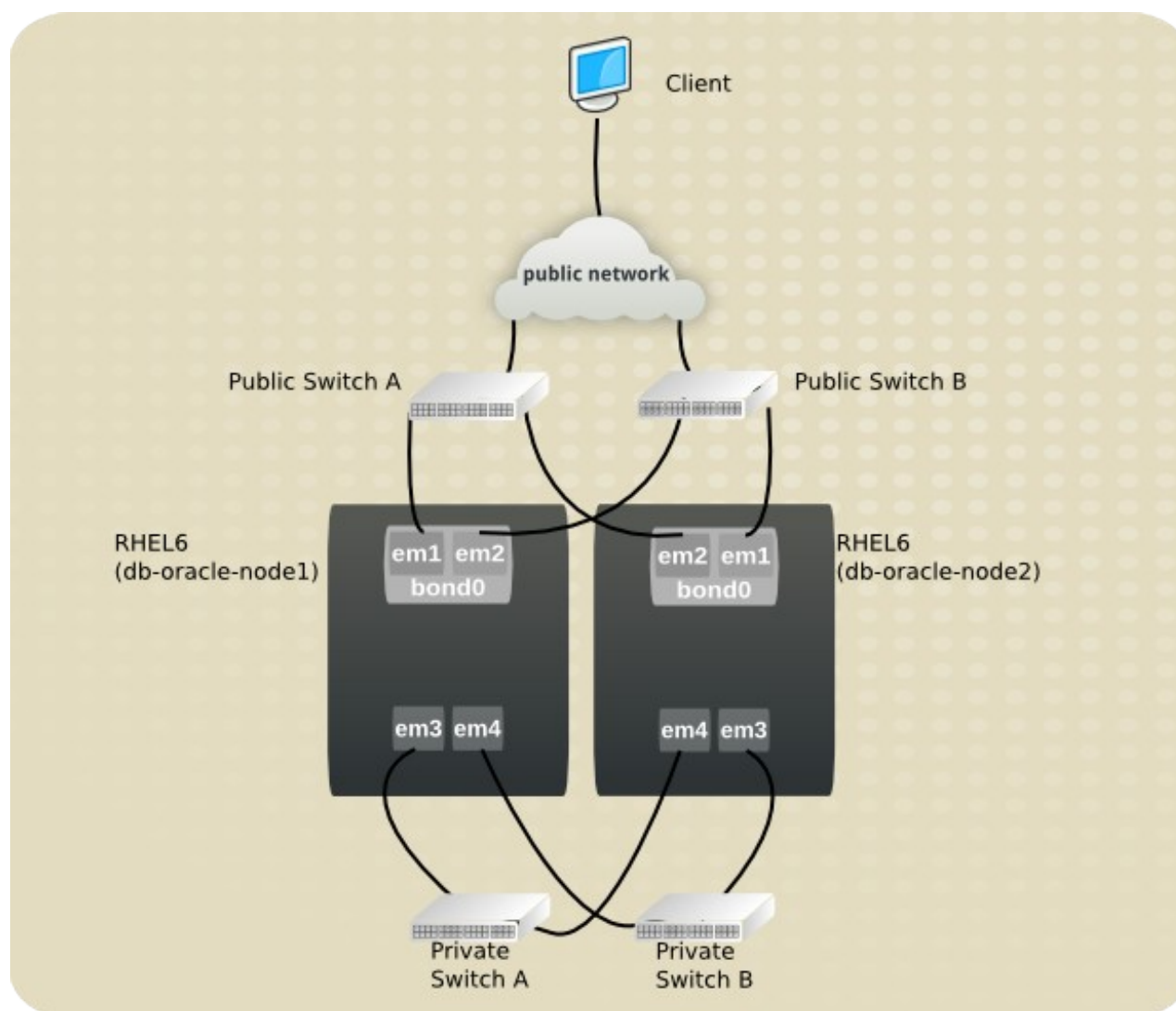


Figure 2.2.1: Network Topology



2.3 Hardware Details

The following are the minimum hardware requirements to properly install Oracle RAC Database 11g Release 2 (11.2.0.3) on a x86_64 system (minimum of two systems required):

- Minimum of 1.5 GB of RAM for the installation of both Oracle Grid Infrastructure and Oracle RAC Database, however 2 GB of memory or more is recommended
- The minimum of three Network Interface Cards (NIC) with the usage of direct attach storage or fibre channel storage; however, four NICs are recommended
- Console access that supports 1024 x 768 resolution to ensure correct display of Oracle's Universal Installer (OUI).
- All nodes within the Oracle RAC Database environment require the same chip architecture. This reference architecture uses 64-bit processors on all nodes within the cluster.¹

Table 2.3.1: Server Details specifies the hardware for each server used within this reference architecture. This hardware meets the minimum requirements for properly installing Oracle RAC Database 11g Release 2 (11.2.0.3) on two x86_64 systems.

Server Hardware	Specifications per Server
Oracle RAC 11g R2 Database (db-oracle-node1, db-oracle-node2) [2 x HP ProLiant DL370 G6 Server]	Red Hat Enterprise Linux 6.4 kernel 2.6.32-358.el6.x86_64
	2 Socket, 8 Core (16 cores) Intel(R) Xeon(R) CPU W5580 @ 3.20 GHz
	48 GB of memory, DDR3 4096 MB @ 1333 MHz DIMMs
	2 x NetXen NX3031 1/10-Gigabit Network Interface Cards (NICs) for public network
	2 x NetXen NX3031 1/10-Gigabit Network Interface Cards (NICs) for private network
	1 x Qlogic ISP2532 8GB Fibre Channel Dual Port HBA ²

Table 2.3.1: Server Details

Table 2.3.2: Switch Details specifies the fibre channel and Ethernet switches used within this reference architecture.

¹ Preparing your Cluster, Oracle Documentation -

http://docs.oracle.com/cd/E11882_01/rac.112/e17264/preparing.htm

² Due to hardware limitations, this reference architecture uses only one dual port HBA. It is recommended to have at least two Fibre Channel Single Port HBAs for high availability.



Switch Hardware	
Fibre Channel	2 x Brocade Silkstorm Fibre Switches
Public Network	1 x HP ProCurve Gigabit Switch 1 x Cisco Catalyst Switch
Private Network (Private VLANs)	1 x Cisco Catalyst Switch 1 x HP ProCurve Gigabit Switch

Table 2.3.2: Switch Details

Table 2.3.3: Storage Details specifies the storage used for storing Oracle data files within this reference architecture.

Storage Hardware	Specifications
HP StorageWorks MSA2324fc Dual Controller Array	24 x 146 GB 15K SAS Hard disks

Table 2.3.3: Storage Details

2.4 File System Layout & Disk Space Details

The following are the minimum disk space requirements for properly installing Oracle RAC Database 11g Release 2 (11.2.0.3) software based upon this reference architecture.

Software	Disk Space
Oracle Grid Infrastructure Home	5.5 GB
Oracle Database Home Enterprise Edition (includes software files and data files)	8.9 GB
/tmp	1 GB

Table 2.4.1: Disk Space Requirements

NOTE: The actual amount of disk space consumed for Oracle Grid Infrastructure Home and Oracle Database Home Enterprise Edition may vary.



Table 2.4.2: File System Layout specifies the file system layout for the two servers used in this reference architecture. The layout ensures the disk space requirements to properly install the Oracle Grid Infrastructure and Oracle Database software for Oracle RAC Database 11g Release 2 (11.2.0.3).

File System Layout	Disk Space Size
/	15 GB
/dev/shm	24 GB
/boot	248 MB
/home	8 GB
/tmp	4 GB
/u01	50 GB
/usr	5 GB
/var	8 GB

Table 2.4.2: File System Layout

Oracle RAC Database 11g Release 2 (11.2.0.3) recommends three volumes each of 1 GB in size to store the Oracle Cluster Registry (OCR) and voting disks within an Oracle ASM disk group with the use of normal redundancy. The OCR manages the Oracle Clusterware and Oracle RAC Database 11g Release 2 (11.2.0.3) configuration information. The voting disk manages any information pertaining to the node membership. While the size of the Oracle data files varies for each solution, the following are the Oracle data file sizes used for this reference architecture.

Volume	Volume Size
Oracle Database Volume 1 (db1)	100 GB
Oracle Database Volume 2 (db2)	100 GB
Fast Recovery Area (fra)	200 GB
Oracle Redo Log Volume (redo)	10 GB
OCR & Voting Disks (ocrvote1)	1 GB
OCR & Voting Disks (ocrvote2)	1 GB
OCR & Voting Disks (ocrvote3)	1 GB

Table 2.4.3: Oracle OCR, Voting Disk, & Data File Sizes



2.5 Storage Layout

Table 2.5.1: Storage Disk Layout for Reference Architecture shows the storage disk layout for each volume.

Virtual Diskgroup Name	Volume Name	Volume Size	RAID Group Type	Harddrive Count	Hot Spares Available	Size of Virtual Disk
vd01	db1	100 GB	Raid 10	8	0	586 GB
vd02	db2	100 GB	Raid 10	8	0	586 GB
vd03	fra	200 GB	Raid 5	5	0	586 GB
vd04	redo	10 GB	Raid 1	2	0	146 GB
vd04	ocrvote1	1 GB	Raid 1	2	0	146 GB
vd04	ocrvote2	1 GB	Raid 1	2	0	146 GB
vd04	ocrvote3	1 GB	Raid 1	2	0	146 GB
-	-	-	-	1	1	146 GB

Table 2.5.1: Storage Disk Layout for Reference Architecture

NOTE: The Hot Spare Available is a Global Hot Spare that can be applied to any virtual disk group in case of failure.

2.6 Swap Space

Swap space is determined by the amount of RAM found within the system. The following table displays the swap space recommendation. This reference architecture allocates 16 GB of RAM for swap space.

RAM	Swap Space
2.5 GB up to 16 GB	Equal to the size of RAM
Greater than 16 GB	16 GB of RAM

Table 2.6.1: Recommended Swap Space

NOTE: When calculating swap space, ensure not to include RAM assigned for *hugepages*. More information on *hugepages* can be found in **Section 4.1.5 Enabling HugePages**



2.7 Security: Firewall Settings

This section focuses on providing the details required to run **iptables** successfully for an Oracle RAC Database 11.2.0.3 environment. It is not uncommon for corporations to be running hardware based firewalls to protect their corporate networks. Due to this, enabling **iptables** might not be required. However, for the purposes of this reference architecture, **iptables** is enabled. For complete details, visit **Section 3.3.4 Configuring Firewall Settings**. The **iptables** configuration can be seen in its entirety at **Appendix D iptables Configuration File**

Table 2.7.1: Firewall Port Settings lists the enabled ports within this reference architecture.

Port	Protocol	Description
22	TCP	Secure Shell (SSH)
80	TCP	Hypertext Transfer Protocol (HTTP)
443	TCP	Hypertext Transfer Protocol over SSL/TLS (HTTPS)
1521	TCP	Oracle Transparent Network Substrate (TNS) Listener default port
1158	TCP	Oracle Enterprise Manager 11g default port

Table 2.7.1: Firewall Port Settings

Table 2.7.2: Firewall Settings lists the source addresses and destination address allowed to accept input traffic.



Interface	Source Address	Destination Address
bond0	10.16.142.51/32	-
bond0	10.16.142.52/32	-
-	192.11.142.0/24	230.0.1.0
-	192.11.142.0/24	224.0.0.251
-	192.12.142.0/24	230.0.1.0
-	192.12.142.0/24	224.0.0.251
bond0	-	230.0.1.0
bond0	-	224.0.0.251
em3 ³	-	-
em4 ³	-	-

Table 2.7.2: Firewall Settings

2.8 Security: SELinux

Oracle RAC Database 11g Release 2 version 11.2.0.3 and later support *SELinux*. All systems in this reference architecture run with *SELinux* enabled and set to *ENFORCING* mode. **Table 2.8.1: SELinux Packages** lists the required *SELinux* packages. Version 3.7.19-211 is currently only available within the downloadable *tar.gz* file from **Appendix K Configuration Files**. It is important to note that at this time, the *SELinux* package 3.7.19-211 is not supported. However, to take advantage of *SELinux* enablement with Oracle *ASMLib*, version 3.7.19-211 is required.

Package	Version
selinux-policy	3.7.19-211
selinux-policy-targeted	3.7.19-211

Table 2.8.1: SELinux Packages

³ Oracle recommends to disable firewall traffic on the private interconnect. Due to this em3 and em4 allow all traffic.



3 Reference Architecture Configuration Details

This reference architecture focuses on the deployment of Oracle RAC Database 11g Release 2 (11.2.0.3) with Oracle Automatic Storage Management (ASM) on Red Hat Enterprise Linux 6.4 x86_64. The configuration is intended to provide a comprehensive Red Hat | Oracle solution. The key solution components covered within this reference architecture consists of:

- Red Hat Enterprise Linux 6 Update 4
- Oracle Grid Infrastructure 11g Release 2 (11.2.0.3)
- Oracle RAC Database 11g Release 2 (11.2.0.3)
- Security-Enhanced Linux (SELinux)
- Device Mapper Multipathing
- *udev* Rules
- Oracle *ASMLib*

3.1 Setting OS Hostname

Each node within the Oracle RAC Database 11g Release 2 (11.2.0.3) cluster requires a unique host name. The host names within this reference architecture are: *db-oracle-node1* and *db-oracle-node2*. To set the host name, please follow the instructions below.

On each node, set the host name via the use of the **hostname** command. An example of setting *db-oracle-node1* host name is shown below.

```
# hostname db-oracle-node1.cloud.lab.eng.bos.redhat.com
```

On each node, edit the */etc/sysconfig/network* file's host name variable with the host name provided above. An example of the */etc/sysconfig/network* file on *db-oracle-node1* is displayed below.

```
# cat /etc/sysconfig/network
NETWORKING=yes
HOSTNAME=db-oracle-node1.cloud.lab.eng.bos.redhat.com
```




3.2 Network Configuration

The network configuration focuses on the proper setup of a public and private network interfaces along with the DNS configuration for the Single Client Access Name (SCAN). The public bonded network interface provides an Oracle environment with high availability in case of a network interface failure. The High Availability Internet Protocol (HAIP) provides the private network interfaces with failover and load balancing across each private network interface. SCAN provides the Oracle RAC Database 11g Release 2 (11.2.0.3) environment a single name that can be used by any client trying to access an Oracle Database within the cluster.

3.2.1 Configuring */etc/resolv.conf* file

The resolver is a set of routines in the C library that provide access to the Internet Domain Name System (DNS). The resolver configuration file contains information that is read by the resolver routines the first time they are invoked by a process. The file is designed to be human readable and contains a list of keywords with values that provide various types of resolver information.⁴ The */etc/resolv.conf* file for this reference architecture consists of two configuration options: *nameserver* and *search*. The search option is used to search for a host name part of a particular domain. The nameserver option is the IP address of the name server the systems (*db-oracle-node1*, *db-oracle-node2*) should query. If more than one nameserver is listed, the resolver library queries them in order. An example of the */etc/resolv.conf* file used on each node of the reference architecture is displayed below.

```
cat /etc/resolv.conf
search cloud.lab.eng.bos.redhat.com
nameserver 10.16.143.247
nameserver 10.16.143.248
nameserver 10.16.255.2
```

For more information, please visit the man pages of the *resolv.conf* file via the command:

```
# man resolv.conf
```

3.2.2 Configure SCAN via DNS

SCAN provides a single name in which a client server can use to connect to a particular Oracle Database. The main benefit of SCAN is the ability to keep a client connection string the same even if changes within the Oracle RAC Database 11g Release 2 environment occur, such as adding or removing of nodes within the cluster. The reason this works is because every client connection sends a request to the SCAN Listener, which then routes the traffic to an available VIP Listener within the Oracle RAC Database 11g Release 2 cluster to establish a database connection. The setup of SCAN requires the creation of a single name, no longer than 15 characters in length not including the domain suffix, resolving to three IP addresses using a round-robin algorithm from the DNS server. SCAN must reside in the same subnet as the public network within the Oracle RAC Database cluster and be resolvable without the

⁴ Linux man pages – man resolv.conf



domain suffix. Within the reference environment, the domain is *cloud.lab.eng.bos.redhat.com* and SCAN name is *db-oracle-scan*

An example DNS entry for the SCAN is as follows:

```
db-oracle-scan    IN A  10.16.142.53
                  IN A  10.16.142.54
                  IN A  10.16.142.55
```

An example of the DNS entry for the SCAN to enable reverse lookups is as follows:

```
53    IN      PTR    db-oracle-scan.cloud.lab.eng.bos.redhat.com.
54    IN      PTR    db-oracle-scan.cloud.lab.eng.bos.redhat.com.
55    IN      PTR    db-oracle-scan.cloud.lab.eng.bos.redhat.com.
```

On each node within the Oracle RAC cluster, verify the SCAN configuration within the DNS server is setup properly using the **nslookup** and **host** command as follows:

```
# nslookup db-oracle-scan
Server:          10.16.143.247
Address:        10.16.143.247#53

Name: db-oracle-scan.cloud.lab.eng.bos.redhat.com
Address: 10.16.142.54
Name: db-oracle-scan.cloud.lab.eng.bos.redhat.com
Address: 10.16.142.55
Name: db-oracle-scan.cloud.lab.eng.bos.redhat.com
Address: 10.16.142.53
```

```
# host db-oracle-scan
db-oracle-scan.cloud.lab.eng.bos.redhat.com has address 10.16.142.53
db-oracle-scan.cloud.lab.eng.bos.redhat.com has address 10.16.142.54
db-oracle-scan.cloud.lab.eng.bos.redhat.com has address 10.16.142.55
```

On each node within the Oracle RAC cluster, verify the SCAN configuration reverse lookup is setup properly using the **nslookup** and **host** command as follows:

```
# nslookup 10.16.142.53
Server:          10.16.143.247
Address:        10.16.143.247#53

53.142.16.10.in-addr.arpa    name = db-oracle-
scan.cloud.lab.eng.bos.redhat.com.
```

Repeat the above step for the reverse lookup on the remaining IP addresses used for the SCAN.



NOTE: The reference environment resolves the following IP address to the following host names:

IP	Hostname
10.16.142.53	db-oracle-scan
10.16.142.54	db-oracle-scan
10.16.142.55	db-oracle-scan

Table 3.2.2.1: SCAN IP & Hostnames

For more information on SCAN, please refer to Oracle's documentation⁵.

3.2.3 Configure Virtual IP (VIP) via DNS

The virtual IP is an IP address assigned to each node within an Oracle RAC Database environment with the IP address residing in the public subnet. During the installation of the Oracle Grid Infrastructure, each VIP Listener registers with every SCAN Listener. The reason is because when a client sends a request, the SCAN Listener routes the incoming traffic to one of the VIP Listeners within the Oracle RAC Database cluster. If a client connection string uses the VIP to talk directly to the VIP Listener (as done in prior versions), every time changes to the Oracle RAC Database environment are made, such as adding or removing nodes within the cluster, the client connection string would require updating. Due to this, Oracle recommends always using the SCAN for client connection string.

An example DNS entry for our VIPs is as follows:

```
db-oracle-node1-vip    IN A 10.16.142.56
db-oracle-node2-vip    IN A 10.16.142.57
```

On each node within the Oracle RAC cluster, verify the VIP address for *db-oracle-node1-vip* and *db-oracle-node2-vip* within the DNS server is setup properly using the **nslookup** and **host** command. An example of checking *db-oracle-node1-vip* can be seen below.

```
# nslookup db-oracle-node1-vip
Server:          10.16.143.247
Address:         10.16.143.247#53

Name: db-oracle-node1-vip.cloud.lab.eng.bos.redhat.com
Address: 10.16.142.56
```

```
# host db-oracle-node1-vip
db-oracle-node1-vip.cloud.lab.eng.bos.redhat.com has address 10.16.142.56
```

⁵ Oracle Single Client Access Name (SCAN)
<http://www.oracle.com/technetwork/products/clustering/overview/scan-129069.pdf>



An example of the DNS entry for the SCAN to enable reverse lookups is as follows:

```
56      IN      PTR      db-oracle-node1-vip.cloud.lab.eng.bos.redhat.com.
57      IN      PTR      db-oracle-node2-vip.cloud.lab.eng.bos.redhat.com.
```

On each node within the Oracle RAC Database cluster, verify the VIP address reverse lookup for both VIP addresses (10.16.142.56 and 10.16.142.57) is setup properly using the **nslookup** and **host** command . An example is shown using VIP address 10.16.142.56 below.

```
# nslookup 10.16.142.56
Server:          10.16.143.247
Address:        10.16.143.247#53

56.142.16.10.in-addr.arpa  name = db-oracle-node1-
vip.cloud.lab.eng.bos.redhat.com.
```

```
# host 10.16.142.56
56.142.16.10.in-addr.arpa domain name pointer db-oracle-node1-
vip.cloud.lab.eng.bos.redhat.com.
```

NOTE: The VIP address should provide a 'Destintation Host Unreachable' response if an attempt to **ping** the VIP or VIP host name is attempted.

NOTE: This reference environment resolves the following Virtual IP addresses to the following host names:

IP	Hostname
10.16.142.56	db-oracle-node1-vip
10.16.142.57	db-oracle-node2-vip

Table 3.2.3.1: Virtual IP & Hostnames

3.2.4 Public Network Configuration

The public network configuration consists of two network interfaces bonded together to provide high availability. The example below shows how to bond physical interfaces *em1* and *em2* with a bond device labeled *bond0*. If *NetworkManager* is installed, ensure it is *disabled*.

