Oracle RAC on VMware vSphere Deployment Guide

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1. Introduction

This document describes an installation example of Oracle Real Application Clusters (RAC) on the VMware vSphere™ platform, for Oracle DBAs planning to virtualize Oracle RAC on the VMware platform. The reader is assumed to have some hands-on experience with the VMware vSphere client. A database administrator should work with a VMware and storage administrator to successfully install Oracle RAC on VMware.

Some aspects of the virtualized installation are the same as with a physical installation:

- After virtual machines are created and correctly configured, the installation of the guest OS and Oracle RAC software is the same as with a physical installation.
- Storage layout guidelines for Oracle Database on VMware, with respect to the number of LUNs and maximizing I/O performance, are the same as with a physical installation.

Because installation details are specific to the software versions used in this deployment, there might be differences from this document if using different versions. In some cases the installation steps in this document are at high level – in these situations the detailed procedures can be found in referenced Oracle and VMware installation guides / knowledge base articles.

The sizes of VMware ESX™ virtual machines (memory, CPU and virtual CPU) used in this document are not based on any specific business scenario. These configuration parameters are different in customer deployments and depend on customer-specific sizing requirements.

The major software components used in this installation are:

- VMware ESX 4.1 Update 1 – VMware ESX abstracts processor, memory, storage and networking resources into multiple virtual machines, increasing hardware utilization.
- VMware vCenter™ Server 4.1 Update 1 – Delivers comprehensive virtualization, management, resource optimization, application availability and operational automation into an integrated product suite.
- VMware vSphere Client 4.1 – Delivers comprehensive virtualization, management, resource optimization, application availability and operational automation into an integrated product suite.
- Oracle Database 11g Release 2 Grid Infrastructure (GRID) – Oracle RAC uses multiple Oracle instances on multiple nodes (servers) to connect to single database.
- Oracle Database 11g Release 2 – The latest RDBMS Server from Oracle.
- Oracle Automatic Storage Management (ASM) – ASM integrates the file system with the volume manager designed for Oracle files.
- Oracle Enterprise Linux x86_64 5.5.

For the VMware Oracle support policy, go to [http://www.vmware.com/support/policies/oracle-support.html](http://www.vmware.com/support/policies/oracle-support.html).
2. **Infrastructure Environment**

This section summarizes the infrastructure environment and covers hardware, software versions, virtual machines deployed, storage, and network configuration.

### 2.1 Hardware

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMware ESX Hosts</td>
<td>4</td>
<td>Cisco UCS blades</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 x 6 core CPUs, 196GB RAM and 4 NICs</td>
</tr>
<tr>
<td>Storage</td>
<td>1</td>
<td>EMC CLARiiON storage system (FC-based array)</td>
</tr>
<tr>
<td>Ethernet Switches</td>
<td>4</td>
<td>Cisco 3750</td>
</tr>
<tr>
<td>FC Switches</td>
<td>2</td>
<td>Cisco MDS 9134</td>
</tr>
<tr>
<td>Host Based Adapters</td>
<td>8</td>
<td>2 per physical server</td>
</tr>
</tbody>
</table>

### 2.2 Software Environment

<table>
<thead>
<tr>
<th>Component</th>
<th>Version</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMware vSphere</td>
<td>4.1 U1</td>
<td>Hypervisor hosting all virtual machines</td>
</tr>
<tr>
<td>VMware vCenter</td>
<td>4.1 U1</td>
<td>Management of VMware vSphere</td>
</tr>
<tr>
<td>Oracle Enterprise Linux x86_64</td>
<td>5.5</td>
<td>Guest operating system for virtual machines running Oracle Database server</td>
</tr>
<tr>
<td>Oracle Database 11g (with Oracle RAC and Oracle Grid Infrastructure) Enterprise Edition</td>
<td>11.2.0.1</td>
<td>Oracle cluster database software for grid computing</td>
</tr>
<tr>
<td>Microsoft Windows Server</td>
<td>2008 R2</td>
<td>Operating system to host vCenter Server</td>
</tr>
</tbody>
</table>

### 2.3 VMware Virtual Machines

<table>
<thead>
<tr>
<th>Virtual Machine Role</th>
<th>Quantity</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle RAC nodes</td>
<td>4</td>
<td>8vCPU, 128GB RAM, Oracle Enterprise Linux x86_64 5.5</td>
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<tr>
<td>VMware vCenter</td>
<td>1</td>
<td>2 vCPUs, 8GB RAM, Windows Server 2008 R2</td>
</tr>
</tbody>
</table>
### 2.4 Virtual Disk Layout

<table>
<thead>
<tr>
<th>Datastore Name</th>
<th>Virtual Disk Name on ESX</th>
<th>Guest OS Device Name</th>
<th>Virtual Device</th>
<th>Virtual SCSI Driver</th>
<th>Size (GB)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMDATASTORE</td>
<td>VMDK – Hard disk 1</td>
<td>/dev/sda</td>
<td>SCSI 0:0</td>
<td>LSI Logic</td>
<td>50</td>
<td>Oracle Enterprise Linux 5.5 OS and Oracle binaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRS1</td>
<td>VMDK – Hard disk 2</td>
<td>Shared disk</td>
<td>SCSI 1:0</td>
<td>Paravirtual</td>
<td>20</td>
<td>CRS and voting disk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/dev/sdb1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CRS2</td>
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<td>Paravirtual</td>
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<td>CRS and voting disk</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRS3</td>
<td>VMDK – Hard disk 4</td>
<td>Shared disk</td>
<td>SCSI 1:2</td>
<td>Paravirtual</td>
<td>20</td>
<td>CRS and voting disk</td>
</tr>
<tr>
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<td></td>
<td>/dev/sdd1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA01</td>
<td>VMDK – Hard disk 5</td>
<td>Shared disk</td>
<td>SCSI 1:3</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td></td>
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<td>/dev/sde</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA02</td>
<td>VMDK – Hard disk 6</td>
<td>Shared disk</td>
<td>SCSI 1:4</td>
<td>Paravirtual</td>
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<td>RAC database DATA</td>
</tr>
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<td>/dev/sdl1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA03</td>
<td>VMDK – Hard disk 7</td>
<td>Shared disk</td>
<td>SCSI 1:5</td>
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<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
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<td>/dev/sdg1</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>VMFSDATA04</td>
<td>VMDK – Hard disk 8</td>
<td>Shared disk</td>
<td>SCSI 1:6</td>
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<td>300</td>
<td>RAC database DATA</td>
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<tr>
<td></td>
<td></td>
<td>/dev/sgl</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VMFSDATA05</td>
<td>VMDK – Hard disk 9</td>
<td>Shared disk</td>
<td>SCSI 1:7</td>
<td>Paravirtual</td>
<td>300</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>/dev/ssh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA06</td>
<td>VMDK – Hard disk 10</td>
<td>Shared disk</td>
<td>SCSI 1:8</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/dev/ssl</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA07</td>
<td>VMDK – Hard disk 11</td>
<td>Shared disk</td>
<td>SCSI 1:9</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/dev/sdkl</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VMFSDATA08</td>
<td>VMDK – Hard disk 12</td>
<td>Shared disk</td>
<td>SCSI 1:10</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/dev/sdl</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA09</td>
<td>VMDK – Hard disk 13</td>
<td>Shared disk</td>
<td>SCSI 1:11</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/dev/sdm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMFSDATA10</td>
<td>VMDK – Hard disk 14</td>
<td>Shared disk</td>
<td>SCSI 1:12</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/dev/sdn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Datastore Name | Virtual Disk on ESX | Guest OS Device Name | Virtual Device | Virtual SCSI Driver | Size (GB) | Purpose
--- | --- | --- | --- | --- | --- | ---
VMFSREDO01 | VMDK – Hard disk 15 | Shared disk /dev/sdo1 | SCSI 2:0 | Paravirtual | 64 | RAC database REDO
VMFSREDO02 | VMDK – Hard disk 16 | Shared disk /dev/sdp1 | SCSI 2:1 | Paravirtual | 64 | RAC database REDO
VMFSREDO03 | VMDK – Hard disk 17 | Shared disk /dev/sdq1 | SCSI 2:2 | Paravirtual | 64 | RAC database REDO
VMFSREDO04 | VMDK – Hard disk 18 | Shared disk /dev/sdr1 | SCSI 2:3 | Paravirtual | 64 | RAC database REDO

