Deploying Oracle 11g RAC Release 2 with IBM Storwize V7000 on Red Hat Enterprise Linux

IBM Systems and Technology Group ISV Enablement
October 2010
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1. **Abstract**

This white paper is intended to assist those who are implementing Oracle Database 11g Release 2 with Oracle Real Application Clusters (RAC) on IBM System x™ servers running Red Hat Enterprise Linux® 5.5 and the new storage system, IBM Storwize V7000.

The document describes the IBM Storwize V7000 innovative technologies and functionalities, Oracle Database 11g RAC Release 2 new features, and a step-by-step configuration of IBM Storwize V7000 and Oracle Database 11g, RAC, and Oracle Automatic Storage Management (ASM) on RHEL 5.5.

IBM Storwize V7000 is a new storage solution combined with the latest storage system components, and integrated enterprise-class technology for data availability and data protection. It also defines new standards for storage efficiency, manageability, and performance optimization to manage rapid data growth more effectively.

An implementation of Oracle Real Application Clusters typically consists of three main steps:

1. Planning the hardware for Oracle RAC implementation
2. Configuring the servers and storage systems
3. Installing and configuring Oracle Grid Infrastructure 11g Release 2 and Oracle Database 11g Release 2 with RAC.
2. Introduction

2.1. IBM Storwize V7000 Introduction

IBM Storwize V7000 is a mid-range, virtualizing Redundant Array of Independent Disks (RAID) controller. It incorporates the well-established IBM SAN Volume Controller code, to provide copy services, virtualization, and interoperability for open system platforms, and code from existing IBM DS8000® storage systems, to provide robust RAID functions. It also provides a fresh new embedded web graphic user interface (GUI) based on the easy-to-use XIV interface. The Storwize V7000 system thus delivers essential storage efficiency technologies, exceptional ease of use and performance—all integrated into a compact, modular design that’s offered at an affordable, midrange price.

![Storwize V7000 hardware](image)

The IBM Storwize V7000 storage system consists of two integrated controller units and a drive enclosure that includes 12 x 3.5 inch or 24 x 2.5 inch disks. It is able to support up to 120 x 3.5 inch or 240 x 2.5 inch serial-attached SCSI (SAS) disk drives, by attaching separate expansion enclosures. The disk drives are attached using a SAS fabric and may be SAS, Serial Advanced Technology Attachment (SATA), or solid-state (flash). Control enclosures contain disk drives and two node canisters. The two nodes make up an I/O group that should be attached to a switch fabric. A pair of nodes is responsible for servicing all I/O in an active-active way to a given volume. Because each volume is served by two nodes, there is no loss of availability if one node fails or is taken offline. Expansion enclosures provide additional drives, and should be attached to control enclosures. Expansion enclosures include the SAS interface hardware that enables the nodes to utilize the expansion enclosure’s drives.
IBM Storwize V7000 has incorporated the features of SAN Volume Controller virtualization appliance and adds the following:

- Exceptional ease of deployment and use, greatly simplifying administration tasks and so reducing cost of ownership
- Scalable and extensible RAID storage, allowing incremental system growth as storage capacity and performance needs change
- A range of disk drive technologies, including solid-state drives (SSDs), supporting multiple storage tiers in a single system with nondisruptive migration between them

The IBM Storwize V7000 software performs the following functions for host systems:

- Presents a single pool of storage combining all storage systems it manages
- Provides logical unit virtualization
- Manages logical volumes
- Mirrors logical volumes
A key feature of IBM Storwize V7000 is its ability to consolidate various vendors’ disk controllers into a common pool of storage. Figure 3 shows IBM Storwize V7000 as a traditional RAID storage system with internal disks, as well as an in-band appliance that provides the virtualization capability for other storage systems as SVC does. The Storwize V7000 system provides a single user interface for both internal and external storage, and the virtualized external storage can inherit all Storwize V7000 rich functions including FlashCopy, Easy Tier, and thin provisioning.

Note that data on the legacy system can be preserved or discarded based on your requirements when importing it into Storwize V7000.

For more information on Storwize V7000, please refer to IBM Storwize V7000 Information Center:

2.2. Oracle 11g Release 2 technologies

This section describes the Oracle 11g Release 2 technologies.

2.2.1. Oracle RAC 11g Release 2

Oracle RAC is a cluster database system with a shared cache architecture that overcomes the limitations of traditional shared-nothing and shared-disk approaches, to provide highly scalable and available database solutions for all business applications. Oracle RAC is a key component of the Oracle enterprise grid architecture. Oracle RAC uses the shared disk method of clustering databases.
Oracle processes, running on each node, access the same data residing on shared data disk storage. Oracle RAC uses a "shared everything" data architecture. This means that all data storage needs to be globally available to all RAC nodes. First introduced with Oracle Database 9i, RAC provides high availability and flexible scalability. If one of the clustered nodes fails, Oracle continues processing on the other nodes. If additional capacity is required, nodes can be dynamically added without taking down the cluster. In Oracle Database 11g Release 2, Oracle provides Oracle Clusterware, which is designed specifically for Oracle RAC. You do not need a third-party Clusterware product to implement Oracle RAC. Because storage is shared, the file system and volume management must be cluster-aware.

From Oracle Database 11g Release 2, Oracle Clusterware files can be stored in Oracle ASM. Oracle Clusterware and Oracle ASM are installed under a single directory called grid home.

The Grid Infrastructure was introduced with Oracle RAC 11g Release 2. This software is complementary to the Oracle Database and provides additional infrastructure, such as volume management, file system, and cluster management. This is a single set of binaries that includes both the Oracle Clusterware and Automatic Storage Management.

Oracle RAC 11g requires a virtual IP address (VIP) to be assigned for each node in the cluster. This virtual IP address should be an unused IP address on the same subnet as the local area network (LAN). It is used by applications to connect to the RAC database. If a node fails, the VIP fails over to another node in the cluster, which can provide an immediate response to connection requests.

Oracle RAC 11g Release 2 also introduces the Grid Naming Service (GNS) for cluster, as a method for automating the management of the VIP requirements in the cluster. The use of GNS requires a Dynamic Host Configuration Protocol (DHCP) server on the public network, and Oracle uses DHCP to dynamically allocate the required VIP addresses as servers join the cluster.

Single Client Access Name (SCAN) is introduced with Oracle RAC 11g Release 2 to simplify client access to databases. SCAN provides a single name to be used in client connection requests that does not change as the cluster expands or if any of the nodes in the cluster change over time. When using GNS, only the name and listener port are needed for the SCAN; otherwise, SCAN must be defined in the DNS as a single name that round-rotins through three IP addresses on the same subnet as the public network for the cluster.

### 2.2.2. Oracle Clusterware

Oracle Clusterware (previously called Cluster Ready Services or CRS) provides Cluster Management Services and High Availability Services to Oracle and third-party software. Oracle Clusterware is a prerequisite for all Oracle RAC implementations. Oracle Clusterware needs to be installed on all nodes of the cluster before installing the database software, itself. During installation, administrators will be prompted to configure a virtual IP, voting disk and cluster registry. Oracle Clusterware monitors and manages Oracle RAC databases. When a node in the cluster is started, all instances, listeners and services are automatically started and monitored. If an instance fails, Clusterware will automatically restart the instance. With Oracle Database 11g, managing applications is made easier through the graphical interface provided by Oracle Enterprise Manager. Additionally, the High Availability Framework, included in Oracle Clusterware, provides improved management and dependency options.
2.2.3. Automatic Storage Management

Automatic Storage Management (ASM) in Oracle Database 11g Release 2 extends the previous ASM functionality to manage all data: Oracle database files, Oracle Clusterware files and non-structured general purpose data, such as binaries, text files and external files. ASM simplifies, automates and reduces cost and overhead by providing a unified and integrated solution for all file management needs, eliminating the need for third-party volume managers, file systems and Clusterware platforms.

The Storwize V7000 provides Volume Mirroring where a single volume image is provided to the attached host systems while maintaining pointers to two copies of data in separate storage pools. Copies can be on completely separate disk storage systems that are being virtualized. In the case of one copy failing Storwize V7000 will provide continuous data access by redirecting I/O to the remaining copy. When the copy becomes available automatic resynchronization occurs.

Oracle ASM provides the following benefits:

- **Striping**: Oracle ASM spreads data evenly across all disks in a disk group to optimize performance and utilization. This even distribution of database files eliminates the need for regular monitoring and I/O performance tuning.

- **Mirroring**: Oracle ASM can increase data availability by (optionally) mirroring any file. Oracle ASM mirrors at the file level, unlike volume-level mirroring. Mirroring involves keeping redundant, mirrored copies of each extent of the file, to help avoid data loss caused by disk failures. The mirrored copy of each file extent should be always kept on a different disk from the original copy. If a disk fails, Oracle ASM can continue to access affected files by accessing mirrored copies on the surviving disks in the disk group.

- **Online storage reconfiguration and dynamic rebalancing**: Oracle ASM permits the addition and removal of disks from a disk storage system, while the database is in operation. When a disk is added to a disk group, Oracle ASM automatically redistributes the data, so that it is evenly spread across all disks in the disk group, including the new disk. The process of data redistribution is known as **rebalancing**. It is carried out in background, and with minimal impact to database performance.

- **Managed file creation and deletion**: Oracle ASM further reduces administration tasks by enabling files stored in Oracle ASM disk groups to be managed by Oracle Database. Oracle ASM automatically assigns file names when files are created, and automatically deletes files when they are no longer required by the database.

ASM 11g Release 2 introduces key enhancements and extensions that further simplify storage management.

- General purpose ASM Cluster File System (ACFS)
- ASM Dynamic Volume Manager (ADVM)
- Snapshot data service for ACFS
- Oracle Clusterware OCR and Voting File Support
- Extensions for system and database administrators
- Functional enhancements
- Tunable performance

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**Note:** Oracle recommends the use of Oracle ASM for Oracle Clusterware files and Oracle RAC data files, rather than raw devices or a file system provided by the operating system. Oracle databases can use both Oracle ASM files and non-Oracle ASM files. It is also possible to create an ACFS to store your database, Oracle Home and any other external (non-database) files in the cluster.

For further information on Oracle RAC, go to:
3. Prerequisites and Environment

This section describes the prerequisites and environment.

3.1. Hardware requirements

Consider the following hardware guidelines before deploying your Oracle RAC environment:

- **Server CPU**
  
  There should be sufficient CPU capacity, that is, speed and number of cores, to handle the workload.

- **Server memory**
  
  An Oracle Database can utilize a lot of memory. This depends on the activity level of users and the nature of the workload. As a rule, the server should have more memory than it normally uses. After physical memory becomes saturated, the system swaps data to disk, and hence, performance will be degraded.

  It is important to select available servers installed with sufficient memory, including potential for growth. During production use, physical memory utilization should be no higher than 85%, to avoid the risk of server-performance degradation.

- **Network**
  
  Servers in Oracle Real Application Clusters need at least two separate networks, a public network and a private network. The public network is used for the communication between the clients or applications servers and the database. The private network, sometimes referred to as network interconnect, is used for cluster node communication. It is used for monitoring the cluster heartbeat and by Oracle Real Application Clusters for Cache Fusion.

  InfiniBand networking is supported with Oracle Database 11g.

- **Shared storage**
  
  Shared storage for Oracle Real Application Clusters devices can be logical drives or logical units (LUNs) from a storage area network (SAN) controller or a Network File System (NFS) from a supported network attached storage (NAS) device. There are certain advantages of using NAS, but for higher performance, a SAN is the recommended option.

  For SAN products, IBM offers enterprise disk systems such as IBM XIV Storage System and DS8000, mid-range disk systems such as Storwize V7000. Ensure the IBM System Storage product you are using is supported with Oracle Real Application Clusters’ implementations. Third party storage subsystems can also be used with IBM System x servers. Refer to third-party documentation or contact a third-party representative for product certification information. For more information on IBM System Storage product offerings, visit [ibm.com/systems/storage/disk](http://ibm.com/systems/storage/disk)

  For Oracle Real Application Clusters implementation, Oracle Database files can be located on shared storage using the following options:
1. A certified cluster file system

A file system that may be accessed (read and write) by all members in a cluster, at the same time, with all cluster members having the same view of the file system. It allows all nodes in a cluster to access a device concurrently via the standard file system interface.

2. Oracle Automated Storage Management (ASM)

ASM is a simplified database storage management and provisioning system that provides file system and volume management capabilities in Oracle. It allows database administrators (DBA) to reference disk groups instead of individual disks and files which ASM manages internally. ASM is included in Oracle Database 11g, and is designed to handle Oracle Database files, control files and log files. In Oracle 11g Release 2, Oracle ACFS is introduced. It is a multi-platform, scalable file system that supports database and application files (executables), database trace files, database alert logs, application reports, BFILES, and configuration files. However, it does not support any file that can be directly stored in Oracle ASM, or any files for the Oracle grid infrastructure home.

For more information on Oracle ACFS, please refer to Oracle Database Storage Administrator's Guide 11g Release 2 (11.2), Part Number E10500-02.

Before starting the configuration, first, check the hardware requirements:

- Select servers with the same chip architecture; running 32-bit and 64-bit Oracle software versions, together, in the same cluster stack, is not supported.
- Ensure that the server is started with run level 3 or run level 5.
- Ensure servers run the same operating system binary. Oracle grid infrastructure installations and Oracle RAC support servers with different hardware in the same cluster.

Each system must meet the following minimum hardware requirements:

- 1.5 GB of physical RAM for grid infrastructure for a cluster installation without Oracle RAC; at least 2.5 GB of physical RAM if you plan to install Oracle RAC after installing grid infrastructure for a cluster
- 1024 x 768 display resolution, to support Oracle Universal Installer (OUI)
- Oracle recommends swap space is set to 1.5 times the physical memory, for systems with 2 GB or less. For systems with 2 to 16 GB physical memory, use an equal amount of swap space. For systems with more than 16 GB RAM, use 16 GB of RAM for swap space. If the swap space and the grid home are on the same file system, then add together their respective disk space requirements for the total minimum space required
- 1 GB of available space in the /tmp directory
- 4.5 GB of space for the grid infrastructure for a cluster home (Grid home). This includes Oracle Clusterware and Oracle Automatic Storage Management (Oracle ASM) files and log files.
- If installing Oracle Database on Linux x86, 4 GB hard disk space is required for Oracle base code installation
If installing Oracle Database on Linux x86_64 platforms, 4.6 GB hard disk space is required for Oracle base code installation.