Check the status of *NetworkManager*:

```
# chkconfig --list | grep NetworkManager
NetworkManager 0:off 1:off 2:off 3:off 4:off 5:off 6:off
```

Disable *NetworkManager*:

```
# service NetworkManager stop
# chkconfig NetworkManager off
```



On each node, as the root user, execute the following command which creates a file named *bonding.conf* within the */etc/modprobe.d/* directory needed to create a bonded device for multiple network interfaces. The *bonding.conf* file is also part of **Appendix K Configuration Files**

```
# echo "alias bond0 bonding" > /etc/modprobe.d/bonding.conf
```

On each node, as the root user, create a backup of the *ifcfg-em1* & *ifcfg-em2* files, create the *ifcfg-bond0* file and edit the *ifcfg-em1* & *ifcfg-em2* configuration files found within */etc/sysconfig/network-scripts*. An example can be seen below.

```
# cp /etc/sysconfig/network-scripts/ifcfg-em1 /etc/sysconfig/network-scripts/em1.bkup
# cp /etc/sysconfig/network-scripts/ifcfg-em2 /etc/sysconfig/network-scripts/em2.bkup
```

```
# cat /etc/sysconfig/network-scripts/ifcfg-bond0
```

```
DEVICE="bond0"
BONDING_OPTS="mode=1 miimon=100 primary=em1"
NM_CONTROLLED="no"
IPADDR="10.16.142.51"
NETMASK="255.255.248.0"
GATEWAY="10.16.143.254"
ONBOOT="yes"
```

```
# cat /etc/sysconfig/network-scripts/ifcfg-em1
```

```
DEVICE="em1"
BOOTPROTO="none"
HWADDR="00:25:B3:A8:6F:18"
IPV6INIT="no"
NM_CONTROLLED="no"
ONBOOT="yes"
TYPE="Ethernet"
UUID="3db45d28-e63c-401b-906a-ef095de4fc1e"
SLAVE="yes"
MASTER="bond0"
```

```
# cat /etc/sysconfig/network-scripts/ifcfg-em2
```

```
DEVICE="em2"
BOOTPROTO="none"
HWADDR="00:25:B3:A8:6F:19"
IPV6INIT="no"
NM_CONTROLLED="no"
ONBOOT="yes"
TYPE="Ethernet"
UUID="7d29d87f-52bb-4dc6-88ca-d0857c7d7fd9"
SLAVE="yes"
MASTER="bond0"
```



After all the network scripts are configured, restart the network service on each node via the command:

```
# service network restart
Shutting down interface bond0: [ OK ]
Shutting down loopback interface: [ OK ]
Bringing up loopback interface: [ OK ]
Bringing up interface bond0: [ OK ]
```

Once the *bond0* device is configured on each node, use the **ping** command to verify connectivity as follows:

On node one labeled *db-oracle-node1*,

```
# ping db-oracle-node2
PING db-oracle-node2.cloud.lab.eng.bos.redhat.com (10.16.142.52) 56(84)
bytes of data.
64 bytes from db-oracle-node2.cloud.lab.eng.bos.redhat.com (10.16.142.52):
icmp_seq=1 ttl=64 time=0.179 ms
```

On node two labeled *db-oracle-node2*,

```
# ping db-oracle-node1
PING db-oracle-node1.cloud.lab.eng.bos.redhat.com (10.16.142.51) 56(84)
bytes of data.
64 bytes from db-oracle-node1.cloud.lab.eng.bos.redhat.com (10.16.142.51):
icmp_seq=1 ttl=64 time=0.755 ms
```

NOTE: Please ensure a DNS entry that resolves to the appropriate *hostname* is set. This reference architecture resolves the following IP address to the following host names:

IP	Hostname
10.16.142.51	db-oracle-node1
10.16.142.52	db-oracle-node2

Table 3.2.4.1: Public IP & Hostnames

3.2.5 Private Network Configuration

The private network configuration consists of two network interfaces *em3* and *em4*. The private network is used to provide interconnect communication between all the nodes in the cluster. This is accomplished via Oracle's Redundant Interconnect, also known as Highly Available Internet Protocol (HAIP), that allows the Oracle Grid Infrastructure to activate and load balance traffic on up to four Ethernet devices for private interconnect communication. The example below shows how to set up physical interfaces *em3* and *em4* to be used with HAIP.

On each node, as the root user, create a backup of the *ifcfg-em3* & *ifcfg-em4* files, and edit the *ifcfg-em3* & *ifcfg-em4* configuration files found within */etc/sysconfig/network-scripts*. An example of *ifcfg-em3* and *ifcfg-em4* on *db-oracle-node1* is displayed below.



```
# cp /etc/sysconfig/network-scripts/ifcfg-em3 /etc/sysconfig/network-  
scripts/em3.bkup  
# cp /etc/sysconfig/network-scripts/ifcfg-em4 /etc/sysconfig/network-  
scripts/em4.bkup
```

```
# cat /etc/sysconfig/network-scripts/ifcfg-em3
```

```
DEVICE="em3"  
BOOTPROTO="static"  
HWADDR="00:25:B3:A8:6F:18"  
IPV6INIT="no"  
NM_CONTROLLED="no"  
ONBOOT="yes"  
TYPE="Ethernet"  
UUID="3db45d28-e63c-401b-906a-ef095de4fc1e"  
IPADDR="192.11.142.51"  
NETMASK="255.255.255.0"  
MTU="9000"
```

```
# cat /etc/sysconfig/network-scripts/ifcfg-em4
```

```
DEVICE="em4"  
BOOTPROTO="static"  
HWADDR="00:25:B3:A8:6F:19"  
IPV6INIT="no"  
NM_CONTROLLED="no"  
ONBOOT="yes"  
TYPE="Ethernet"  
UUID="7d29d87f-52bb-4dc6-88ca-d0857c7d7fd9"  
IPADDR="192.12.142.51"  
NETMASK="255.255.255.0"  
MTU="9000"
```

NOTE: The MTU size is set to 9000 for the enablement of Jumbo Frames. Ensure Jumbo Frames are enabled on the private Ethernet switches.

After all the network scripts are configured on each node, restart the network service on each node:

```
# service network restart  
Shutting down interface bond0: [ OK ]  
Shutting down interface em3: [ OK ]  
Shutting down interface em4: [ OK ]  
Shutting down loopback interface: [ OK ]  
Bringing up loopback interface: [ OK ]  
Bringing up interface bond0: [ OK ]  
Bringing up interface em3: [ OK ]  
Bringing up interface em4: [ OK ]
```



NOTE: Ensure that all private Ethernet interfaces i.e. *em3* and *em4*, are set to different subnets on each node. If different subnets are not used and connectivity is lost, this can cause a node reboot within the cluster. For the reference environment, subnets 192.11.142.X and 192.12.142.X are used on each node within the Oracle RAC Database 11.2.0.3 cluster.

Once the Ethernet devices are configured on each node, use the **ping** command to verify connectivity as follows:

On node one labeled *db-oracle-node1*,

```
# ping 192.11.142.52
PING 192.11.142.52 (192.11.142.52) 56(84) bytes of data.
64 bytes from 192.11.142.52: icmp_seq=1 ttl=64 time=0.145 ms
```

```
# ping 192.12.142.52
PING 192.12.142.52 (192.12.142.52) 56(84) bytes of data.
64 bytes from 192.12.142.52: icmp_seq=1 ttl=64 time=0.183 ms
```

On node two labeled *db-oracle-node2*,

```
# ping 192.11.142.51
PING 192.11.142.51 (192.11.142.51) 56(84) bytes of data.
64 bytes from 192.11.142.51: icmp_seq=1 ttl=64 time=0.138 ms
```

```
# ping 192.12.142.51
PING 192.12.142.51 (192.12.142.51) 56(84) bytes of data.
64 bytes from 192.12.142.51: icmp_seq=1 ttl=64 time=0.164 ms
```

IP	Ethernet Interface	Host
192.11.142.51	em3	db-oracle-node1
192.12.142.51	em4	db-oracle-node1
192.11.142.52	em3	db-oracle-node2
192.12.142.52	em4	db-oracle-node2

Table 3.2.5.1: Private IP, Ethernet Interfaces, & Host



3.2.6 NTP Configuration

The **ntpd** program is an operating system daemon which sets and maintains the system time, synchronizing with Internet standard time servers⁶. The **ntpd** program operates by exchanging messages with one or more configured servers at designated poll intervals³. Oracle RAC Databases require time synchronization for all nodes within the cluster.

To configure the **ntpd** daemon, on each node, follow the instructions below.

1. Edit the `/etc/ntp.conf` file with a text editor such as **vi**.

```
# vi /etc/ntp.conf
```

2. Locate the following public server pool section, and modify to include the appropriate NTP servers. For the purposes of this reference architecture, only one NTP server is used, but three are recommended. The **iburst** option was added to speed up the time in which it takes to properly sync with the NTP servers.

```
# Use public servers from the pool.ntp.org project.
# Please consider joining the pool (http://www.pool.ntp.org/join.html).
server 10.16.255.2 iburst
```

3. Save all the changes within the `/etc/ntp.conf` file
4. The following `-x` option within the `/etc/sysconfig/ntpd` file needs to be added to prevent the time synced by the NTP daemon to be adjusted backward.
Original `/etc/sysconfig/ntpd` file content:

```
OPTIONS="-u ntp:ntp -p /var/run/ntpd.pid -g"
```

Modified `/etc/sysconfig/ntpd` file content:

```
OPTIONS="-x -u ntp:ntp -p /var/run/ntpd.pid -g"
```

5. Save all the changes within the `/etc/sysconfig/ntpd` file
6. Restart the **ntpd** daemon via the command:

```
# service ntpd restart
Shutting down ntpd: [FAILED]
Starting ntpd: [ OK ]
```

NOTE: Shutting down **ntpd** daemon provides a status of 'FAILED' if the **ntpd** daemon is currently off.

7. Ensure that the **ntpd** daemon is started when the system is booted.

```
# chkconfig ntpd on
```

⁶ ntpd – Network Time Protocol (NTP) daemon man page – man ntpd (8)



3.3 OS Configuration

3.3.1 Accessing the RHN Repository

Instructions on how to register a system and manage subscriptions on Red Hat Enterprise Linux 6 can be found within the Red Hat Linux 6 Deployment Guide documentation⁷.

The following table shows the required channels via the Red Hat Network to support the installation of Oracle.

Channel	Source
rhel-x86_64-server-6	RHN Classic
rhel-x86_64-server-supplementary-6	RHN Classic

Table 3.3.1.1: Required Channels

NOTE: The rhel-x86_64-server-supplementary-6 channel is a requirement for the implementation of Oracle *ASMLib* found in **Section 3.4.3.2 Configuring Oracle ASMLib**. However, Oracle *ASMLib* is not required for the use of Oracle ASM disks. This reference architecture features both methods of implementation within **Section 3.4.3.1 Oracle ASMLib Alternative: Configuring udev Rules** and **Section 3.4.3.2 Configuring Oracle ASMLib**

3.3.2 Oracle RAC Database 11g Release 2 (11.2.0.3) Package Requirements

A specific set of packages is required to properly deploy Oracle RAC Database 11g Release 2 (11.2.0.3) on Red Hat Enterprise Linux 6 (x86_64). The number of installed packages required varies depending on whether a default or minimal installation of Red Hat Enterprise Linux 6 (x86_64) is performed. For the purposes of this reference architecture, a minimal Red Hat Enterprise Linux 6 installation is performed to reduce the number of installed packages. A sample kickstart file as been provided within **Appendix K Configuration Files**. Red Hat Enterprise Linux 6 installation requires the following group packages:

Required Group Packages
@Base
@Core

Table 3.3.2.1: Group Packages

⁷ Red Hat Enterprise Linux 6 Deployment Guide, https://access.redhat.com/site/documentation/en-US/Red_Hat_Enterprise_Linux/6/html-single/Deployment_Guide/index.html#entitlements



Oracle Grid Infrastructure 11.2 and Oracle RAC Database 11.2 require the following x86_64 RPM packages⁸:

Required Packages	
cloog-ppl	libXxf86misc
compat-libcap1	libXxf86vm
compat-libstdc++-33	libaio-devel
cpp	libdmx
gcc	libstdc++-devel
gcc-c++	mpfr
glibc-devel	make
glibc-headers	ppl
kernel-headers	xorg-x11-utils
libXmu	xorg-x11-xauth
libXt	libXv
ksh	libXxf86dga

Table 3.3.2.2: Required Packages

After the installation of Red Hat Enterprise Linux 6 is completed on each node within the Oracle RAC Database cluster, create a file, *req-rpm.txt*, that contains the name of each RPM package listed above on a separate line. An example of the *req-rpm.txt* file is included in **Appendix F Oracle Database Package Requirements Text File**.

On each node, use the **yum** package manager to install the packages and any of their dependencies with the following command:

```
# yum install `awk '{print $1}' ./req-rpm.txt`
```

A minimum installation of Red Hat Enterprise Linux 6 does not install the *X Window System* server package, but only the required *X11* client libraries. In order to run the Oracle Universal Installer (OUI), a system with the *X Window System* server package installed is required. Via a system with *X Window System* installed, **SSH** into node one of the Oracle RAC Database cluster with the *Y* option to ensure trusted *X11* forwarding is set. The command is as follows:

```
# ssh -Y db-oracle-node1
```

Alternatively, if a system with the *X Window System* server package is unavailable, install the *X Window System* server package directly on node one of the Oracle RAC Database cluster.

```
# yum groupinstall "X Window System"
```

⁸ Linux OS Installation with Reduced Set of Packages for Running Oracle Database Server [ID 728346.1] via <http://support.oracle.com>



3.3.3 Configuring Security-Enhanced Linux (SELinux)

SELinux is an implementation of a mandatory access control (MAC) mechanism developed by the National Security Agency (NSA). The purpose of *SELinux* is to apply rules on files and processes based on defined policies. When policies are appropriately defined, a system running *SELinux* enhances application security by determining if an action from a particular process should be granted thus protecting against vulnerabilities within a system. The implementation of Red Hat Enterprise Linux 6 enables *SELinux* by default and appropriately sets it to the default setting of *ENFORCING*. Starting with Oracle Database 11g Release 2, SELinux is supported for Red Hat Enterprise Linux 6⁹. It is highly recommended that *SELinux* be kept in *ENFORCING* mode when running Oracle RAC Database 11g Release 2 (11.2.0.3).

On each node, verify that *SELinux* is running and set to *ENFORCING*:

As the root user,

```
# sestatus
SELinux status:                enabled
SELinuxfs mount:              /selinux
Current mode:                  enforcing
Mode from config file:        enforcing
Policy version:                24
Policy from config file:      targeted
```

If the system is running in *PERMISSIVE* or *DISABLED* mode, modify the `/etc/selinux/config` file and set *SELinux* to enforcing as shown below.

```
SELINUX=enforcing
```

The modification of the `/etc/selinux/config` file takes effect after a reboot. To change the setting of *SELinux* immediately without a reboot, run the following command:

```
# setenforce 1
```

For more information on Security-Enhanced Linux, please visit the [Red Hat Enterprise Linux 6 Security-Enhanced Linux User Guide](#)

3.3.4 Configuring Firewall Settings

Firewall access and restrictions play a critical role in securing your Oracle RAC Database 11g Release 2 (11.2.0.3) environment. It is not uncommon for corporations to be running hardware based firewalls to protect their corporate networks. Due to this, enabling iptables might not be required. However, the reference environment demonstrates how to successfully implement firewall settings for an Oracle RAC Database environment. The following iptables rules are used on each node:

```
# Generated by iptables-save v1.4.7 on Mon Aug  5 19:20:53 2013
*filter
:INPUT ACCEPT [0:0]
:FORWARD ACCEPT [0:0]
```

⁹ Oracle Documentation http://docs.oracle.com/cd/E11882_01/install.112/e22489/prelinux.htm#CWLIN220



```
:OUTPUT ACCEPT [25:2660]
-A INPUT -s 10.16.142.51/32 -i bond0 -j ACCEPT
-A INPUT -s 10.16.142.52/32 -i bond0 -j ACCEPT
-A INPUT -i em3 -j ACCEPT
-A INPUT -i em4 -j ACCEPT
-A INPUT -m state --state RELATED,ESTABLISHED -j ACCEPT
-A INPUT -p icmp -j ACCEPT
-A INPUT -i lo -j ACCEPT
-A INPUT -s 192.11.142.0/24 -d 230.0.1.0 -j ACCEPT
-A INPUT -s 192.11.142.0/24 -d 224.0.0.251 -j ACCEPT
-A INPUT -s 192.12.142.0/24 -d 230.0.1.0 -j ACCEPT
-A INPUT -s 192.12.142.0/24 -d 224.0.0.251 -j ACCEPT
-A INPUT -i bond0 -d 230.0.1.0 -j ACCEPT
-A INPUT -i bond0 -d 224.0.0.251 -j ACCEPT
-A INPUT -p tcp -m state --state NEW -m tcp --dport 22 -j ACCEPT
-A INPUT -p tcp -m state --state NEW -m tcp --dport 443 -j ACCEPT
-A INPUT -m state --state NEW -m tcp -p tcp -s 10.16.142.54 --dport 1521 -j
ACCEPT
-A INPUT -m state --state NEW -m tcp -p tcp -s 10.16.142.54 --dport 1158 -j
ACCEPT
-A INPUT -j REJECT --reject-with icmp-host-prohibited
-A FORWARD -j REJECT --reject-with icmp-host-prohibited
COMMIT
```

The key points from the iptables configuration are:

- Enable all traffic from the private interconnect interfaces *em3* and *em4*
- Enable Oracle SCAN Listener Port 1521 for Oracle DB client access
- Enable Oracle Enterprise Manager 11g Port 1158 for Oracle DB client access
- Enable SSH, HTTPS via ports 22 and 443
- Enable Oracle's Multicast address IPs: 230.0.1.0 and 224.0.0.251

Once the rules have been modified within the */etc/sysconfig/iptables*, on each node within the Oracle RAC Database cluster, run the following command to activate:

```
# service iptables restart
iptables: Flushing firewall rules: [ OK ]
iptables: Setting chains to policy ACCEPT: nat mangle filte [ OK ]
iptables: Unloading modules: [ OK ]
iptables: Applying firewall rules: [ OK ]
```

NOTE: A full listing of all the firewall settings within the */etc/sysconfig/iptables* file for this reference architecture can be found at **Appendix D iptables Configuration File**.

3.3.5 Setting Virtual Memory

Tuning virtual memory requires the modification of five kernel parameters that affect the rate at which virtual memory is used within Oracle RAC Database cluster. It is important to note the recommended values are to be used as a starting point when setting virtual memory. A



brief description¹⁰ and recommended settings for the virtual memory parameters, as well as, the definition of dirty data are described below.

*SWAPPINESS*¹⁰ - A value from 0 to 100 which controls the degree to which the system swaps. A high value prioritizes system performance, aggressively swapping processes out of physical memory when they are not active. A low value prioritizes interactivity and avoids swapping processes out of physical memory for as long as possible, which decreases response latency. The default value is 60. The Oracle recommended value is 0.

DIRTY_DATA – Dirty data is data that has been modified and held in the page cache for performance benefits. Once the data is flushed to disk, the data is clean.

*DIRTY_RATIO*¹⁰ – Contains, as a percentage of total system memory, the number of pages at which a process which is generating disk writes will itself start writing out dirty data. The default value is 20. The recommended value is 80.

*DIRTY_BACKGROUND_RATIO*¹⁰ – Contains, as a percentage of total system memory, the number of pages at which the background write back daemon will start writing out dirty data. The Oracle recommended value is 3.

*DIRTY_EXPIRE_CENTISECS*¹⁰ - Defines when dirty in-memory data is old enough to be eligible for writeout. The default value is 3000, expressed in hundredths of a second. The Oracle recommended value is 500.

*DIRTY_WRITEBACK_CENTISECS*¹⁰ - Defines the interval of when writes of dirty in-memory data are written out to disk. The default value is 500, expressed in hundredths of a second. The Oracle recommended value is 100.

Prior to making any changes to the */etc/sysctl.conf* ensure to create a backup on each node as follows:

```
# cp /etc/sysctl.conf /etc/sysctl.conf.bkup
```

The following is a snippet from the */etc/sysctl.conf* file with the five virtual memory parameters set on each node with the recommended settings:

```
vm.swappiness = 0
vm.dirty_background_ratio = 3
vm.dirty_ratio = 80
vm.dirty_expire_centisecs = 500
vm.dirty_writeback_centisecs = 100
```

For the changes take effect immediately, run the following command on each node:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the */etc/sysctl.conf* file can be found at **Appendix G Kernel Parameters**.

¹⁰ RHEL6 Kernel Documentation - */usr/share/doc/kernel-doc-2.6.32/Documentation/sysctl/vm.txt*



3.3.6 Setting Shared Memory

Shared memory allows processes to communicate with each other by placing regions of memory into memory segments. In the case of Oracle, shared memory segments are used by the System Global Area (SGA) to store incoming data and control information. The size of Oracle's SGA impacts the amount of shared memory pages and shared memory segments to be set within a system. By default, Red Hat Enterprise Linux 6 provides a large amount of shared memory pages and segments, however, the appropriate allocation for a system depends on the amount of RAM within the system.

In order to allocate the appropriate amount of shared memory pages and shared memory segments for a system running an Oracle RAC database, the kernel parameters *SHMALL*, *SHMMAX*, and *SHMMNI* must be set on each node within the cluster.

SHMALL – is the maximum total amount of shared memory pages

SHMMAX – is the maximum size in bytes of a single shared memory segment

SHMMNI – is the maximum total amount of shared memory segments

On each node within the Oracle RAC Database 11g Release 2 cluster, determine the maximum amount of shared memory pages (*SHMALL*) in each system's page size in bytes. The following command can be used to obtain the system page size.

```
# getconf PAGE_SIZE
4096
```

Once the page size is captured, calculate *SHMALL* as follows:

$$TOTAL\ RAM\ IN\ BYTES / PAGE_SIZE$$

For example, on a system with 48 GB of memory the *SHMALL* calculation would look as follows:

```
# echo "48 * 1024^3 / 4096" | bc
12582912
```

The calculation of *SHMMAX*, is as follows:

$$HALF\ OF\ TOTAL\ RAM\ IN\ BYTES$$

For example, on a system with 48 GB of memory the *SHMMAX* calculation would look as follows:

```
# echo "48 * 1024^3 / 2" | bc
25769803776
```

As for *SHMMNI*, Oracle recommends the value of *SHMMNI* to be set to 4096.

NOTE: If the current value found within */etc/sysctl.conf* for any parameter is higher than the value calculated for *SHMMAX* and *SHMALL* on any nodes within the Oracle RAC cluster, do not change the value found within the */etc/sysctl.conf* file.



Since the values of `SHMMAX` and `SHMALL` calculated are smaller than the values already set, no changes to those parameters are made within `/etc/sysctl.conf`. However, an entry for `SHMMNI` is required on any of the Oracle RAC Database nodes within the cluster. A snippet of the `/etc/sysctl.conf` file:

```
kernel.shmmax = 68719476736
kernel.shmall = 4294967296
kernel.shmmni = 4096
```

In order for the changes take effect immediately, on each node run the following command:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the `/etc/sysctl.conf` file can be found at **Appendix G Kernel Parameters**.

3.3.7 Setting Semaphores

Red Hat Enterprise Linux 6 provides semaphores for synchronization of information between processes. The kernel parameter `sem` is composed of four parameters:

`SEMMSL` – is defined as the maximum number of semaphores per semaphore set

`SEMMNI` – is defined as the maximum number of semaphore sets for the entire system

`SEMMNS` – is defined as the total number of semaphores for the entire system

NOTE: `SEMMNS` is calculated by `SEMMSL * SEMMNI`

`SEMOPM` – is defined as the total number of semaphore operations performed per `semop` system call.

The following line is required within the `/etc/sysctl.conf` file of each node of the Oracle RAC Database cluster to provide sufficient semaphores for Oracle:

```
kernel.sem = 250 32000 100 128
```

In order for the changes take effect immediately, on each node run the following command:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the `/etc/sysctl.conf` file can be found at **Appendix G Kernel Parameters**.

3.3.8 Ephemeral Network Ports

Oracle recommends that the ephemeral default port range be set starting at 9000 to 65500. This ensures that all well known ports, ports used by Oracle and other applications are avoided. To set the ephemeral port range, modify the `/etc/sysctl.conf` file on each node of the Oracle RAC Database cluster and add the following line:

```
net.ipv4.ip_local_port_range = 9000 65500
```




In order for the changes take effect immediately, on each node of the Oracle RAC Database 11g Release 2 cluster run the following command:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the */etc/sysctl.conf* file can be found at **Appendix G Kernel Parameters**.