## 2.5 Oracle RAC Database Environment

<table>
<thead>
<tr>
<th>Node Name</th>
<th>ASM Instance</th>
<th>RAC Instance</th>
<th>Database</th>
<th>ASM Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMORARAC1.vmware.com</td>
<td>+ASM1</td>
<td>VMORARAC1</td>
<td>VMORARAC</td>
<td>ASM file system</td>
</tr>
<tr>
<td>VMORARAC2.vmware.com</td>
<td>+ASM2</td>
<td>VMORARAC2</td>
<td>VMORARAC</td>
<td>ASM file system</td>
</tr>
<tr>
<td>VMORARAC3.vmware.com</td>
<td>+ASM3</td>
<td>VMORARAC3</td>
<td>VMORARAC</td>
<td>ASM file system</td>
</tr>
<tr>
<td>VMORARAC4.vmware.com</td>
<td>+ASM4</td>
<td>VMORARAC4</td>
<td>VMORARAC</td>
<td>ASM file system</td>
</tr>
</tbody>
</table>

## 2.6 Network Configuration

All four nodes in the cluster must be able to communicate with each other and with external clients using TCP/IP. Communication between clients and the nodes in the cluster is across the public network. All nodes need a network adapter configured for the public network.

To enable high availability and failover, a virtual IP (VIP) address is also required for each node. A VIP address can be moved between nodes in case of a failure. CRS manages the VIP addresses. To support a virtual IP address, both nodes require an unused IP address that is compatible with the public network's subnet and subnet mask.

For communications between instances running on the four nodes, a private network is required. This private network connects only the nodes in the cluster and cannot be accessed from outside the cluster. All nodes need a separate network adapter configured for this private network.
This deployment uses the following network configuration:

- Four physical network interface cards (NIC) – vmnic1 and vmnic5 for Oracle Public and Oracle Private, vmnic0 for ESX Console and vmnic2 for vMotion.
- Two virtual switches – Oracle Public (vSwitch1) and Oracle Private (vSwitch2).
- Three static IP addresses per server – example for node 1 (VMORARAC1):
  - One public static IP address (eth0): 10.1.1.30
  - One private static IP address (eth1): 192.168.2.30
  - One virtual static IP address (VIP): 10.1.1.40

The physical NIC vmnic0 (Gigabit recommended) is connected to the public network which is then connected to public virtual switch vSwitch1. The Service Console is also connected to vSwitch0, and vMotion is connected to vSwitch3. The physical NIC vmnic1 is connected to the private network which is connected to the private virtual switch vSwitch2. The RAC network is also connected to vSwitch1. To create virtual switches vSwitch1 and vSwitch2, refer to the networking section of the ESX Configuration Guide

Each server in the cluster requires three IP addresses. One IP address is for the public network connected to the public network virtual switch (Oracle Public), and a second IP address is for the private cluster interconnect connected to the private network virtual switch (Oracle Private). The third IP address, which is a virtual IP address, is configured by Oracle when Oracle Grid Infrastructure is installed.

**Figure 1. Network Configuration**
2.7 Physical Architecture

The following architecture diagram depicts the physical architecture of the Oracle RAC deployment environment on VMware vSphere 4.1.

**Figure 2. Physical Architecture of Oracle RAC on vSphere**
Logical Architecture

The following diagram describes the logical architecture of a two-node RAC on VMware vSphere 4.1. The actual deployment uses four nodes.

Figure 3. Logical Architecture of Two-Node Oracle RAC on vSphere
3. Overview of Deployment Steps

The following process diagram illustrates the deployment steps for deploying a four-node Oracle RAC on VMware vSphere 4.1 with VMFS. For deploying Oracle RAC with RDM refer Appendix A: Deployment of Oracle RAC with RDM.

Figure 4. Deployment Steps for Four-Node Oracle RAC on vSphere with VMFS
4. Configure NTP Client on all ESX Hosts

The correct system time is required with Oracle Database. VMware Tools has an option to allow virtual machines to synchronize the time with the ESX host they are running on. All ESX hosts in a given resource cluster should synchronize their system clocks.

ESX hosts include NTP software and start the ntpd service by default. ESX hosts are not configured to actually make use of NTP upon installation, nor is there anything in the standard installation process which gives the administrator the option to set this. In the four-node example, synchronizing the time is done for all four ESX hosts.

To configure the NTP client settings

1. Click Properties to display the NTP Daemon (ntpd) Options dialog box.
2. Click NTP Settings.
3. Click Add to add NTP servers.

Figure 5. NTP Daemon (ntpd) Options – NTP Settings
4. For the **Startup Policy**, select the **Start and stop with host** option.

5. Click **OK**.

**Figure 6. NTP Daemon (ntpd) Options – General**

![NTP Daemon (ntpd) Options](image)

6. After the configuration is complete, the configuration screen looks similar to the following illustration.

**Figure 7. VMware ESX Configuration Screen**

![VMware ESX Configuration Screen](image)
5. Prepare a Virtual Machine for the First RAC Node

This section describes the following steps:

- Creation of the first virtual machine, which is the first RAC node, using the vSphere client. This is created on VMFS and corresponds to the root drive. Two NICs are assigned for the public and private networks. Three datastores, CRS1, CRS2, and CRS3, are created from the storage LUNs and three VMDKs are created and assigned to the virtual machine for CRS and voting. Only one VMDK is required but three are used for redundancy.

- Installation of the Linux operating system in the virtual machine followed by installation of VMware Tools.

- Synchronization of the time within the guest OS with the ESX host.

5.1 Create a Virtual Machine

Four ESX hosts have been created and are visible in vCenter.

**To create a new virtual machine**

1. Log in to vCenter using the vSphere client.
2. Select a host and click Create a new virtual machine on the Getting Started tab.
3. In the Create New Virtual Machine wizard, select Typical for the Configuration, and click Next.
4. On the Name and Location page, enter VMORARAC1 for the Name, and click Next.
5. On the Datastore page, select VMDATASTORE, and click Next.
6. On the Guest Operating System page, select Linux from the Guest Operating System list. For the Version, select Oracle Linux 4/5 (64-bit) from the drop-down menu. Click Next.
7. On the Create a Disk page, set the Virtual Disk Size to 50GB, and click Next.
8. On the Ready to Complete page, select the Edit the virtual machine settings before completion check box. Click Continue.
9. On the Virtual Machine Properties page for the VMORARAC1 virtual machine, select 8 CPUs and 128GB Memory.
10. Click Finish.

5.2 Add Two NICs

In this section, two NICs are added. One NIC is for the public network, and the other is for the private network. The procedure for each is similar, differing only in the selection of RAC Public or Private for the network label.