The hardware used to build our example Oracle RAC 11g environment consists of two Linux servers (two Oracle RAC nodes), one IBM Storwize V7000 storage system and other associated components, including Ethernet switches, network interface cards (NICs) and host bus adapters (HBAs).

**Oracle RAC Node1 – (racnode1)**

<table>
<thead>
<tr>
<th>Host Type/Model</th>
<th>IBM x3650: 7979-MC1</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS Version</td>
<td>GGE141AUS-1.12</td>
</tr>
<tr>
<td>Processor</td>
<td>8 * Intel(R) Xeon(R) CPU E5345 @2.33GHz</td>
</tr>
<tr>
<td>Memory</td>
<td>8040284 KB</td>
</tr>
<tr>
<td>OS Version (With Service Pack)</td>
<td>Red Hat Enterprise Linux Server release 5.5 (Tikanga)</td>
</tr>
<tr>
<td>OS Architecture (x32, x64, etc)</td>
<td>X86_64</td>
</tr>
<tr>
<td>SAN Boot OS (Yes or No)</td>
<td>No</td>
</tr>
<tr>
<td>Cluster &amp; Arbitration type</td>
<td>Oracle Database 11g Release 2 Grid</td>
</tr>
<tr>
<td>Kernel Version</td>
<td>2.6.18-194.el5</td>
</tr>
<tr>
<td>HBA Model</td>
<td>LPe12002</td>
</tr>
<tr>
<td>HBA Driver</td>
<td>8.2.0.63.3p</td>
</tr>
<tr>
<td>HBA Firmware</td>
<td>1.11A5</td>
</tr>
<tr>
<td>MPIO</td>
<td>DMMP</td>
</tr>
<tr>
<td>Oracle Software</td>
<td>Oracle Database 11g Release 2 Grid Infrastructure(11.2.0.1.0) for Linux x86_64</td>
</tr>
</tbody>
</table>

**Figure 5. Oracle RAC node 1 Detail**

**Oracle RAC Node2 – (racnode2)**

<table>
<thead>
<tr>
<th>Host Type/Model</th>
<th>IBM x3650: 7979-MC1</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS Version</td>
<td>GGE141AUS-1.12</td>
</tr>
<tr>
<td>Processor</td>
<td>4 * Intel(R) Xeon(R) CPU E5130 @2.00GHz</td>
</tr>
<tr>
<td>Memory</td>
<td>6106608 KB</td>
</tr>
<tr>
<td>OS Version (With Service Pack)</td>
<td>Red Hat Enterprise Linux Server release 5.5 (Tikanga)</td>
</tr>
<tr>
<td>OS Architecture (x32, x64, etc)</td>
<td>X86_64</td>
</tr>
<tr>
<td>SAN Boot OS (Yes or No)</td>
<td>No</td>
</tr>
<tr>
<td>Cluster &amp; Arbitration type</td>
<td>Oracle Database 11g Release 2 Grid</td>
</tr>
<tr>
<td>Kernel Version</td>
<td>2.6.18-194.el5</td>
</tr>
<tr>
<td>HBA Model</td>
<td>QLA2462</td>
</tr>
<tr>
<td>HBA Driver</td>
<td>8.03.01.04.05.05-k</td>
</tr>
<tr>
<td>HBA Firmware</td>
<td>4.04.09</td>
</tr>
<tr>
<td>MPIO</td>
<td>DMMP</td>
</tr>
</tbody>
</table>
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

Figure 6. Oracle RAC node 2 Detail

Figure 7 provides a conceptual look at what the environment would look like after connecting all of the hardware components:

Figure 7. SAN Topology

3.2. Software requirements

The following sections describe the software requirements.

3.2.1. Operating system

This scenario uses Red Hat Enterprise Linux 5 Update 5.

3.2.2. Oracle 11g R2

- Oracle Database 11g Release 2 Grid Infrastructure (11.2.0.1.0) for Linux x86-64
  linux.x64_11gR2_grid.zip
- Oracle Database 11g Release 2 (11.2.0.1.0) for Linux x86-64
  linux.x64_11gR2_database_1of2.zip

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linux.x64_11gR2_database_2of2.zip
4. IBM Storwize V7000 setup

4.1. Storwize V7000 Virtualization Overview

The Storwize V7000 uses basic storage units called managed disks or MDisk for short, and collects them into one or more storage pools. A managed disk must be protected by RAID to prevent loss of the entire storage pool. In Storwize V7000 a RAID array is created as MDisk at the point that you add the array into the pool. There are two different MDisk types:

- External SAN attached MDisk
  
  An external storage system provides the RAID function and presents a Logical Unit (LU) to the Storwize V7000.

- Internal Array MDisk
  
  The internal drives cannot be directly added to storage pools. The internal RAID implementation inside the system takes drives and builds a RAID array with protection against drive failures.

A storage pool provides the capacity to create volumes within it for use by hosts. Whenever you create a new volume you must pick a single storage pool to provide the capacity, and by default the created volume will stripe all of its data across all the managed disks in the storage pool.

![Diagram of MDisk, Storage Pool, and Volume](image)

IBM Storwize V7000 fully supports RAID-0, RAID-1, RAID-5, RAID-6, and RAID-10.

When you add managed disks to a pool they should have the same performance characteristics:

- Same RAID level
- Roughly the same number of drives per array
- Same drive type (SAS, NL SAS, SSD except if using Easy Tier)
- Similar performance characteristics for external storage system MDisks

This is because data from each volume will be spread across all MDisks in the pool, so the volume will perform approximately at the speed of the slowest MDisk in the pool. The exception to this rule is that...
if using Easy Tier, you can have 2 different tiers of storage in the same pool, that contains MDisks derived from SSDs can also contain MDisks derived from hard-disk drives (HDDs), and Easy Tier automatically move data from highly-active HDD extents to faster responding SSD extents.

For most customers it is recommended no more than one external storage system per storage pool for reasons of fault isolation. To minimize the risk of data loss, only virtualize storage systems where LUNs are configured using a RAID level other than RAID-0 (stripping).

Included with IBM Storwize V7000 is a very simple and easy-to-use web GUI with Point-and-Click system management which is designed to allow storage to be managed without complexity. The interface includes a number of preset configuration options for RAID, volume and FlashCopy creations, which are aimed at simplifying the implementation process. It also provides automated wizards, called Directed Maintenance Procedures (DMP), to assist in resolving any error events that may occur.

4.2. Configuring Storwize V7000 for Oracle RAC

In Figure 10, we show a setup and configuration path for the storage on RHEL systems with IBM Storwize V7000. For example, in the left part, MDisks are firstly created and then storage pools, followed by volumes.
4.2.1. Zoning your servers with IBM Storwize V7000

Before starting to create zones, you can refer to “8.1. SAN consideration” for better performance for IBM Storwize V7000.

Because it differs from traditional storage devices, create your zoning configuration carefully.

Here are the basic Storwize V7000 zoning steps:
   a) Create Storwize V7000 intra-cluster zone.
   b) Create Storwize V7000 cluster.
   c) Create Storwize V7000 → external storage subsystem zones if you plan to use external storage as well.
   d) Assign external storage to the Storwize V7000.
   e) Create host → Storwize V7000 zones.
   f) Create host definitions on the Storwize V7000.

The zoning scheme that we describe next is a statement of our understanding of the best way to set up zoning, even if other ways are possible and supported.

- Storwize V7000 intra-cluster zone
  This zone needs to contain every Storwize V7000 node port on the SAN fabric. While it will overlap with the external storage zones that you will create soon, it is handy to have this zone as a “fail-safe,” in case you ever make a mistake with your external storage zones.

- Storwize V7000 external zones
  You need to avoid zoning different vendor storage subsystems together; the ports from the external storage subsystem need to be split evenly across the dual fabrics. Each controller might
have its own recommended best practice.

- **Storwize V7000 host zones**
  There must be a single zone for each host port. This zone must contain the host port, and one port from each Storwize V7000 node that the host will need to access. While there are two ports from each node per SAN fabric in a usual dual-fabric configuration, make sure that the host only accesses one of them. Refer to Figure 11.

This configuration provides four paths to each Volume, which is the number of paths per Volume for which the multipathing software and the Storwize V7000 have been tuned.

**Figure 11. Typical Host - Storwize V7000 Zoning**

It looks like the following:

```text
zone: Racnode2_zone_A
50:05:07:68:01:40:01:41;
50:05:07:68:01:40:0e:62;
21:00:00:1b:32:14:84:f1

zone: Racnode2_zone_B
50:05:07:68:01:30:01:41;
50:05:07:68:01:30:0e:62;
21:01:00:1b:32:34:84:f1

zone: Racnode1_zone_A
50:05:07:68:01:40:01:41;
50:05:07:68:01:40:0e:62;
10:00:00:00:c9:73:2d:08
```
Configuration tasks that we will describe next are how to create a host, storage pool and volume, and map the volumes to your hosts by Storwize V7000 management GUI.

4.2.2. Creating hosts on Storwize V7000

On the Storwize V7000 management GUI, select “Host->All hosts”, and click “New Host” to start creating a host as showed in Figure 12.

![Figure 12. Creating a New Host](image)

Select host type that you want, here we select FC type (Figure 13), the GUI will switch to next page (Figure 14):
In “Host Name” item, input “racnode1” for the first Oracle RAC node name, and select the WWPNs of the Host HBA ports from “Fibre-Channel Ports” list. Check “Advanced” choice, set the “Host Type” to “Generic”. Click “Create Host” to finish the creation. The GUI also displays the corresponding command line (Figure 15) if the detail option is turned on.
The same steps are used for creating the second Oracle RAC node.

4.2.3. Managing MDisks and storage pools

In Storwize V7000, these internal drives can not be directly added to storage pools. They need to be included in a RAID to provide protection against the failure of individual drives. A RAID array is created as an MDisk, and during the array creation, wizards and presets are available to suggest configurations to users based on the hardware attached to the system. Recommendation is to use these presets for easy configuration and generally the best performance.

The following content will show how to create arrays on the system using the GUI. The Storwize V7000 CLI would not be needed though it is flexible in most cases.

When you first setup the Storwize V7000 the initial setup wizard will prompt the user to use the fully automated RAID setup. Here, we will start from “Configure Storage” on the GUI (Figure 16).
Figure 16. Starting to Configure Storage

Figure 17 shows the internal drive status before storage configuring, where by default, Nearline SAS drives will be configured as RAID 6 with 12 members and 1 spare.

Figure 17. Internal Storage
We can choose to use the recommended configuration (fully automatic configuration) or a different configuration for customization (Figure 18). Here we use a different configuration. In this step, first select the Drive Class, and then the GUI will provide a preset list based on the drive class. You can decide whether to configure spares automatically, and optimize the array for performance or capacity. The number of drives to provision can also be indicated. The configuration summary displays what the system will attempt to do or inform you that it can not meet the RAID creation requirement.

We are configuring the internal Nearline SAS storage, and choose the preset of Basic RAID-5 (A Basic RAID-5 preset has a width goal of 8 if we choose to optimize for performance). In this example, we will use all drives for capacity.

![Configure Internal Storage](image)

**Figure 18. Configuring Internal Storage Options**

The Optimize for Performance option allows the system create one array though it has enough drives to meet the width goal of the preset, which means all arrays in a pool will have the same performance characteristics, and potentially leave unused drives in the system. The Optimize for Capacity option
will use all drives in the system which means that some of the arrays will not meet the array width goals. It will do this by reducing the number of drives in one or more arrays to be created by an equal amount, and you will get an optimal performance layout (all arrays have the same width or +/-1 drive, but the width will not be the same as the width goal).

**Note:** If the perfect number of drives exists, Optimize for Capacity will create the same layout as optimize for performance.

Next, we will decide whether to expand an exiting pool or create a new one or more with the array(s) to be created. Here, we create a pool dedicated for internal storage (Figure 19).

![Figure 19. Creating Array and Pool](image)

And at last, you will see the creation progress and the command line result if the Details option is turned on (Figure 20).
Figure 20. RAID Arrays Creation

Navigate to the Pools page, we will see that a new MdiskGrp_Internal pool shows and it has two members mdisk0 and mdisk1, both online as array (Figure 21).

Figure 21. Storage Pool and Array Status
We now have completed managing the internal storage. For the external storage system, MDisks are protected outside and the storage devices are provided as Logical Unit (LU) to Storwize V7000 (Figure 22). These MDisks can be added to storage pools directly.

![Figure 22. External Storage MDisks](image)

4.2.4. Creating volumes for Oracle Cluster files and RAC files on Storwize V7000

There is currently no empirical data to suggest that splitting a database into multiple physical volumes enhances or degrades performance. Therefore, the decision on how to structure the volumes used to store a database should be driven by backup, restore, and mirroring requirements. We plan to verify “Volume Mirroring” and “Thin Provisioning” of Storwize V7000 in this white paper, so we will create a "Volume Mirroring" for grid ASM group, and "Thin-provisioned volumes" for both RAC Database ASM groups and Flash Recovery Area ASM groups.

We will create volumes from pools both from internal and external storage sources (Figure 23).

![Figure 23. Storwize V7000 Pools](image)
1. We plan to create a 4GB mirrored volume for the grid CRS ASM group:

   a) On Storwize V7000 management GUI, select “Volumes->All Volumes”, and click “New Volume” (Figure 24),

   b) Select “Mirror” type in preset list, and set the internal pool “MdiskGrp_Internal” as a Primary Pool and set the external pool “DS8K3650Grp_Eternal” as a Secondary Pool. Also, input a volume name “Ora_ASM_CRS” in the blank of “Volume Name” item and “4” GB in the blank of “Size”. Click “Create” to finish the mirror volume creation (Figure 25), and the creation progress and corresponding command line is shown on Figure 26.