3.3.9 Optimizing Network Settings

Optimizing the network settings for the default and maximum buffers for the application sockets in Oracle is done by setting static sizes to *RMEM* and *WMEM*. The *RMEM* parameter represents the receive buffer size, while the *WMEM* represents the send buffer size. The recommended values by Oracle are modified within each node of the Oracle RAC Database cluster within the */etc/sysctl.conf* file.

```
net.core.rmem_default = 262144
net.core.rmem_max = 4194304
net.core.wmem_default = 262144
net.core.wmem_max = 1048576
```

In order to make the changes take effect immediately, on each node of the Oracle RAC Database cluster, run the following command:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the */etc/sysctl.conf* file can be found at **Appendix G Kernel Parameters**.

3.3.10 Increasing synchronous I/O Requests

The kernel parameter *FS.AIO-MAX-NR* sets the maximum number of on current asynchronous I/O requests. Oracle recommends setting the value to 1048576. In order to add *FS.AIO-MAX-NR* to 1048576, modify on each node of the Oracle RAC Database cluster the */etc/sysctl.conf* file as follows:

```
fs.aio-max-nr = 1048576
```

In order for the changes take effect immediately, on each node of the Oracle RAC Database cluster run the following command:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the */etc/sysctl.conf* file can be found at **Appendix G Kernel Parameters**.



3.3.11 Increasing File Handles

The kernel parameter `FS.FILE-MAX` sets the maximum number of open file handles assigned to the Red Hat Enterprise Linux 6 operating system. Oracle recommends that for each Oracle RAC Database instance found within a system, allocate $512 * PROCESSES$ in addition to the open file handles already assigned to the Red Hat Enterprise Linux 6 operating system. `PROCESSES` within a database instance refers to the maximum number of processes that can be concurrently connected to the Oracle RAC Database by the `oracle` user. The default value for `PROCESSES` is 150. To properly calculate the `FS.FILE-MAX` for a system, first identify the current `FS.FILE-MAX` allocated on each node of the Oracle RAC Database cluster via the following command:

```
# cat /proc/sys/fs/file-max
4909067
```

Next, add all the `PROCESSES` together from each Oracle RAC Database instance found within the cluster and multiple by 512 as seen in the following command. The reference environment contains one Oracle RAC Database instance per server for a total of 300 `PROCESSES` (150 `PROCESSES` for each instance).

```
# echo "512 * 300" | bc
153600
```

NOTE: Since a Oracle RAC Database cluster has yet to be created within the reference environment, the default value of 150 `PROCESSES` is used for each instance. The `FS.FILE-MAX` parameter can be adjusted later if an increase in Oracle `PROCESSES` is required.

Finally, add the current `FS.FILE-MAX` value to each node within the Oracle RAC Database cluster with the new value found from multiplying $512 * PROCESSES$ to obtain the new `FS.FILE-MAX` value.

```
# echo "4909067 + 153600" | bc
5062667
```

While the value of the `FS.FILE-MAX` parameter varies upon your Oracle RAC Database environment, the reference environment sets the value at 6815744. Oracle recommends a value no smaller than 6815744. Due to the calculation in the above example equating to 5062667, the minimum Oracle recommended value is used. In order to add `FS.FILE-MAX` to 6815744, modify the `/etc/sysctl.conf` file on each node of the Oracle RAC Database cluster as follows:

```
fs.file-max = 6815744
```

In order for the changes take effect immediately, on each node of the Oracle RAC Database cluster run the following command:

```
# sysctl -p
```



NOTE: Oracle *ASMLib* does not open file descriptors for each device, but instead opens one file descriptor per Oracle process. The reference environment features both methods of implementation within **Section 3.4.3.1 Oracle ASMLib Alternative: Configuring udev Rules** and **Section 3.4.3.2 Configuring Oracle ASMLib**. However, during the installation of Oracle RAC Database cluster the *FS.FILE-MAX* kernel parameter must be set to at least 6815744 on each node.

NOTE: It is recommended to revisit the *FS.FILE-MAX* value if the *PROCESSES* value is increased for the Oracle RAC Database instances.

NOTE: A full listing of all the kernel parameters modified within the */etc/sysctl.conf* file can be found at **Appendix G Kernel Parameters**.

3.3.12 Reverse Path Filtering

Red Hat Enterprise Linux 6 defaults to the use of Strict Reverse Path filtering. The reason strict mode is the default is to prevent IP spoofing from Distributed Denial-of-service (DDoS) attacks. However, having strict mode enabled on the private interconnect of Oracle RAC Database cluster may cause disruption of interconnect communication. It is recommended to set the *RP_FILTER* from strict mode to loose mode. Loosening the security on the private Ethernet interfaces should not be of concern as best practices recommend for an isolated private network that can only communicate between nodes specifically for Oracle's private interconnect. Add the following modifications to the */etc/sysctl.conf* on each node of the Oracle RAC Database cluster as follows:

```
net.ipv4.conf.em3.rp_filter = 2
net.ipv4.conf.em4.rp_filter = 2
```

In order for the changes take effect immediately, on each node of the Oracle RAC Database 11g Release 2 cluster run the following command:

```
# sysctl -p
```

NOTE: A full listing of all the kernel parameters modified within the */etc/sysctl.conf* file can be found at **Appendix G Kernel Parameters**.

3.3.13 User Accounts & Groups

Prior to the installation of Oracle RAC Database 11g Release 2 (11.2.0.3), Oracle recommends the creation of a `grid` user for the Oracle Grid Infrastructure and an `oracle` user for the Oracle RAC Database software installed on the system. For the purposes of the reference environment, the Oracle RAC Database software owner is the user `oracle` and the Oracle Grid Infrastructure software owner is the user `grid`. Each user is designated different groups to handle specific roles based on the software installed. However, the creation of separate users requires that both the `oracle` user and the `grid` user have a common primary group, the Oracle central inventory group (`OINSTALL`).

The following are the recommended system groups created for the installation of the Oracle RAC Database cluster and part of the `oracle` user.



OSDBA group (*DBA*) – determines OS user accounts with DBA privileges

OSOPER group (*OPER*) – an optional group created to assign limited DBA privileges (*SYSOPER* privilege) to particular OS user accounts

The following are the recommended system groups created for the installation of the Oracle Grid Infrastructure and part of the `grid` user

OSDBA group (*ASMDBA*) – provides administrative access to Oracle ASM instances

OSASM group (*ASMADMIN*) – provides administrative access for storage files via the *SYSASM* privilege

OSOPER group (*ASMOPER*) – an optional group created to assign limited DBA privileges with regards to ASM to particular OS user accounts

On each node within the Oracle RAC Database cluster, as the `root` user, create the following user accounts, groups, and group assignments using a consistent UID and GID assignments across your organization:

```
# groupadd --gid 54321 oinstall
# groupadd --gid 54322 dba
# groupadd --gid 54323 asmdba
# groupadd --gid 54324 asmoper
# groupadd --gid 54325 asmadmin
# groupadd --gid 54326 oper

# useradd --uid 54321 --gid oinstall --groups dba,oper,asmdba,asmoper oracle
# passwd oracle

# useradd --uid 54322 --gid oinstall --groups dba,asmadmin,asmdba,asmoper grid
# passwd grid
```

Verify the `grid` and `oracle` user correctly display the appropriate primary and supplementary groups on each node of the Oracle RAC Database cluster via the commands:

```
# id oracle
uid=54321(oracle) gid=54321(oinstall)
groups=54321(oinstall),54322(dba),54323(asmdba),54324(asmoper),54326(oper)

# id grid
uid=54322(grid) gid=54321(oinstall)
groups=54321(oinstall),54322(dba),54323(asmdba),54324(asmoper),54325(asmadmin)
```

3.3.14 Setting Shell Limits for the Grid and Oracle User

Oracle recommends the following settings for the soft and hard limits for the number of open file descriptors (`nfile`), number of processes (`nproc`), and size of the stack segment (`stack`) allowed by each user respectively. The purpose of setting these limits is to prevent a system wide crash that could be caused if an application, such as Oracle, were allowed to exhaust all of the OS resources under an extremely heavy workload.

Create a file labeled `99-grid-oracle-limits.conf` within `/etc/security/limits.d` on each node of the Oracle RAC Database cluster as follows:

```
# touch /etc/security/limits.d/99-grid-oracle-limits.conf
```



Within the `/etc/security/limits.d/99-grid-oracle-limits.conf` file, on each node of the Oracle RAC Database cluster, add the following soft and hard limits for the `oracle` and `grid` user:

```
oracle soft nproc 2047
oracle hard nproc 16384
oracle soft nofile 1024
oracle hard nofile 65536
oracle soft stack 10240
oracle hard stack 32768
grid soft nproc 2047
grid hard nproc 16384
grid soft nofile 1024
grid hard nofile 65536
grid soft stack 10240
grid hard stack 32768
```

NOTE: The reason that the `/etc/security/limits.conf` file is not directly modified is due to the order in which limit files are read in the system. After reading the `/etc/security/limits.conf` file, files within the `/etc/security/limits.d/` directory are read. If two files contain the same entry, the entry read last takes precedence. For more information visit Red Hat Article: “What order are the limit files in the limits.d directory read in?”¹¹

NOTE: Modifications made to the `limits.conf` file take effect immediately. However, please ensure that any previously logged in `oracle` or `grid` user sessions (if any) are logged out and logged back in for the changes to take effect.

On each node of the Oracle RAC Database cluster, as the `root` user, create a shell script labeled `oracle-grid.sh` within `/etc/profile.d/` to create the appropriate `ulimits` for the `oracle` and `grid` user. The contents of the `oracle-grid.sh` script is displayed below.

```
#Setting the appropriate ulimits for oracle and grid user
if [ $USER = "oracle" ]; then
    if [ $SHELL = "/bin/ksh" ]; then
        ulimit -u 16384
        ulimit -n 65536
    else
        ulimit -u 16384 -n 65536
    fi
fi

if [ $USER = "grid" ]; then
    if [ $SHELL = "/bin/ksh" ]; then
        ulimit -u 16384
        ulimit -n 65536
    else
        ulimit -u 16384 -n 65536
    fi
fi
```

11 What order are the limits files in the limits.d directory read in? - <https://access.redhat.com/site/solutions/199993>



NOTE: While the *ulimit* values can be set directly within the */etc/profile* file, it is recommended to create a custom shell script within */etc/profile.d* instead. The *oracle-grid.sh* script can be downloaded from the **Appendix K Configuration Files**

As the oracle and grid users on each node, verify the *ULIMIT* values by running the following command:

```
# ulimit -a
core file size          (blocks, -c) 0
data seg size          (kbytes, -d) unlimited
scheduling priority    (-e) 0
file size              (blocks, -f) unlimited
pending signals        (-i) 385878
max locked memory      (kbytes, -l) 64
max memory size        (kbytes, -m) unlimited
open files             (-n) 65536
pipe size              (512 bytes, -p) 8
POSIX message queues   (bytes, -q) 819200
real-time priority     (-r) 0
stack size             (kbytes, -s) 10240
cpu time               (seconds, -t) unlimited
max user processes     (-u) 16384
virtual memory         (kbytes, -v) unlimited
file locks             (-x) unlimited
```

3.4 Storage Configuration

The following storage configuration section provides recommendations for setting up device mapper multipath, the use of *udev* rules or Oracle ASMLib for ASM disk management, and the use of the *tuned* package for optimal performance.

3.4.1 Setting up DM-Multipath

Device mapper multipath provides the ability to aggregate multiple I/O paths to a newly created device mapper path to achieve high availability, I/O load balancing, and persistent naming. The following procedures provides the recommendations for installing and configuring *device mapper multipath* devices.

NOTE: Ensure Oracle RAC Database volumes are accessible via the operating system on all nodes within the Oracle RAC Database cluster prior to continuing with the section below.

The following instructions are required on each node within the Oracle RAC Database 11g Release 2 Cluster.

1. As the root user, install the *device-mapper-multipath* package using the **yum** package manager.

```
# yum install device-mapper-multipath
```

2. Copy the *multipath.conf* file found within */usr/share/doc/device-mapper-multipath-0.4.9/* to */etc/*



```
# cp /usr/share/doc/device-mapper-multipath-0.4.9/multipath.conf /etc/
```

- Capture the scsi id of the local disk(s) on the system.

```
# scsi_id --whitelisted --replace-whitespace --device=/dev/sda
3600508b1001030353434363646301200
```

- Uncomment and modify the blacklist section within the `/etc/multipath.conf` file to include the `scsi id` of the local disk on the system. Once complete, save the changes made to the `multipath.conf` file.

```
blacklist {
    wwid 3600508b1001030353434363646301200
    devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
    devnode "^hd[a-z]"
}
```

- Start the `multipath` daemon.

```
# service multipathd start
Starting multipathd daemon: [ OK ]
```

- Enable the `multipath` daemon to ensure it is started upon boot time.

```
# chkconfig multipathd on
```

- Identify the `dm- device`, `size`, and `WWID` of each `device mapper` volume for Oracle OCR and voting disks, data disks and recovery disks. In this example, volume `mpathb` is identified via the following command:

```
# multipath -ll
```

```

multipath alias name      world wide identifier (WWID)  dm- device
      ↓                ↓                ↓
size → mpathb (3600c0ff000d7e7a89e85ac5101000000) dm-10 HP,MSA2324fc
      | size=186G features='1 queue_if_no_path' hwhandler='0' wp=rw
      | +- policy='round-robin 0' prio=130 status=active
      | | - 3:0:0:3 sdd  8:48  active ready running
      | | - 3:0:1:3 sdh  8:112 active ready running
      | | - 4:0:0:3 sdt  65:48 active ready running
      | | - 4:0:1:3 sdx  65:112 active ready running
      | +- policy='round-robin 0' prio=10 status=enabled
      | | - 3:0:2:3 sdl  8:176 active ready running
      | | - 3:0:3:3 sdp  8:240 active ready running
      | | - 4:0:2:3 sdab 65:176 active ready running
      | | - 4:0:3:3 sdaf 65:240 active ready running

```

Figure 3.4.1.1: Multipath Device (mpathb)



Figure 3.4.1.1: Multipath Device (mpathb) identifies the current multipath alias name, size, *WWID*, and *dm* device. This information is required for the application of a custom alias to each volume as shown in step 9.

NOTE: Due to the size of some the disks being the same, compare the *WWID* found on the system with the *WWID* located on the storage array to ensure the multipath alias name assigned corresponds with the name of the volume from the storage array.

8. Uncomment the defaults section found within the */etc/multipath.conf* file.

```
defaults {
    udev_dir                /dev
    polling_interval        10
    path_selector            "round-robin 0"
    path_grouping_policy    multibus
    getuid_callout          "/lib/udev/scsi_id --whitelisted"
    --device="/dev/%n"
    prio                    alua
    path_checker            readsector0
    rr_min_io               100
    max_fds                 8192
    rr_weight               priorities
    failback                immediate
    no_path_retry           fail
    user_friendly_names     yes
}
```

NOTE: The standard options can be customized to better fit your storage array's capabilities. Check with your storage vendor for details.

9. Un-comment the multipath section found within the */etc/multipath.conf* file and create an alias for each *device mapper* volume in order to enable persistent naming of those volumes. Once complete, save the changes made to the *multipath.conf* file. The output should resemble the example below. For reference, refer the Oracle data volumes created for the reference environment as displayed in **Table 2.4.3: Oracle OCR, Voting Disk, & Data File Sizes.**

/etc/multipath.conf

```
multipaths {
    multipath {
        wwid                3600c0ff000d7e7a854a0f65101000000
        alias                db1
    }
    multipath {
        wwid                3600c0ff000dabfe562a0f65101000000
        alias                db2
    }
    multipath {
        wwid                3600c0ff000d7e7a874a0f65101000000
        alias                fra
    }
    multipath {
```




```

        wwid          3600c0ff000dabfe585a0f65101000000
        alias         redo
    }
    multipath {
        wwid          3600c0ff000dabfe596a0f65101000000
        alias         ocrvote1
    }
    multipath {
        wwid          3600c0ff000dabfe5a2a0f65101000000
        alias         ocrvote2
    }
    multipath {
        wwid          3600c0ff000dabfe5b4a0f65101000000
        alias         ocrvote3
    }
}

```

10. Restart the *device mapper multipath* daemon.

```

# service multipathd restart
ok
Stopping multipathd daemon:      [ OK ]
Starting multipathd daemon:     [ OK ]

```

11. Verify the *device mapper* paths and aliases are displayed properly. Below is an example of one *device mapper* device labeled *fra*.

```

# multipath -ll
fra (3600c0ff000d7e7a89e85ac5101000000) dm-10 HP,MSA2324fc
size=186G features='1 queue_if_no_path' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=130 status=active
|  |- 3:0:0:3 sdd  8:48  active ready running
|  |- 3:0:1:3 sdh  8:112 active ready running
|  |- 4:0:0:3 sdt  65:48 active ready running
|  `-- 4:0:1:3 sdx  65:112 active ready running
`--+- policy='round-robin 0' prio=10 status=enabled
    |- 3:0:2:3 sdl  8:176 active ready running
    |- 3:0:3:3 sdp  8:240 active ready running
    |- 4:0:2:3 sdab 65:176 active ready running
    `-- 4:0:3:3 sdaf 65:240 active ready running

```

3.4.2 Partitioning Device Mapper Shared Disks

Partitioning of the *device mapper* shared disks is only required when using Oracle *ASMLib*. This reference architecture provides instructions to configure either Oracle *ASMLib* or *udev* rules. Partitions for each device mapper volume are created to comply with either option.

On the first node of the Oracle RAC Database cluster, create a partition for each device mapper volume (*db1*, *db2*, *fra*, *redo*, *ocrvote1*, *ocrvote2*, *ocrvote3*) using parted as displayed below for device *db1*.

```

# parted /dev/mapper/db1 mklabel gpt mkpart primary "1 -1"
Information: You may need to update /etc/fstab.

```



Once the partitions are created, verify a newly created device mapper device is created for each. An example of verifying the *db1p1* partition as follows:

```
# ls -l /dev/mapper/db1p1
lrwxrwxrwx. 1 root root 8 Apr 16 15:15 /dev/mapper/db1p1 -> ../dm-11
```

NOTE: A newly created partition requires the alias name followed by *p1* such as *db1p1*, see above. If *p1* is missing, please run the following **kpartx** command to add the partition mappings to the device mapper disks. If the following command does not add the *p1*, reboot the system.

```
# kpartx -a /dev/mapper/db1
```

Once the partitions are created, on all other nodes in the Oracle RAC Database cluster, run the following **kpartx** command on each device mapper volume in order to update the partition table mapping.

```
# kpartx -a /dev/mapper/db1
```

NOTE: If the following **kpartx** command does not add the *p1* suffix to each partition, reboot the system.

3.4.3 Configuring Oracle ASM Disks

The configuration of Oracle ASM requires the use of either *udev* rules or Oracle's *ASMLib*. Oracle's *ASMLib* is an optional utility used to manage and assist users with Oracle ASM devices and is not required for proper operation of Oracle ASM disks. Moreover, Oracle *ASMLib* does not have any impact on Oracle Database performance and requires a kernel module labeled **kmod-oracleasm** and proprietary user space utilities to properly function. *udev* rules represent an alternative to Oracle's *ASMLib* and does not require additional kernel modules thus keeping an overall smaller footprint on the Linux systems. While this reference architecture documents both methods of implementation, only one method can be applied for a given solution. This section covers best practices of using Red Hat's native *udev* rules to setup the appropriate permissions for each device mapper disk, as well as, the best practices for Oracle's *ASMLib*.

3.4.3.1 Oracle ASMLib Alternative: Configuring udev Rules

The configuration of Oracle ASM requires the use of either *udev* rules or Oracle's *ASMLib*. This section, focuses on the best practices of using Red Hat's native *udev* rules to setup the appropriate permissions for each device mapper disk.

NOTE: If following the steps in this section, please ignore **Section 3.4.3.2 Configuring Oracle ASMLib**

1. On the first node of the Oracle RAC cluster, as the root user, identify the *Device Mapper Universally Unique Identifier (DM_UUID)* for each *device mapper* volume. The example below shows the *DM_UUID* for the partitions of the volumes labeled *ocrvote1,ocrvote2,ocrvote3,db1,db2,fra,* and *redo*.



```
# for i in ocrvote1p1 ocrvote2p1 ocrvote3p1 db1p1 db2p1 frap1 redop1; do
printf "%s %s\n" "$i" "$(udevadm info --query=all --name=/dev/mapper/$i |
grep -i dm_uuid)"; done
ocrvote1p1 E: DM_UUID=part1-mpath-3600c0ff000dabfe596a0f65101000000
ocrvote2p1 E: DM_UUID=part1-mpath-3600c0ff000dabfe5a2a0f65101000000
ocrvote3p1 E: DM_UUID=part1-mpath-3600c0ff000dabfe5b4a0f65101000000
db1p1 E: DM_UUID=part1-mpath-3600c0ff000d7e7a854a0f65101000000
db2p1 E: DM_UUID=part1-mpath-3600c0ff000dabfe562a0f65101000000
frap1 E: DM_UUID=part1-mpath-3600c0ff000d7e7a874a0f65101000000
redop1 E: DM_UUID=part1-mpath-3600c0ff000dabfe585a0f65101000000
```

2. Create a file labeled *99-oracle-asmdevices.rules* within */etc/udev/rules.d/*



3. Within `99-oracle-asmdevices.rules` file, create rules for each device similar to the example below:

`/etc/udev/rules.d/99-oracle-asmdevices.rules`

```
KERNEL=="dm- *", ENV{DM_UUID}=="part1-mpath-3600c0ff000dabfe5f4d8515101000000", OWNER="grid", GROUP="asmadmin", MODE="0660"
```

To understand the rule above, it can be read as follows:

If any `dm-` device matches the `DM_UUID` of `part1-mpath-3600c0ff000dabfe5f4d8515101000000`, assign to that `dm-` device to be owned by the `grid` user and part of the `asmadmin` group with the permission mode set to `0660`. The `0660` value provides read and write permissions to the user `grid` and owner `asmadmin`.