**To add a NIC to the virtual machine for the public network**

1. Select a virtual machine
2. Click Edit settings to display the Virtual Machine Properties pane
3. Click Add.
4. Select Ethernet Adaptor and click Next to display the Add Hardware wizard.
5. On the Network connection page, select VMXNET 3 from the Adapter Type drop-down menu.
6. In the Network Connection section of the Network connection page, select Named network with specified label.
7. In the **Named network with specified label** drop-down menu, select **RAC Public**.

8. In the **Device Status** section of the **Network connection** page, select the **Connect at power on** check box.

9. On the **Ready to Complete** page, click **Finish**, and then click **OK**.

**To add a NIC to the virtual machine for the private network**

1. Repeat steps 1 through 7 from the preceding procedure

2. In the **Named network with specified label** drop-down menu, select **Private**.

3. Continue with steps 9 and 10 from the preceding procedure

### 5.3 Add CRS and Voting Disk

Three 20GB disks are created and VMDKs are created and added to the virtual machine for RAC CRS and voting. Although only one is required, three are used for redundancy. The datastores are created from the assigned LUNs which are attached to a SCSI controller configured as VMware Paravirtual. The SCSI BUS sharing policy of the SCSI controller is set to none.

The procedures in this section describe the steps needed to create disks for one virtual machine. Repeat all the steps in this section for each of the four virtual machines named VMORARAC1, VMORARAC2, VMORARAC3, and VMORARAC4.

**To create one 20GB datastore for a virtual machine**

1. In the vSphere client, select a virtual machine.

2. Right-click on the name of the virtual machine and select **Edit Settings** to display the **Virtual Machine Properties** pane.

3. Click **Add** to display the **Add Hardware** wizard.

4. In the **Add Hardware** wizard select **Hard Disk** for the **Device Type**, and click **Next**.

5. In the **Disk** section of the **Select a Disk** page, select **Create a new virtual disk**. Set the disk size to **20GB**, select the **Support clustering features such as Fault Tolerance** check box, and select **CRS1** to specify a datastore. Click **Next**.

6. On the **Compatibility Mode** page, click **Next**.

7. On the **Advanced Options** page, in the **Virtual Device Node** section, select **SCSI (1:0)**. In the **Mode** section, select **Independent**. Click **Next**.

8. On the **Ready to Complete** page, click **Finish**.

9. Click **OK**.

**To create a second 20GB datastore for the virtual machine**

1. Select the virtual machine that was selected in the preceding step 1.

2. Repeat steps 2 through 6 in the preceding procedure to create one 20GB datastore.

3. On the **Advanced Options** page, in the **Virtual Device Node** section, select **SCSI (1:1)**. In the **Mode** section, select **Independent**. Click **Next**.

4. Repeat steps 8 and 9 of the preceding procedure to create one 20GB datastore.
To create a third 20GB datastore for the virtual machine
1. Select the virtual machine that was selected in the preceding step 1.
2. Repeat steps 2 through 6 in the preceding procedure to create one 20GB datastore.
3. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:2). In the Mode section, select Independent. Click Next.
4. Repeat steps 8 and 9 of the preceding procedure to create one 20GB datastore.

To set the SCSI controller type to paravirtual
1. Select the virtual machine that was selected in the preceding step 1.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. In the device list, select SCSI controller 1.
4. In the SCSI Bus Sharing section, select None, keep the default selection.
5. In the SCSI Controller Type section, click Change Type.
6. Select VMware Paravirtual.
7. Click OK, and click OK again.

Add Configuration parameters for each Oracle RAC virtual machine as described in Disabling simultaneous write protection provided by VMFS using the multi-writer flag http://kb.vmware.com/kb/1034165.

To add configuration parameters to the virtual machines
1. In the vSphere client, select a virtual machine.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Click the Options tab, click Advanced, and click General.
4. Click Configuration Parameters.
5. On the Configuration Parameters page, add rows and entries for the shared disks in the virtual machine's configuration parameters as shown in the following screenshot.
6. Repeat steps 1 through 5 for each of the remaining virtual machines.
Figure 8. Virtual Machine Configuration Parameters

### Configuration Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
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</tr>
<tr>
<td>pcBridge6. pr...</td>
<td>true</td>
</tr>
<tr>
<td>pcBridge6. vir...</td>
<td>rootPort</td>
</tr>
<tr>
<td>pcBridge6. fu...</td>
<td>8</td>
</tr>
<tr>
<td>pcBridge7. pr...</td>
<td>true</td>
</tr>
<tr>
<td>pcBridge7. vir...</td>
<td>rootPort</td>
</tr>
<tr>
<td>pcBridge7. fu...</td>
<td>8</td>
</tr>
<tr>
<td>vmware.tools...</td>
<td>8295</td>
</tr>
<tr>
<td>vmware.tools...</td>
<td>8295</td>
</tr>
<tr>
<td>vmware.tools...</td>
<td>none</td>
</tr>
<tr>
<td>vmware.tools...</td>
<td>unknown</td>
</tr>
<tr>
<td>sched.swap.d...</td>
<td>/vmlinuz/volumes/1d641b74-5e57f43c-777e-0025b5eddb3f/VMORARAC2/VMORARAC2-6b6169a...</td>
</tr>
<tr>
<td>scsi1:0 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scsi1:1 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scsi1:2 sharing</td>
<td>multi-writer</td>
</tr>
</tbody>
</table>

Add Row

OK  Cancel  Help
You can view the virtual machine properties for the VMORARAC2 virtual machine in vCenter as in the following screenshot.

**Figure 9. First Virtual Machine RAC Node Hardware Devices**

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>131072 MB</td>
</tr>
<tr>
<td>CPUs</td>
<td>8</td>
</tr>
<tr>
<td>Video card</td>
<td>Video card</td>
</tr>
<tr>
<td>VMCI device</td>
<td>Restricted</td>
</tr>
<tr>
<td>SCSI controller 0</td>
<td>LSI Logic Parallel</td>
</tr>
<tr>
<td>SCSI controller 1</td>
<td>Paravirtual</td>
</tr>
<tr>
<td>SCSI controller 2</td>
<td>Paravirtual</td>
</tr>
<tr>
<td>Hard disk 1</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 2</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 3</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 4</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 5</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 6</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 7</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 8</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 9</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 10</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 11</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 12</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 13</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 14</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 15</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 16</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 17</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 18</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>CD/DVD Drive 1</td>
<td></td>
</tr>
<tr>
<td>Network adapter 1</td>
<td>Oracle Public</td>
</tr>
<tr>
<td>Network adapter 2</td>
<td>Oracle Private</td>
</tr>
</tbody>
</table>
5.4 Install the Guest Operating System

The Oracle Enterprise Linux 5.5 x64 operating system is installed from an ISO image that has been loaded into a VMFS datastore.

To install Linux as the guest operating system in a virtual machine

1. In the vSphere client, select a virtual machine.
2. Click on Edit settings
4. In the Device Status section of this pane, select the Connect at power on check box.
5. In the Device Type section of this pane, select Datastore ISO File and enter the path to your Linux ISO image file.
6. In the Virtual Device Node section of this pane, select IDE (1:0) CD/DVD Drive 1 from the drop-down menu.
7. Click OK.
8. Power on the virtual machine.
9. Install Linux with the following settings.