![Figure 24. Creating a New Volume](image-url)
c) The mirrored volume is shown as Figure 27.
We plan to create a 32GB Thin-provisioned Volumes for RAC database file ASM group and a 42 GB Thin-provisioned Volumes for FRA ASM group in internal pool:

Select “Thin Provision” type, and set “MdiskGrp_Internal” to Primary Pool. And input “Ora_ASM_Database” in the blank of “Volume Name” and “32” in the blank of “Size”. Two percent of the physical space is initially allocated to a thin provisioned volume by default, and as seen in Figure 28, 655.4 MB storage space is allocated to real capacity. You can modify the real capacity to what you want. Here, we need a 10GB real capacity, so click “Advanced” item and set “10GB” to “Real” item in Figure 29. To click “OK”, the GUI will return to Figure 28, click “Create” to start the Thin Provisioned volume creation.

Figure 30 shows the thin provisioned volume creation progress and the corresponding command line called.
Figure 28. Creating a Thin Provision Volume

Figure 29. Advanced Settings for New Volume
Repeat the steps above, and create a 42GB thin provisioned volume with 10GB real capacity for FRA ASM group. After that, we have three volumes as shown in Figure 31.

**4.2.4. Mapping volumes for both nodes**
To map these three created volumes, and click “Action->Map to Host”, choose “racnode1” and next, the volumes will be mapped into racnode1 (Figure 32 and 33).

Figure 32. Mapping Volumes To RAC Node 1

Figure 33. Mapped Volumes
Repeat the steps and mapped the same three volumes into racnode2. Select “Host->Host Mappings”, we find that both racnode1 and racnode2 share the same three volumes (Figure 34).

Figure 34. Host Mappings

Repeat the steps and mapped the same three volumes into racnode2. Select “Host->Host Mappings”, we find that both racnode1 and racnode2 share the same three volumes (Figure 34).
5. Oracle grid installation

5.1. Installing the required Linux packages for Oracle RAC

Make sure that you meet the package requirements (Oracle recommends that the Linux operating systems be installed with the default software packages).

To check the required Oracle patches and their versions for Asianux Server 3, Oracle Enterprise Linux 5, and Red Hat Enterprise Linux 5, issue the following command.

```
rpm -q --qf '%{NAME}-%{VERSION}-%{RELEASE} (%{ARCH})
compat-libstdc++-33
elfutils-libelf
elfutils-libelf-devel
gcc
gcc-c++
glibc
glibc-common
glibc-devel
glibc-headers
ksh
libaio
libaio-devel
libgcc
libstdc
libstdc++
libstdc++-devel
make
sysstat
unixODBC
unixODBC-devel
```

5.2. Network configuration

Perform the following network configuration on both Oracle RAC nodes in the cluster.

Network hardware requirements

The following list shows hardware requirements for the network configuration:

- Each Oracle RAC node must have at least two network adapters or network interface cards (NICs): One for the public network interface and one for the private network interface. To use multiple NICs for the public network or for the private network, Oracle recommends that you use NIC bonding. Use separate bonding for the public and private networks (that is, bond0 for the public network and bond1 for the private network), because during the installation, each interface is defined as a public or private interface. NIC bonding is not covered in this paper. Here, we will use one public network interface and one private network interface.

- The public interface names associated with the network adapters for each network must be the same on all nodes, and the private interface names, associated with the network adaptors, must be the same on all nodes.
For example, with the two-node cluster, you cannot configure network adapters on racnode1 with eth0 as the public interface, but on racnode2 have eth1 as the public interface. Public interface names must be the same, so you must configure eth0 as public on both nodes. You should also configure the private interfaces on the same network adapters. If eth1 is the private interface for racnode1, then eth1 must be the private interface for racnode2.

- For the public network, each network adapter must support TCP/IP
- For the private network, the interconnect must support the User Datagram Protocol (UDP) using high-speed network adapters and switches that support TCP/IP (minimum requirement 1 Gigabit Ethernet).

UDP is the default interconnect protocol for Oracle RAC, and TCP is the interconnect protocol for Oracle Clusterware. You must use a switch for the interconnect. Oracle recommends that you use a dedicated switch.

Oracle does not support token-rings or crossover cables for the interconnect:

- For the private network, the endpoints of all designated interconnect interfaces must be reachable on the network. All nodes must be connected to each private network interface. Use the ping utility to test whether an interconnect interface is reachable.
- During installation of Oracle grid infrastructure, you are asked to identify the planned use for each network interface that OUI detects on your cluster node. You must identify each interface as a public interface, a private interface or as unused, and you must use the same private interfaces for both Oracle Clusterware and Oracle RAC.

You can bond separate interfaces to a common interface to provide redundancy, in order to protect against NIC failure, but Oracle recommends that you do not create separate interfaces for Oracle Clusterware and Oracle RAC. If you use more than one NIC for the private interconnect, then Oracle recommends that you use NIC bonding. Note that multiple private interfaces provide load balancing but not failover, unless bonded.

Starting with Oracle Clusterware 11g Release 2, you no longer need to provide a private name or IP address for the interconnect. IP addresses on the subnet that you identify as private are assigned as private IP addresses for cluster member nodes. You do not need to configure these addresses manually in a host’s directory. If you want name resolution for the interconnect, then you can configure private IP names in the hosts’ file or DNS. However, Oracle Clusterware assigns interconnect addresses on the interface defined during installation as the private interface (eth1, for example), and to the subnet used for the private subnet. In practice, and for the purpose of this guide, continue to include a private name and IP address on each node for the RAC interconnect. It provides self-documentation and a set of endpoints on the private network that you can use for troubleshooting purposes:

```
10.11.110.80 racnode1-priv
10.11.110.201 racnode2-priv
```

IP address requirements
Before starting the installation, you must have at least two interfaces configured on each node: One for the private IP address and one for the public IP address. You can configure IP addresses with one of the following options:

- **Dynamic IP address assignment**, using Oracle Grid Naming Service (GNS). If you select this option, then network administrators must assign a static IP address for the physical host name, and dynamically allocated IP addresses for the Oracle Clusterware managed VIP addresses. In this case, IP addresses for the VIPs are assigned by DHCP, and resolved using a multicast domain name server configured as part of Oracle Clusterware within the cluster. If you plan to use GNS, then you must meet the following prerequisites:
  - A DHCP service running on the public network for the cluster
  - A sufficient number of available addresses on DHCP to provide one IP address for each node's VIP, and three IP addresses for the cluster used by the Single Client Access Name (SCAN) for the cluster

- **Static IP address assignment**. If you select this option, then network administrators assign a fixed IP address for each physical host name in the cluster, and for IP addresses for the Oracle Clusterware managed VIPs. In addition, DNS-based static name resolution is used for each node.

Oracle recommends that a static host name is used for all server node public host names. Public IP addresses and VIP addresses must be in the same subnet.

**Manually assigning static IP address (the DNS method)**

Manual definition of static IP addresses is still possible with Oracle Clusterware 11g Release 2, and this is the method used in this scenario to assign all required Oracle Clusterware networking components (public IP address for the node, RAC interconnect, V IP address and SCAN).

Notice that the title of this section includes the phrase "the DNS method." Oracle recommends that static IP addresses be manually configured in a domain name server (DNS), before starting the Oracle grid infrastructure installation. However, when building an inexpensive Oracle RAC, it is not always possible to have access to a DNS server. Previous to 11g Release 2, this would not present a huge obstacle, as it was possible to define each IP address in the host file, /etc/hosts, on each node, without the use of DNS. This would include public IP address for the node, the RAC interconnect and the VIP. This, however, does not apply in Oracle grid infrastructure 11g Release 2.

Starting with the RAC private interconnect, it is no longer a requirement to provide a private name or IP address for the interconnect during the Oracle grid infrastructure installation (that is, racnode1-priv or racnode2-priv). Oracle Clusterware now assigns interconnect addresses on the interface defined during installation as the private interface (eth1, for example), and to the subnet used for the private subnet, which is 10.11.110.0, in this scenario. If you want name resolution for the interconnect, then you can configure private IP names in the hosts file or DNS. In practice, and for the purpose of this guide, continue to include a private name and IP address on each node for the RAC interconnect. It provides self-documentation and a set of endpoints on the private network that you can use for troubleshooting purposes:

```
10.11.110.80 racnode1-priv
10.11.110.201 racnode2-priv
```
The public IP address for the node and the VIP remain the same in 11g Release 2. Oracle recommends defining the name and IP address for each node to be resolved through DNS, and included in the /etc/hosts file on each node. With the current release of Oracle grid infrastructure, and previous releases, Oracle Clusterware is able to resolve the public IP address for the node and the VIP, using only the /etc/hosts file:

<table>
<thead>
<tr>
<th>IP Address</th>
<th>Host Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.11.110.80</td>
<td>racnode1</td>
</tr>
<tr>
<td>9.11.110.20</td>
<td>racnode1-vip</td>
</tr>
<tr>
<td>9.11.111.201</td>
<td>racnode2</td>
</tr>
<tr>
<td>9.11.110.18</td>
<td>racnode2-vip</td>
</tr>
</tbody>
</table>

The SCAN VIP is new to 11g Release 2, and has been of great interest to many users. SCAN must be configured in GNS or DNS for round-robin resolution to three addresses (recommended), or at least one address. If you choose not to use GNS, then Oracle states that SCAN must be resolved through DNS, and not through the /etc/hosts file. If the SCAN cannot be resolved through DNS (or GNS), the Cluster Verification Utility check fails during the Oracle grid infrastructure installation.

**Single Client Access Name (SCAN) for the cluster**

If you have ever been tasked with extending an Oracle RAC cluster by adding a new node (or shrinking a RAC cluster by removing a node), then you know the effort of going through a list of all clients and updating their SQL*Net or JDBC(Java Database Connectivity) configuration to reflect the new or deleted node. To address this problem, Oracle 11g Release 2 introduced a new feature, known as Single Client Access Name (SCAN). SCAN is a feature that provides a single host name for clients to access an Oracle Database running on a cluster. Clients using SCAN do not need to change their TNS(Transparent Network Substrate) configuration when adding or removing nodes to and from the cluster. The SCAN resource and its associated IP address or addresses provide a stable name for clients to use for connections, independent of the nodes that make up the cluster. You have to provide the host name and up to three IP addresses to be used for the SCAN resource during the interview phase of the Oracle grid infrastructure installation. For high availability and scalability, Oracle recommends that you configure the SCAN name so that it resolves to three IP addresses. At a minimum, the SCAN must resolve to at least one address.

The SCAN VIP name is similar to the names used for a node’s VIP addresses, such as racnode1-vip. However, unlike a VIP, the SCAN is associated with the entire cluster, rather than an individual node, and can be associated with multiple IP addresses, not just one address. Note that SCAN addresses, VIP addresses and public IP addresses must all be on the same subnet.

SCAN should be configured so that it is resolvable either by using Grid Naming Service (GNS) within the cluster, or by using DNS resolution. In this scenario, configure SCAN to resolve to only one using the DNS method:

<table>
<thead>
<tr>
<th>IP Address</th>
<th>Host Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.11.110.26</td>
<td>racnode-cluster-scan</td>
</tr>
</tbody>
</table>

**Configuring a public and private network**

In the two-node example, you need to configure the network on both Oracle RAC nodes, to provide access to the public network as well as their private interconnect. The simplest way to configure network settings in Enterprise Linux is with the Network Configuration program. Network Configuration is a GUI application that can be started from the command-line as the "root" user as follows:
Using the Network Configuration application, you must configure both NIC devices, as well as the /etc/hosts file. You can complete both of these tasks using Network Configuration. Notice that the /etc/hosts settings are the same for both nodes and that any entries relating to IPv6 are removed for this scenario. For example:

::1 localhost6.localdomain6 localhost6

The example Oracle RAC configuration uses the following network settings:

**RAC Node1**

<table>
<thead>
<tr>
<th>Device</th>
<th>IP Address</th>
<th>Subnet</th>
<th>Gateway</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>eth0</td>
<td>9.11.110.80</td>
<td>255.255.254.0</td>
<td>9.11.110.1</td>
<td>public network</td>
</tr>
<tr>
<td>eth1</td>
<td>10.11.110.80</td>
<td>255.255.254.0</td>
<td></td>
<td>private network</td>
</tr>
</tbody>
</table>

Do not remove the following line in /etc/hosts, or various programs that require network functionality will fail.

127.0.0.1 localhost.localdomain localhost
#::1 localhost6.localdomain6 localhost6

# Public Network - (eth0)
9.11.110.80 racnode1.storage.tucson.ibm.com racnode1
9.11.111.201 racnode2.storage.tucson.ibm.com racnode2

# Private Interconnect - (eth1)
10.11.110.80 racnode1-priv.storage.tucson.ibm.com racnode1-priv
10.11.111.201 racnode2-priv.storage.tucson.ibm.com racnode2-priv

# VIP Address - (eth0:1)
9.11.110.20 racnode1-vip.storage.tucson.ibm.com racnode1-vip
9.11.110.18 racnode2-vip.storage.tucson.ibm.com racnode2-vip

# SCAN
9.11.110.26 rac-scan.storage.tucson.ibm.com rac-scan

**RAC Node2**

<table>
<thead>
<tr>
<th>Device</th>
<th>IP Address</th>
<th>Subnet</th>
<th>Gateway</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>eth0</td>
<td>9.11.111.201</td>
<td>255.255.254.0</td>
<td>9.11.110.1</td>
<td>public network</td>
</tr>
<tr>
<td>eth1</td>
<td>10.11.110.201</td>
<td>255.255.254.0</td>
<td></td>
<td>private network</td>
</tr>
</tbody>
</table>

Do not remove the following lines in /etc/hosts, or various programs that require network functionality will fail.

127.0.0.1 localhost.localdomain localhost
#::1 localhost6.localdomain6 localhost6
# Public Network - (eth0)
9.11.110.80 racnode1.storage.tucson.ibm.com racnode1
9.11.111.201 racnode2.storage.tucson.ibm.com racnode2

# Private Interconnect - (eth1)
10.11.110.80 racnode1-priv.storage.tucson.ibm.com racnode1-priv
10.11.111.201 racnode2-priv.storage.tucson.ibm.com racnode2-priv

# VIP Address - (eth0:1)
9.11.110.20 racnode1-vip.storage.tucson.ibm.com racnode1-vip
9.11.110.18 racnode2-vip.storage.tucson.ibm.com racnode2-vip

# SCAN
9.11.110.26 rac-scan.storage.tucson.ibm.com rac-scan

In the following example, only Oracle RAC Node 1 (racnode1) is shown. Be sure to make all the proper network settings to both Oracle RAC nodes.