4. Save the file labeled `99-oracle-asmdevices.rules`
5. Copy the `99-oracle-asmdevices.rules` file to each node within the Oracle RAC Database 11g Release 2 cluster using the `scp` command and enter the appropriate password credentials for the other nodes. The example below shows how to copy the file to node two of the Oracle RAC Database 11g Release 2 cluster.

```
# scp /etc/udev/rules.d/99-oracle-asmdevices.rules db-oracle-node2:/etc/udev/rules.d/
Warning: Permanently added 'db-oracle-node2,10.16.142.52' (RSA) to the list of known hosts.
root@db-oracle-node2's password:
99-oracleasmdevices.rules          100% 833      0.8KB/s   00:00
```

6. On each node within the Oracle RAC Database cluster, locate the `dm-` device for each Oracle related partition. An example of how to find the `dm-` device for each partition is to run the following command:

```
# for i in db1p1 db2p1 frap1 redop1 ocrvote1p1 ocrvote2p1 ocrvote3p1; do
printf "%s %s\n" "$i" "$(ls -ll /dev/mapper/$i)"; done
db1p1 lrwxrwxrwx. 1 root root 8 Aug  1 15:21 /dev/mapper/db1p1 -> ../dm-14
db2p1 lrwxrwxrwx. 1 root root 8 Aug  1 15:22 /dev/mapper/db2p1 -> ../dm-15
frap1 lrwxrwxrwx. 1 root root 8 Aug  1 15:22 /dev/mapper/frap1 -> ../dm-17
redop1 lrwxrwxrwx. 1 root root 8 Aug  1 15:22 /dev/mapper/redop1 -> ../dm-16
ocrvote1p1 lrwxrwxrwx. 1 root root 8 Aug  1 15:22 /dev/mapper/ocrvote1p1
-> ../dm-18
ocrvote2p1 lrwxrwxrwx. 1 root root 8 Aug  1 15:22 /dev/mapper/ocrvote2p1
-> ../dm-19
ocrvote3p1 lrwxrwxrwx. 1 root root 8 Aug  1 15:22 /dev/mapper/ocrvote3p1
-> ../dm-20
```

7. On each node within the Oracle RAC Database cluster, apply and test the rules for each `dm-` device created within the `99-oracle-asmdevices.rules` by running a `udevadm test` on each device. The example below demonstrates a `udevadm test` on `dm-11`.

```
# udevadm test /sys/block/dm-11
[ ... Output Abbreviated ... ]
udevadm_test: DM_NAME=db1p1
udevadm_test: DM_UUID=part1-mpath-3600c0ff000d7e7a86485ac5101000000
```



```
udevadm_test: DM_SUSPENDED=0
udevadm_test: DEVLINKS=/dev/mapper/db1p1 /dev/disk/by-id/dm-name-db1p1
/dev/disk/by-id/dm-uuid-part1-mpath-3600c0ff000d7e7a86485ac5101000000
/dev/block/253:11
udevadm_test: ID_FS_TYPE=oracleasm
```

8. Confirm each device has the desired permissions on each node within the cluster.

```
# ls -lh /dev/dm-*
brw-rw----. 1 grid asmadmin 253, 14 Aug 1 16:02 /dev/dm-14
brw-rw----. 1 grid asmadmin 253, 15 Aug 1 16:02 /dev/dm-15
brw-rw----. 1 grid asmadmin 253, 16 Aug 1 16:02 /dev/dm-16
brw-rw----. 1 grid asmadmin 253, 17 Aug 1 16:02 /dev/dm-17
brw-rw----. 1 grid asmadmin 253, 18 Aug 1 16:02 /dev/dm-18
brw-rw----. 1 grid asmadmin 253, 19 Aug 1 16:03 /dev/dm-19
brw-rw----. 1 grid asmadmin 253, 20 Aug 1 16:02 /dev/dm-20
```

NOTE: If the desired permissions are not visible, please reboot the particular node from the Oracle RAC Database cluster.

NOTE: For simplicity, this *99-oracle-asmdevices.rules* file is included in **Appendix I 99-oracle-asmdevices.rules**

3.4.3.2 Configuring Oracle ASMLib

In order to configure Oracle ASMLib the following components are required: **kmod-oracleasm**, **oracleasm-support**, and **oracleasm-lib**

NOTE: If **Section 3.4.3.1 Oracle ASMLib Alternative: Configuring udev Rules** has been configured, ignore this section and continue to **Section 3.4.4 Optimizing Database Storage using Automatic System Tuning**

The *ASMLib* kernel module package (**kmod-oracleasm**) is provided for Red Hat customers via the Supplementary Channel on Red Hat Network (RHN). In order to properly install and configure ASMLib the following procedures must be followed.

1. Enable the Red Hat Enterprise Linux 6 Supplementary repository on RHN¹².
2. Download the ASMLib library package (**oracleasm-lib**)

```
# wget http://download.oracle.com/otn_software/asmlib/oracleasm-lib-2.0.4-1.el6.x86_64.rpm
```

3. Download the ASMLib utilities package (**oracleasm-support**)

```
# wget http://public-yum.oracle.com/repo/OracleLinux/OL6/latest/x86_64/oracleasm-support-2.1.8-1.el6.x86_64.rpm
```

¹² Enabling the Supplementary Repository Knowledge Base Article, <https://access.redhat.com/knowledge/articles/58637>



4. Install the ASMLib kernel module package (**kmod-oracleasm**), ASMLib library package (**oracleasm-lib**), and the ASMLib utilities package (**oracleasm-support**) using the following command:

```
# yum install kmod-oracleasm oracleasm-lib-2.0.4-1.el6.x86_64.rpm
oracleasm-support-2.1.8-1.el6.x86_64.rpm
```

5. Configure ASMLib using the following command:

```
# /usr/sbin/oracleasm configure -i
Configuring the Oracle ASM library driver.
```

This will configure the on-boot properties of the Oracle ASM library driver. The following questions will determine whether the driver is loaded on boot and what permissions it will have. The current values will be shown in brackets ('[]'). Hitting <ENTER> without typing an answer will keep that current value. Ctrl-C will abort.

```
Default user to own the driver interface []: grid
Default group to own the driver interface []: asmadmin
Start Oracle ASM library driver on boot (y/n) [ n ]: y
Scan for Oracle ASM disks on boot (y/n) [y]: y
Writing Oracle ASM library driver configuration: done
```

6. Within `/etc/sysconfig/oracleasm`, set the **ORACLEASM_SCANORDER** and **ORACLEASM_SCANEXCLUDE** parameters as follows:

```
# ORACLEASM_SCANORDER: Matching patterns to order disk scanning
ORACLEASM_SCANORDER="dm"

# ORACLEASM_SCANEXCLUDE: Matching patterns to exclude disks from scan
ORACLEASM_SCANEXCLUDE="sda"
```

NOTE: The **ORACLEASM_SCANORDER** set to `dm` ensures that when `oracleasm` scans disks, it is appropriately scanning devices known by the kernel. The **ORACLEASM_SCANEXCLUDE** set to `sda` is ensuring that local disk `sda` is to be ignored by ASMLib.

7. Prior to creating disks with **oracleasm**, ensure the *SELinux* policy files version **3.7.19-211** is downloaded from **Appendix K Configuration Files**. This ensures that **oracleasm** properly runs with *SELinux* enabled and avoids any *SELinux* errors¹³. Enable the *SELinux* policy and modules as follows:

- Update the `selinux-policy` via the following commands:

```
# rpm -Uvh selinux-policy-3.7.19-211.el6.noarch.rpm selinux-policy-
targeted-3.7.19-211.el6.noarch.rpm
Preparing... ##### [100%]
1:selinux-policy ##### [ 50%]
2:selinux-policytargeted##### [100%]
```

13 `oracleasm createdisk` fails with *SELinux* enabled [ID 1430947.1]



8. Run the following **oracleasm** command to ensure that *oracleasm* is enabled.

```
# /etc/init.d/oracleasm enable
Writing Oracle ASM library driver configuration: done
Initializing the Oracle ASMLib driver:           [ OK ]
Scanning the system for Oracle ASMLib disks:    [ OK ]
```

9. Repeat steps one thru nine on all remaining nodes within the Oracle RAC Database cluster.
10. On only node one of the Oracle RAC cluster, run the following **oracleasm** command to create and label all Oracle related volumes as an ASM disk. The example below creates an ASM disk labeled *DATA1* for the following */dev/mapper/db1p1* partition.

```
# /usr/sbin/oracleasm createdisk DATA1 /dev/mapper/db1p1
Writing disk header: done
Instantiating disk: done
```

NOTE: It is highly recommended to have all Oracle related disks to be included within Oracle ASM.

11. Once all the ASM disks have been created on node one of the Oracle RAC cluster, run the **oracleasm scandisks** command to scan the ASM disks on the remaining nodes within the cluster as follows:

```
# /usr/sbin/oracleasm scandisks
Reloading disk partitions: done
Cleaning any stale ASM disks...
Scanning system for ASM disks...
Instantiating disk "DATA1"
Instantiating disk "FRA1"
Instantiating disk "DATA2"
Instantiating disk "OCRVOTE2"
Instantiating disk "RED01"
Instantiating disk "OCRVOTE1"
Instantiating disk "OCRVOTE3"
```

12. Verify all the Oracle ASM disks created are listed on all nodes within the Oracle RAC cluster via the **oracleasm listdisks** command:

```
# /usr/sbin/oracleasm listdisks
DATA1
DATA2
FRA1
OCRVOTE1
OCRVOTE2
OCRVOTE3
RED01
```

13. If no disks are listed or if any disks are missing, run the following command to rescan the ASM disks on that specific node.

```
# /usr/sbin/oracleasm scandisks
```



```
Reloading disk partitions: done  
Cleaning any stale ASM disks...  
Scanning system for ASM disks...
```

NOTE: If the issue persists after a rescan of the Oracle ASM disks, a reboot of the system might be required via the **reboot**, **shutdown**, or **init 6** command:

```
# reboot
```




3.4.4 Optimizing Database Storage using Automatic System Tuning

The **tuned** package in Red Hat Enterprise Linux 6 is recommended for automatically tuning the system for common workloads via the use of profiles. Each profile is tailored for different workload scenarios such as:

- enterprise-storage
- power savings
- high network throughput

It is recommended to create a custom profile with the same settings as the enterprise-storage profile but that disables Transparent HugePages (THP) for Oracle RAC database workload environments. For more information on why THP is disabled, see **Section 4.1.5 Enabling HugePages** **Table 3.4.4.1: Profile Comparison** provides details of the enterprise-storage profile attributes that are adjusted versus the defaults found within the Red Hat Enterprise Linux 6 distribution.

Tuned Parameters	default	enterprise-storage	enterprise-storage-no-thp
I/O Elevator	CFQ	deadline	deadline
CPU governor	OnDemand	performance	performance
kernel.sched_min_granularity_ns	4ms	10ms	10ms
kernel.sched_wake_up_granularity_ns	4ms	15ms	15ms
Disk read-ahead	1x	4x	4x
vm.dirty_ratio	20%	40% ¹⁴	40% ¹³
File-system barrier	on	off	off
Transparent HugePages	on	on	off

Table 3.4.4.1: Profile Comparison

The following procedures provide the steps that are required to create, install, enable, and select the **enterprise-storage-no-thp** profile.

On each node within the Oracle RAC Database cluster, as the root user,

1. Install the **tuned** package via the **yum** package manager.

```
# yum install tuned
```

¹⁴ The vm.dirty_ratio value explicitly set within the /etc/sysctl.conf file has precedence over the value set by tuned.



2. Enable **tuned** to ensure it is started upon boot time.

```
# chkconfig tuned on
```

3. Start the **tuned** service

```
# service tuned start
Starting tuned: [ OK ]
```

4. Copy the existing enterprise-storage profile into a new directory called enterprise-storage-no-thp via the following commands:

```
# cd /etc/tune-profiles/
# cp -r enterprise-storage enterprise-storage-no-thp
```

5. Disable Transparent HugePages in the new profile via the following command:

```
# sed -ie 's,set_transparent_hugepages always,set_transparent_hugepages never', /etc/tune-profiles/enterprise-storage-no-thp/ktune.sh
```

6. Verify the change was properly set via the following command:

```
# grep set_transparent_hugepages /etc/tune-profiles/enterprise-storage-no-thp/ktune.sh
set_transparent_hugepages never
```

7. Select the newly created enterprise-storage-no-thp profile

```
# tuned-adm profile enterprise-storage-no-thp
Stopping tuned: [ OK ]
Switching to profile 'enterprise-storage-no-thp'
Applying ktune sysctl settings:
/etc/ktune.d/tunedadm.conf: [ OK ]
Calling '/etc/ktune.d/tunedadm.sh start': [ OK ]
Applying sysctl settings from /etc/sysctl.conf
Applying deadline elevator: dm-0 dm-1 dm-10 dm-11 dm-12 dm-13 dm-14 dm-15
dm-16 dm-17 dm-18 dm-19 dm-2 dm-20 dm-3 dm-4 dm-5 dm-6 dm-7 dm-8 dm-9 sda
sdaa sdab sdac sdb sdc sdd sde sdf sdg sdh sdi sdj sdk sdl sdm sdn sdo
sdp sdq sdr sds sdt sdu sdv sdw sdx sdy sdz
[ OK ]
Starting tuned: [ OK ]
```

8. Verify that THP is now disabled via the following command:

```
# cat /sys/kernel/mm/redhat_transparent_hugepage/enabled
always madvise [never]
```

For simplicity, the enterprise-storage-no-thp profile is included in **Appendix K Configuration Files**



NOTE: If at any point in time a revert to the original settings are required, the following command can be run on each node within the Oracle RAC Database cluster:

```
# tuned-adm off
```

To make the change permanent across reboots, run the following command on each node within the Oracle RAC Database cluster:

```
# chkconfig tuned off
```



4 Oracle 11gR2 Configuration

4.1.1 Installing Oracle Grid Infrastructure (Required for ASM)

The installation of the Oracle Grid Infrastructure for Oracle RAC Database 11g Release 2 (11.2.0.3) is required for the use of Oracle ASM. Prior to the installation of the Oracle Grid Infrastructure, ensure the following prerequisites from the following sections have been met:

- **Section 2 Reference Architecture Environment**
- **Section 3 Reference Architecture Configuration Details**

NOTE: The reference architecture uses the `/u01/app/grid` as the grid base. The owner is set to `grid` and the group is set to `oinstall`. Run the following commands to create the grid base directory and set the appropriate permissions:

On each node within the Oracle RAC environment, as the root user, create the following directory structure and set the proper permissions.

```
# mkdir --parents /u01/app/grid
# chown --recursive grid.oinstall /u01/
```

The following steps are intended for only node one of the Oracle RAC Database environment unless otherwise specified.

1. Download the Oracle Grid Infrastructure software¹⁵ from the My Oracle Support site.
2. As the `grid` user, create a temporary directory within `/u01/app/grid/grid-software` to store the Oracle Grid Software gunzip file, move the Oracle Grid Software gunzip file to the `/u01/app/grid/grid-software` location, ensure the Oracle Grid Software gunzip has the proper permissions and unpack its contents.

As the `grid` user,

```
# mkdir /u01/app/grid/grid-software
# mv p10404530_112030_Linux-x86-64_3of7.zip /u01/app/grid/grid-software
```

As the root user,

```
# chown grid.oinstall p10404530_112030_Linux-x86-64_3of7.zip
```

As the `grid` user,

```
# cd /u01/app/grid/grid-software
# unzip p10404530_112030_Linux-x86-64_3of7.zip
```

3. As the `grid` user, locate the Oracle Grid Infrastructure software and modify the file labeled `cvu_config` to ensure the Oracle Universal Installer (OUI) performs the correct prerequisite checks for Red Hat Enterprise Linux 6.

¹⁵ Patch 10404530: 11.2.0.3.0 PATCH SET FOR ORACLE DATABASE SERVER, via <http://support.oracle.com>



- Edit the `cvu_config` file as follows:

```
# sed -i 's/CV_ASSUME_DISTID=0EL4/CV_ASSUME_DISTID=0EL6/'  
/u01/app/grid/grid-software/grid/stage/cvu/cv/admin/cvu_config
```

4. As the `grid` user, start the OUI via the command:

```
# /u01/app/grid/grid-software/grid/runInstaller  
Starting Oracle Universal Installer...  
  
Checking Temp space: must be greater than 120 MB.   Actual 3690 MB  
Passed  
Checking swap space: must be greater than 150 MB.   Actual 16383 MB  
Passed  
Checking monitor: must be configured to display at least 256 colors.  
Actual 16777216   Passed
```

NOTE: Ensure to **SSH** with the `-Y` option as the `grid` user from the client server, otherwise the following error will occur.

```
# /u01/app/grid/grid-software/grid/runInstaller  
Starting Oracle Universal Installer...  
  
Checking Temp space: must be greater than 120 MB.   Actual 3690 MB  
Passed  
Checking swap space: must be greater than 150 MB.   Actual 20479 MB  
Passed  
Checking monitor: must be configured to display at least 256 colors  
>>> Could not execute auto check for display colors using command  
/usr/bin/xdpyinfo. Check if the DISPLAY variable is set.   Failed <<<<  
  
Some requirement checks failed. You must fulfill these requirements  
before continuing with the installation,  
  
Continue? (y/n) [n] n
```

5. Within the **Download Software Updates** window, select the option to either enter the My Oracle Support credentials to **download latest software updates** or select **Skip software updates**. This reference architecture selected **Skip software updates** and click **Next**.
6. Within the **Installation Option** window, select **Install and Configure Oracle Grid Infrastructure for a Cluster** and click **Next**.
7. Within the **Installation Type** window, select **Advanced Installation**, and click **Next**.
8. Within the **Product Languages** window, select the appropriate language, and click **Next**.
9. Within the **Grid Plug and Play Information** window, provide the appropriate credentials for the SCAN. This reference architecture provides the following SCAN credentials:



- Cluster Name: *db-ora-cluster*
- SCAN Name: *db-oracle-scan.cloud.lab.eng.bos.redhat.com*

NOTE: The SCAN Name is the name registered with the DNS Server as seen in **Section 3.2.2 Configure SCAN via DNS**

- SCAN Port: *1521*
- Uncheck **Configure GNS**

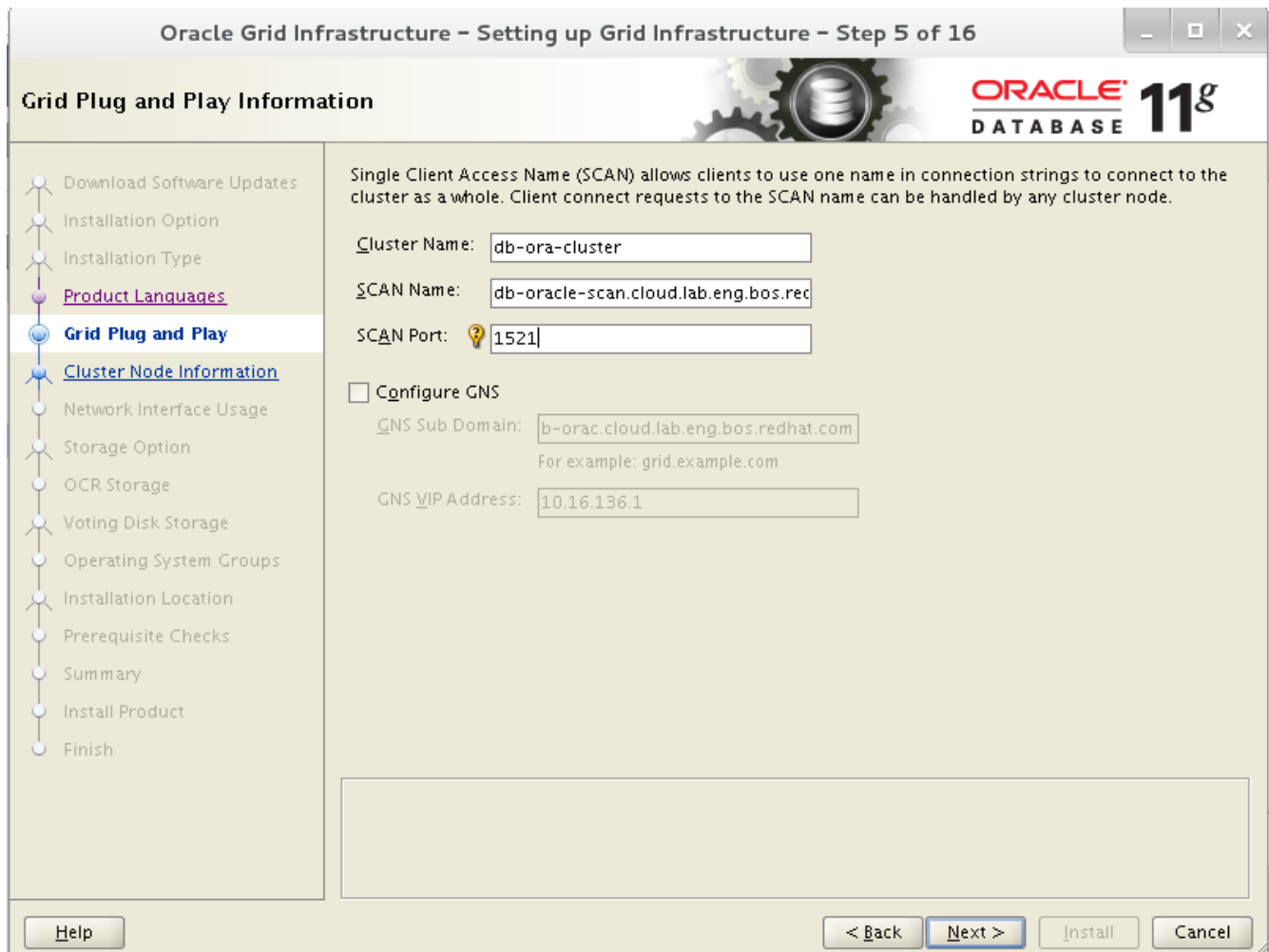


Figure 4.1.1.1: Oracle Plug and Play Window



10. Within the **Cluster Node Information** window, click the **Add** button to add each node within the Oracle RAC Database cluster and click **OK**. Each node within the Oracle RAC cluster requires the public *hostname* and *VIP* information as seen in **Figure 4.1.1.2: Cluster Node Information Window, Add button** below.