   Custom partitioning scheme:

   ```
   /dev/sda1 ext3 15GB mounted on /
   /dev/sda2 ext3 25GB mounted on /u01
   /dev/sda3 swap 10GB
   ```

   Installed packages – use the default package selection, plus the following:

   - oracle-validat-ed-1.0.0-22.el5.x86_64
   - oracleas-m-2.6.18-194.el5-2.0.5-1.el5.x86_64
   - oracleas-m-support-2.1.3-1.el5.x86_64
   - systat-7.0.2-3.el5.x86_64

10. Download and install the ASM library from the Oracle Web site:
    http://www.oracle.com/technetwork/topics/linux/asmlib/index-101839.html
11. View the installed packages with this command:

   run command “rpm -q <package name>”

12. Confirm that the following packages have been installed:

   - binutils-2.17.50.0.6
   - compat-libstdc++-33-3.2.3
   - elfutils-libelf-0.125
   - elfutils-libelf-devel-0.125
   - elfutils-libelf-devel-static-0.125
   - gcc-4.1.2
   - gcc-c++-4.1.2
   - glibc-2.5-24
   - glibc-common-2.5
   - glibc-devel-2.5
   - glibc-headers-2.5
   - ksh-20060214
   - libaio-0.3.106
   - libaio-devel-0.3.106
   - libgcc-4.1.2
   - libstdc++-4.1.2
   - libstdc++-devel
   - make-3.81
   - sysstat-7.0.2
   - unixODBC-2.2.11
   - unixODBC-devel-2.2.11

5.5 Install VMware Tools

VMware Tools is a suite of utilities that enhance the performance of the virtual machine’s guest operating system and improve management of the virtual machine. VMware Tools must be installed inside the guest OS. The installation steps are described in Installing VMware Tools in a Linux virtual machine using Red Hat Package Manager (RPM)


To install VMware Tools

1. Confirm that the Linux virtual machine is powered on.
2. In the vSphere client, right click on the virtual machine and select Guest > Install VMware Tools.
3. In the Linux guest OS, create a mount point and run the following command:

   mkdir /mnt/cdrom

4. Mount the CD-ROM with the following command:

   mount /dev/cdrom /mnt/cdrom

5. Install VMware Tools using RPM, with the following command

   rpm -ivh /mnt/cdrom/VMwareTools-8.3.2-257589.rpm

   “8.3.2-257589” is the version of VMware Tools used here.

6. Configure VMware Tools, by running the following command

   /usr/bin/vmware-config-tools.pl

7. Unmount the CD-ROM with the following command

   umount /mnt/cdrom

8. Click VM in the virtual machine menu, and click Guest > End VMware Tools Install.
5.6 Time Keeping with Linux Guest Operation System

Next, follow VMware KB: 1006427 recommendations to configure NTP and when using NTP in the guest, disable VMware Tools periodic time synchronization.

To disable VMware Tools periodic time sync, perform one of these options:

1. Set `tools.syncTime = "False"` in the configuration file (.vmx file) of the virtual machine.

    OR

2. Deselect Time **synchronization between the virtual machine and the host operating system** in the VMware Tools toolbox GUI of the guest operating system.

    OR

3. Run the `vmware-guestd --cmd "vmx.set_option synctime 1 0"` command in the guest operating system.

For ESX 4.x, Use these parameters for Linux:

1. To display the current status of the service
   
   `vmware-toolbox-cmd timesync status`

2. Disables periodic time synchronization

   `vmware-toolbox-cmd timesync disable`
6. Prepare Subsequent Virtual Machines/RAC Nodes

Now that the first RAC node virtual machine (VMORARAC1) has been created, this virtual machine can be cloned to create the remaining three cluster node virtual machines. The high level procedure is:

- In vCenter clone VMORARAC1.
- On the newly created virtual machine remove the three RDM virtual disks that came over from the source virtual machine.
- Attach the same three VMFS disks (VMDKs) for CSR and voting as used by the first virtual machine, VMORARAC1. These three disks were configured to be shared by multiple virtual machines using the procedures outlined in Disabling simultaneous write protection provided by MVFS using the multiwriter flag [http://kb.vmware.com/kb/1034165](http://kb.vmware.com/kb/1034165).
- Change the hostname and IP address in the guest OS.

6.1 Clone the First Virtual Machine/RAC Node

To clone the first virtual machine for the second, third, and fourth nodes

1. Confirm that the first virtual machine VMORARAC1 is offline.
2. In the vSphere client, select the virtual machine, VMORARAC1.
3. Right-click on the name of the virtual machine and select Clone.
4. In the Clone Virtual Machine wizard on the Name and Location page, enter VMORARAC2 for the Name. Click Next.
5. On the Host / Cluster page, select a host or cluster. Click Next.
6. On the Specific Host page, select a unique ESX host (that is, one not running a RAC node virtual machine). Click Next.
7. On the Datastore page, select a VMFS datastore. Click Next.
8. On the Disk Format page, select Same format as source. Click Next.
11. Repeat steps 1 through 10 for nodes 3 and 4 using VMORARAC3 and VMORARAC4 in step 4.

6.2 Change the Hostname and Assign an IP Address

To assign unique names and IP addresses to each RAC Node virtual machine

1. Using the console, log in as root to the VMORARAC2 cloned virtual machine.
2. Go to System > Administration > Network.
3. On the Devices tab, change the IP address for eth0 and eth1, with the required subnet masks:
   a. For eth0, change the IP address from 10.1.1.30 to 10.1.1.31.
   b. For eth1, change the IP address from 192.168.2.30 to 192.168.2.31.
4. On DNS tab, change the hostname from VMORARAC1 to VMORARAC2.
5. Repeat steps 1 through 4 for the remaining two virtual machines (VMORARAC3 and VMORARAC4), using appropriate IP addresses and subnet masks in steps 3a and 3b, and the corresponding hostname in step 4.
6.3 Configure CSR and Voting Disks

The new virtual machine has been cloned, but the links to Hard disks 2, 3 and 4 are incorrect. These are removed so that one disk (VMFS) remains, corresponding to the root drive. The CSR and voting disks are then added. Finally, the SCSI controller type is changed to paravirtual.

The procedures in this section describe the steps needed for one virtual machine. Repeat all the steps in this section for each of the four virtual machines named VMORARAC1, VMORARAC2, VMORARAC3, and VMORARAC4.

To remove incorrect links from the clone

1. In the vSphere client, select a virtual machine.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Select Hard disk 2 and click Remove. In the Removal Options section, select Remove from virtual machine and click OK.
4. Select Hard disk 3 and click Remove. In the Removal Options section, select Remove from virtual machine and click OK.
5. Select Hard disk 4 and click Remove. In the Removal Options section, select Remove from virtual machine and click OK.

To add the first CSR and voting disk for a virtual machine

1. In the vSphere client, select a virtual machine.
2. Right-click on the name of a virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Click Add to display the Add Hardware wizard.
4. In the Add Hardware wizard select Hard Disk for the Device Type, and click Next.
5. In the Disk section of the Select a Disk page, select Use an existing virtual disk and click Next.
6. On the Select Existing Disk page, enter the path to the first VMDK of the virtual machine (selected in step 1) used for the CSR and voting datastores. Click Next.
7. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:0). In the Mode section, select Independent and Persistent. Click Next.
9. Click OK.

To add the second CSR and voting disk for a virtual machine

1. Repeat steps 1 through 5 in the preceding procedure to add the first CSR and voting disk.
2. On the Select Existing Disk page, enter the path to the second VMDK of the virtual machine (selected in step 1) used for the CSR and voting datastores. Click Next.
3. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:1). In the Mode section, select Independent and Persistent. Click Next.
4. Repeat steps 8 and 9 in the preceding procedure to add the first CSR and voting disk.
**To add the third CSR and voting disk for a virtual machine**

1. Repeat steps 1 through 5 in the preceding Configure CSR and Voting Disks procedure to add the first CSR and voting disk.