After the network is configured, use the ifconfig command for verification. The following example is from racnode1:

```
[root@racnode1 ~]# ifconfig -a
eth0    Link encap:Ethernet  HWaddr 00:1A:64:CA:6A:AA
        inet addr:9.11.110.80  Bcast:9.11.111.255  Mask:255.255.254.0
        inet6 addr: fe80::21a:64ff:feca:6aaa/64 Scope:Link
        UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
        RX packets:604159 errors:0 dropped:0 overruns:0 frame:0
        TX packets:45025 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:62804170 (59.8 MiB)  TX bytes:5485301 (5.2 MiB)
        Interrupt:169 Memory:ca000000-ca012800

eth1    Link encap:Ethernet  HWaddr 00:1A:64:CA:6A:A8
        inet addr:10.11.110.80  Bcast:10.11.111.255  Mask:255.255.254.0
        inet6 addr: fe80::21a:64ff:feca:6aa8/64 Scope:Link
        UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
        RX packets:1407594 errors:0 dropped:0 overruns:0 frame:0
        TX packets:644496 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:566469059 (540.2 MiB)  TX bytes:284688808 (271.5 MiB)
        Interrupt:122 Memory:ce000000-ce012800
```

### 5.3. Cluster Time Synchronization Service

Oracle Clusterware 11g release 2 (11.2) requires time synchronization across all nodes within a cluster, where Oracle RAC is deployed. You have two options for time synchronization: an operating system configured Network Time Protocol (NTP) or Oracle Cluster Time Synchronization Service. Oracle Cluster Time Synchronization Service is designed for organizations whose cluster servers are unable to access NTP services. If you use NTP, then the Oracle Cluster Time Synchronization daemon (ctssd) starts up in observer mode. If you do not have NTP daemons, then ctssd starts up in active mode and synchronizes time among cluster members without contacting an external time server.
Use NTP instead of Cluster Time Synchronization Service. You have to modify the NTP configuration to set the -x flag, which prevents time from being adjusted backwards. Restart the NTP daemon after this task has been completed.

To do this, on Oracle Enterprise Linux, Red Hat Linux, and Asianux systems, edit the /etc/sysconfig/ntpd file to add the -x flag, as in the following example:

```plaintext
# Drop root to id 'ntp:ntp' by default.
OPTIONS="-x -u ntp:ntp -p /var/run/ntpd.pid"

# Set to 'yes' to sync hw clock after successful ntpdate
SYNC_HWCLOCK=no

# Additional options for ntpdate
NTPDATE_OPTIONS=""
```

Then, restart the NTP service.

```
# /sbin/service ntpd restart
```

5.4. Installing the cvuqdisk package for Linux

Install the operating system package cvuqdisk. Without cvuqdisk, Cluster Verification Utility cannot discover shared disks, and you receive the error message `Package cvuqdisk not installed` when you run Cluster Verification Utility. Use the cvuqdiskrpm for your hardware (for example, x86_64, or i386).

To install the cvuqdiskRPM, complete the following procedure:

1. Locate the cvuqdisk RPM package, which is in the rpm directory on the installation media. If you have already installed Oracle grid infrastructure, then it is located in the directory `grid_home/rpm`.

2. Copy the cvuqdisk package to each node on the cluster. You should ensure that each node is running the same version of Linux.

3. Log in as root.

4. Use the following command to find out if you have an existing version of the cvuqdisk package:

   ```plaintext
   rpm -qi cvuqdisk
   ```

   If an existing version is installed, enter the following command to uninstall it:

   ```plaintext
   rpm -e cvuqdisk
   ```

5. Set the environment variable CVUQDISK_GRP to point to the group that will own cvuqdisk, which is typically oinstall. For example:

   ```plaintext
   CVUQDISK_GRP=oinstall; export CVUQDISK_GRP
   ```
6. In the directory where you have saved the cvuqdisk rpm, use the following command to install
the cvuqdisk package:

```
rpm -iv cvuqdisk-1.0.7-1.rpm
```

5.5. Create operating system privilege groups, users, and directories using job role separation

**Note:** Perform the following user, group, directory configuration, and set shell limit tasks for the grid
and Oracle users on both nodes in the Oracle RAC cluster.

This section provides instructions on how to create the operating system users and groups to install all
Oracle software using a Job Role Separation configuration. Perform the commands in this section on
both Oracle RAC nodes, as root, to create these groups, users, and directories. Note that the group
and user IDs must be identical on both Oracle RAC nodes in the cluster. Check to make sure that the
group and user IDs that you want to use are available on each node, and confirm that the primary

group for each grid infrastructure for a cluster installation owner has the same name and group ID,
which, for the purpose of this guide, is oinstall (GID 1000).

The Oracle Job Role Separation privileges configuration is the configuration of operating system
groups and users that divide administrative access privileges to the Oracle grid infrastructure
installation from other administrative privileges users and groups associated with other Oracle
installations (for example, the Oracle Database software). Administrative privileges access is granted
by membership in separate operating system (OS) groups, and installation privileges are granted by
using different installation owners for each Oracle installation.

Create an OS user to own each Oracle software product — **grid** for the Oracle grid infrastructure
owner, and **oracle** for the Oracle RAC software. Throughout this scenario, a user created to own the
Oracle grid infrastructure binaries is called the **grid user**. This user owns both the Oracle Clusterware
and Oracle Automatic Storage Management binaries. The user created to own the Oracle Database
binaries (Oracle RAC) is called the **oracle user**. Both Oracle software owners must have the Oracle
Inventory group (oinstall) as their primary group, so that each Oracle software installation owner can
write to the central inventory (oraInventory), and so that OCR and Oracle Clusterware resource
permissions are set correctly. The Oracle RAC software owner must also have the OSDBA group and
the optional OSOPER group as secondary groups.

This type of configuration is optional but highly recommend by Oracle for organizations that need to
restrict user access to Oracle software for different administrator users, according to their areas of
responsibility. For example, a small organization could simply allocate operating system user
privileges so that one administrative user and one group for operating system authentication could be
used for all system privileges on the storage and database tiers. With this type of configuration, you
can designate the oracle user to be the sole installation owner for all Oracle software (grid
infrastructure and the Oracle Database software), and designate the group called **oinstall** to be the
single group whose members are granted all system privileges for Oracle Clusterware, Automatic
Storage Management, and all Oracle Databases on the servers, and all privileges as installation
owners.

Other organizations, however, have specialized system roles, defining who is responsible for installing
the Oracle software, such as system administrators, network administrators and storage administrators.
These different administrator users can configure a system in preparation for an Oracle grid
infrastructure for a cluster installation, and complete all configuration tasks that require operating
system root privileges. When the grid infrastructure installation and configuration is completed
successfully, a system administrator should only need to provide configuration information and to grant access to the database administrator to run scripts as root user during an Oracle RAC installation.

The following OS groups will be created:

<table>
<thead>
<tr>
<th>Description</th>
<th>OS group name</th>
<th>OS users assigned to this group</th>
<th>Oracle privilege</th>
<th>Oracle group name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle inventory and software Owner</td>
<td>oinstall</td>
<td>grid, oracle</td>
<td>SYSASM</td>
<td>OSASM</td>
</tr>
<tr>
<td>Oracle automatic storage management group</td>
<td>asmadmin</td>
<td>grid</td>
<td>SYSDBA for ASM</td>
<td>OSDBA for ASM</td>
</tr>
<tr>
<td>ASM database administrator group</td>
<td>asmdba</td>
<td>grid, oracle</td>
<td>SYSOPER for ASM</td>
<td>OSOPER for ASM</td>
</tr>
<tr>
<td>ASM operator group</td>
<td>asmoper</td>
<td>grid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Database administrator</td>
<td>dba</td>
<td>oracle</td>
<td>SYSDBA</td>
<td>OSDBA</td>
</tr>
<tr>
<td>Database operator</td>
<td>oper</td>
<td>oracle</td>
<td>SYSOPER</td>
<td>OSOPER</td>
</tr>
</tbody>
</table>

Creating groups and the user for the grid infrastructure

Create the recommended OS groups and the user for the grid infrastructure on both Oracle RAC nodes:

```
[root@racnode1 ~]# groupadd -g 1000 oinstall
[root@racnode1 ~]# groupadd -g 1200 asmadmin
[root@racnode1 ~]# groupadd -g 1201 asmdba
[root@racnode1 ~]# groupadd -g 1202 asmoper
[root@racnode1 ~]# useradd -m -u 1100 -g oinstall -G asmadmin,asmdba,asmoper -d /home/grid -s /bin/bash -c "Grid Infrastructure Owner" grid
[root@racnode1 ~]# id grid
uid=1100(grid) gid=1000(oinstall) groups=1000(oinstall),1200(asmadmin),1201(asmdba),1202(asmoper)
```

Set the password for the grid account:

```
[root@racnode1 ~]# passwd grid
Changing password for user grid.
New UNIX password: xxxxxxxxxxx
Retype new UNIX password: xxxxxxxxxxx
passwd: all authentication tokens updated successfully.
```

Create groups and the user for the Oracle Database software
Next, create the recommended OS groups and the user for the Oracle Database software on both Oracle RAC nodes:

```
[root@racnode1 ~]# groupadd -g 1300 dba
[root@racnode1 ~]# groupadd -g 1301 oper
[root@racnode1 ~]# useradd -m -u 1101 -g oinstall -G dba,oper,asmdba -d /home/oracle -s /bin/bash -c "Oracle Software Owner" oracle
[root@racnode1 ~]# id oracle
uid=1101(oracle) gid=1000(oinstall) groups=1000(oinstall),1201(asmdba),1300(dba),1301(oper)
```

Set the Password for the `oracle` user account:

```
[root@racnode1 ~]# passwd oracle
Changing password for user oracle.
New UNIX password: xxxxxxxxxxx
Retype new UNIX password: xxxxxxxxxxx
passwd: all authentication tokens updated successfully
```

**Creating the Oracle base directory path**

The final step is to configure an Oracle base path that is compliant with an Optimal Flexible Architecture (OFA) structure and has the correct permissions. In this scenario, the `/u01` directory is being created in the root file system. Note that this is being done for the sake of brevity and is not recommended as a general practice. Normally, the `/u01` directory would be provisioned as a separate file system, with either hardware or software mirroring configured.

```
[root@racnode1 ~]# mkdir -p /u01/app/grid
[root@racnode1 ~]# mkdir -p /u01/app/11.2.0/grid
[root@racnode1 ~]# chown -R grid:oinstall /u01
[root@racnode1 ~]# mkdir -p /u01/app/oracle
[root@racnode1 ~]# chown oracle:oinstall /u01/app/oracle
[root@racnode1 ~]# chmod -R 775 /u01
```

You need to perform these steps on both Oracle RAC nodes in the cluster as root.

At the end of this section, you should have the following items on both Oracle RAC nodes:

- An Oracle central inventory group, or oraInventory group (oinstall), whose members have the central inventory group as their primary group, and are granted permissions to write to the oraInventory directory.
- A separate OSASM group (asmadmin), whose members are granted the SYSASM privilege to administer Oracle Clusterware and Oracle ASM.
- A separate OSDBA for ASM group (asmdba), whose members include grid and oracle, and who are granted access to Oracle ASM.
- A separate OSOPER for ASM group (asmoper), whose members include grid, and who are granted limited Oracle ASM administrator privileges, including the permissions to start and stop the Oracle ASM instance.
An Oracle grid installation for a cluster owner (grid), with the oraInventory group as its primary group, and with the OSASM (asmadmin), OSDBA for ASM (asmdba) and OSOPER for ASM (asmoper) groups as secondary groups.

A separate OSDBA group (dba), whose members are granted the SYSDBA privilege to administer the Oracle Database.

A separate OSOPER group (oper), whose members include oracle, and who are granted limited Oracle Database administrator privileges.

An Oracle Database software owner (oracle), with the oraInventory group as its primary group, and with the OSDBA (dba), OSOPER (oper), and the OSDBA for ASM group (asmdba) as their secondary groups.

An OFA-compliant mount point /u01 owned by grid:oinstall before the installation.

An Oracle base for the grid /u01/app/grid owned by grid:oinstall with 775 permissions, and changed during the installation process to 755 permissions. The grid installation owner’s Oracle base directory is the location where Oracle ASM diagnostic and administrative log files are placed.

A Grid home /u01/app/11.2.0/grid owned by grid:oinstall with 775 (drwxdrwxr-x) permissions. These permissions are required for the installation, and are changed during the installation process to root:oinstall with 755 permissions (drwxr-xr-x).

During installation, OUI creates the Oracle Inventory directory in the path /u01/app/oraInventory. This path remains owned by grid:oinstall to enable other Oracle software owners to write to the central inventory.

An Oracle base /u01/app/oracle owned by oracle:oinstall, with 775 permissions.

5.6. Configuring the grid infrastructure user environments for the software owner

These sections explain how to configure the user environment in the Oracle grid infrastructure for the software owner.

5.6.1. Environment requirements for Oracle grid infrastructure software owner

Make the following changes to configure the environment for the Oracle grid infrastructure software owner:

1. In the shell startup file, set the installation software owner user (grid, oracle) default file mode creation mask (umask) to 022. Setting the mask to 022 ensures that the user performing the software installation creates files with 644 permissions.

2. Configure the ulimit settings for file descriptors and processes for the installation software owner (grid, oracle).

3. Set the software owner's environment variable, DISPLAY, in preparation for the Oracle grid infrastructure installation.

5.6.2. Configuring the Oracle software owner environments

To set the Oracle software owners' environments, follow these steps, for each software owner (grid, oracle):

1. If you are not already logged in as the required user, then switch to the software owner user you are configuring. For example, with the grid user:

   [root@racnode1 ~]# su - grid
2. Open the user’s shell startup file in a text editor:

   [grid@racnode1 ~]# vi .bash_profile

3. Enter or edit the following line, specifying a value of 022 for the default file mode creation mask:

   umask 022

4. If the ORACLE_SID, ORACLE_HOME, or ORACLE_BASE environment variables are set in the file, then remove these lines from the shell startup file.