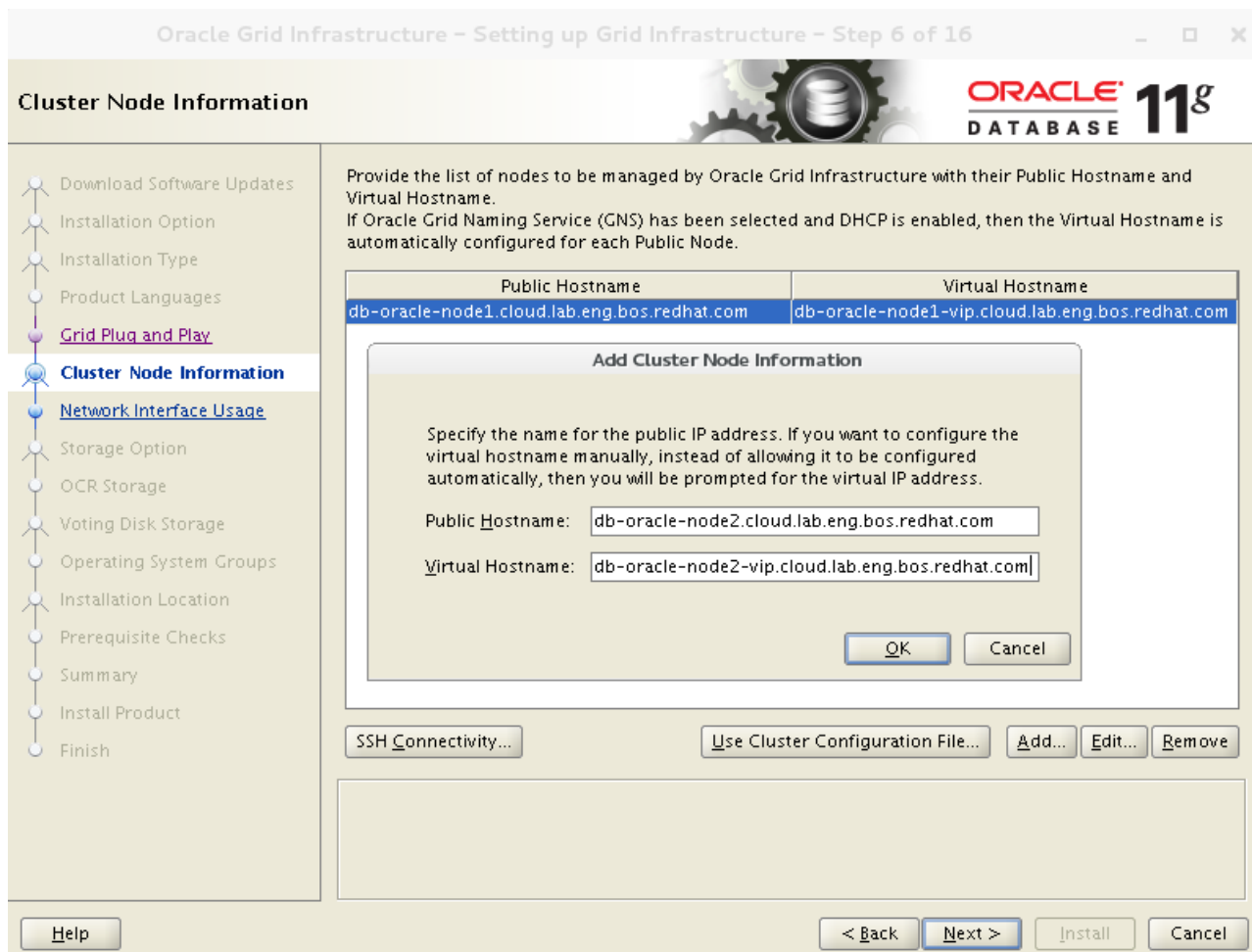


Figure 4.1.1.2: Cluster Node Information Window, Add button



11. Within the same **Cluster Node Information** window, select the **SSH Connectivity** button to set the passwordless SSH connectivity by entering the **OS Password:** credentials for the `grid` user and clicking **Setup**. Once a dialog box returns with 'Successfully established passwordless SSH connectivity between the selected nodes', click **OK** and click **Next** to continue to the next window.

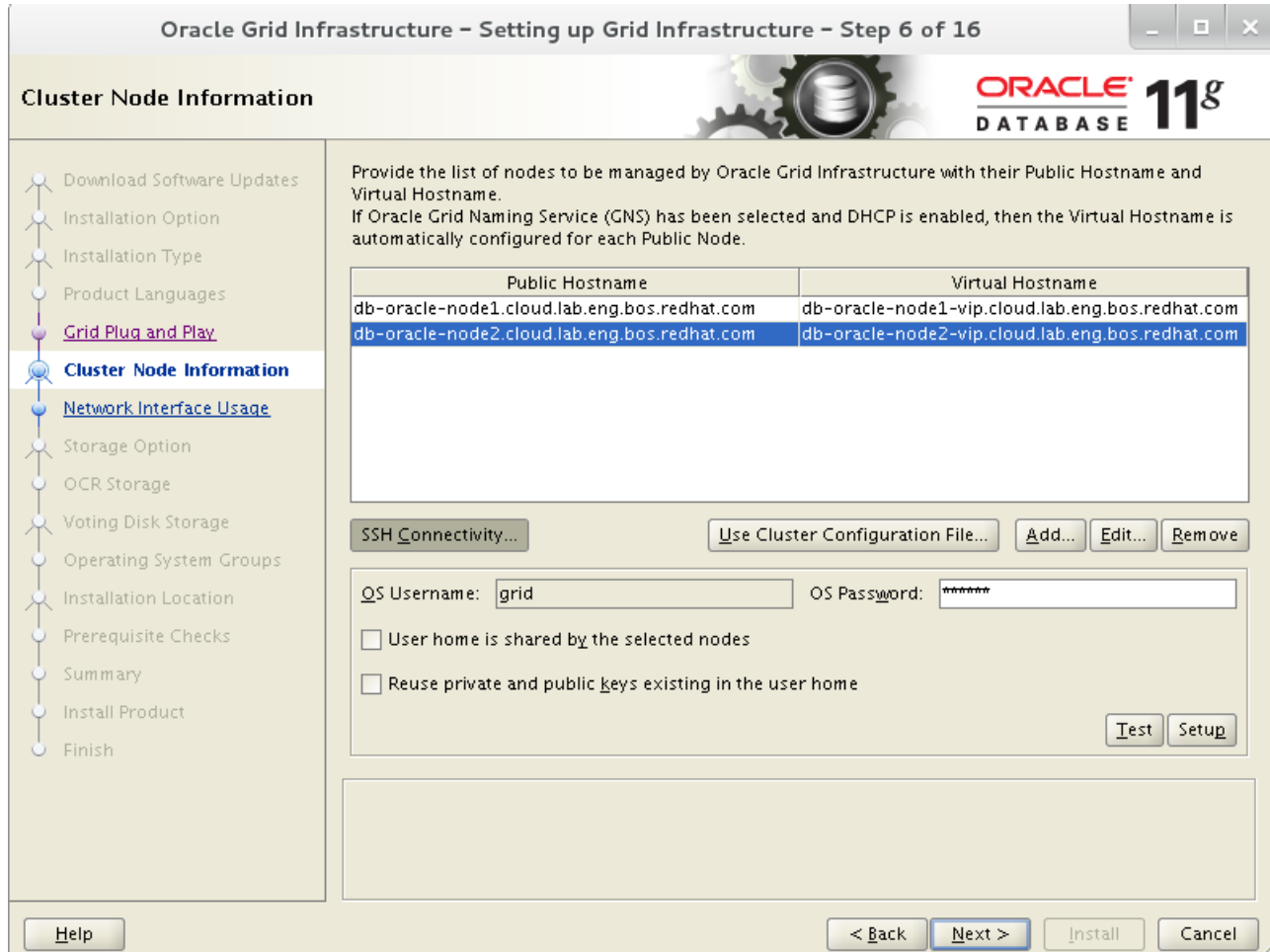


Figure 4.1.1.3: Cluster Node Window, SSH Connectivity

NOTE: The password for the `grid` user must be the same across all nodes within the Oracle RAC Database cluster.

12. Within the **Network Interface Usage** window, select the Interface Name, `bond0`, to be set as the Interface Type *Public* and the Interface Name, `em3` and `em4`, to be set as the Interface Type *Private*. Any other interfaces should be set to *Do Not Use*. Select **Next** to continue.
13. Within the **Storage Option** window, select **Oracle Automatic Storage Management (Oracle ASM)** radio button and click **Next**.



14. Within the Create ASM Disk Group window, provide the following:

- Disk Group Name
- Redundancy Level
 - *EXTERNAL* – redundancy provided by the storage system RAID, and not by Oracle ASM.
 - *NORMAL* – provides two-way mirroring by Oracle ASM, thus provided two copies of every data extent.
 - *HIGH* – provides three-way mirroring by Oracle ASM thus enduring the loss of two ASM disks within different failure groups.
- Disks to be assigned to the ASM Disk Group

The following **Table 4.1.1.1: ASM Disk Group Window** provides the details for the reference environment.

ASM Disk Group Window		
Disk Group Name	<i>OCRVOTE</i>	-
Redundancy Level	Normal	-
If using <i>device mapper multipath</i> and <i>udev</i> rules, Disks Assigned to ASM Disk Group	<i>/dev/mapper/ocrvote1p1</i> <i>/dev/mapper/ocrvote2p1</i> <i>/dev/mapper/ocrvote3p1</i>	Header Status: <i>Candidate</i>
If using Oracle <i>ASMLib</i> , Disks Assigned to ASM Disk Group	<i>/dev/oracleasm/disks/OCRVOTE1</i> <i>/dev/oracleasm/disks/OCRVOTE2</i> <i>/dev/oracleasm/disks/OCRVOTE3</i>	Header Status: <i>Provisioned</i>

Table 4.1.1.1: ASM Disk Group Window



To display the appropriate candidate disks if not already displayed, click on the **Change Discovery Path** button and enter as the **Disk Discovery Path** one of the following:

- For Device Mapper devices, type:
/dev/mapper/*
- For Oracle ASMLib marked disks, type:
/dev/oracleasm/disks/*

NOTE: For device mapper disks, Header Status is *Candidate*, but for Oracle *ASMLib* disks the Header Status is *Provisioned*.

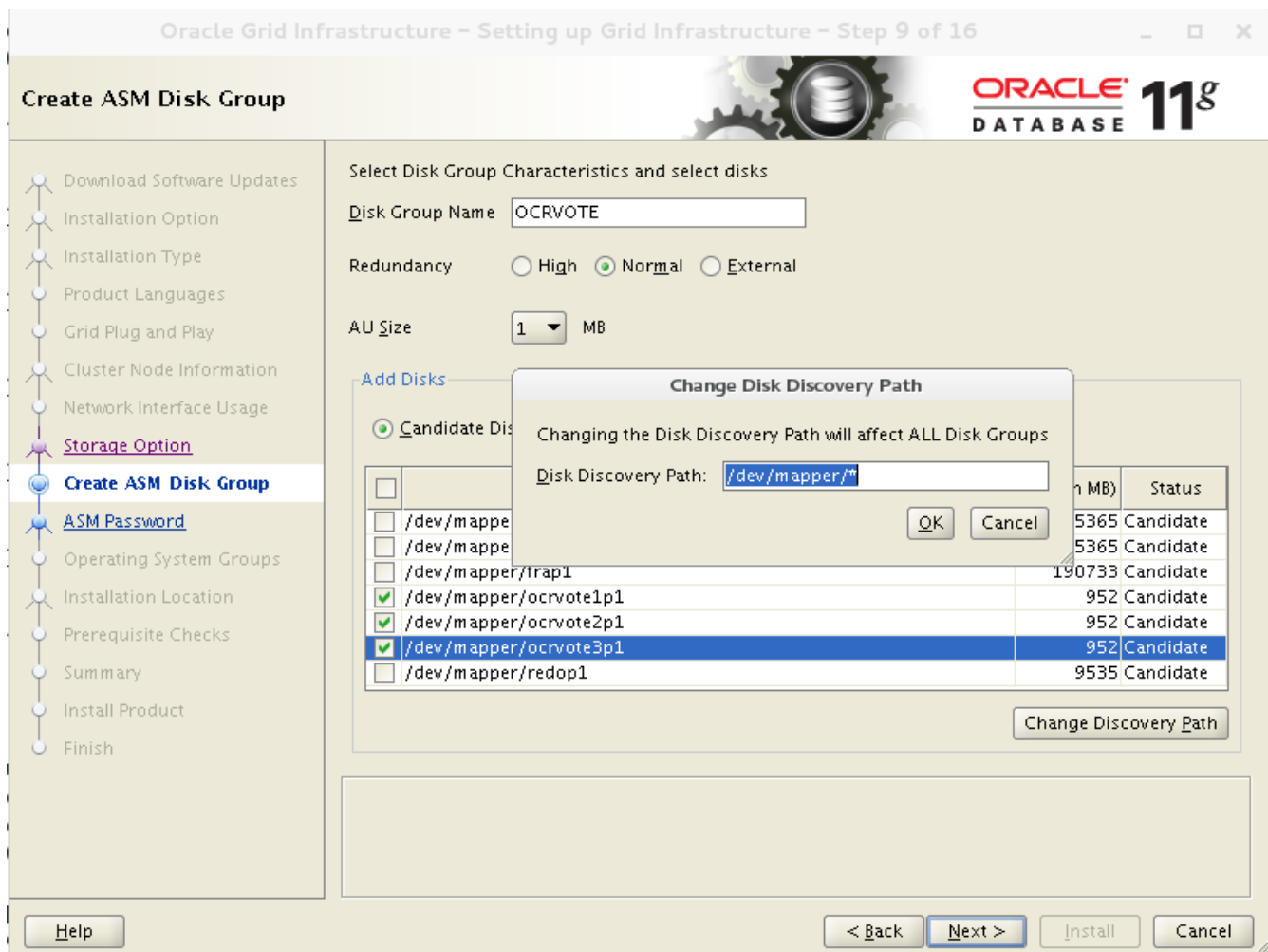


Figure 4.1.1.4: Create ASM Disk Group Window

16. Click **Next** once complete within the **Create ASM Disk Group** window

17. Within the **ASM Password** window, specify the password for the SYS and ASMSNMP user accounts.



18. Within the **Failure Isolation Support** window, select whether to use or not use the Intelligent Platform Management Interface (IPMI). This reference architecture selects the **Do not use Intelligent Platform Management Interface (IPMI)** radio button and clicks **Next**.
19. Within the **Privileged Operating System Groups** window, select the appropriate OS groups and click **Next** to continue. The values as created and assigned within this reference architecture are as follows:
 - Oracle ASM DBA (OSDBA for ASM) Group – *ASMDBA*
 - Oracle ASM Operator (OSOPER for ASM) Group – *ASMOPER*
 - Oracle ASM Administrator (OSASM) Group – *ASMADMIN*
20. Within the **Installation Location** window, specify the appropriate Oracle base and software locations and click **Next** to continue. The values used by the reference environment are as follows:
 - *ORACLE BASE* - */u01/app/grid*
 - *SOFTWARE LOCATION* - */u01/app/11.2.0/grid*
21. Within the **Create Inventory** window, specify the inventory directory and click **Next**. The values used for the reference environment are as follows:
 - *INVENTORY DIRECTORY* - */u01/app/orainventory*
22. Within the **Prerequisite Checks** window, review the status and ensure there are no errors prior to continuing the installation. For failures with a status set to Fixable, select the **Fix & Check Again** button. The execution of the **Fix & Check Again** button provides a *runfixup.sh* script provided by the OUI. As root, run the *runfixup.sh* and click on the **Check Again** button once the *runfixup.sh* has finished. Repeat step within **Prerequisite Checks** window until all prerequisites are met and fixed by the OUI or manual involvement. For errors that can be ignored, select the **Ignore All** check box and click **Next**.
 - The following check errors are common and extra details are provided below.
 - Task resolv.conf Integrity – This task checks consistency of the file */etc/resolv.conf* across all nodes and displays a *PRVF-5637* error (bug *16038314*). Manually verify that all nodes across the Oracle RAC Database cluster provide the appropriate response with the use of **nslookup**. If the appropriate response is achieved, this error can be safely ignored. For more information please visit My Oracle Support Doc ID [1480242.1]¹⁶

16 PRVF-5637 : DNS response time could not be checked on following nodes (Doc ID 1480242.1), via <http://support.oracle.com>



- Package: **cvuqdisk-1.0.9-1** – An rpm package required for the installation of the Oracle Grid Infrastructure. If the **Prerequisite Checks** window does not provide a Fixable script, the rpm can be found in the following location: `/u01/app/grid/grid-software/grid/rpm`. This rpm is required to be installed on all nodes within the cluster.
- Device Checks for ASM – checks to ensure all the ASM disks specified meet the requirements by the OUI and displays a `PRVF-7017` error. This error will disappear once the installation of the **cvuqdisk-1.0.9-1** package on each node within the Oracle RAC Database cluster is met.
- Device Checks for ASM – checks to ensure all the ASM disks specified meet the requirements by the OUI and displays a `PRVF-5150` error. This is bug 14112643 and can be safely ignored. The OUI should not verify Oracle ASMLib disks in this manner. Please refer to My Oracle Support Doc ID [1474961.1] for more information.

23. Within the **Summary** window, review all the information provided, and select **Install** to start the installation.

24. Once the installation completes, execute the scripts within the **Execute Configuration scripts** window. As the root user, run the following on each node within the Oracle RAC Database cluster:

```
# /u01/app/oraInventory/orainstRoot.sh
Changing permissions of /u01/app/oraInventory.
Adding read,write permissions for group.
Removing read,write,execute permissions for world.
Changing groupname of /u01/app/oraInventory to oinstall.
The execution of the script is complete.

# /u01/app/11.2.0/grid/root.sh
Performing root user operation for Oracle 11g

The following environment variables are set as:
    ORACLE_OWNER= grid
    ORACLE_HOME= /u01/app/11.2.0/grid

Enter the full pathname of the local bin directory: [/usr/local/bin]:
/usr/local/bin
Copying dbhome to /usr/local/bin ...
Copying oraenv to /usr/local/bin ...
Copying coraenv to /usr/local/bin ...

[ ... Abbreviated Ouput ... ]
Configure Oracle Grid Infrastructure for a Cluster ... succeeded
```



NOTE: When running the `root.sh` on node two of the cluster, the following “CRS: 4402: The CSS daemon was started in exclusive mode but found an active CSS daemon on node db-oracle-node1, number 1, and is terminating An active cluster was found during exclusive startup, restarting to join the cluster.” message appears prior to the successful installation of the Oracle Grid Infrastructure for a Cluster. This message is not an error when running Oracle Grid Infrastructure 11.2.0.3, and can be safely ignored. For more information on CRS-4402 please visit My Oracle Support Doc ID [1212703.1]¹⁷

25. Click **OK** within the Execute Configuration scripts window.

NOTE: It is possible the Oracle Cluster Verification Utility within the Oracle Grid Infrastructure Installer 11.2.0.3 might end up with a status of 'Failed'. If so, wait 5 minutes, then click on the **Retry** button to reinitiate the Oracle Cluster Verification Utility. If problem persists, click **Next** and click **Yes** to confirm.

26. Within the Finish window, click **Close**.

27. On node one of the cluster, as the `grid` user, verify the cluster health via the following command:

```
# /u01/app/11.2.0/grid/bin/crs_stat -t
Name                Type                Target              State              Host
-----
ora....ER.lsnr      ora....er.type      ONLINE             ONLINE            db-o...ode1
ora....N1.lsnr      ora....er.type      ONLINE             ONLINE            db-o...ode2
ora....N2.lsnr      ora....er.type      ONLINE             ONLINE            db-o...ode1
ora....N3.lsnr      ora....er.type      ONLINE             ONLINE            db-o...ode1
ora.OCRVOTE.dg      ora....up.type      ONLINE             ONLINE            db-o...ode1
ora.asm             ora.asm.type        ONLINE             ONLINE            db-o...ode1
ora.cvu             ora.cvu.type        ONLINE             ONLINE            db-o...ode1
ora....SM1.asm      application          ONLINE             ONLINE            db-o...ode1
ora....E1.lsnr      application          ONLINE             ONLINE            db-o...ode1
ora....de1.gsd      application          OFFLINE            OFFLINE
ora....de1.ons      application          ONLINE             ONLINE            db-o...ode1
ora....de1.vip      ora....t1.type      ONLINE             ONLINE            db-o...ode1
ora....SM2.asm      application          ONLINE             ONLINE            db-o...ode2
ora....E2.lsnr      application          ONLINE             ONLINE            db-o...ode2
ora....de2.gsd      application          OFFLINE            OFFLINE
ora....de2.ons      application          ONLINE             ONLINE            db-o...ode2
ora....de2.vip      ora....t1.type      ONLINE             ONLINE            db-o...ode2
ora.gsd             ora.gsd.type        OFFLINE            OFFLINE
ora....network      ora....rk.type      ONLINE             ONLINE            db-o...ode1
ora.oc4j            ora.oc4j.type       ONLINE             ONLINE            db-o...ode1
ora.ons             ora.ons.type        ONLINE             ONLINE            db-o...ode1
ora.scan1.vip       ora....ip.type      ONLINE             ONLINE            db-o...ode2
ora.scan2.vip       ora....ip.type      ONLINE             ONLINE            db-o...ode1
ora.scan3.vip       ora....ip.type      ONLINE             ONLINE            db-o...ode1
```

17 Grid Infrastructure Startup During Patching, Install or Upgrade May Fail Due to Multicasting Requirement (Doc ID 1212703.1) - https://support.oracle.com/epmos/faces/DocumentDisplay?_adf.ctrl-state=osgi7wnt9_14&_afrlLoop=392592718553079



NOTE: Everything should have a target and state of *ONLINE* except for anything ending in *.gsd*. Global Services Daemon (GSD) is disabled by default starting with Oracle Grid Infrastructure 11.2. For more information on GSD, visit My Oracle Support Doc ID [429966.1] - GSD is Used Only if 9i RAC Database is Present

4.1.2 Installing Oracle 11g R2 Database Software

Prior to the installation of Oracle RAC Database 11g Release 2 (11.2.0.3), ensure the following prerequisites from the following sections have been met:

- **Section 2 Reference Architecture Environment**
- **Section 3 Reference Architecture Configuration Details**

NOTE: The reference environment uses the */u01/app/oracle* as the Oracle base. The owner is set to *oracle* and the group is set to *oinstall*. Run the following commands to create the Oracle base directory set the appropriate permissions:

On each node within the Oracle RAC environment, as the root user, create the following directory structure and set the proper permissions.

```
# mkdir /u01/app/oracle
# chown --recursive oracle.oinstall /u01/app/oracle
```

The following steps are intended for only node one of the Oracle RAC Database 11.2.0.3 environment unless otherwise specified.

1. Download the Oracle Database software¹⁸ from the My Oracle Support site.
2. As the *oracle* user, create a temporary directory within */u01/app/oracle/oracle-software* to store the Oracle Database Software gunzip files, move the Oracle Database software gunzip files to the */u01/app/oracle/oracle-software* location, ensure the Oracle Database software gunzip has the proper permissions and unpack its contents.

As the *oracle* user,

```
# mkdir /u01/app/oracle/oracle-software
# mv p10404530_112030_Linux-x86-64_1of7.zip p10404530_112030_Linux-x86-64_2of7.zip /u01/app/oracle/oracle-software/
```

As the root user,

```
# chown oracle.oinstall /path/to/p10404530_112030_Linux-x86-64_1of7.zip
# chown oracle.oinstall /path/to/p10404530_112030_Linux-x86-64_2of7.zip
```

As the *oracle* user,

```
# cd /u01/app/oracle/oracle-software
# unzip p10404530_112030_Linux-x86-64_1of7.zip
# unzip p10404530_112030_Linux-x86-64_2of7.zip
```

¹⁸ Patch 10404530: 11.2.0.3.0 PATCH SET FOR ORACLE DATABASE SERVER, via <http://support.oracle.com>



3. As the `oracle` user, locate the Oracle Database software and modify the file labeled `cvu_config` to ensure the Oracle Universal Installer (OUI) performs the correct prerequisite checks for Red Hat Enterprise Linux 6.