2. On the Select Existing Disk page, enter the path to the third VMDK of the virtual machine (selected in step 1) used for the CSR and voting datastores. Click Next.

3. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:2). In the Mode section, select Independent and Persistent. Click Next.

4. Repeat steps 8 and 9 in the preceding procedure to add the first CSR and voting disk.

**To set the SCSI controller type to paravirtual**

1. In the vSphere client, select the virtual machine that was selected in the preceding step 1.

2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.

3. In the device list, select SCSI controller 1.

4. In the SCSI Controller Type section, click Change Type.

5. Select VMware Paravirtual.

6. Click OK, and click OK again.
6.4 Format the Added Disks Using fdisk

On node 1, you must partition and format the virtual disks. You can use the Linux fdisk utility to accomplish this. Refer to the following illustration showing the output of the fdisk utility.

To partition and format three virtual disks

1. Log in as root on node1.
2. Enter the command:
   
   fdisk /dev/sdb

3. Enter n to create a new partition.
4. Enter p to create a primary partition.
5. Enter 1 to create the first partition.
6. Press Enter to take the default value of 1 for the first cylinder.
7. Press Enter to take the default value of 20480 for the last cylinder.
8. Enter w to write the new partition table to disk and exit fdisk.
9. Repeat steps 2 through 8, using the following command for the second virtual disk:
   
   fdisk /dev/sdc

10. Repeat steps 2 through 8, using the following command for the third virtual disk:

   fdisk /dev/sdd

Figure 10. Commands to Run fdisk

```bash
root@vmorarac1 ~# fdisk /dev/sdb

Device contains neither a valid DOS partition table, nor Sun, SGI or OSF disklabel
Building a new DOS disklabel. Changes will remain in memory only, until you decide to write them. After that, of course, the previous content won't be recoverable.

Warning: invalid flag 0x0000 of partition table 4 will be corrected by w(rite)

Command (m for help): n
Command action  e extended  p primary partition (1-4)
P
Partition number (1-4): 1
First cylinder (1-20480, default 1):
Using default value 1
Last cylinder or +size or +sizeM or +sizeK (1-20480, default 20480):
Using default value 20480
Command (m for help): w

The partition table has been altered!
Calling ioctl() to re-read partition table.
Syncing disks.
```
7. **Install Oracle Grid Infrastructure**

The four virtual machines are cloned and ready for the installation of Oracle Grid Infrastructure.

**To install Oracle Grid Infrastructure**

1. Configure SSH for all the nodes to allow SSH to all nodes without a password.
2. Configure Oracle ASM and create three disks CRSVOL1, CRSVOL2, and CRSVOL3 from /dev/sdb1, /dev/sdc1, and /dev/sdd1 respectively.
3. From VM1 (VMORARAC1) 64-bit (x86_64) Installations download unzip the following software packages (File 1 and File 2) from http://www.oracle.com/technology/software/products/database/oracle11g/112010_linx86_64soft.html.
   - Oracle Database 11g Release 2 Grid Infrastructure (11.2.0.1.0) for Linux x86_64
   - Oracle Database 11g Release 2 (11.2.0.1.0) for Linux x86_64
4. Launch the Oracle Grid Infrastructure installation wizard.
5. On the Installation Option page, in the Select any of the following installation options, select Install and Configure Infrastructure for a Cluster. Click Next.
6. On the Installation Type page, select Advanced Installation and click Next.
7. On the Product Languages page, select English and click Next.
8. On the Grid Plug and Play page, enter.vmorarac for the Cluster Name, vmorarac-scan.vmware.com for the SCAN Name and 1521 for the SCAN Port. Click Next.
9. On the Cluster Node Information page, click Add to enter a Hostname and Virtual IP Name. Repeat the process for each of the four hosts, as follows:

<table>
<thead>
<tr>
<th>Hostname</th>
<th>Virtual IP Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>vmorarac1.vmware.com</td>
<td>vmorarac1-vip.vmware.com</td>
</tr>
<tr>
<td>vmorarac2.vmware.com</td>
<td>vmorarac2-vip.vmware.com</td>
</tr>
<tr>
<td>vmorarac3.vmware.com</td>
<td>vmorarac3-vip.vmware.com</td>
</tr>
<tr>
<td>vmorarac4.vmware.com</td>
<td>vmorarac4-vip.vmware.com</td>
</tr>
</tbody>
</table>

10. Click Next.
11. On the Network Interface Usage page, enter the following information for the Interface Name, Subnet and Interface Type:

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>Subnet</th>
<th>Interface Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>eth0</td>
<td>10.1.1.0</td>
<td>Public</td>
</tr>
<tr>
<td>eth1</td>
<td>192.168.2.0</td>
<td>Private</td>
</tr>
</tbody>
</table>

12. Click Next.
13. On the **Storage Option** page, select **Automatic Storage Management (ASM)**, and click **Next**.

14. On the **Create ASM Disk Group** page, enter **CRS** for the **Disk Group Name**, select **Normal** for **Redundancy**.

15. In the **Add Disks** section of the **Create ASM Disk Group** page, select **Candidate Disks**. Make the following entries:

<table>
<thead>
<tr>
<th>Disk Path</th>
<th>Size (in MB)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORCL:CRSVOL1</td>
<td>20479</td>
<td>Candidate</td>
</tr>
<tr>
<td>ORCL:CRSVOL2</td>
<td>20479</td>
<td>Candidate</td>
</tr>
<tr>
<td>ORCL:CRSVOL3</td>
<td>20479</td>
<td>Candidate</td>
</tr>
</tbody>
</table>

16. Select the check box to the left of each of these entries, and click **Next**.

17. On the **ASM Password** page, select **Use same passwords for these accounts** and enter the password “**oracle1**” in the **Specify Password** and **Confirm Password** fields. Click **Next**.

18. On the **Failure Isolation** page, select **Do not use Intelligent Platform Management Interface (IPMI)**. Click **Next**.

19. On the **Operating System Groups** page, make the following entries:

<table>
<thead>
<tr>
<th>Field</th>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASM Database Administrator (OSDBA) Group</td>
<td>asmdba</td>
</tr>
<tr>
<td>ASM Instance Administration Operator (OSOPER) Group</td>
<td>asmoper</td>
</tr>
<tr>
<td>ASM Instance Administrator (OSASM) Group</td>
<td>asadmin</td>
</tr>
</tbody>
</table>

20. Click **Next**.

21. On the **Installation Location** page, enter `/u01/app/grid` for the Oracle Base, and `/u01/app/11.2.0/grid` for the **Software Location**. Click **Next**

22. On the **Create Inventory** page, enter `/u01/app/orainventory` for the **Inventory Directory**. Click **Next**

23. Wait while the setup application conducts the prerequisite checks and installs Grid on each node. After setup is complete, execute the following configuration scripts on the four nodes VMORARAC1, VMORARAC2, VMORARAC3, and VMORARAC4. These scripts must be executed in a terminal window as root.

   `/u01/app/orainventory/orinstRoot.sh`

   `/u01/app/11.2.0/grid/root.sh`

24. Click **OK**, and click **Finish**.
8. Verify the Grid Infrastructure Installation

The following figures show how to run various RAC commands in the guest OS to check the status of the cluster.