5. Save the file, and exit from the text editor.

6. To run the shell startup script, enter one of the following commands (Bash shell):

   [grid@racnode1 ~] ./.bash_profile

7. If you are not installing the software on the local system, then enter a command, similar to the following, to direct X applications to display on the local system:

   [grid@racnode1 ~] DISPLAY=local_host:0.0 ; export DISPLAY

   Test X Configuration by running xterm:

   [grid@racnode1 ~]xterm &

8. If you determined that the /tmp directory has less than 1 GB of available space, then identify a file system with at least 1 GB of available space and set the TEMP and TMPDIR environment variables to specify a temporary directory on this file system:

   [grid@racnode1 ~]# su - root

   [root@racnode1 ~]# chmod 777 /tmp

   [root@racnode1 ~]# exit

   Enter commands equivalent to the following code to set the TEMP and TMPDIR environment variables:

   $ TEMP=/tmp
   $ TMPDIR=/tmp
   $ export TEMP TMPDIR

   Note: You cannot use a shared file system as the location of the temporary file directory (typically /tmp) for Oracle RAC installation. If you place /tmp on a shared file system, then the installation will fail.

9. To verify that the environment has been set up correctly, enter the following commands:

   $ umask $ env | more
Verify that the umask command displays a value of 22, 022, or 0022, and that the environment variables you set in this section have the correct values.

The same steps are applied for the oracle user.

5.6.3. Setting resource limits for the Oracle software installation users

To improve the performance of the software on Linux systems, you must increase the following resource limits for the Oracle software owner users (grid, oracle):

1. On each node, add the following lines to the /etc/security/limits.conf file

   Note: The following example shows the software account owners oracle and grid):

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

2. Repeat this procedure on all other nodes in the cluster, and for all Oracle software owners that you intend to use to install Oracle software.

3. When the limits.conf file is changed, these changes take effect immediately. However, if the grid or Oracle users are logged in, then these changes will not take effect until you log these users out and log them back in. You must do this before you attempt to use these accounts to install.

5.6.4. Preventing installation errors caused by stty commands

During an Oracle grid infrastructure installation, OUI uses secure shell (SSH) to run commands and copy files to the other nodes. During the installation, environment files on the system (for example, .bashrc or .cshrc) cause makefile and other installation errors if they contain stty commands.

To avoid this problem, you must modify these files in each Oracle installation owner user’s home directory, to suppress all output on STDERR, as shown in the following examples (Bourne, Bash, or Korn shell):

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

5.7. Using automatic SSH configuration during the installation

To install Oracle software, you have to set up SSH connectivity among all cluster member nodes. OUI uses the SSH and SCP commands during the installation to run remote commands on and copy files to the other cluster nodes. You must configure SSH so that these commands do not prompt for a
password. You can configure SSH from the Oracle Universal Installer (OUI) interface during the installation for the user account running the installation. The automatic configuration creates “passwordless” SSH connectivity (no prompting for password occurs) among all cluster member nodes. Oracle recommends that you use the automatic procedure if possible.

5.8. Disabling SELinux and Firewall

Before you begin the Oracle 11g r2 installation, you have to disable both SELinux and Firewall. You can disable them by GUI:

1. Log into the Red Hat server desktop environment (GUI).
3. When prompted for the password, enter it.
4. On the Firewall Options tab, select Disabled.
5. On the SELinux tab, select Disabled.
6. Click Apply and exit the configuration page. Both SELinux and Firewall are disabled successfully.

5.9. Installing and configuring ASMLib

Note: The installation and configuration procedures in this section should be performed on both of the Oracle RAC nodes in the cluster. Creating the ASM disks, however, only needs to be performed on a single node within the cluster (racnode1).

In this section, you install and configure ASMLib 2.0, which is a support library for the Automatic Storage Management (ASM) feature of the Oracle Database. In this scenario, use ASM as the shared file system and volume manager for Oracle Clusterware files (OCR and voting disk), Oracle Database files (data, online redo logs, control files, archived redo logs), and the Fast Recovery Area.

Automatic Storage Management simplifies database administration by eliminating the need for the DBA to directly manage thousands of potential Oracle database files, while requiring only the management of groups of disks allocated to the Oracle Database. ASM is built into the Oracle kernel and can be used for both single and clustered instances of Oracle. All of the files and directories to be used for Oracle are contained in a disk group — (or for the purpose of this scenario, three disk groups). ASM automatically performs load balancing in parallel across all available disk drives to prevent hot spots and maximize performance, even with rapidly changing data usage patterns. ASMLib provides an Oracle Database using ASM more efficient and capable access to the disk groups it is using.

Keep in mind that ASMLib is only a support library for the ASM software. The ASM software is installed as part of Oracle grid infrastructure later in this guide. Starting with Oracle grid infrastructure 11g release 2 (11.2), the Automatic Storage Management and Oracle Clusterware software is packaged together in a single binary distribution and installed into a single home directory, which is referred to as the Grid Infrastructure home. The Oracle grid infrastructure software will be owned by the user grid.

So, is ASMLib required for ASM?

Not at all. In fact, there are two different methods to configure ASM on Linux:
• **ASM with ASMLib I/O**: This method creates all Oracle Database files on raw block devices managed by ASM using ASMLib calls. RAW devices are not required with this method as ASMLib works with block devices.

• **ASM with Standard Linux I/O**: This method does not make use of ASMLib. Oracle database files are created on raw character devices, managed by ASM, using standard Linux I/O system calls. You will be required to create RAW devices for all disk partitions used by ASM.

In this paper, the "ASM with ASMLib I/O" method is used. If you would like to learn more about Oracle ASMLib 2.0, visit [www.oracle.com/technetwork/cn/topics/linux/downloads/rhel5-083144-ja.html](http://www.oracle.com/technetwork/cn/topics/linux/downloads/rhel5-083144-ja.html).

**Installing ASMLib 2.0 packages**

At this point, you need to download the ASMLib 2.0 software from Oracle ASMLib Downloads for Red Hat Enterprise Linux Server 5. The ASMLib 2.0 software stack includes the following packages:

32-bit (x86) Installations

- **ASMLib kernel driver**
  - oracleasm-x.x.x-x.el5-x.x.x-x.el5.i686.rpm - (for default kernel)
  - oracleasm-x.x.x-x.el5xen-x.x.x-x.el5.i686.rpm - (for Xen kernel)
- **Userspace library**
  - oracleasmlib-x.x.x-x.el5.i386.rpm
- **Driver support files**
  - oracleasm-support-x.x.x-x.el5.i386.rpm

64-bit (x86_64) installations

- **ASMLib kernel driver**
  - oracleasm-x.x.x-x.el5-x.x.x-x.el5.x86_64.rpm - (for default kernel)
  - oracleasm-x.x.x-x.el5xen-x.x.x-x.el5.x86_64.rpm - (for Xen kernel)
- **Userspace library**
  - oracleasmlib-x.x.x-x.el5.x86_64.rpm
- **Driver support files**
  - oracleasm-support-x.x.x-x.el5.x86_64.rpm

**Downloading Oracle ASMLib**

- oracleasm-2.6.18-194.el5-2.0.5-1.el5.x86_64.rpm
- oracleasmlib-2.0.4-1.el5.x86_64.rpm
- oracleasm-support-2.1.3-1.el5.x86_64.rpm

After downloading the ASMLib packages to both Oracle RAC nodes in the cluster, install them using the following command:

```
# rpm -ivh oracleasm-support-2.1.3-1.el5.x86_64.rpm
# rpm -ivh oracleasmlib-2.0.4-1.el5.x86_64.rpm
# rpm -ivh oracleasm-2.6.18-194.el5-2.0.5-1.el5.x86_64.rpm
```
Configuring ASMLib

Now that you have installed the ASMLib Packages for Linux, you need to configure and load the ASM kernel module. This task needs to be run on both Oracle RAC nodes as the root user account.

Enter the following command to run the oracleasm initialization script with the configure option:

```
[root@racnode1 ~]# /usr/sbin/oracleasm configure –i
```

Configuring the Oracle ASM library driver.

These settings configure the on-boot properties of the Oracle ASM library driver. The following questions determine whether the driver is loaded on boot and what permissions it will have. The current values are shown in brackets (')[']. Hitting <ENTER> without typing an answer keeps the current value. Press Ctrl-C to cancel the configuration..

```
Default user to own the driver interface []: grid
Default group to own the driver interface []: asadmin
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
```

The script completes the following tasks:

- Creates the /etc/sysconfig/oracleasm configuration file
- Creates the /dev/oracleasm mount point
- Mounts the ASMLib driver file system

Note: The ASMLib driver file system is not a regular file system. It is used only by the Automatic Storage Management library to communicate with the Automatic Storage Management driver.

Enter the following command to load the oracleasm kernel module:

```
[root@racnode1 ~]# /usr/sbin/oracleasm init
Creating /dev/oracleasm mount point: /dev/oracleasm
Loading module "oracleasm": oracleasm
Mounting ASMlib driver filesystem: /dev/oracleasm
```

Repeat this procedure on each node in the cluster (racnode2) on which you plan to install Oracle RAC.

Configuring ASMLIB for multipath disks

Oracle ASM requires that each disk is uniquely identified. If the same disk appears under multiple paths, then errors will be produced.

Most system software is unaware of multipath configurations. They can use any paths. ASMLIB also is unaware of multipath configurations. By default, ASMLIB recognizes the first disk path that Linux reports to it. But, because it imprints an identity on that disk, it recognizes that disk only under one path. Depending on your storage driver, it might recognize the multipath disk, or it might recognize one of the single disk paths. Instead of relying on the default setting, you should configure Oracle ASM to recognize the multipath disk.
The ASMLIB configuration file is located in the path /etc/sysconfig/oracleasm. It contains all of the startup configuration information that you specified with the command /etc/init.d/oracleasm configure. That command cannot configure scan ordering. The configuration file contains many configuration variables. The ORACLEASM_SCANORDER variable specifies disks to be scanned first. ORACLEASM_SCANEXCLUDE variable specifies the disks that are to be ignored.

The configuration file should be modified according to the following contents:

```
[grid@racnode1 ~]$ more /etc/sysconfig/oracleasm
#
# This is a configuration file for automatic loading of the Oracle
# Automatic Storage Management library kernel driver. It is generated
# By running /etc/init.d/oracleasm configure. Please use that method
# to modify this file
#
# ORACLEASM_ENABLED: 'true' means to load the driver on boot.
ORACLEASM_ENABLED=true

# ORACLEASM_UID: Default user owning the /dev/oracleasm mount point.
ORACLEASM_UID=grid

# ORACLEASM_GID: Default group owning the /dev/oracleasm mount point.
ORACLEASM_GID=asmadmin

# ORACLEASM_SCANBOOT: 'true' means scan for ASM disks on boot.
ORACLEASM_SCANBOOT=true

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

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

In this scenario, there are three multi-path disks for ASM groups, included /dev/mapper/mpath1, /dev/mapper/mpath2, /dev/mapper/mpath3.

**Creating ASM disks for Oracle**

Creating the ASM disks only needs to be performed from one node in the RAC cluster, as the root user account. Run these commands on racnode1. On the other Oracle RAC node or nodes, you need to perform invoke scandisk to recognize the new volumes. When that is complete, you should then run the oracleasm listdisks command on both Oracle RAC nodes to verify that all ASM disks were created and available.

To create the ASM disks type the following command:

```
[root@racnode1 qpan_sw]# oracleasm createdisk CRSVOL1 /dev/mapper/mpath1
Writing disk header: done
Instantiating disk: done