4. Edit the `cvu_config` file as follows:

```
sed -i 's/CV_ASSUME_DISTID=OEL4/CV_ASSUME_DISTID=OEL6/'  
/u01/app/oracle/oracle-software/database/stage/cvu/cv/admin/cvu_config
```

5. As the `oracle` user, start the OUI via the command:

```
# /u01/app/oracle/oracle-software/database/runInstaller
```

NOTE: Ensure to **SSH** with the `-Y` option as the `oracle` user from the client server, otherwise the following error will occur.

```
# /u01/app/oracle/oracle-software/database/runInstaller  
Starting Oracle Universal Installer...  
  
Checking Temp space: must be greater than 120 MB.   Actual 3461 MB  
Passed  
Checking swap space: must be greater than 150 MB.   Actual 20479 MB  
Passed  
X11 connection rejected because of wrong authentication.  
X11 connection rejected because of wrong authentication.  
Checking monitor: must be configured to display at least 256 colors  
>>> Could not execute auto check for display colors using command /  
usr/bin/xdpyinfo. Check if the DISPLAY variable is set.   Failed <<<<  
  
Some requirement checks failed. You must fulfill these requirements  
before continuing with the installation,  
  
Continue? (y/n) [n] n
```

6. Within the **Configure Security Updates** window, provide the My Oracle Support email address for the latest security issues information, otherwise uncheck the **I wish to receive security updates via My Oracle Support** and click **Next**. A follow up dialog box asking **Do you wish to remain informed of critical security issues in your configuration?** click **Yes**.
7. Within the **Download Software Updates** window, provide the My Oracle Support credentials to download the latest security updates, otherwise select the **Skip software updates** radio button. The reference environment selected **Skip software updates**. Click **Next**.



8. Within the *Installation Option* window, select **Install database software only** and click **Next**.



Figure 4.1.2.1: Installation Option Window



9. Within the **Grid Installation Options** window, select **Oracle Real Application Clusters database installation** radio button and click on the **SSH Connectivity** button. Within the **OS Password:** dialog box enter the user `oracle`'s password and click **Setup**. Once a dialog box returns with 'Successfully established passwordless SSH connectivity between the selected nodes', click **OK** and **Next** to continue to the next window.

NOTE: The `oracle` password must be the same for all nodes within the Oracle RAC Database 11.2.0.3 cluster.

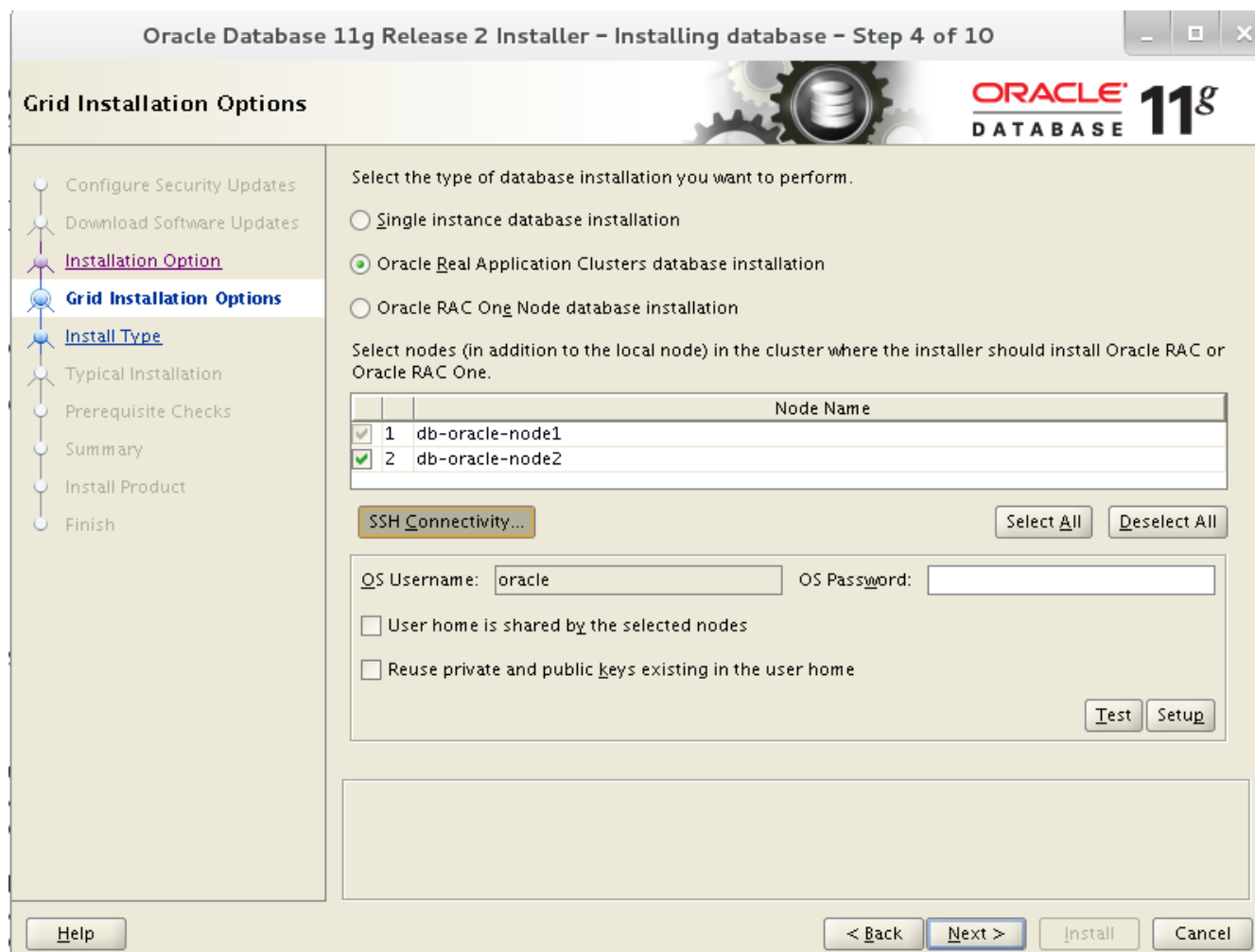


Figure 4.1.2.2: Grid Installation Options Window

10. Within the **Product Languages** window, select the appropriate language for the installation.
11. Within the **Database Edition** window, select the appropriate database edition and click **Next**. For the purposes of the reference environment, *Enterprise Edition* is the edition of choice.



12. Within the **Installation Location** window, select the appropriate Oracle base and software location and click **Next**. For the purposes of the reference environment, the following values are set:

- *ORACLE BASE* - /u01/app/oracle
- *SOFTWARE LOCATION* - /u01/app/oracle/product/11.2.0/dbhome_1

13. Within the **Operating System Groups** window, select the appropriate OS groups and click **Next**. For the purposes of the reference environment, the following values are set:

- *DATABASE ADMINISTRATOR GROUP* – DBA
- *DATABASE OPERATOR GROUP* – OPER

14. Within the **Prerequisite Checks** window, review the status and ensure there are no errors prior to continuing the installation. For failures with a status set to Fixable, select the **Fix & Check Again** button. The execution of the **Fix & Check Again** button provides a *runfixup.sh* script provided by the OUI. As root, run the *runfixup.sh* and click on the **Check Again** button once the *runfixup.sh* has finished. For errors that can be ignored, select the **Ignore All** check box and click **Next**.

- The following check errors are common and extra details are provided below.
 - **Task resolv.conf Integrity** – This task checks consistency of the file */etc/resolv.conf* across all nodes and displays a *PRVF-5637* error (bug *16038314*). Manually verify that all nodes across the Oracle RAC Database cluster provide the appropriate response with the use of **nslookup**. If the appropriate response is achieved, this error can be safely ignored. For more information please visit My Oracle Support Doc ID [1480242.1]¹⁹
 - **Node Connectivity** – The Node Connectivity task checks TCP connectivity is available between all subnets within the Oracle RAC environment cluster and displays a *PRVF-7617* error if it cannot. Within a new terminal, as the `oracle` user, verify that each interface has node connectivity with the following command. For the purposes of this reference architecture, *bond0*, *em3*, and *em4* are the interfaces that are examined.

```
# /u01/app/11.2.0/grid/bin/cluvfy comp nodecon -i bond0,em3,em4  
-n db-oracle-node1,db-oracle-node2 -verbose
```

The output expected for each interface should result in 'Verification of node connectivity was successful. ' If successful, this error can be safely ignored. Otherwise, consult My Oracle Support Doc ID [1335136.1]²⁰

19 PRVF-5637 : DNS response time could not be checked on following nodes (Doc ID 1480242.1), via <http://support.oracle.com>

20 PRVF-7617: TCP connectivity check failed for subnet (Doc ID 1335136.1), via <http://support.oracle.com>



- Clock Synchronization – checks the Oracle Cluster Time Services and provides within the **Details** button the following *PRVG -1015* error. The workaround to remove this error is as follows:
 - Stop **ntpd** service on each node within the Oracle RAC Database cluster via the command:

```
# service ntpd stop
```
 - On each node, as the root user, run the following **ntpdate** command where 10.16.255.2 is the IP of the NTP server:

```
# ntpdate 10.16.255.2
```
 - Restart the **ntpd** service on each node within the Oracle RAC Database cluster via the command:

```
# service ntpd start
```
 - Within the Oracle Database OUI, select the **Check Again** button.

15. Within the **Summary** window, review all the information provided, and select **Install** to start the installation.

16. Once the installation completes, execute the scripts within the **Execute Configuration scripts** window for each node within the Oracle RAC Database 11.2.0.3 environment. As the root user, run the following:

```
# /u01/app/oracle/product/11.2.0/dbhome_1/root.sh
Performing root user operation for Oracle 11g

The following environment variables are set as:
  ORACLE_OWNER= oracle
  ORACLE_HOME=  /u01/app/oracle/product/11.2.0/dbhome_1

Enter the full pathname of the local bin directory: [/usr/local/bin]:
/usr/local/bin
The contents of "dbhome" have not changed. No need to overwrite.
The contents of "oraenv" have not changed. No need to overwrite.
The contents of "coraenv" have not changed. No need to overwrite.

Entries will be added to the /etc/oratab file as needed by
Database Configuration Assistant when a database is created
Finished running generic part of root script.
Now product-specific root actions will be performed.
Finished product-specific root actions.
```

17. Click **OK** within the **Execute Configuration scripts** window.

18. Within the **Finish** window, click **Close**.



4.1.3 Creating ASM Diskgroups via the ASM Configuration Assistant (ASMCA)

Prior to the creation of an Oracle RAC database, create the Database, Fast Recovery Area and Redo Logs Oracle ASM diskgroups via Oracle's ASM Configuration Assistant (ASMCA).

The following steps should be done on node one of the Oracle RAC Database cluster environment.

1. **ssh** with the `-Y` option as the `grid` user to node one of the Oracle RAC Database cluster.
2. As the `grid` user, start **asmca** via the following command:

```
# /u01/app/11.2.0/grid/bin/asmca
```

NOTE: In the example above, `/u01/app/11.2.0/grid` is the `grid` home directory.

3. Via the **asmca** application, select the **Disk Groups** tab and click **Create**.

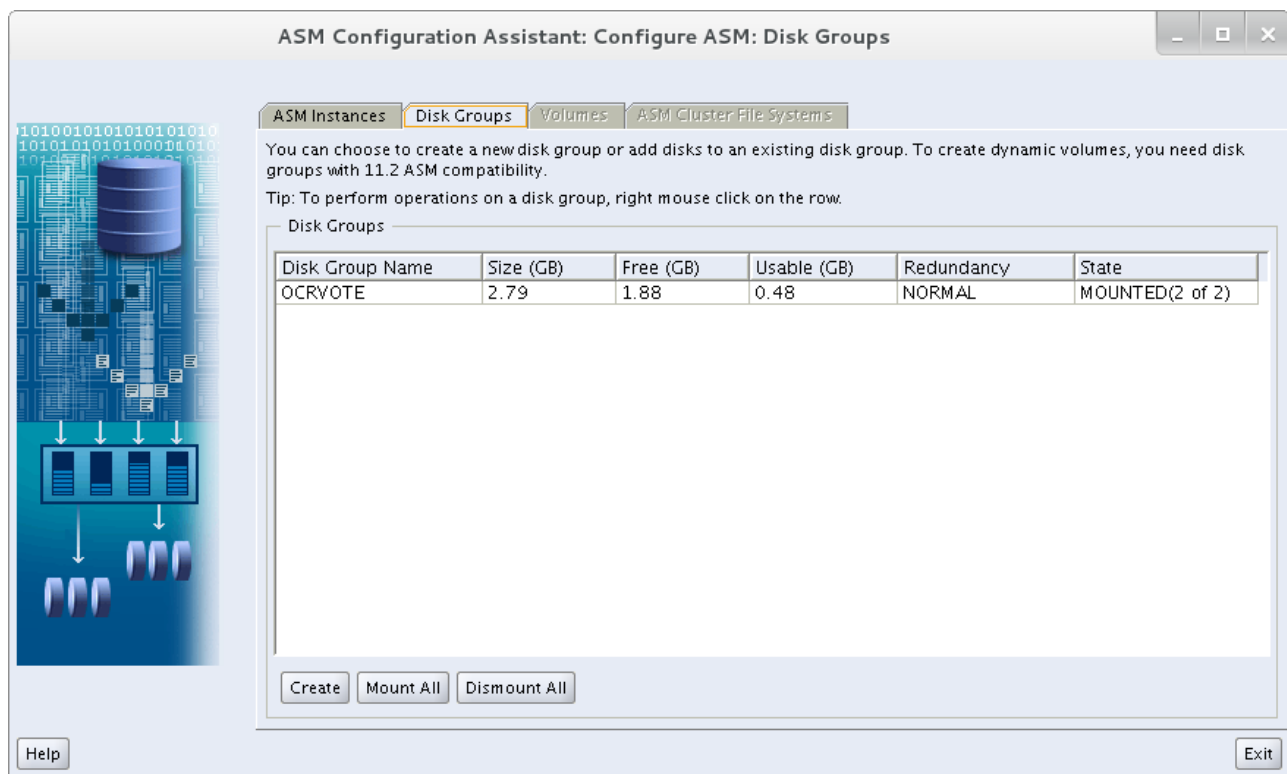


Figure 4.1.3.1: ASMCA DiskGroup Tab



3. Within the **Create Disk Group** window, create the following disk groups as follows:

- Disk Group Name
- Redundancy level
- Selection of the disks to be added to each Disk Group

ASMCA Disk Group		
Diskgroup Name	Disk Path	Header Status
<i>DATADG</i>	If using <i>device mapper multipath</i> : <i>/dev/mapper/db1p1</i> <i>/dev/mapper/db2p1</i> If using Oracle ASMLib: <i>/dev/oracleasm/disks/DATA1</i> <i>/dev/oracleasm/disks/DATA2</i>	If using <i>device mapper multipath</i> : <i>Candidate</i> If using Oracle ASMLib: <i>Provisioned</i>
<i>FRADG</i>	If using <i>device mapper multipath</i> : <i>/dev/mapper/frac1</i> If using Oracle ASMLib: <i>/dev/oracleasm/disks/FRA1</i>	If using <i>device mapper multipath</i> : <i>Candidate</i> If using Oracle ASMLib: <i>Provisioned</i>
<i>REDODG</i>	If using <i>device mapper multipath</i> : <i>/dev/mapper/redop1</i> If using Oracle ASMLib: <i>/dev/oracleasm/disks/REDO1</i>	If using <i>device mapper multipath</i> : <i>Candidate</i> If using Oracle ASMLib: <i>Provisioned</i>

Table 4.1.3.1: ASMCA Create Disk Group

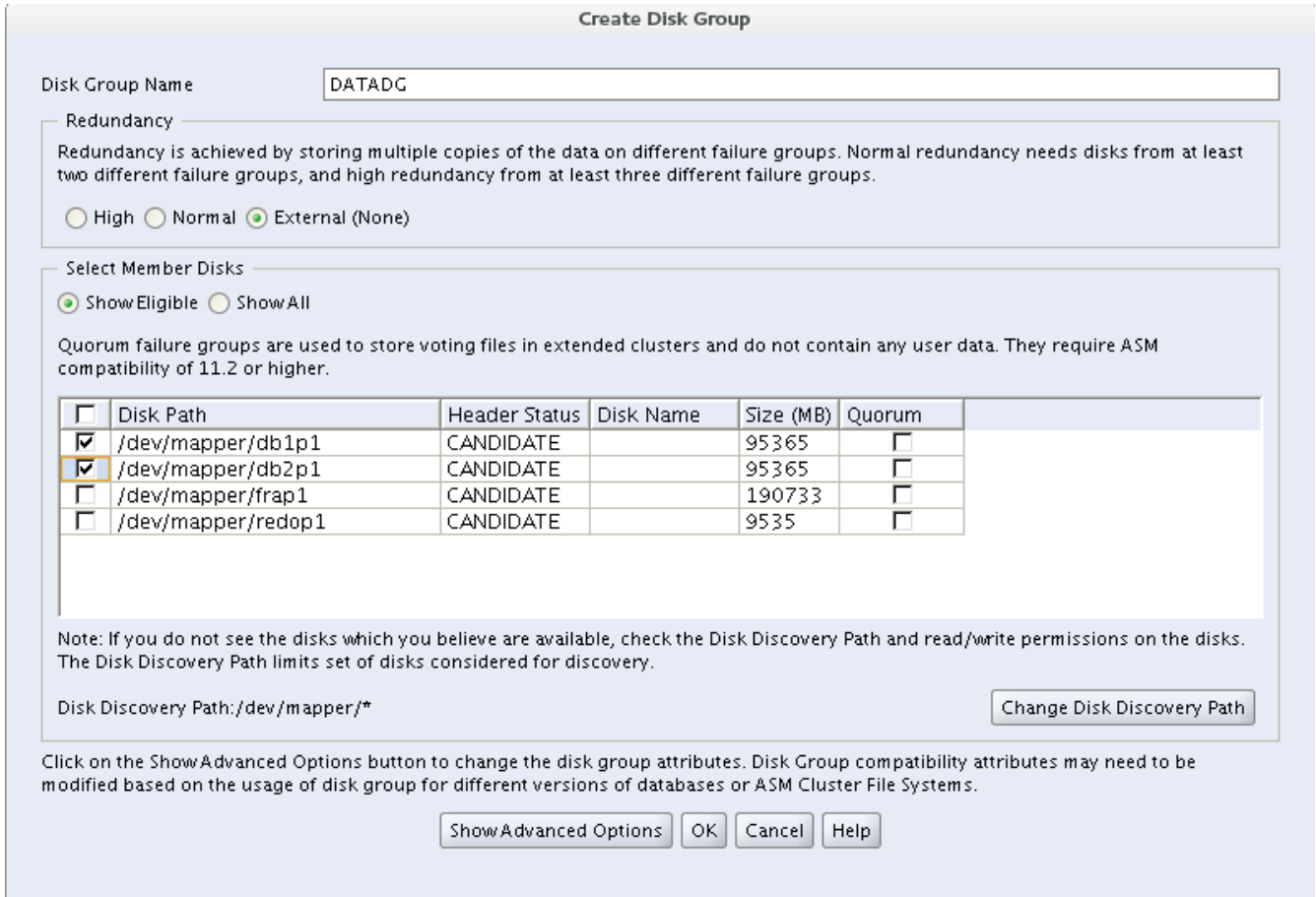


Figure 4.1.3.2: ASMCA Disk Group Creation Window

NOTE: To display the appropriate eligible disks, click on the **Change Discovery Path** button and enter as the 'Disk Discovery Path' one of the following:

- For Device Mapper devices, type:
/dev/mapper/*
- For Oracle ASMLib marked disks, type:
/dev/oracleasm/disks/*

NOTE: For device mapper disks, Header Status is *Candidate*, but for Oracle *ASMLib* disks the Header Status is *Provisioned*.



Click the **OK** button within the **Create Diskgroup** window once the steps above are complete.

4. Repeat steps 2 and 3 to configure both a disk group for the Fast Recovery Area (FRA) and the redo logs.
NOTE: Separation of redo logs into a separate Oracle ASM disk group is optional, but recommended.
5. Once all disk groups are created, click the **Exit** button from the main ASM **Configuration Assistant** window. Click **yes**, when asked to confirm quitting the application.

4.1.4 Creating a Database using Database Configuration Assistant (DBCA)

When creating an Oracle database, the recommended method is the usage of the DBCA utility. The following section describes the step-by-step to create a custom database.

1. **ssh** with the **-Y** option as the `oracle` user to node one of the Oracle RAC Database cluster.
2. As the `oracle` user, run the **dbca** utility via the command:

```
# /u01/app/oracle/product/11.2.0/dbhome_1/bin/dbca
```

NOTE: In the example above, `/u01/app/oracle/product/11.2.0/dbhome_1` is the Oracle home directory.

2. Within the **Welcome** window, ensure **Oracle Real Application Clusters (RAC) database** is selected and click **Next**.
3. Within the **Operations** window, select **Create a Database** radio button and click **Next**.
4. Within the **Database Template** window, select **Custom Database** radio button and click **Next**.
5. Within the **Database Identification** window, specify the Configuration Type, Global Database Name, SID Prefix, and nodes to be associated with the cluster database and click **Next**. For the purposes of the reference environment, the following values are used:
 - *CONFIGURATION TYPE* – Admin-Managed
 - *GLOBAL DATABASE NAME* – racdb
 - *SID PREFIX* – racdb
 - *Nodes selected for the cluster database* – `db-oracle-node1,db-oracle-node2`
6. Within the **Management Options** window, select the check box **Configure Enterprise Manager** and click **Next**.
7. Within the **Database Credentials** window, provide the administrative passwords for each username and click **Next**.