Figure 5. Check the CRS Status on the First Node as Grid User

```
[root@vmoreac1 ora1inventory]# su grid
[grid@vmoreac1 ora1inventory]# cd
[grid@vmoreac1 -]$d .bash_profile
+ASM1:/home/grid -> crsctl check crs
CRS-4618: Oracle High Availability Services is online
CRS-4617: Cluster Ready Services is online
CRS-6529: Cluster Synchronization Services is online
CRS-4513: Event Manager is online
+ASM1:/home/grid ->
```

Figure 6. Check for Cluster Nodes

```
+ASM1:/home/grid -> clsnodes -n
vmoreac1 1
vmoreac2 2
vmoreac3 3
vmoreac4 4
+ASM1:/home/grid ->
```
Figure 7. Check for Cluster Registry (OCR)

```
+ASM1 /home/grid -D ocrcheck
Status of Oracle Cluster Registry is as follows:
  Version : 3
  Total space (kbytes) : 262140
  Used space (kbytes)  : 2656
  Available space (kbytes) : 259084
  ID : 1885277757
  Device/File Name : /dev/sdS
                  Device/File integrity check succeeded
                  Device/File not configured
                  Device/File not configured
                  Device/File not configured
                  Device/File not configured
Cluster registry integrity check succeeded
Logical corruption check bypassed due to non-privileged user.
```

Figure 8. Check Voting Disk

```
+ASM1 /home/grid -D crsctl query css votedisk
### STATE    File Universal Id    File Name   Disk group
----------  ---------------------  -----------  -----------
1. ONLINE   91667ba2625c4fe32b7e2c893eb88df78 (ORCL:CRSVOL1) [CRS]
2. ONLINE   30277d6d8a34d5df5d3fad3b987667332 (ORCL:CRSVOL2) [CRS]
3. ONLINE   48046da754f17410e5ff237cd027925e6 (ORCL:CRSVOL3) [CRS]
Located 3 voting disk(s).
```

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9. Add DATA and REDO Disks to Virtual Machine RAC Nodes

In this section, the database disks for data and redo logs are added to the virtual machine RAC nodes in the following way:

- Data and redo datastores are created with the assigned LUNs, and corresponding VMDKs are added to the virtual machine VMORARAC1. The SCSI controller type is set to VMware Paravirtual.

- The same Data and Redo VMDKs are added to the remaining three nodes (VMORARAC2, VMORARAC3, and VMORARAC4) by selecting the VMDKs that were created for VMORARAC1. Again, the SCSI controller type is set to VMware Paravirtual.

- The added disks are formatted using the Linux fdisk utility.

- Configuration parameters are added for each virtual machine.

The procedures in this section describe the steps needed for one virtual machine. Repeat all the steps in this section for each of the four virtual machines named VMORARAC1, VMORARAC2, VMORARAC3, and VMORARAC4.

To add DATA or REDO disks to the first virtual machine

1. In the vSphere client, select the virtual machine.

2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.

3. Click Add to display the Add Hardware wizard.

4. In the Add Hardware wizard select Hard Disk for the Device Type, and click Next.

5. In the Disk section of the Select a Disk page, select Create a new virtual disk. Set the disk size to 300GB for DATA or 64GB for REDO, and select the Support clustering features such as Fault Tolerance check box. Select VMFSDATA01 for DATA, or VMFSREDO01 for REDO to specify a datastore. Click Next.

6. On the Compatibility Mode page, click Next.

7. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:3) for DATA, or SCSI (2:0) for REDO. Set the Mode to Independent. Click Next.


9. Click OK.

10. Repeat steps 1 through 9 for all the DATA and REDO datastores. Change step 7 to use SCSI (1:4) for the next DATA datastore, or SCSI (2:1) for the next REDO datastore. For additional DATA or REDO datastores, repeat steps 1 through 9 and continue the numbering sequence in step 7. For example, the third DATA datastore uses the numbering SCSI (1:5), and the third REDO datastore uses the numbering SCSI (2:2).
To set the SCSI controller type to paravirtual
1. Select the virtual machine that was selected in the preceding step 1.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. In the device list, select SCSI controller 1.
4. In the SCSI Bus Sharing section, select None, keep the default selection.
5. In the SCSI Controller Type section, click Change Type.
6. Select VMware Paravirtual.
7. Click OK, and click OK again.

To format disks using the Linux fdisk utility
1. Follow the steps in Section 6.4 to format one disk.
2. Repeat, using fdisk to format each disk.

To add configuration parameters for each Oracle RAC virtual machine
Add Configuration parameters for each Oracle RAC virtual machine as per Disabling simultaneous write protection provided by VMFS using the multi-writer flag http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1034165.

To add configuration parameters to the virtual machines
1. In the vSphere client, select a virtual machine.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Click the Options tab, click Advanced, and click General.
4. Click Configuration Parameters.
5. On the Configuration Parameters page, add rows and entries for the shared disks in the virtual machine's configuration parameters as shown in the following screenshot.
6. Repeat steps 1 through 5 for each of the remaining virtual machines.
Figure 9. Virtual Machine Configuration Parameters

Modify or add configuration parameters as needed for experimental features or as instructed by technical support. Entries cannot be removed.

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>scs1:2 redo</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:3 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:4 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:5 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:6 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:8 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:9 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:10 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:11 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:12 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs1:13 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs2:0 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs2:1 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs2:2 sharing</td>
<td>multi-writer</td>
</tr>
<tr>
<td>scs2:3 sharing</td>
<td>multi-writer</td>
</tr>
</tbody>
</table>
The devices for the virtual machine should look like the following screenshot.

**Figure 10. Virtual Machine Properties**

![Virtual Machine Properties](image-url)
10. Create DATA and REDO ASM Disk Groups as Grid User

To prepare for the installation of Oracle Database binary and database

1. Using Oracle ASM, create disks DATAVOL1 through DATAVOL10 using /dev/sde1 through /dev/sdn1, and disks REDOVOL1 through REDOVOL4 using /dev/sdo1 through /dev/sdr1.

2. Using ASM Configuration Assistant logged in as Grid user at node1 (VMORARAC), create two disk groups RACDATA (selecting all ten disks DATAVOL1 through DATAVOL10) and RACREDO (selecting all four disks REDOVOL1 through REDOVOL4).

3. In the ASM Configuration Assistant, on the Create Disk Group page, enter RACDATA for the Disk Group Name. In the Redundancy section, select External (None). Click OK, and click OK again.

4. On the Create Disk Group page, in the Select Member Disks section, select ORCL:DATAVOL1, ORCL:DATAVOL2, ORCL:DATAVOL3, and ORCL:DATAVOL4. Set the size of each to 300GB. Click OK.

5. On the Create Disk Group page, enter RACREDO for the Disk Group Name. In the Redundancy section, select External (None). Click OK, and click OK again.

6. On the Create Disk Group page, in the Select Member Disks section, select ORCL:REDOVOL1, ORCL:REDOVOL2, ORCL:REDOVOL3, and ORCL:REDOVOL4. Set the size of each to 64GB. Click OK.
11. Install and Create the Oracle Database 11gR2 RAC

To install and create the Oracle Database 11gR2 RAC

1. Log in into VMORARAC1 as oracle user and launch `runInstaller` from the Oracle software location to install the Oracle binaries.

2. In the Oracle Installer wizard, on the Configure Security Updates page, leave the Email field blank, and do not select I wish to receive security updates via My Oracle Support. Click Next.

3. On the Installation Option page, select Install database software only. Click Next.

4. On the Grid Options page, select Real Application Clusters database installation. Select the four nodes VMORARAC1, VMORARAC2, VMORARAC3, and VMORARAC4. Click Next.