[root@racnode1 qpan_sw]# oracleasm createdisk DATAVOL1 /dev/mapper/mpath2
```

© Copyright, IBM Corporation 2010, all rights reserved
Writing disk header: done
Instantiating disk: done

[root@racnode1 qpan_sw]# oracleasm createdisk FRAVOL1 /dev/mapper/mpath3
Writing disk header: done
Instantiating disk: done

[root@racnode1 qpan_sw]# oracleasm listdisks
CRSVOL1
DATAVOL1
FRAVOL1

To make the disk available on the other nodes in the cluster (racnode2), enter the following command as root on each node:

[root@racnode2 ASMlib]# /usr/sbin/oracleasm scandisks
Reloading disk partitions: done
Cleaning any stale ASM disks...
Scanning system for ASM disks...
Instantiating disk "CRSVOL1"
Instantiating disk "DATAVOL1"
Instantiating disk "FRAVOL1"

You can now test that the ASM disks were successfully created by using the following command on both nodes in the RAC cluster as the root user account. This command identifies shared disks attached to the node that are marked as Automatic Storage Management disks:

[root@racnode1 ~]# /usr/sbin/oracleasm listdisks
CRSVOL1
DATAVOL1
FRAVOL1

[root@racnode2 ~]# /usr/sbin/oracleasm listdisks
CRSVOL1
DATAVOL1
FRAVOL1
6. Installing the Oracle grid infrastructure for a cluster

The following sections explain how to install the Oracle grid infrastructure in a cluster environment.

6.1. Installing the Oracle grid infrastructure

Perform the following installation procedures from only one of the Oracle RAC nodes in the cluster (racnode1). The Oracle grid infrastructure software (Oracle Clusterware and Automatic Storage Management) will be installed on both Oracle RAC nodes in the cluster by the Oracle Universal Installer.

We are now ready to install the "grid" part of the environment — Oracle Clusterware and Automatic Storage Management. Complete the following steps to install Oracle grid infrastructure on your cluster.

At any time during installation, if you have a question about what you are being asked to do, click the Help button on the OUI page.

Perform the following tasks as the grid user to install the Oracle grid infrastructure:

To run “runInstaller” to start the grid installation process:

Select Installation Option: Select Install and Configure Grid Infrastructure for a Cluster
Select Installation Type: Select Advanced Installation
Select Product Languages: Make the appropriate selections for your environment.

Grid Plug and Play Information

1. Provide the information for Cluster Name, SCAN Name and SCAN port.
2. Clear Configure GNS.
3. Click Next. The OUI attempts to validate the SCAN information:
   1. Use this panel to add the node racnode2 to the cluster and to configure SSH connectivity.
   2. Click Add to add racnode2 and its virtual IP address racnode2-vip
   3. Next, click SSH Connectivity.
   4. Enter the OS Password for the grid user and click Setup. The SSH Connectivity configuration process starts.
   5. After the SSH configuration process has completed successfully, acknowledge the dialog box.
   6. To verify passwordless SSH connectivity, click Test.

Cluster Node Information

Specify Network Interface Usage: Identify the network interface to be used for the "Public" and "Private" network.

Storage Option Information

Select Automatic Storage Management.

1. Under Disk Group Name, type CRS and Select External Redundancy.
2. In candidate disks lists, select ORCL:CRSVOL1 as a disk of the ASM disk group, which is created in "5.9 Install and Configure ASMLib."

ASM Password

Select Use same passwords for these accounts and input the password.
Failure Isolation

Configuring Intelligent Platform Management Interface (IPMI) is beyond the scope of this article. Select **Do not use Intelligent Platform Management Interface (IPMI)**.

This scenario makes use of role-based administrative privileges and high granularity in specifying Automatic Storage Management roles using a Job Role Separation configuration.

Operating System Groups

Make any changes necessary to match the values in the table below:

- **OSDBA Group**: asmdba
- **OSOPER Group**: asmoper
- **OSASM Group**: asmadmin

Set the **Oracle Base** ($ORACLE_BASE) and **Software Location** ($ORACLE_HOME) for the Oracle grid infrastructure installation:

- **Oracle Base**: /u01/app/grid
- **Software Location**: /u01/app/11.2.0/grid

Because this is the first installation on the host, you need to create the Oracle Inventory. Use the default values provided by the OUI:

- **Inventory Directory**: /u01/app/oraInventory
- **oraInventory Group Name**: oinstall

Create Inventory

The installer runs through a series of checks to determine if both Oracle RAC nodes meet the minimum requirements for installing and configuring the Oracle Clusterware and Automatic Storage Management software.

From Oracle Clusterware 11g release 2 (11.2), if any checks fail, the installer (OUI) creates shell script programs, called **fixup scripts**, to resolve many incomplete system configuration requirements. If OUI detects an incomplete task that is marked "fixable," then you can easily fix the issue by generating the fixup script by clicking **Fix & Check Again**.

The fixup script is generated during installation. You are prompted to run the script as root in a separate terminal session. When you run the script, it raises kernel values to required minimums, if necessary, and completes other operating system configuration tasks.

If all prerequisite checks pass (as was the case for our testing), the OUI continues to the Summary panel.

Prerequisite Checks

Summary

Click **Finish** to start the installation.

Setup

The installer performs the Oracle grid infrastructure setup process on both of the Oracle RAC nodes.

After the installation has completed, you are prompted to run the /u01/app/oraInventory/orainstRoot.sh and /u01/app/11.2.0/grid/root.sh scripts. Open a new console window on both Oracle RAC nodes in the cluster, (starting with the node that you are performing the install from), as the root user account.

Run the orainstRoot.sh script on both nodes in the RAC cluster:

```
root@racnode1 ~# /u01/app/oraInventory/orainstRoot.sh
root@racnode2 ~# /u01/app/oraInventory/orainstRoot.sh
```

Within the same new console window on both Oracle RAC nodes in the cluster, (starting with the node you are performing the install from), stay logged in as the root user. Run the root.sh script on both nodes in the RAC cluster one at a time starting with the node you are performing the install from:

```
root@racnode1 ~# /u01/app/11.2.0/grid/root.sh
```
root@racnode2 ~# /u01/app/11.2.0/grid/root.sh
The root.sh script can take several minutes to run. When running root.sh on the last node, you will receive output similar to the following which signifies a successful install: ...
The inventory pointer is located at /etc/oraInst.loc
The inventory is located at /u01/app/oraInventory'UpdateNodeList' was successful. Go back to OUI and acknowledge the "Execute Configuration scripts" dialog window.

Finish
At the end of the installation, click Close to exit the OUI.

6.2. Performing post-installation tasks for Oracle grid infrastructure for a cluster

Note: Perform the following post-installation procedures on both Oracle RAC nodes in the cluster.

- Verify the Oracle Clusterware installation

After the installation of Oracle grid infrastructure, you should run through several tests to verify that the installation was successful. Run the following commands on both nodes in the RAC cluster as the grid user.

- Check the CRS status:

  [grid@racnode1 ~]$ crsctl check crs
  CRS-4638: Oracle High Availability Services is online
  CRS-4537: Cluster Ready Services is online
  CRS-4529: Cluster Synchronization Services is online
  CRS-4533: Event Manager is online

- Check the Oracle Clusterware resources:

  Note: The crs_stat command is deprecated in Oracle Clusterware 11g release 2 (11.2).

  [grid@racnode1 bin]$ ./crs_stat -t -v

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>R/RA</th>
<th>F/FT</th>
<th>Target</th>
<th>State</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td>ora....ER.lsnr</td>
<td>ora....er.type</td>
<td>0/5</td>
<td>0/</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
</tr>
<tr>
<td>ora....N1.lsnr</td>
<td>ora....er.type</td>
<td>0/5</td>
<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode1</td>
</tr>
<tr>
<td>ora....SM2.asm</td>
<td>application</td>
<td>0/5</td>
<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td>racnode2</td>
</tr>
<tr>
<td>ora....E2.lsnr</td>
<td>application</td>
<td>0/5</td>
<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
</tr>
<tr>
<td>ora....de2.gsd</td>
<td>application</td>
<td>0/5</td>
<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td></td>
</tr>
<tr>
<td>ora....de2.ons</td>
<td>application</td>
<td>0/3</td>
<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora....de2.vip</td>
<td>ora....t1.type</td>
<td>0/0</td>
<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora....SM1.asm</td>
<td>application</td>
<td>0/5</td>
<td>0/0</td>
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<td>OFFLINE</td>
<td></td>
</tr>
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<td>ora....E1.lsnr</td>
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<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora....del.gsd</td>
<td>application</td>
<td>0/5</td>
<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td></td>
</tr>
<tr>
<td>ora....del.ons</td>
<td>application</td>
<td>0/3</td>
<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora....del.vip</td>
<td>ora....t1.type</td>
<td>0/0</td>
<td>0/0</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora.asm</td>
<td>ora.asm.type</td>
<td>0/5</td>
<td>0/</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td></td>
</tr>
<tr>
<td>ora.eons</td>
<td>ora.eons.type</td>
<td>0/3</td>
<td>0/</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora.gsd</td>
<td>ora.gsd.type</td>
<td>0/5</td>
<td>0/</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td></td>
</tr>
<tr>
<td>ora....network</td>
<td>ora....rk.type</td>
<td>0/5</td>
<td>0/</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
<tr>
<td>ora.oc4j</td>
<td>ora.oc4j.type</td>
<td>0/5</td>
<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td></td>
</tr>
<tr>
<td>ora.ons</td>
<td>ora.ons.type</td>
<td>0/3</td>
<td>0/</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td></td>
</tr>
</tbody>
</table>

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• Check the cluster nodes:

```
[grid@racnode1 /]# /u01/app/11.2.0/grid/bin/olsnodes -n
racnode1  1
racnode2  2
```

• Check the Oracle TNS listener process on both nodes:

```
[grid@racnode1 ~]$ ps -ef | grep lsnr | grep -v 'grep' | grep -v 'ocfs' | awk '{print $9}'
LISTENER_SCAN1
LISTENER
[grid@racnode2 ~]$ ps -ef | grep lsnr | grep -v 'grep' | grep -v 'ocfs' | awk '{print $9}'
LISTENER
```

• Check the Oracle Cluster Registry (OCR):

```
[grid@racnode1 /]# /u01/app/11.2.0/grid/bin/ocrcheck
Status of Oracle Cluster Registry is as follows:
Version : 3
Total space (kbytes) : 262120
Used space (kbytes) : 2700
Available space (kbytes) : 259420
ID : 2112126892
Device/File Name : /u02/storage/ocr
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 succeeded
```

• Check the voting disk:

```
[grid@racnode1 /]# /u01/app/11.2.0/grid/bin/crsctl query css votedisk
##  STATE    File Universal Id                File Name Disk group
-  -    ---                --- ----
1. ONLINE   2eddccd3ae574f85bfe06adf71d47e9d (/u02/storage/vdsk)
```
7. Installing Oracle Database 11g with Oracle Real Application Clusters

The following sections explain how to install Oracle Database 11g with Oracle Real application clusters.

7.1. Creating ASM disk groups for the data and fast recovery area

Run the ASM Configuration Assistant (asmca) as grid user from just one node in the cluster (racnode1) to create the ASM disk groups that are used to create the clustered database. In this section, create two ASM disk groups using the asmca. These new ASM disk groups will be used later in this guide when creating the clustered database.

The first ASM disk group is named +RACDB_DATA and is used to store all Oracle physical database files (data, online redo logs, control files, archived redo logs). A second ASM disk group is created for the Fast Recovery Area named +FRA.

Before starting the asmca, log in to racnode1 as the owner of the Oracle grid infrastructure software, which for this scenario is grid. Next, if you are using a remote client to connect to the Oracle RAC node that is performing the installation (SSH or Telnet to racnode1 from a workstation configured with an X Server), verify your X11 display server settings.

Creating additional ASM disk groups using asmca

Perform the following tasks as the grid user to create two additional ASM disk groups:

```
[grid@racnode1 ~]$ asmca &
```

<table>
<thead>
<tr>
<th>Screen name</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk Groups</td>
<td>From the Disk Groups tab, click Create.</td>
</tr>
<tr>
<td>Create Disk Group</td>
<td>The Create Disk Group dialog should show two of the ASMLib volumes we created earlier in this guide.</td>
</tr>
</tbody>
</table>
| | 1. If the ASMLib volumes you created earlier in this scenario do not show up in the Select Member Disks window as eligible (ORCL:DATAVOL1 and ORCL:FRAVOL1), click Change Disk Discovery Path and type ORCL:*.
| | 2. When creating the "Data" ASM disk group, for the Disk Group Name, use RACDB_DATA.
| | 3. In the Redundancy section, select External (none).
| | 4. In the Select Member Disks section, check the ASMLib volume ORCL:DATAVOL1.
| | 5. After verifying that all values in this dialog are correct, click the OK. |
| Disk Groups | After creating the first ASM disk group, you are returned to the initial dialog. Click Create again to create the second ASM disk group. |
| Create Disk Group | The Create Disk Group dialog should now show the final remaining ASMLib volume. |
| | When creating the Fast Recovery Area disk group, for Disk Group Name, use FRA. In the Redundancy section, select External (none).
| | Finally, in the Select Member Disks" section, check the ASMLib volume ORCL:FRAVOL1 After verifying that all values in this dialog are correct, click |
Disk Groups To exit the ASM Configuration Assistant, click Exit.

7.2. Install Oracle Database 11g with Oracle Real Application Clusters

Note: Perform the Oracle Database software installation from only one of the Oracle RAC nodes in the cluster (racnode1)! The Oracle Database software is installed to both of the Oracle RAC nodes in the cluster by the Oracle Universal Installer, using SSH.

Now that the grid infrastructure software is functional, you can install the Oracle Database software on one node in your cluster (racnode1) as the oracle user. OUI copies the binary files from this node to all other nodes in the cluster during the installation process.

In this scenario, ignore the Create Database option when installing the Oracle Database software. The clustered database will be created later in scenario, using the Database Configuration Assistant (DBCA) after all installations have been completed.

Verifying the terminal shell environment

Before starting the Oracle Universal Installer (OUI), log in to racnode1 as the owner of the Oracle Database software, which, for this scenario, is oracle. Next, if you are using a remote client to connect to the Oracle RAC node performing the installation (SSH or Telnet to racnode1 from a workstation configured with an X Server), verify your X11 display server settings.

Installing Oracle Database 11g Release 2 software

Perform the following tasks as the oracle user to install the Oracle Database software:

```bash
[oracle@racnode1 ~]$ DISPLAY=<your local workstation>:0.0
[oracle@racnode1 ~]$ export DISPLAY
[oracle@racnode1 ~]$ cd /home/oracle/software/oracle/database
[oracle@racnode1 database]$ ./runInstaller
```

<table>
<thead>
<tr>
<th>Screen name</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configure Security Updates</td>
<td>For the purposes of this scenario, clear the security updates check box and click Next to continue. Acknowledge the warning dialog indicating you have not provided an e-mail address by clicking Yes.</td>
</tr>
<tr>
<td>Installation Option</td>
<td>Select Install database software only.</td>
</tr>
<tr>
<td>Grid Options</td>
<td>1. Select Real Application Clusters database installation (default) and verify that both Oracle RAC nodes are checked in the Node Name window.</td>
</tr>
<tr>
<td></td>
<td>2. Next, click SSH Connectivity.</td>
</tr>
<tr>
<td></td>
<td>3. For the oracle user, enter the OS Password and click Setup to start the SSH Connectivity configuration process. After the SSH configuration process has successfully completed, acknowledge the dialog box.</td>
</tr>
<tr>
<td></td>
<td>4. To verify passwordless SSH connectivity, click Test.</td>
</tr>
<tr>
<td>Product Languages</td>
<td>Make the appropriate selections for your environment.</td>
</tr>
</tbody>
</table>
**Database Edition**  Select **Enterprise Edition**.

Specify the Oracle base and software location (Oracle_home) as follows:

**Installation Location**  
- **Oracle Base**: /u01/app/oracle
- **Software Location**: /u01/app/oracle/product/11.2.0/dbhome_1

**Operating System**

Select the OS groups to be used for the SYSDBA and SYSOPER privileges:
- Database Administrator (OSDBA) Group: dba
- Database Operator (OSOPER) Group: oper

The installer runs through a series of checks to determine if both Oracle RAC nodes meet the minimum requirements for installing and configuring the Oracle Database software.

From Oracle RAC 11g release 2 (11.2), if any checks fail, the installer (OUI) creates shell script programs, called **fixup scripts**, to resolve many incomplete system configuration requirements. If OUI detects an incomplete task that is marked "fixable," then these issues can be easily fixed by generating the fixup script by clicking **Fix & Check Again**.

The fixup script is generated during installation. You are prompted to run the script as root in a separate terminal session. When you run the script, it raises kernel values to required minimums, if necessary, and completes other operating system configuration tasks.

If all prerequisite checks pass (as was the case for our installation), the OUI continues to the Summary screen.

**Summary**

To start the installation, click **Finish**.

**Install Product**

The installer performs the Oracle Database software installation process on each Oracle RAC node.

After the installation has completed, you are prompted to run the /u01/app/oracle/product/11.2.0/dbhome_1/root.sh script on both Oracle RAC nodes. Open a new console window on both Oracle RAC nodes in the cluster, (starting with the node you are performing the installation from), as the root user.

**Execute Configuration scripts**

Run the root.sh script on all nodes in the RAC cluster:

```
[root@racnode1 ~]# /u01/app/oracle/product/11.2.0/dbhome_1/root.sh
[root@racnode2 ~]# /u01/app/oracle/product/11.2.0/dbhome_1/root.sh
```

Go back to OUI and acknowledge the Execute Configuration scripts dialog window.

**Finish**

To exit the OUI, click **Close**.

### 7.3. Creating the Oracle Cluster database

**Note**: The database creation process should only be performed from one of the Oracle RAC nodes in the cluster (racnode1).

Use the Oracle **Database Configuration Assistant** (DBCA) to create the clustered database.

Before running the DBCA, make certain that the $ORACLE_HOME and $PATH are set appropriately for the $ORACLE_BASE/product/11.2.0/dbhome_1 environment.
You should also verify that all services you have installed up to this point (Oracle TNS listener, Oracle Clusterware processes, and so on) are running before attempting to start the clustered database creation process:

```
[root@racnode1 /]# /u01/app/11.2.0/grid/bin/crs_stat -t -v
Name           Type           R/RA   F/FT   Target    State     Host
--------------------------------------------------- -------------------
ora.FRA.dg     ora....up.type 0/5    0/     ONLINE    ONLINE    racnode2
ora....ER.lsnr ora....er.type 0/5    0/     ONLINE    ONLINE    racnode2
ora....N1.lsnr ora....er.type 0/5    0/0    ONLINE    ONLINE    racnode2
ora....DATA.dg ora....up.type 0/5    0/     ONLINE    ONLINE    racnode2
ora....SM2.asm application 0/5    0/0    ONLINE    ONLINE    racnode2
ora.... E2.lsnr
application    0/5    0/0    ONLINE    ONLINE    racnode2
ora....de2.gsd application 0/5    0/0    OFFLINE    OFFLINE
ora....de2.ons application 0/3    0/0    ONLINE    ONLINE    racnode2
ora....de2.vip ora....t1.type 0/0    0/0    ONLINE    ONLINE    racnode2
ora....SM1.asm application 0/5    0/0    ONLINE    ONLINE    racnode1
ora....E1.lsnr application 0/5    0/0    ONLINE    ONLINE    racnode1
ora....del.gsd application 0/5    0/0    OFFLINE    OFFLINE
ora....del.ons application 0/3    0/0    ONLINE    ONLINE    racnode1
ora....del.vip ora....t1.type 0/0    0/0    ONLINE    ONLINE    racnode1
ora.asm        ora.asm.type   0/5    0/     ONLINE    ONLINE    racnode2
ora.eons       ora.eons.type  0/3    0/     ONLINE    ONLINE    racnode2
ora.gsd        ora.gsd.type   0/5    0/     OFFLINE    OFFLINE
ora....network ora....rk.type 0/5    0/     ONLINE    ONLINE    racnode2
ora.oc4j       ora.oc4j.type  0/5    0/0    OFFLINE    OFFLINE
ora.ons        ora.ons.type   0/3    0/     ONLINE    ONLINE    racnode2
ora....ry.acfs ora....fs.type 0/5    0/     ONLINE    ONLINE    racnode2
ora.scan1.vip  ora....ip.type 0/0    0/0    ONLINE    ONLINE    racnode2
```

To start the database creation process, run the following as the oracle user:

```
oracle@racnode1 ~$ dbca
```

Welcome Screen
Select Oracle Real Application Clusters database

Operations
Select Create a Database.

Database Templates
Select Custom Database.

Cluster database configuration.
Configuration Type: Admin-Managed
Global Database Name: racdb.rhel5.info
SID Prefix: racdb

Database Identification
Note: This scenario uses rhel5.info for the database domain. You can use any database domain. Keep in mind that this domain does not have to be a valid DNS domain.
Node Selection.
Click Select All to select all servers: racnode1 and racnode2.

Management Options
Accept default options, here, which are to Configure Enterprise Manager / Configure Database Control for local management.

Database Credentials
Select Use the Same Administrative Password for All Accounts. Enter
the password (twice) and make sure that the password does not start with a numeric character. Specify storage type and locations for database files.

**Database File Locations**
- **Storage Type**: Automatic Storage Management (ASM)
- **Storage Locations**: Use Oracle-Managed Files
- **Database Area**: +RACDB_DATA

**Specify ASMSNMP Password**
Specify the ASMSNMP password for the ASM instance

**Recovery Configuration**
Check the option for **Specify Fast Recovery Area**. For the Fast Recovery Area, click **Browse** and select the disk group name **+FRA**.

**Database Content**
All of the Database Components (and destination tablespaces) are left at their default values, although you could select **Sample Schemas**. This option is available because you installed the Oracle Database 11g examples.

**Initialization Parameters**
Change any parameters for your environment. In the scenario, all were left at their default settings.

**Database Storage**
Change any parameters for your environment. In the scenario, all were left at their default settings.

1. Ensure that the default option **Create Database** and **Generate Database Creation Scripts** are selected.
2. To initiate the database creation process, click **Finish**.
3. After acknowledging the database creation report and script generation dialog, the database creation starts. On the Summary screen, click **OK**.

**Creation Options**
1. Ensure that the default option **Create Database** and **Generate Database Creation Scripts** are selected.
2. To initiate the database creation process, click **Finish**.
3. After acknowledging the database creation report and script generation dialog, the database creation starts. On the Summary screen, click **OK**.

**End of Database Creation**
At the end of the database creation, exit from the DBCA.

When the DBCA has completed, a fully functional Oracle RAC cluster should be running. Verify that the clustered database is open:

```
root@racnode1# /u01/app/11.2.0/grid/bin/crsctl status resource -w "TYPE co 'ora'' -t
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>TARGET</th>
<th>STATE</th>
<th>SERVER</th>
<th>STATE_DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ora.CRS.dg</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
<td></td>
</tr>
<tr>
<td>ora.FRA.dg</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
<td></td>
</tr>
<tr>
<td>ora.LISTENER.lsnr</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
<td></td>
</tr>
<tr>
<td>ora.RACDB_DATA.dg</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
<td></td>
</tr>
<tr>
<td>ora.asm</td>
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<td>ONLINE</td>
<td>racnode1</td>
<td>Started</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
<td>Started</td>
</tr>
<tr>
<td>ora.eons</td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>ONLINE</td>
<td>racnode2</td>
<td></td>
</tr>
</tbody>
</table>
```
<table>
<thead>
<tr>
<th>Resource</th>
<th>State</th>
<th>Node 1</th>
<th>Node 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ora.gsd</td>
<td>OFFLINE</td>
<td>racnode1</td>
<td>racnode2</td>
</tr>
<tr>
<td>ora.net1.network</td>
<td>OFFLINE</td>
<td>racnode1</td>
<td>racnode2</td>
</tr>
<tr>
<td>ora.ons</td>
<td>ONLINE</td>
<td>racnode1</td>
<td>racnode2</td>
</tr>
<tr>
<td>ora.registry.acfs</td>
<td>ONLINE</td>
<td>racnode1</td>
<td>racnode2</td>
</tr>
</tbody>
</table>

------------------- ---------------------
Cluster Resources
------------------- ---------------------
<table>
<thead>
<tr>
<th>Resource</th>
<th>State</th>
<th>Node 1</th>
<th>Node 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ora.LISTENER_SCAN1.lsnr</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td>ora.racnode2.vip</td>
<td>ONLINE</td>
<td>racnode2</td>
<td></td>
</tr>
<tr>
<td>ora.racnode1.vip</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td>ora.oc4j</td>
<td>OFFLINE</td>
<td>racnode1</td>
<td></td>
</tr>
<tr>
<td>ora.racdb.db</td>
<td>ONLINE</td>
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<td>Open</td>
</tr>
<tr>
<td></td>
<td>ONLINE</td>
<td>racnode2</td>
<td>Open</td>
</tr>
<tr>
<td>ora.scan1.vip</td>
<td>ONLINE</td>
<td>racnode1</td>
<td></td>
</tr>
</tbody>
</table>
8. Deployment recommendations

The following sections provide you with recommendations for deploying Storwize V7000.

8.1. SAN consideration

A minimum of two fabrics are recommended to provide a redundant storage area network (SAN) configuration for IBM Storwize V7000 and its associated hosts and any external storage systems. In each fabric, a cluster zone has to be created from only IBM Storwize V7000 worldwide port names (WWPNs), two from each node canister. Other zones, so called storage zones, might also be created in case that external storage systems are to be attached to IBM Storwize V7000. In this situation, each fabric storage zone will include two ports from each Storwize V7000 node canister, along with up to a maximum of eight WWPNs from the external storage system.

The IBM Storwize V7000 host zones allow hosts to access the storage. In a best practice deployment, the following recommendations are worth considering:

- Single HBA port zoning: Each host zone contains only one initiator, and exactly one port from each IBM Storwize V7000 node canister.
- Balanced host load across HBA ports: Each host port should be zoned with a different group of IBM Storwize V7000 ports for best performance
- Balanced host load across storage ports: Typically, approximately the same number of host ports to each IBM Storwize V7000 port should guarantee an equal workload;
- Maximum host paths per LUN: For any given volume assigned to a host, the number of paths must not exceed 8, whereas 4 paths are recommended.

Figure 35 shows an overview of the recommended SAN architecture.
8.2. IBM Storwize V7000 best practices

8.2.1. Planning ahead

Though IBM Storwize V7000 aims to avoid the complexity in deployment and administrator, to make ideal use of Storwize V7000 in terms of performance and scalability, it is necessary for storage and database administrators to prepare well. Typically, following a standard installation of IBM Storwize V7000, some additional steps are recommended, to achieve a best-practices deployment.

For example, document the number of hosts (application servers) that are required to attach to Storwize V7000, the traffic profile activity (read, write, sequential or random), and the performance requirements (for example, peak IOPS - I/Os per second).

It is important to predict the application workload and performance requirements before starting the deployment. IBM recommends Disk Magic as the storage performance modeling tool for wide purposes. Disk Magic supports disk subsystems from multiple vendors, but it offers the most detailed support for IBM subsystems.
Disk Magic is a tool used by IBM and IBM Business Partners to model disk storage subsystem performance. Contact your IBM Representative or IBM Business Partner to discuss a Disk Magic study.

8.2.2. Volume mirroring

IBM Storwize V7000 provides volume mirroring functionality, to create a volume with two copies on two different physical storage systems. Each copy is identical. This feature guarantees high availability characteristics, since host applications are insulated from failures experienced in internal drive enclosures’ physical disks, or even an entire disk controller system.

When a server writes to a mirrored volume, the cluster writes the data to both copies. When a server reads a mirrored volume, the cluster picks one of the copies to read. If one of the mirrored volume copies is temporarily unavailable; for example, because the storage system that provides the storage pool is unavailable, IBM Storwize V7000 will automatically take the alternative copy, to serve the host system. Thus, there is no outage for the application, for example, Oracle Database. The cluster remembers which areas of the volume are written and resynchronizes these areas when both copies are available. You can convert a non-mirrored volume into a mirrored volume by adding a copy. When a copy is added in this way, the Storwize V7000 cluster synchronizes the new copy so that it is a replica of the existing volume. Servers are still able to access the volume during the synchronization process.

The volume copies can be of completely different structure: image, striped, sequential, and space-efficient, which provides a high flexibility for data migration. Anything that can be done today with a volume can be done with a mirrored volume including migration, expand/shrink and so on.

Using mirrored volumes can assist with volume migration between storage pools that have different extent sizes, and can provide a mechanism to migrate fully allocated volumes to thin-provisioned volumes, without any disk outages.

Mirrored volumes can be used to meet the following requirements:

• Improving availability of volumes by protecting them from a single storage system failure.
• Providing concurrent maintenance of a storage system that does not support concurrent maintenance natively.
• Providing an alternative method of data migration with better availability characteristics.

While a volume is being migrated using the data migration feature, it is vulnerable to failures on both the source and target storage pool. Volume mirroring provides a safe alternative, because it is possible to start with a non-mirrored volume in the source storage pool, and then add a copy to that volume in the destination storage pool. After the volume is synchronized, the original source storage pool copy may be deleted. During the synchronization process, the volume remains available, even if there is a problem with the destination storage pool.

Note that Volume Mirroring should be implemented between disks with similar response times. Otherwise, the slowest disks slow down the overall volume response times.

For an example of this process, go to “4.2.4 Create volumes for Oracle Cluster files and RAC files on Storwize V7000”.

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The mirrored volume “Ora_ASM_CRS” has two copies, located on MdiskGrp_Internal Pool and DS8K3650Grp_External Pool, respectively. In order to verify the mirror function, we set one pool (for example, DS8K3650Grp_External Pool) to offline state. As soon as DS8K3650Grp_External Pool is offline, it is expected that only one copy of volume “Ora_ASM_CRS” continues to support Oracle CRS with no any effect.

The following steps describe the process in detail.

1. Check the status of the mirrored volume “Ora_ASM_CRS”, and both “Copy 0” and “Copy 1” of this volume are online (Figure 36).

![Figure 36. The Mirrored Volume “Ora_ASM_CRS” with Two Online Copies](image)

2. Check the Oracle CRS status:

```
[root@racnode1 ~]# crsctl check crs
CRS-4638: Oracle High Availability Services is online
CRS-4537: Cluster Ready Services is online
CRS-4529: Cluster Synchronization Services is online
CRS-4533: Event Manager is online
[grid@racnode1 ~]$ crs_stat -t -v
Name           Type           R/RA   F/FT   Target    State     Host
--------------------------------------------------- ------------------
ora.CRS.dg     ora....up.type 0/5    0/     ONLINE    ONLINE    racnode1
ora....ER.lsnr ora....er.type 0/5    0/     ONLINE    ONLINE    racnode1
ora....N1.lsnr ora....er.type 0/5    0/0    ONLINE    ONLINE    racnode1
```

To simulate the backend external storage offline, we can remove the fabric zones between DS8000 and Storwize V7000. Then the Storwize V7000 system will not see the DS8000 devices, and all MDisks of the DS8K3650Grp_External Pool are offline, as Figure 37 shows.

![Figure 37. DS8K3650Grp_External is offline](image)

4. Check the mirrored volume “Ora_ASM_CRS” status, one copy “Copy 1” located DS8K3650Grp_External Pool becomes offline (Figure 38).
5. Then check the Oracle CRS status again:

```
[root@racnode1 ~]# crsctl check crs
CRS-4638: Oracle High Availability Services is online
CRS-4537: Cluster Ready Services is online
CRS-4529: Cluster Synchronization Services is online
CRS-4533: Event Manager is online
[grid@racnode1 ~]$ crs_stat -t -v
```

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>R/RA</th>
<th>F/FT</th>
<th>Target</th>
<th>State</th>
<th>Host</th>
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<tr>
<td>ora.CRS.dg</td>
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<td>ONLINE</td>
<td>racnode1</td>
</tr>
<tr>
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<td>ora....er.type</td>
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<td>racnode1</td>
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<td>ONLINE</td>
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<tr>
<td>ora.asm</td>
<td>ora.asm.type</td>
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<td>ONLINE</td>
<td>racnode1</td>
</tr>
<tr>
<td>ora.eons</td>
<td>ora.eons.type</td>
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<td>0/0</td>
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<td>ONLINE</td>
<td>racnode1</td>
</tr>
<tr>
<td>ora.gsd</td>
<td>ora.gsd.type</td>
<td>0/5</td>
<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td>racnode1</td>
</tr>
<tr>
<td>ora....network</td>
<td>ora....rk.type</td>
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<td>0/0</td>
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<td>racnode1</td>
</tr>
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<td>ora.oc4j.type</td>
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<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td></td>
</tr>
<tr>
<td>ora.ons</td>
<td>ora.ons.type</td>
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<td>0/0</td>
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<td>racnode1</td>
</tr>
<tr>
<td>ora....SM1.asm</td>
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<td>0/0</td>
<td>ONLINE</td>
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<tr>
<td>ora....E1.lsnr</td>
<td>application</td>
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<td>0/0</td>
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<td>racnode1</td>
</tr>
<tr>
<td>ora....del.gsd</td>
<td>application</td>
<td>0/5</td>
<td>0/0</td>
<td>OFFLINE</td>
<td>OFFLINE</td>
<td>racnode1</td>
</tr>
</tbody>
</table>
The test demonstrates that IBM Storwize V7000 automatically takes the alternative copy to serve as the host system, and thus, there is no outage for the application when one Storage Pool becomes unavailable. This test demonstrates delivery of high availability.

### 8.2.3. Easy Tier

It is well-known that database applications require more spindles to deliver I/O performance. Solid state drives (SSDs) support very high levels of random I/O with low latency. SSDs can bring direct benefits to database environments by improving responsiveness for different workloads, and also improving database recovery performance. However, solid-state storage implementations are considerably more expensive than traditional disks per unit capacity. Without appropriate assistance from optimization tools, clients have been over-provisioning SSD to realize their benefits. They face the challenges of where and how much capacity to deploy. Storage administrators also spend considerable time monitoring, reporting, and tuning tiers.

The IBM System Storage Easy Tier™ feature offered with Storwize V7000 enables clients to deploy solid-state storage confidently, effectively and economically. This is achieved, automatically, based on workload and performance trends, by dynamically moving only appropriate data to SSDs. Easy Tier automates the granular movement of data to the right drive tier, so clients need not worry about over-provisioning these expensive drives, unnecessarily. Such effective storage tiering can help clients enjoy the performance benefits of SSDs without the need for administrators to create and manage storage tier policies. Easy Tier also eliminates the costs associated with placing too much of the wrong data on these relatively expensive drives.

![Figure 39. Easy Tier Function](image-url)
Easy Tier makes this possible by creating a hybrid pool of storage capacity and dividing it into two tiers within the managed disk group, typically SSD and HDD, though further divisions and definitions are also supported.

- The busiest extents are identified and automatically relocated to high-performance SSDs.
- Remaining data elements can take advantage of higher capacity, price-optimized drives for the best customer value.

Volumes in an SSD or HDD managed disk group are monitored and can be managed automatically or manually by moving hot extents to SSD and cold extents to HDD.

Easy Tier also has the ability to manually and non-disruptively relocate full logical volumes around the system, providing additional flexibility and control for clients looking to more effectively align system performance with their application needs. Automatic solid-state storage with IBM Easy Tier provides substantial performance increase for disk-bound applications, by migrating the most active data to solid-state storage.

As a no-charge feature, Easy Tier makes it easy and economical to deploy SSDs in an Oracle database environment.

### 8.2.4. Thin provisioning

In IBM Storwize V7000, volumes can be configured to either be thin provisioned or fully allocated. A thin-provisioned volume behaves with respect to application reads and writes as though they were fully allocated.

When a volume is created, the user specifies two capacities: the real capacity of the volume and its virtual capacity. The real capacity determines the number of MDisk extents that are allocated for the volume. The virtual capacity will be the capacity of the volume reported to IBM Storwize V7000 and to the host servers. In a fully allocated volume, the virtual capacity and real capacity are the same. In a thin-provisioned volume, however, the virtual capacity can be much larger than the real capacity.

The real capacity will be used to store both the user data and the metadata for the thin provisioned volume. The real capacity can be specified as an absolute value or as a percentage of the virtual capacity. The thin-provisioning feature can be used to create over-allocated volumes, or it can be used in conjunction with the IBM FlashCopy® feature. Thin-provisioned volumes can also be used in conjunction with the mirrored volume feature.

Without thin provisioning, “fully allocated” volumes on Storwize V7000 use physical disk capacity for the entire capacity of a volume. If you create a 500GB virtual disk, Storwize V7000 allocates 500GB of physical disk capacity in an MDisk group for that virtual disk, even if only 100MB of data is written to the virtual disk. This is essentially the same way that traditional disk systems operate. With thin provisioning, Storwize V7000 allocates and uses physical disk space for a volume only when you write data to the volume. Thin-provisioned volumes can help simplify server administration. Instead of assigning a volume with some capacity to an application, and increasing that capacity as the requirements change, you can configure a volume with a large virtual capacity and then increase or shrink the real capacity as the application’s needs change, without disrupting the server or application.

Customers can choose the type of volumes they need to create: You can create thin-provisioned volumes in addition to fully allocated volumes, to meet different needs. For example, in Oracle
database deployment, fixed size volumes can be created for voting and OCR purposes, whereas thin-provisioned volumes are created for ASM data and ACFS usage.

When a thin-provisioned volume is configured, it can use the warning level attribute to generate a warning event when the used real capacity exceeds a specified level, or percentage of the total real capacity. You can also use the warning event to trigger other actions, such as taking low-priority applications offline or migrating data on to other storage pools. If a thin-provisioned volume does not have enough real capacity for a write operation, the volume is taken offline and an error is logged (error code 1865, event ID 060001). Access to the thin-provisioned volume is restored by either increasing the real capacity of the volume or increasing the size of the storage pool upon which it is allocated.

When creating a thin-provisioned volume, the grain size can be selected for space allocation, in 32 KB, 64 KB, 128 KB, or 256 KB increments. Generally, smaller grain sizes save space, but require more metadata access, which can impact performance. If you are not going to use a thin-provisioned volume as a FlashCopy source or target volume, use 256 KB to maximize performance. If you are going to use a thin-provisioned volume as a FlashCopy source or target volume, specify the same grain size for the volume as for the FlashCopy target.

When you create a thin-provisioned volume, set the cache mode to “readwrite” to get maximize performance. If the cache mode is set to none, the Storwize V7000 cluster cannot cache the thin-provisioned metadata, which decreases performance. The autoexpand feature prevents a thin-provisioned volume from using up its capacity and going offline. As a thin-provisioned volume uses capacity, the autoexpand feature maintains a fixed amount of unused real capacity, called the contingency capacity. For thin-provisioned volumes that are not configured with the autoexpand feature, the contingency capacity can get used up, causing the volume to go offline. To determine if an application requires a thin-provisioned volume with the autoexpand feature, create a thin-provisioned volume with the autoexpand feature turned off. If the application causes the volume to run out of capacity and go offline, you can then create a thin-provisioned volume with the autoexpand feature turned on to provide the following advantages:

- Improves efficiency of physical disk asset utilization
- Can minimize server disruption due to disk provisioning actions by pre-allocating anticipated disk capacity, before it is actually used
- Provides a foundation for space-efficient FlashCopy

With thin provisioning, storage administrators can spend less time monitoring spare capacity on individual volumes or LUNs. They can spend their time on more valuable, strategically important functions, such as monitoring overall capacity utilization, following trends in storage usage, and planning new storage acquisitions for use, as pools on Storwize V7000 as the available capacity is approached.

An example of “Creating Volume Mirroring” for Oracle DB usage is described in “4.2.3 Create volumes for Oracle Cluster files and RAC files on Storwize V7000.”

Here, in order to show the behavior of thin provisioned IBM Storwize 7000, tablespaces are created to simulate storage usage. The test shows that storage capacity is only allocated when a tablespace is created.

The following steps describe the process in detail:
1. In 4.2.3, you create a thin-provisioned volume “Ora_ASM_Database” for Oracle RAC database ASM group. This volume indicates that the ASM has not allocated all storage from IBM Storwize V7000, 12.6 GB of used storage is displayed while the total capacity is 32 GB. This means that the storage is allocated at the time it is required (Figure 40).

![Figure 40. An Initialized Thin Provisioned Volume “Ora_ASM_Database”](image)

2. Logon to the database in SQLPLUS and create a new tablespace, which is 15 GB in size and can extend to 20 GB:

   ```sql
   SQL> create tablespace test_tbs datafile '+RACDB_DATA/test_tbs01.dbf' size 15360M autoextend on maxsize 20480M;
   Tablespace created.
   ```

   The tablespace was created correctly with the given parameters.

3. Check the status of this volume from IBM Storwize V7000 again. From Figure 41, you can determine that only the needed capacity appears as used capacity. The Volume shows the expected behavior.
8.2.5. Performance monitoring

Storwize V7000 provides performance data for itself and for other components on the SAN.

IBM Tivoli® Storage Productivity Center for Disk is an essential tool in an IBM SAN environment to help ensure good data center reliability. Tivoli Storage Productivity Center for Disk offers the following features:

- A graphical overview of the entire data center topology, from hosts to Fibre Channel switches to storage.
- The ability to drill down into each object in the topology. For example, you can select a given storage controller and expand it to view all of the layers of the virtualization hierarchy.
- Collection of very detailed performance data on Mdisks, RAID arrays, switches, and so on.

For example, for a given Mdisk over a specified time period, you can see the IOPS, the response time, the throughput, and the read or write cache hit ratio.
• A wide range of reports can be produced and used to analyze SAN-wide performance data.

Tivoli Storage Productivity Center for Disk allows you to monitor and report on all of the layers of the technology stack in an IBM SAN environment, and is an important component in the setup of a data center.

For more information about IBM Tivoli Storage Productivity Center, visit

ibm.com/systems/storage/software/center/

With the introduction of Easy Tier function into IBM System storage products, a new easy-to-use tool Storage Tier Advisor is offered that can help clients determine which volumes are likely candidates for Easy Tier optimization by analyzing the performance of their current application workloads. Even clients that have not activated the Easy Tier feature or that do not even have SSDs deployed on the system can use the advisor tool to help identify where and how much data in the system can benefit from SSDs. This can help prevent unnecessary and costly over-provisioning of SSD technology for particular application workloads. Storage Tier Advisor helps clients understand exactly how SSDs can benefit their current workloads, so they no longer have to spend unnecessary resources or guess how SSDs can improve performance.

8.3. Oracle 11g RAC best practice

See the following best practices that you should know when implementing Storwize V7000 with Oracle Database:

• Use ASM to manage Oracle data files and cluster files.
• Use LUNs with similar capacity and performance within an ASM disk group, because ASM distributes the data across all available LUNs within an ASM disk group. Different characteristics like disks with different capacity would lead to degradation in response time.
• Use volumes with equal capacity and performance when adding space to an ASM disk group.
• Use multiple LUNs per ASM disk group to evenly distribute database read and write tasks across members of the disk group.
• Use External Redundancy when creating ASM disk groups to allow better processor resource utilization for data management and less for IO management.

ASM helps to simplify database-file management on System Storage disk products. External redundancy allows the host to use processor resources for data management and less processor resources for storage management. Oracle RAC and IBM Storwize V7000 work together to enhance database administrator and system administrator productivity.
9. Summary

IBM Storwize V7000 is a powerful midrange disk system that has been designed to be easy to use and enable rapid deployment for Oracle database environment without additional resources. Storwize V7000 offers IBM storage virtualization, SSD optimization and thin provisioning technologies built in to improve storage utilization and to enable the system to be reconfigured to meet changing needs quickly and easily.
10. Glossary of terms

A
ACFS • General purpose ASM Cluster File System

ADVM • ASM Dynamic Volume Manager

C
CTSS Cluster Time Synchronization Service (from Oracle)

G
GNS Grid naming service: A system for automating the management of the Virtual IP address (VIP) requirements in the cluster.

N
NAS Network attached storage

NFS Network File System

O
OCFS2 Oracle Cluster File System Release 2

OUI Oracle Universal Installer

S
SAN Storage area network

SCAN Single client access name: A system to simplify client access to databases.
11. Reference

These Web sites provide useful references to supplement the information contained in this document:

- System Storage on IBM PartnerWorld®
  ibm.com/partnerworld/systems/storage

- IBM Systems on IBM PartnerWorld®
  ibm.com/partnerworld/systems/IBM Publications Center

- IBM Publications Center

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