8. Within the **Database File Locations** window, select the appropriate storage type and storage location. For the purposes of the reference environment the following selections are made:
 - *STORAGE TYPE* – *Automatic Storage Management (ASM)*
 - *STORAGE LOCATIONS* – *Use Oracle-Managed Files*
 - *DATABASE AREA: +DATADG*

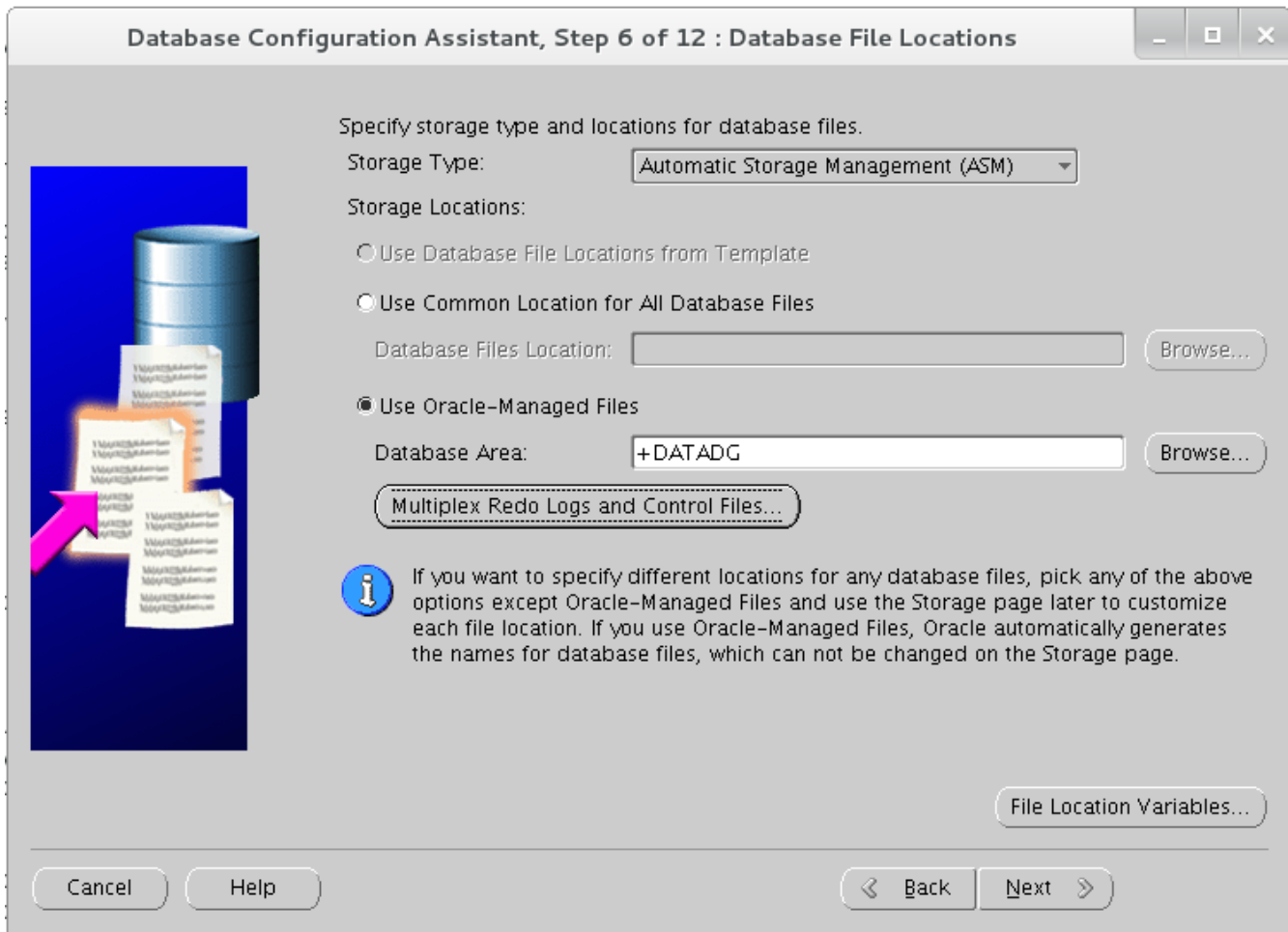


Figure 4.1.4.1: Database File Locations Window



9. Select the **Multiplex Redo Logs and Control Files** button and within the **Multiplex Redo Logs and Control Files** window, add the Redo Logs diskgroup, i.e. +REDODG and click **OK**, then click **Next**.

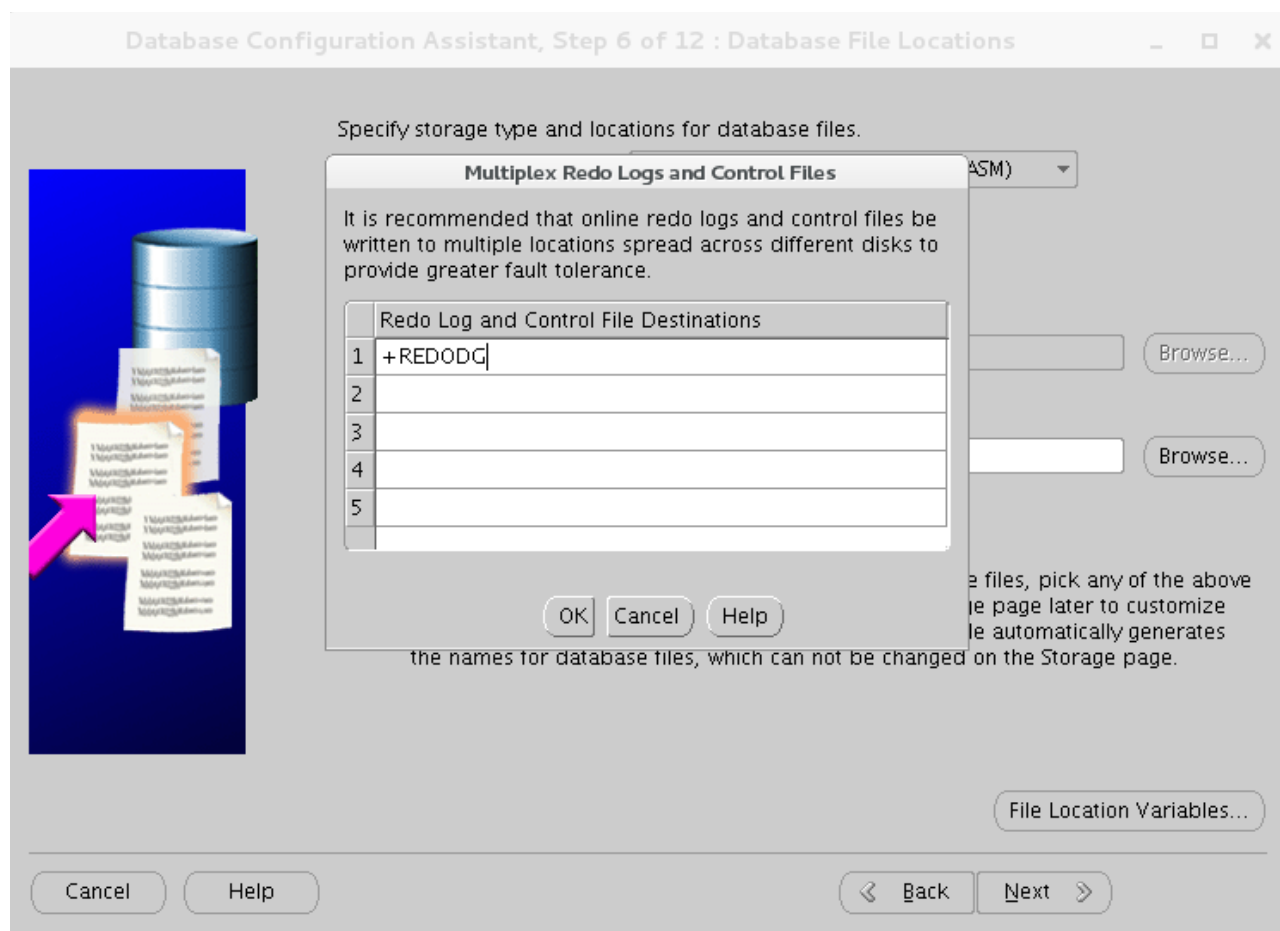


Figure 4.1.4.2: Multiplex Redo Logs and Control Files Window

10. Within the **ASM Credentials** window, specify a **ASMSNMP** password and click **OK**.



11. Within the **Recovery Configuration** window, select the recovery options appropriate for the database. The selections for the reference environment enable the Fast Recovery Area (FRA) and Archiving. Archiving is enabled to prevent the loss of data in case a failure occurs when writing data to disk. The delta is stored within the redo logs. The FRA location and size values are displayed below. Click **Next**.

- FRA – +FRADG
- FRA Size – 190680 Megabytes (total size of FRA)

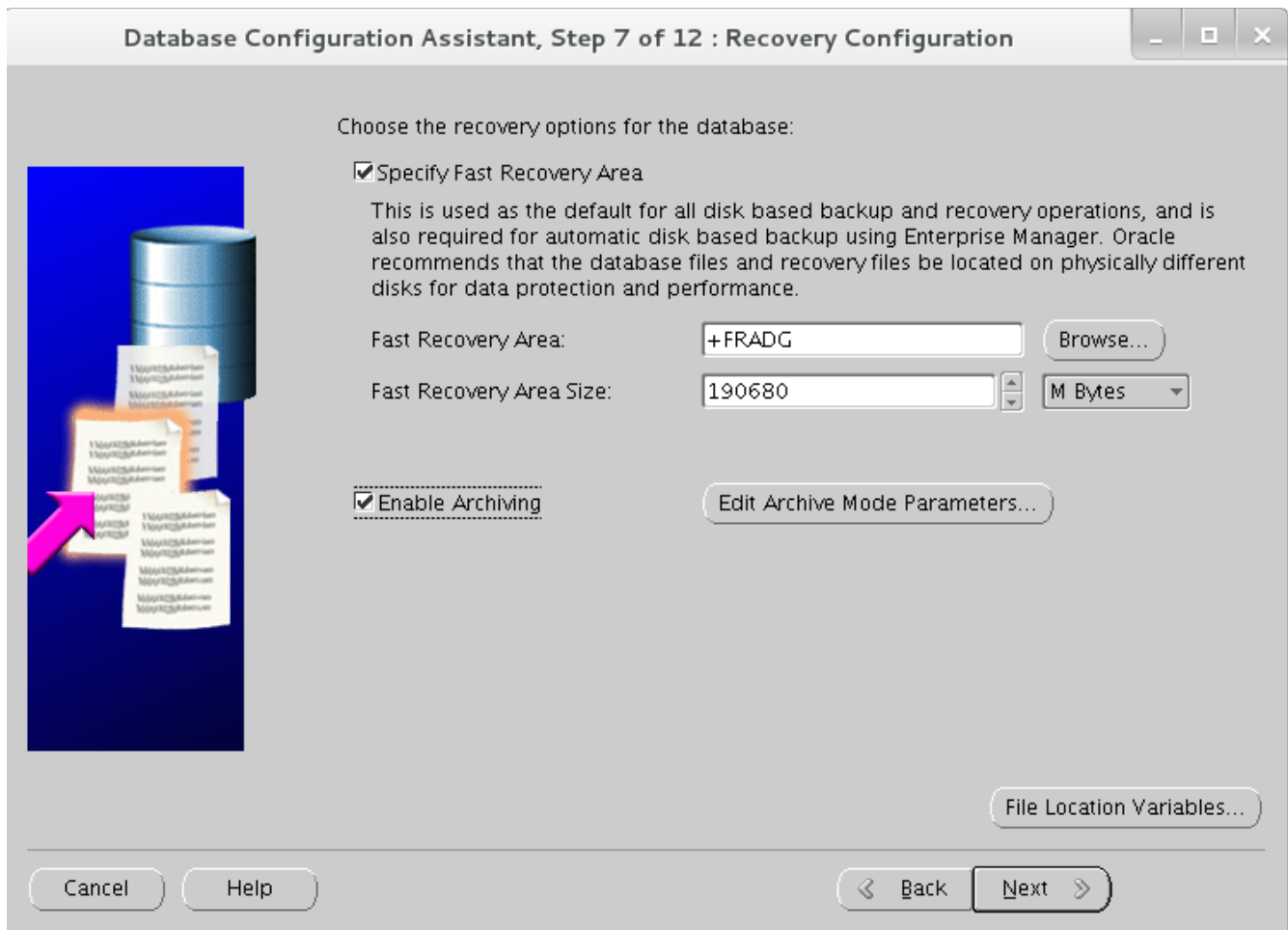


Figure 4.1.4.3: Recovery Configuration Window

NOTE: It is recommended, to modify the values above based on the database's recovery requirements. For more information, visit My Oracle Support Doc ID [305648.1]²¹

²¹ What is a Flash Recovery Area and how to configure it ? (Doc ID 305648.1) -

https://support.oracle.com/epmos/faces/DocumentDisplay?_afLoop=34803820034309&id=305648.1&_afWindowMode=0&_adf.ctrl-state=4d6uvx8f3_58



12. Within the **Database Content** window, select the components to be configured for the database and click **Next**. Default settings are used for the reference environment.
13. Within the **Initialization Parameters** window, select **Custom** and enter the appropriate values for the *SGA* and *PGA* size and click **Next**. It is recommended that the Memory Management be set as *Automatic Shared Memory Management*. The values set for the reference environment for *SGA* and *PGA* are the following:
 - SGA – 14475 Megabytes
 - PGA – 4825 Megabytes

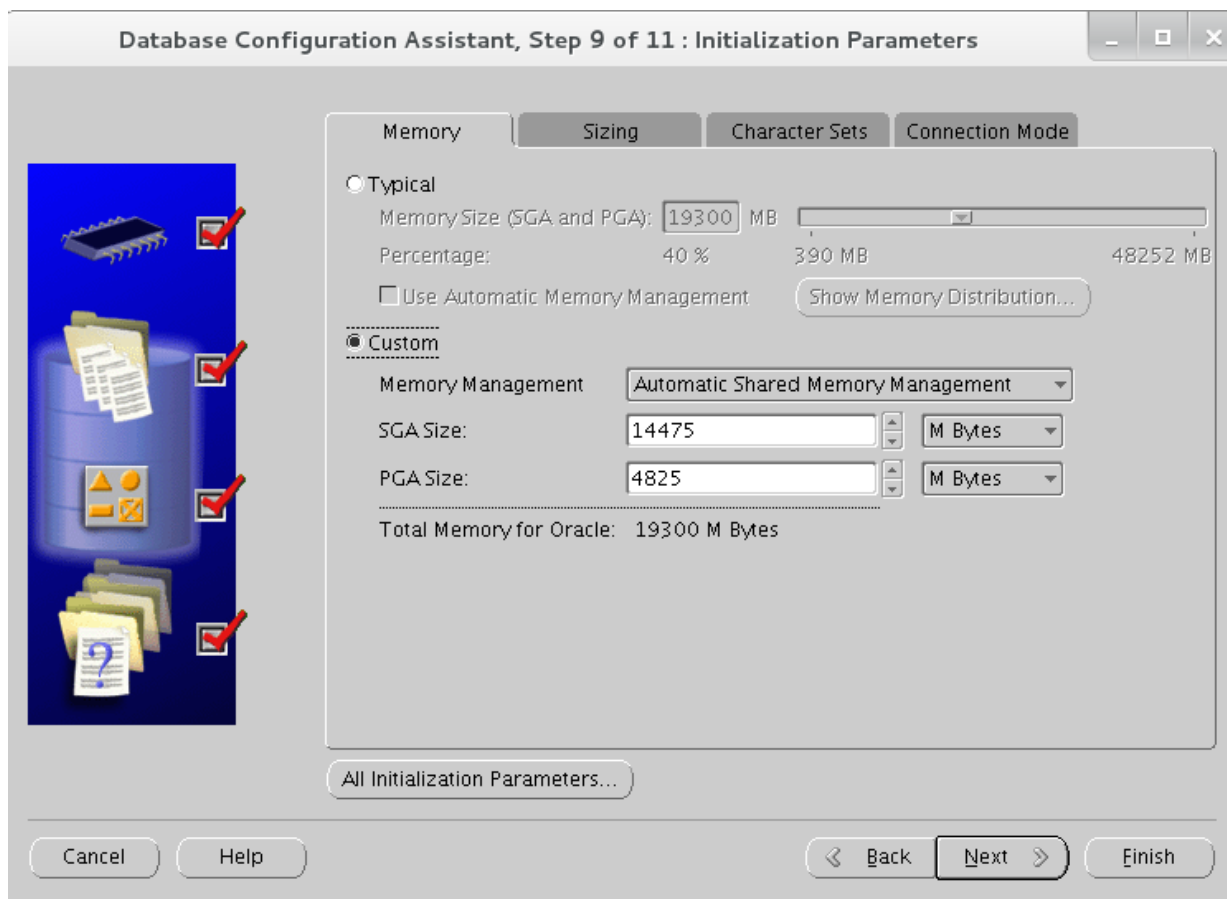


Figure 4.1.4.4: Initialization Parameters Window

NOTE: It is recommended to modify the values above based on the database's SGA and PGA requirements.

14. Within the **Database Storage** window, click **Next**.
15. Within the **Creation Options** window, ensure the **Create Database** box is checked and click **Finish**.
16. Within the **Confirmation** window, review the database configuration summary, and click **OK** to start the database creation.



4.1.5 Enabling HugePages

Transparent Huge Pages (THP) are implemented within Red Hat Enterprise Linux 6 to improve memory management by removing many of the difficulties of manually managing huge pages by dynamically allocating huge pages as needed. Red Hat Enterprise Linux 6, by default, uses *transparent huge pages* also known as *anonymous huge pages*. Unlike static huge pages, no additional configuration is needed to use them. Huge pages can boost application performance by increasing the chance a program will have quick access to a memory page. Unlike traditional huge pages, transparent huge pages can be swapped out (as smaller 4kB pages) when virtual memory clean up is required.

Unfortunately, Oracle Databases do not take advantage of transparent huge pages for interprocess communication. In fact, My Oracle Support [ID 1557478.1]²² states to disable THP due to unexpected performance issues or delays when THP is found to be enabled. To reap the benefit of huge pages for an Oracle database, it is required to allocate static huge pages and disable THP. Due to the complexity of properly configuring huge pages, it is recommended to copy the bash shell script found within **Appendix E Huge Pages Script** and run the script once the database is up and running. The reasoning behind allocating huge pages once the database is up and running is to provide a proper number of pages to handle the running shared memory segments. The steps are as follows:

On each node within the Oracle RAC Database environment,

1. Copy the bash script found within **Appendix E Huge Pages Script** and save it as *huge_pages_settings.sh*
2. As the root user, ensure the *huge_pages_settings.sh* is executable by running the following command:

```
# chmod +x huge_pages_settings.sh
```

3. As the root user, execute the *huge_pages_settings.sh* script as follows:

```
# ./huge_pages_settings.sh
Recommended setting within the kernel boot command line: hugepages = <value>
Recommended setting within /etc/security/limits.conf: oracle soft memlock
<value>
Recommended setting within /etc/security/limits.conf: oracle hard memlock
<value>
```

²² ALERT: Disable Transparent HugePages on SLES11,RHEL6,OEL6 and UEK2 Kernels (DOC ID: 1557478.1)



4. Add the number of *hugepages* provided by the *huge_pages_settings.sh* script to the kernel boot command line within the */etc/grub.conf* and disable *transparent huge pages* persistently across reboots as follows:

/etc/grub.conf

```
title Red Hat Enterprise Linux (2.6.32-358.el6.x86_64)
    root (hd0,0)
    kernel /vmlinuz-2.6.32-358.el6.x86_64 ro root=/dev/mapper/myvg-root
rd_NO_LUKS LANG=en_US.UTF-8 rd_NO_MD SYSFONT=latarcyrheb-sun16
crashkernel=auto rd_NO_DM rd_LVM_LV=myvg/root KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=myvg/swap rhgb quiet hugepages=<value-provided-by-script> transparent_hugepage=never
    initrd /initramfs-2.6.32-358.el6.x86_64.img
```

NOTE: Allocating the number of huge pages within the kernel boot command line is the most reliable method due to memory not yet becoming fragmented.²³

5. Add the Oracle soft and hard limits with regards to *memlock* within */etc/security/limits.conf* as follows:

/etc/security/limits.conf

```
oracle soft memlock <value-provided-by-script>
oracle hard memlock <value-provided-by-script>
```

6. Reboot each node to ensure the *nr_hugepages* setting takes effect properly.
7. Verify the total number of huge pages on the system with the following command:

```
# cat /proc/meminfo | grep -i hugepages_total
HugePages_Total: <value-provided-by-script>
```

8. Verify the current status of the transparent huge pages is set to *NEVER* via the following command:

```
# cat /sys/kernel/mm/transparent_hugepage/enabled
always [never]
```

NOTE: Starting with Oracle Database version 11.2.0.2, the initialization parameter “*USE_LARGE_PAGES*” was introduced to allocate huge pages on a per database use case. The default value for Oracle Database 11.2.0.2 is true, while for Oracle Databases running 11.2.0.3 or higher it is set to auto. For more information on the parameter and its value refer to My Oracle Support²⁴.

NOTE: Huge Pages is not compatible with Automatic Memory Management (AMM).

²³ <https://www.kernel.org/doc/Documentation/vm/hugetlbpage.txt>

²⁴ [USE_LARGE_PAGES To Enable HugePages In 11.2 \[ID 1392497.1\]](#)



5 Logging into an Oracle RAC Database 11g Release 2 Instance (11.2.0.3)

This section focuses on ensuring once the Oracle RAC Database 11g Release 2 (11.2.0.3) deployment is complete, one can successfully log into an Oracle RAC database instance. The following steps provide the details to connect to a particular instance, `racdb1`, of the database created within the Oracle RAC Database environment.

The following steps are to be done only on node one of the Oracle RAC environment.

As the `oracle` user,

1. Set the environment variable for `ORACLE_HOME` with the location of your Oracle Database 11g Release 2 (11.2.0.3) home. The reference environment sets `ORACLE_HOME` to `/u01/app/oracle/product/11.2.0/dbhome_1`

```
# export ORACLE_HOME=/u01/app/oracle/product/11.2.0/dbhome_1
# echo $ORACLE_HOME
/u01/app/oracle/product/11.2.0/dbhome_1
```

NOTE: There is a bug within Oracle Database 11g Release 2 (11.2.0.3) that requires that the export of `ORACLE_HOME` not include a trailing forward slash (`/`).

2. Set the Oracle System ID (`ORACLE_SID`) used to identify the database.

```
# export ORACLE_SID=racdb1
# echo $ORACLE_SID
racdb1
```

3. Invoke the `sqlplus` binary to log into the Oracle instance as a `sysdba`.

```
# $ORACLE_HOME/bin/sqlplus / as sysdba;
SQL*Plus: Release 11.2.0.3.0 Production on Wed Jun 5 13:55:05 2013
```

```
Copyright (c) 1982, 2011, Oracle. All rights reserved.
```

```
Connected to:
Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit Production
With the Partitioning, Automatic Storage Management, OLAP, Data Mining
and Real Application Testing options
```

NOTE: Similar procedures can be followed for each node within the Oracle RAC Database 11.2.0.3 cluster by simply altering the `ORACLE_SID` environment variable for the particular node in which to connect too.



6 Conclusion

Red Hat has a history of creating solutions that include Oracle Databases dating back several years. Red Hat Enterprise Linux 6 provides an excellent foundation for database deployments with demonstrated stability, scalability, and performance. With support for Oracle RAC Database 11g Release 2 (11.2.0.3) on Red Hat Enterprise Linux 6, customers can increasingly look to deploy Oracle Databases in advanced configurations.

The steps and procedures described in this reference architecture should provide system and storage administrators the blueprint required to create a robust and performing solution based on Oracle Real Application Clusters (RAC) Databases. Administrators can reference this document to simplify and optimize the deployment process and employ the latest best practices for configuring Red Hat technologies while implementing the following tasks:

- Deploying Oracle Grid Infrastructure 11g R2 (11.2.0.3)
- Deploying Oracle RAC Database 11g R2 (11.2.0.3) with shared SAN disks
- Using Oracle ASM disks with *udev* rules
- Using Oracle ASM disks with Oracle ASMLib (RHEL 6.4 and above)
- Enabling the Oracle RAC Database 11gR2 environment with *SELinux*



Appendix A: Revision History

Revision 1.1

Tuesday December 10, 2013 Roger Lopez

- Modified the Section 3.4.4 Optimizing Database Storage using Automatic System Tuning by creating a custom tuned profile that disables THP
- Removed step 6 from Section 4.1.5 Enabling HugePages relating to disabling THP as it is now fixed using the custom profile from Section 3.4.4
- Modified any mention of the use of *limits.conf* from Section 3.3.14 Setting Shell Limits for the Grid and Oracle User to the more appropriate *99-grid-oracle-limits.conf*
- Removed any mention of adding “*session required pam_limits.so*” to the */etc/pam.d/login* file as the file */etc/pam.d/system-auth* already includes it by default and is not necessary to add it in the */etc/pam.d/login* file
- Appendix K Configuration Files contains the new *enterprise-storage-no-thp* directory for ease of use of tuned profiles
- Miscellaneous grammar corrections within the document.