5. On the Product Languages page, select English. Click Next.


7. On the Installation Location page, enter `/u01/app/oracle` for Oracle Base, and `/u01/app/oracle/product/11.2.0/dbhome_1` for Software Location. Click Next.


9. Review the configuration on the Summary page, and click Finish.

10. After the installation is complete, open a terminal window, log in as root, and run the following script:

    ```shell
    /u01/app/oracle/product/11.2.0/dbhome_1/root.sh
    ```

    Repeat for each of the four nodes, and click OK.


12. Create the Oracle RAC database using Oracle Database Configuration Assistant (DBCA).
12. References

The following are resources and references for Oracle and VMware vSphere.

**ESX Configuration Guide**

**Guide to configure NTP on ESX servers**
http://kb.vmware.com/kb/1003063

**Timekeeping in VMware Virtual Machines**

**Installing VMware Tools in a Linux virtual machine using Red Hat Package Manager (RPM)**
http://kb.vmware.com/kb/1018392

**Oracle ASMLib**
http://www.oracle.com/technetwork/topics/linux/asmlib/index-101839.html

**Oracle Database Oracle Clusterware and Oracle Real Application Clusters Installation Guide 10g Release 2 (10.2) for Linux**
http://download.oracle.com/docs/cd/B19306_01/install.102/b14203/toc.htm

**Oracle Clusterware Installation Guide 11g Release 1 (11.1) for Linux**
http://www.oracle.com/pls/db111/to_toc?pathname=install.111/b28263/toc.htm

**Oracle Real Application Clusters Installation Guide 11g Release 1 (11.1) for Linux and UNIX**
http://www.oracle.com/pls/db111/to_toc?pathname=install.111/b28264/toc.htm
13. Appendix A: Deployment of Oracle RAC with RDM

This section describes the following:

- Deployment steps for Four-Node Oracle RAC with RDM
- Virtual disk layout for RDMs.
- Adding CRS, DATA, and REDO RDMs to an Oracle RAC virtual machine.

13.1 Deployment Steps for Oracle RAC on vSphere with RDM

The following process diagram illustrates the deployment steps for deploying a four-node Oracle RAC on VMware vSphere 4.1 with RDM.

Figure 15. Deployment Steps for a Four-Node Oracle RAC on vSphere with RDM

13.2 Virtual Disk Layout

Table 1. Virtual Disk Layout
<table>
<thead>
<tr>
<th>Virtual Disk on ESX</th>
<th>Guest OS Device Name</th>
<th>Virtual Device</th>
<th>Virtual SCSI Driver</th>
<th>Size (GB)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMDK – Hard disk 1</td>
<td>/dev/sda</td>
<td>SCSI 0:0</td>
<td>LSI Logic</td>
<td>50</td>
<td>Oracle Enterprise Linux 5.5 OS and Oracle binaries</td>
</tr>
<tr>
<td>RDM – Hard disk 2</td>
<td>Shared disk</td>
<td>SCSI 1:0</td>
<td>Paravirtual</td>
<td>20</td>
<td>CRS and voting disk</td>
</tr>
<tr>
<td>RDM – Hard disk 3</td>
<td>Shared disk</td>
<td>SCSI 1:1</td>
<td>Paravirtual</td>
<td>20</td>
<td>CRS and voting disk</td>
</tr>
<tr>
<td>RDM – Hard disk 4</td>
<td>Shared disk</td>
<td>SCSI 1:2</td>
<td>Paravirtual</td>
<td>20</td>
<td>CRS and voting disk</td>
</tr>
<tr>
<td>RDM – Hard disk 5</td>
<td>Shared disk</td>
<td>SCSI 1:3</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 6</td>
<td>Shared disk</td>
<td>SCSI 1:4</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 7</td>
<td>Shared disk</td>
<td>SCSI 1:5</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 8</td>
<td>Shared disk</td>
<td>SCSI 1:6</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 9</td>
<td>Shared disk</td>
<td>SCSI 1:8</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 10</td>
<td>Shared disk</td>
<td>SCSI 1:9</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 11</td>
<td>Shared disk</td>
<td>SCSI 1:10</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 12</td>
<td>Shared disk</td>
<td>SCSI 1:11</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 13</td>
<td>Shared disk</td>
<td>SCSI 1:12</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 14</td>
<td>Shared disk</td>
<td>SCSI 1:13</td>
<td>Paravirtual</td>
<td>300</td>
<td>RAC database DATA</td>
</tr>
<tr>
<td>RDM – Hard disk 15</td>
<td>Shared disk</td>
<td>SCSI 2:0</td>
<td>Paravirtual</td>
<td>64</td>
<td>RAC database REDO</td>
</tr>
<tr>
<td>Virtual Disk on ESX</td>
<td>Guest OS Device Name</td>
<td>Virtual Device</td>
<td>Virtual SCSI Driver</td>
<td>Size (GB)</td>
<td>Purpose</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>---------------------</td>
<td>-----------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>RDM – Hard disk 16</td>
<td>Shared disk</td>
<td>SCSI 2:1</td>
<td>Paravirtual</td>
<td>64</td>
<td>RAC database REDO</td>
</tr>
<tr>
<td></td>
<td>/dev/sdp1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDM – Hard disk 17</td>
<td>Shared disk</td>
<td>SCSI 2:2</td>
<td>Paravirtual</td>
<td>64</td>
<td>RAC database REDO</td>
</tr>
<tr>
<td></td>
<td>/dev/sdq1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDM – Hard disk 18</td>
<td>Shared disk</td>
<td>SCSI 2:3</td>
<td>Paravirtual</td>
<td>64</td>
<td>RAC database REDO</td>
</tr>
<tr>
<td></td>
<td>/dev/sdr1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13.3 Create a Virtual Machine

The section describes creation of the first virtual machine (that is the first RAC node) using the vSphere client. This is created on VMFS and corresponds to the root drive. Two NICs are assigned for the public and private networks. Three RDM LUNs are assigned to the virtual machine for CRS and voting. Only one LUN is required but three are used for redundancy.

Four ESX hosts have been created and are visible in vCenter.

**To create a new virtual machine**

1. Log in to vCenter using the vSphere client.
2. Select a host and click Create a new virtual machine on the Getting Started tab.
3. In the Create New Virtual Machine wizard, select Typical for the Configuration, and click Next.
4. On the Name and Location page, enter VMORARAC1 for the Name, and click Next.
5. On the Datastore page, select VMDATASTORE, and click Next.
6. On the Guest Operating System page, select Linux from the Guest Operating System list. For the Version, select Oracle Linux 4/5 (64-bit) from the drop-down menu. Click Next.
7. On the Create a Disk page, set the Virtual Disk Size to 50GB, and click Next.
8. On the Ready to Complete page, select the Edit the virtual machine settings before completion check box. Click Continue.
9. On the Virtual Machine Properties page for the VMORARAC1 virtual machine, select 8 CPUs and 128GB Memory.
10. Click Finish.

13.4 Add CRS and Voting Disk

Three 20GB LUNs are attached to the virtual machine for RAC CRS and voting. Although only one is required, three are used for redundancy. With these LUNs:

- The LUNs are assigned as RDMs.
- The LUNs are attached to a SCSI controller configured as VMware Paravirtual.
- For the SCSI controller the SCSI BUS sharing policy is set to physical to allow these LUNs to be shared by multiple virtual machines on any ESX host.