Revision 1.0

Friday September 13, 2013 Roger Lopez

Initial Release



Appendix B: Contributors

1. Brett Thurber, content review and technical review of Oracle deployment procedures
2. Yan Fisher, content review
3. John Boero, content review



Appendix C: DM Multipath Configuration File

```
# This is a basic configuration file with some examples, for device mapper
# multipath.
# For a complete list of the default configuration values, see
# /usr/share/doc/device-mapper-multipath-0.4.9/multipath.conf.defaults
# For a list of configuration options with descriptions, see
# /usr/share/doc/device-mapper-multipath-0.4.9/multipath.conf.annotated
#
# REMEMBER: After updating multipath.conf, you must run
#
# service multipathd reload
#
# for the changes to take effect in multipathd

## By default, devices with vendor = "IBM" and product = "S/390.*" are
## blacklisted. To enable mulitpathing on these devies, uncomment the
## following lines.
#blacklist_exceptions {
#    device {
#        vendor    "IBM"
#        product   "S/390.*"
#    }
#}

## Use user friendly names, instead of using WWIDs as names.
defaults {
    user_friendly_names yes
}
##
## Here is an example of how to configure some standard options.
##
#
defaults {
    udev_dir                /dev
    polling_interval        10
    path_selector            "round-robin 0"
    path_grouping_policy    multibus
    getuid_callout          "/lib/udev/scsi_id --whitelisted
--device=/dev/%n"
    prio                    alua
    path_checker            readsector0
    rr_min_io               100
    max_fds                 8192
    rr_weight               priorities
    failback                immediate
    no_path_retry           fail
    user_friendly_names     yes
}
##
## The wwid line in the following blacklist section is shown as an example
```



```
## of how to blacklist devices by wwid. The 2 devnode lines are the
## compiled in default blacklist. If you want to blacklist entire types
## of devices, such as all scsi devices, you should use a devnode line.
## However, if you want to blacklist specific devices, you should use
## a wwid line. Since there is no guarantee that a specific device will
## not change names on reboot (from /dev/sda to /dev/sdb for example)
## devnode lines are not recommended for blacklisting specific devices.
##
blacklist {
    wwid 3600508b1001030353434363646301200
    devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
    devnode "^hd[a-z]"
}
multipaths {
    multipath {
        wwid                3600c0ff000d7e7a899d8515101000000
        alias                db1
    }
    multipath {
        wwid                3600c0ff000dabfe5a7d8515101000000
        alias                db2
    }
    multipath {
        wwid                3600c0ff000dabfe596a0f65101000000
        alias                ocrvote1
    }
    multipath {
        wwid                3600c0ff000dabfe5a2a0f65101000000
        alias                ocrvote2
    }
    multipath {
        wwid                3600c0ff000dabfe5b4a0f65101000000
        alias                ocrvote3
    }
    multipath {
        wwid                3600c0ff000dabfe5f4d8515101000000
        alias                redo
    }
    multipath {
        wwid                3600c0ff000d7e7a8dbd8515101000000
        alias                fra
    }
}
#devices {
#    device {
#        vendor            "COMPAQ  "
#        product           "HSV110 (C)COMPAQ"
#        path_grouping_policy multibus
#        getuid_callout    "/lib/udev/scsi_id --whitelisted"
#        --device="/dev/%n"
#        path_checker       readsector0
#        path_selector      "round-robin 0"
#        hardware_handler   "0"
#        failback           15
#    }
#}
```



```
#           rr_weight           priorities
#           no_path_retry       queue
#           }
# device {
#           vendor               "COMPAQ  "
#           product              "MSA1000  "
#           path_grouping_policy multibus
#           }
#}
```

Appendix D: iptables Configuration File

```
# Generated by iptables-save v1.4.7 on Mon Aug  5 19:20:53 2013
*filter
:INPUT ACCEPT [0:0]
:FORWARD ACCEPT [0:0]
:OUTPUT ACCEPT [25:2660]
-A INPUT -s 10.16.142.51/32 -i bond0 -j ACCEPT
-A INPUT -s 10.16.142.52/32 -i bond0 -j ACCEPT
-A INPUT -i em3 -j ACCEPT
-A INPUT -i em4 -j ACCEPT
-A INPUT -m state --state RELATED,ESTABLISHED -j ACCEPT
-A INPUT -p icmp -j ACCEPT
-A INPUT -i lo -j ACCEPT
-A INPUT -s 192.11.142.0/24 -d 230.0.1.0 -j ACCEPT
-A INPUT -s 192.11.142.0/24 -d 224.0.0.251 -j ACCEPT
-A INPUT -s 192.12.142.0/24 -d 230.0.1.0 -j ACCEPT
-A INPUT -s 192.12.142.0/24 -d 224.0.0.251 -j ACCEPT
-A INPUT -i bond0 -d 230.0.1.0 -j ACCEPT
-A INPUT -i bond0 -d 224.0.0.251 -j ACCEPT
-A INPUT -p tcp -m state --state NEW -m tcp --dport 22 -j ACCEPT
-A INPUT -p tcp -m state --state NEW -m tcp --dport 443 -j ACCEPT
-A INPUT -m state --state NEW -m tcp -p tcp -s 10.16.142.54 --dport 1521 -j
ACCEPT
-A INPUT -m state --state NEW -m tcp -p tcp -s 10.16.142.54 --dport 1158 -j
ACCEPT
-A INPUT -j REJECT --reject-with icmp-host-prohibited
-A FORWARD -j REJECT --reject-with icmp-host-prohibited
COMMIT
```



Appendix E: Huge Pages Script

The following hugepages script is from Tuning Red Hat Enterprise Linux For Oracle & Oracle RAC by Scott Crot, Sr. Consultant, Red Hat²⁵ and modified to include the values Oracle's soft and hard memlock.

```
#!/bin/bash
KERN=`uname -r | awk -F. '{ printf("%d.%d\n", $1, $2); }'`
# Find out the HugePage size
HPG_SZ=`grep Hugepagesize /proc/meminfo | awk '{print $2}'`
# Start from 1 pages to be on the safe side and guarantee 1 free HugePage
NUM_PG=1
# Cumulative number of pages required to handle the running shared memory
segments
for SEG_BYTES in `ipcs -m | awk '{print $5}' | grep "[0-9][0-9]*"`
do
MIN_PG=`echo "$SEG_BYTES/($HPG_SZ*1024)" | bc -q`
if [ $MIN_PG -gt 0 ]; then
NUM_PG=`echo "$NUM_PG+$MIN_PG+1" | bc -q`
fi
done
# Finish with results
case $KERN in
'2.4') HUGETLB_POOL=`echo "$NUM_PG*$HPG_SZ/1024" | bc -q`;
echo "Recommended setting: vm.hugetlb_pool = $HUGETLB_POOL" ;;
'2.6') MEM_LOCK=`echo "$NUM_PG*$HPG_SZ" | bc -q`;
echo "Recommended setting within the kernel boot command line: hugepages =
$NUM_PG"
echo "Recommended setting within /etc/security/limits.d/99-grid-oracle-
limits.conf: oracle soft memlock $MEM_LOCK"
echo "Recommended setting within /etc/security/limits.d/99-grid-oracle-
limits.conf: oracle hard memlock $MEM_LOCK" ;;
*) echo "Unrecognized kernel version $KERN. Exiting." ;;
esac
```

²⁵ Tuning Red Hat Enterprise Linux For Oracle & Oracle RAC by Scott Crot, Sr. Consultant, Red Hat, http://www.redhat.com/promo/summit/2010/presentations/summit/decoding-the-code/fri/scott-945-tuning/summit_jbw_2010_presentation.pdf



Appendix F: Oracle Database Package Requirements Text File

```
cloog-ppl
compat-libcap1
compat-libstdc++-33
cpp
gcc
gcc-c++
glibc-devel
glibc-headers
kernel-headers
ksh
libXmu
libXt
libXv
libXxf86dga
libXxf86misc
libXxf86vm
libaio-devel
libdmx
libstdc++-devel
mpfr
make
ppl
xorg-x11-utils
xorg-x11-xauth
```



Appendix G: Kernel Parameters

```
vm.swappiness = 0
vm.dirty_background_ratio = 3
vm.dirty_ratio = 80
vm.dirty_expire_centisecs = 500
vm.dirty_writeback_centisecs = 100
kernel.shmmax = 68719476736
kernel.shmall = 4294967296
kernel.shmmni = 4096
kernel.sem = 250 32000 100 128
# fs.file-max needs to be set to at least 6815744 for the Oracle RAC
Installation.
fs.file-max = 6815744
fs.aio-max-nr = 1048576
net.ipv4.ip_local_port_range = 9000 65500
net.core.rmem_default = 262144
net.core.rmem_max = 4194304
net.core.wmem_default = 262144
net.core.wmem_max = 1048576
# set to the appropriate private eth devices
net.ipv4.conf.em3.rp_filter = 2
net.ipv4.conf.em4.rp_filter = 2
```



Appendix H: Limits Configuration File (99-grid-oracle-limits.conf)

```
oracle soft nproc 2047
oracle hard nproc 16384
oracle soft nofile 1024
oracle hard nofile 65536
oracle soft stack 10240
oracle hard stack 32768
oracle soft memlock <value-provided-by-script>
oracle hard memlock <value-provided-by-script>

grid soft nproc 2047
grid hard nproc 16384
grid soft nofile 1024
grid hard nofile 65536
grid soft stack 10240
grid hard stack 32768
```




Appendix I: 99-oracle-asmdevices.rules

```
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"  
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"  
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"  
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"  
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"  
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"  
KERNEL=="dm- *", ENV{DM_UUID}=="<enter-value-according-to-your-  
environment>", OWNER="grid", GROUP="asmadmin", MODE="0660"
```



Appendix J: Sample Kickstart File

```
# Red Hat | Oracle Solutions Kickstart Script

install
url --url=<place-distro-url-here>
lang en_US.UTF-8
keyboard us
network --onboot yes --device em1 --mtu=1500 --bootproto dhcp
rootpw <add-password-here>
# Reboot after installation
reboot
authconfig --enablemd5 --enablesshadow
selinux --enforcing
timezone America/New_York
bootloader --location=mbr --driveorder=sda --append="crashkernel=auto rhgb
quiet transparent_hugepage=never"
# The following is the partition information you requested
# Note that any partitions you deleted are not expressed
# here so unless you clear all partitions first, this is
# not guaranteed to work
clearpart --all

volgroup myvg --pesize=32768 pv.008002
logvol /home --fstype=ext4 --name=home --vgname=myvg --size=8192
logvol / --fstype=ext4 --name=root --vgname=myvg --size=15360
logvol swap --name=swap --vgname=myvg --size=16400
logvol /tmp --fstype=ext4 --name=tmp --vgname=myvg --size=4096
logvol /u01 --fstype=ext4 --name=u01 --vgname=myvg --size=51200
logvol /usr --fstype=ext4 --name=usr --vgname=myvg --size=5120
logvol /var --fstype=ext4 --name=var --vgname=myvg --size=8192

part /boot --fstype=ext4 --size=256
part pv.008002 --grow --size=1000

%packages
@Base
@Core
```



Appendix K: Configuration Files

All configuration files can be downloaded from the Red Hat customer portal²⁶. A listing of all the files and a brief description can be seen on the **Table 6.1: Configuration Files**. Some of the configuration files require input with the proper information pertaining to your environment.

Files	Description
req-rpm.txt	The required RPMs to deploy Oracle.
huge_page_settings.sh	Script that provides the proper hugepage values to set.
multipath.conf	Device Mapper Multipath configuration file.
sysctl.conf	Configuration file for the kernel parameters
99-grid-oracle-limits.conf	Configuration file to set limits for a user.
selinux-policy	Version: 3.7.19-211. This version ensures that Oracle ASMLib works properly with <i>SELinux</i> enabled.
selinux-policy-targeted	Version: 3.7.19-211. This version ensures that Oracle ASMLib works properly with <i>SELinux</i> enabled.
99-oracle-asmdevices.rules	Udev configuration file for Oracle ASM disks
iptables	iptables configuration
bonding.conf	/etc/modprobe.d/ bonding configuration file
oracle-grid.sh	Shell script used to set user limits
sample-ks.cfg	Sample Kickstart File
enterprise-storage-no-thp	Directory of the custom tuned profile enterprise-storage-no-thp
CHANGELOG	Text file with modifications made to scripts.

Table 6.1: Configuration Files

²⁶ <https://access.redhat.com/site/node/479093/40/1>



Appendix L: Troubleshooting ORA-* Errors

This section focuses on using the command line tool, Automatic Diagnostic Repository Command Interpreter (*ADRCI*), to troubleshoot Oracle RAC database related errors. *ADRCI* was introduced in Oracle RAC Database 11g in order to help users diagnose errors within their Oracle RAC database environments and provide health reports if an issue should arise. The following example shows how one could troubleshoot an Oracle RAC database instance error using the *ADRCI* tool.

NOTE: The following steps are intended to produce an ORA-07445 error that can be troubleshooted using the *ADRCI* tool. Do not attempt on a Oracle RAC Database Production environment. The following is for demonstration purposes only and intended only to show how to troubleshoot ORA-* related errors using the *ADRCI* tool.

1. In order to create an ORA-07445 error, an essential Oracle process will be killed via the following commands:

```
# ps -A --format pid,args | grep ora_dbrm | grep -v grep
7622 ora_dbrm_racdb1
# kill -SEGV 7622
```

2. Export the ORACLE_HOME via the command:

```
# export ORACLE_HOME=/u01/app/oracle/product/11.2.0/dbhome_1
```

3. Start the *ADRCI* command tool via the command:

```
# $ORACLE_HOME/bin/adrci

ADRCI: Release 11.2.0.3.0 - Production on Mon Jul 1 19:42:58 2013

Copyright (c) 1982, 2011, Oracle and/or its affiliates. All rights
reserved.

ADR base = "/u01/app/oracle"
adrci>
```

4. At the *ADRCI* prompt, show Oracle Home's available via the command:

```
adrci> show home
ADR Homes:
diag/rdbms/racdb/racdb1
```

NOTE: If more than one Oracle Home is available, one must specify a particular Oracle Database Home. An example on how to set to a particular Oracle Database Home is as follows:

```
adrci> set home diag/rdbms/racdb/racdb1
```

5. At the *ADRCI* prompt, run the following command to see the last 50 entries in the alert log:

```
adrci> show alert -tail -f
[ ... Output Abbreviated ... ]
Exception [type: SIGSEGV, unknown code] [ADDR:0xD431000057BA]
[PC:0x3B312EAFCA, semtimedop()+10] [exception issued by pid: 22458, uid:
54321] [flags: 0x0, count: 1]
Errors in file
/u01/app/oracle/diag/rdbms/racdb/racdb1/trace/racdb1_dbrm_7622.trc
```



```
(incident=3657):
ORA-07445: exception encountered: core dump [semtimedop()+10] [SIGSEGV]
[ADDR:0xD431000057BA] [PC:0x3B312EAFCA] [unknown code] []
Incident details in:
/u01/app/oracle/diag/rdbms/racdb/racdb1/incident/incdir_3657/racdb1_dbrm_
7622_i3657.trc
Use ADRCI or Support Workbench to package the incident.
See Note 411.1 at My Oracle Support for error and packaging details.
```

NOTE: In this particular case, we are looking for an ORA-07445 within the alert log as seen above. However, this step is just to confirm what is seen in the future *ADRCI* steps. To exit the alert log, CTRL+C.

6. Within the *ADRCI*, there are two key terms to be aware of, problem and incident. An incident is a particular time when a problem occurred. For example, it is possible for an Oracle process to crash at different times with the same ORA-07445. The multiple occurrences of the crash are incidents, while the problem is still the ORA-07445 error. In order to view the problem, the following *ADRCI* command needs to be run.

```
adrci> show problem
ADR Home = /u01/app/oracle/diag/rdbms/racdb/racdb1:
*****
PROBLEM_ID          PROBLEM_KEY          LAST_INCIDENT        LASTINC_TIME
-----
1      ORA 7445 [semtimedop()+10]      3657      2013-08-21 10:35:10.876000
-04:00
```

7. In order to view how many incidents, the following *ADRCI* command needs to be run. In this example, I only have one incident in which the ORA-07445 problem occurred.

```
adrci> show incident
ADR Home = /u01/app/oracle/diag/rdbms/racdb/racdb1:
*****
INCIDENT_ID        PROBLEM_KEY          CREATE_TIME
-----
3657      ORA 7445 [semtimedop()+10]      2013-08-21 10:35:10.876000 -04:00
1 rows fetched
```

8. In order to view the incident in more detail, run the following command:

```
adrci> show incident -mode detail -p "incident_id=3657"
ADR Home = /u01/app/oracle/diag/rdbms/racdb/racdb1:
*****
*****
INCIDENT INFO RECORD 1
*****
INCIDENT_ID        3657
STATUS             ready
CREATE_TIME        2013-08-21 10:35:10.876000 -04:00
PROBLEM_ID         1
CLOSE_TIME         <NULL>
FLOOD_CONTROLLED   none
```



```
ERROR_FACILITY          ORA
ERROR_NUMBER            7445
ERROR_ARG1              semtimedop()+10
ERROR_ARG2              SIGSEGV
ERROR_ARG3              ADDR:0xD431000057BA
ERROR_ARG4              PC:0x3B312EAFCA
ERROR_ARG5              unknown code
ERROR_ARG6              <NULL>
ERROR_ARG7              <NULL>
ERROR_ARG8              <NULL>
ERROR_ARG9              <NULL>
ERROR_ARG10             <NULL>
ERROR_ARG11             <NULL>
ERROR_ARG12             <NULL>
SIGNALLING_COMPONENT    <NULL>
SIGNALLING_SUBCOMPONENT <NULL>
SUSPECT_COMPONENT       <NULL>
SUSPECT_SUBCOMPONENT    <NULL>
ECID                    <NULL>
IMPACTS                 0
PROBLEM_KEY             ORA 7445 [semtimedop()+10]
FIRST_INCIDENT          3657
FIRSTINC_TIME           2013-08-21 10:35:10.876000 -04:00
LAST_INCIDENT           3657
LASTINC_TIME            2013-08-21 10:35:10.876000 -04:00
IMPACT1                 0
IMPACT2                 0
IMPACT3                 0
IMPACT4                 0
KEY_NAME                ProcId
KEY_VALUE               7.1
KEY_NAME                Client ProcId
KEY_VALUE               oracle@db-oracle-
node1.cloud.lab.eng.bos.redhat.com.7622_139933798536960
KEY_NAME                SID
KEY_VALUE               113.1
OWNER_ID                1
INCIDENT_FILE           /u01/app/oracle/diag/rdbms/racdb/racdb1/trace/racdb1_dbrm_7622.trc
OWNER_ID                1
INCIDENT_FILE           /u01/app/oracle/diag/rdbms/racdb/racdb1/incident/incdir_3657/racdb1_dbrm_
7622_i3657.trc
1 rows fetched
```

NOTE: The two parameters of importance here are the PROBLEM_ID and INCIDENT_FILE.

9. When looking at the incident in further detail, the following incident file can be examined further via the following command:

```
adrci> show trace
/u01/app/oracle/diag/rdbms/racdb/racdb1/incident/incdir_3657/racdb1_dbrm_
7622_i3657.trc
Output the results to file: /tmp/utsout_23273_14021_2.ado
/bin/bash: adrci: command not found
```



```
adrci> quit
# cat /tmp/utsout_23273_14021_2.ado
//u01/app/oracle/diag/rdbms/racdb/racdb1/incident/incdir_3657/racdb1_dbrm_
_7622_i3657.trc
-----
LEVEL PAYLOAD
-----
-----
Dump file
/u01/app/oracle/diag/rdbms/racdb/racdb1/incident/incdir_3657/racdb1_dbrm_
7622_i3657.trc
Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit
Production
With the Partitioning, Real Application Clusters, Automatic Storage
Management, OLAP,
Data Mining and Real Application Testing options
ORACLE_HOME = /u01/app/oracle/product/11.2.0/dbhome_1
System name:      Linux
Node name:        db-oracle-node1.cloud.lab.eng.bos.redhat.com
Release:  2.6.32-358.el6.x86_64
Version:  #1 SMP Tue Jan 29 11:47:41 EST 2013
Machine:  x86_64
Instance name: racdb1
Redo thread mounted by this instance: 1
Oracle process number: 7
Unix process pid: 7622, image: ?

*** 2013-08-21 10:35:10.892
*** SESSION ID:(113.1) 2013-08-21 10:35:10.892
*** CLIENT ID:() 2013-08-21 10:35:10.892
*** SERVICE NAME:(SYS$BACKGROUND) 2013-08-21 10:35:10.892
*** MODULE NAME:() 2013-08-21 10:35:10.892
*** ACTION NAME:() 2013-08-21 10:35:10.892

Dump continued from file:
/u01/app/oracle/diag/rdbms/racdb/racdb1/trace/racdb1_dbrm_7622.trc
1> ***** Error Stack *****
ORA-07445: exception encountered: core dump [semtimedop()+10]
[SIGSEGV] [ADDR:0xD431000057BA] [PC:0x3B312EAFCA] [unknown code] []
1< ***** Error Stack *****
1> ***** Dump for incident 3657 (ORA 7445 [semtimedop()+10]) *****
2> ***** Beginning of Customized Incident Dump(s) *****
Exception [type: SIGSEGV, unknown code] [ADDR:0xD431000057BA]
[PC:0x3B312EAFCA, semtimedop()+10] [exception issued by pid: 22458, uid:
54321]
[ ... Output Abbreviated ... ]
```

10. While this concludes how to examine trace files that pertain to a particular ORA error using *ADRCI*; if the issue cannot be solved by the end user, the *ADRCI* provides the *Incident Packaging Service (IPS)* tool to ZIP the necessary trace files based on the problem. It can then be sent to support for further debugging. To create the appropriate ZIP file, log back into *ADRCI* and use the following commands:



```
# $ORACLE_HOME/bin/adrci
adrci> ips create package problem 1 correlate all
Created package 1 based on problem id 1, correlation level all
```

NOTE: Problem 1 is the Problem_ID found step 6.

```
adrci> ips generate package 1 in "/home/oracle"
Generated package 1 in file
/home/oracle/ORA7445se_20130821105403_COM_1.zip, mode complete
```

NOTE: Package 1 is the package ID captured from the ips create output command.

For more information about *ADRCI*, please visit the

http://docs.oracle.com/cd/E11882_01/server.112/e25494/diag001.htm



Appendix M: References

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