The procedures in this section describe the steps needed to add RDMs for one virtual machine. Repeat all the steps in this section for each of the four virtual machines named VMORARAC1, VMORARAC2, VMORARAC3, and VMORARAC4.
To add one 20GB RDM for a virtual machine

1. In the vSphere client, select a virtual machine.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Click Add to display the Add Hardware wizard.
4. In the Add Hardware wizard select Hard Disk for the Device Type, and click Next.
5. In the Disk section of the Select a Disk page, select Raw Device Mappings. Set the LUN size to 20 GB. Click Next.
6. On the Select Datastore page, in the Select datastore on which to store LUN mapping section, select Store with virtual machine. Click Next.
7. On the Compatibility Mode page, in the Compatibility section, select Physical. Click Next.
10. Click OK.

To add a second 20GB RDM for the virtual machine

1. Select the virtual machine that was selected in the preceding step 1.
2. Repeat steps 2 through 7 in the preceding procedure to add one 20GB datastore.
3. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:1). Click Next.
4. Repeat steps 9 and 10 of the preceding procedure to add one 20GB datastore.

To add a third 20GB RDM for the virtual machine

1. Select the virtual machine that was selected in the preceding step 1.
2. Repeat steps 2 through 7 in the preceding procedure to add one 20GB datastore.
3. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:2). Click Next.
4. Repeat steps 9 and 10 of the preceding procedure to add one 20GB datastore.

Change the properties of the SCSI controller for the RDMs so they can be shared and configured as paravirtual.

To set the SCSI controller type to paravirtual

1. Select the virtual machine that was selected in the preceding step 1.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. In the device list, select SCSI controller 1.
4. In the SCSI Bus Sharing section, select Physical.
5. In the SCSI Controller Type section, click Change Type.
6. Select VMware Paravirtual.
7. Click OK, and click OK again.

The virtual machine properties can be viewed in vCenter, as seen in the following screenshot.
### Figure 16. First Virtual Machine RAC Node Hardware Devices

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>31072 MB</td>
</tr>
<tr>
<td>CPUs</td>
<td>8</td>
</tr>
<tr>
<td>Video card</td>
<td>Video card</td>
</tr>
<tr>
<td>VMCI device</td>
<td>Restricted</td>
</tr>
<tr>
<td>SCSI controller 0</td>
<td>LSI Logic Parallel</td>
</tr>
<tr>
<td>SCSI controller 1</td>
<td>Paravirtual</td>
</tr>
<tr>
<td>SCSI controller 2</td>
<td>Paravirtual</td>
</tr>
<tr>
<td>Hard disk 1</td>
<td>Virtual Disk</td>
</tr>
<tr>
<td>Hard disk 2</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 3</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 4</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 5</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 6</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 7</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 8</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 9</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 10</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 11</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 12</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 13</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 14</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 15</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 16</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 17</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>Hard disk 18</td>
<td>Mapped Raw LUN</td>
</tr>
<tr>
<td>CD/DVD Drive 1</td>
<td>[/vmimages/tools-iso...</td>
</tr>
<tr>
<td>Network adapter 1</td>
<td>Oracle Public</td>
</tr>
<tr>
<td>Network adapter 2</td>
<td>Oracle Private</td>
</tr>
</tbody>
</table>
13.5 Add DATA and REDO Disks to Virtual Machine RAC Nodes

In this section, the database disks for data and redo logs are added to the virtual machine RAC nodes. The general procedure is:

- Data and redo LUNs are added to virtual machine VMORARAC1 as RDMs. This creates RDM mapping files in the VMFS datastore. The SCSI controller type is set to VMware Paravirtual.
- The same data and redo LUNs are added to the remaining three nodes (VMORARAC2, VMORARAC2, and VMORARAC3) by selecting the same RDM mappings created in the previous step. Again, the SCSI controller type is set to VMware Paravirtual.

To add DATA or REDO LUNs to the first virtual machine, VMORARAC1

1. In the vSphere client, select the virtual machine, VMORARAC1.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Click Add to display the Add Hardware wizard.
4. In the Add Hardware wizard select Raw Device Mappings for the Device Type, and click Next.
5. In the Select a target LUN section of the Select a Disk page, select a 300GB LUN for DATA or a 64GB LUN for REDO. Click Next.
6. On the Select Datastore page, in the Select datastore on which to store LUN mapping section, select Store with virtual machine. Click Next.
7. On the Compatibility Mode page, in the Compatibility section, select Physical. Click Next.
8. On the Advanced Options page, in the Virtual Device Node section, select SCSI (1:3) for DATA, or SCSI (2:0) for REDO. Click Next.
10. Click OK.
11. Repeat steps 1 through 7 for all the DATA and REDO LUNs. Change step 8 to use SCSI (1:4) for the next DATA LUN, or SCSI (2:1) for the next REDO LUN. For additional DATA or REDO LUNs, repeat steps 1 through 7 and continue the numbering sequence in step 8. For example, the third DATA LUN uses the numbering SCSI (1:5), and the third REDO LUN uses the numbering SCSI (2:2).

To set the SCSI controller type for the RDM LUNs to paravirtual

1. Select the virtual machine VMORARAC1.
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. In the device list, select SCSI controller 1.
4. In the SCSI Controller Type section, click Change Type.
5. Select VMware Paravirtual.
6. Click OK, and click OK again.

To add DATA or REDO LUNs to the remaining virtual machines

1. In the vSphere client, select a virtual machine (VMORARAC2, VMORARAC3, or VMORARAC4).
2. Right-click on the name of the virtual machine and select Edit Settings to display the Virtual Machine Properties pane.
3. Click Add to display the Add Hardware wizard.
4. In the **Add Hardware** wizard select **Hard Disk** for the **Device Type**, and click **Next**.

5. In the **Select the type of disk to use** section of the **Select a Disk** page, select **Use an existing virtual disk**. Click **Next**.

6. On the **Select Existing Disk** page, in the **Disk File Path** section, select the path to the vmdk pointer file for the LUN. Click **Next**.

7. On the **Compatibility Mode** page, click **Next**.

8. On the **Advanced Options** page, in the **Virtual Device Node** section, select **SCSI (1:3)** for DATA, or **SCSI (2:0)** for REDO. Set the **Mode** to **Independent and Persistent**. Click **Next**.

9. On the **Ready to Complete** page, click **Finish**.

10. Click **OK**.

11. Repeat steps 1 through 7 for all the DATA and REDO LUNs. Change step 8 to use **SCSI (1:4)** for the next DATA LUN, or **SCSI (2:1)** for the next REDO LUN. For additional DATA or REDO LUNs, repeat steps 1 through 7 and continue the numbering sequence in step 8. For example, the third DATA LUN uses the numbering **SCSI (1:5)**, and the third REDO LUN uses the numbering **SCSI (2:2)**.

12. Repeat steps 1 through 11 for each of the other virtual machines (VMORARAC2, VMORARAC3, or VMORARAC4).

**To set the SCSI controller type for the RDM LUNs to paravirtual**

1. Select a virtual machine (VMORARAC2, VMORARAC3, or VMORARAC4).

2. Right-click on the name of the virtual machine and select **Edit Settings** to display the **Virtual Machine Properties** pane.

3. In the device list, select **SCSI controller 1**.

4. In the **SCSI Controller Type** section, click **Change Type**.

5. Select **VMware Paravirtual**.

6. Click **OK**, and click **OK** again.

**To format disks using the Linux fdisk utility**

1. Follow the steps in Section 6.4 to format one disk.

2. Repeat, using fdisk to format each disk.
The devices for the virtual machine should look like the following screenshot.

**Figure 17. Virtual Machine RAC Node with All Attached Hardware Devices (Includes All Disks)**