EMC VSPEX FOR VIRTUALIZED ORACLE DATABASE 11g OLTP
Enabled By EMC Next-Generation VNX and EMC Backup

Abstract
This Design Guide describes how to design virtualized Oracle Database resources on the appropriate EMC® VSPEX® Proven Infrastructure for VMware vSphere enabled by EMC Next-Generation VNX® and EMC Backup. This document also illustrates how to size Oracle on VSPEX, allocate resources following best practices, and use all the benefits that VSPEX offers.

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Purpose of this guide

EMC® VSPEX® Proven Infrastructures are optimized for virtualizing business-critical applications. VSPEX provides modular solutions built with technologies that enable faster deployment, more simplicity, greater choice, higher efficiency, and lower risk.

VSPEX provides partners with the ability to design and implement the virtual assets required to support a fully integrated virtualization solution for an Oracle relational database management system (RDBMS) on a VSPEX private-cloud infrastructure.

The VSPEX for virtualized Oracle infrastructure provides customers with a modern system, capable of hosting a virtualized database solution that is scalable and delivers a constant performance level. This solution uses VMware vSphere backed by the EMC Next-Generation VNX® storage array, and EMC Avamar® and Data Domain® for backup. The compute and network components, while vendor-definable, are designed to provide redundancy and sufficient power to handle the processing and data needs of the virtual machine environment.

This Design Guide describes how to design the VSPEX Proven Infrastructure for virtualized Oracle OLTP Database with best practices and how to select the right VSPEX Proven Infrastructure with the EMC VSPEX Sizing Tool for guidance.

Business value

Database management systems software is prevalent in nearly all commercial segments. Growth in sales is expected to continue despite the increasing market share of other data management tools. This growth is expected to accelerate as customers continue to diversify their infrastructures and supporting technologies and drive towards more hardware and software appliances and configurations.

This VSPEX Proven Infrastructure is focused on helping EMC partners understand the value that the VNX series, EMC backup and recovery systems, and Oracle bring to customers who often have growing, isolated IT environments running server-centric applications and who face increasing Oracle backup and recovery issues.

This VSPEX solution is designed to meet the customer’s Oracle database challenges while enabling customers to grow in performance, scalability, reliability, and automation. By consolidating their database applications on EMC VNX, customers can consolidate onto a single centralized storage platform enabling a more effectively managed exploding data growth, which is challenging businesses today. This solution has been sized and proven by EMC to:

- Deploy your systems faster, saving time and effort with EMC Proven solutions
- Increase performance and scalability out of the box
- Reduce the customer’s backup storage requirements and costs
- Meet backup windows
- Enable fast disk-based recovery
Scope

This Design Guide describes how to plan and design a VSPEX Proven Infrastructure for VMware vSphere virtualized Oracle Databases. Furthermore, this guide illustrates how to use the available VSPEX Sizing Tool for Oracle, allocate resources following best practices, and use all the benefits that VSPEX offers.

Audience

This guide is intended for internal EMC personnel and qualified EMC VSPEX partners. The guide assumes that VSPEX partners who intend to deploy this VSPEX for virtualized Oracle Database 11g OLTP solution are:

- Qualified by EMC to sell, install, and configure the EMC VNX family of storage systems
- Qualified to sell, install, and configure the network and server products required for VSPEX Proven Infrastructures
- Certified for selling VSPEX Proven Infrastructure

Partners who plan to deploy the solution must also have the necessary technical training and background to install and configure:

- VMware vSphere 5.1
- Redhat Enterprises Linux 6.3
- Oracle Database 11g or above
- EMC next-generation backup, which includes EMC Avamar and EMC Data Domain

This guide provides external references where applicable. EMC recommends that partners implementing this solution are familiar with these documents. For details, see Essential reading and Chapter 7: Reference Documentation.

Terminology

Table 1 lists the terminology used in the guide.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWR</td>
<td>Automatic Workload Repository</td>
</tr>
<tr>
<td>DNFS</td>
<td>Direct NFS client</td>
</tr>
<tr>
<td>DNS</td>
<td>Domain name system</td>
</tr>
<tr>
<td>FAST™ Cache</td>
<td>Fully Automated Storage Tiering Cache, an EMC storage feature that provides automated storage tiering at the LUN level.</td>
</tr>
<tr>
<td>FAST VP</td>
<td>Fully Automated Storage Tiering for Virtual Pools, an EMC storage feature that provides automatic storage tiering at the sub-LUN level.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>FQDN</td>
<td>Fully Qualified Domain Name</td>
</tr>
<tr>
<td>FRA</td>
<td>Fast Recovery Area (Oracle)</td>
</tr>
<tr>
<td>IOPS</td>
<td>Input/output operations per second</td>
</tr>
<tr>
<td>NFS</td>
<td>Network File System</td>
</tr>
<tr>
<td>NL-SAS</td>
<td>Near-line serial-attached SCSI</td>
</tr>
<tr>
<td>ODM</td>
<td>Oracle Disk Manager</td>
</tr>
<tr>
<td>OLTP</td>
<td>Online transaction processing</td>
</tr>
<tr>
<td>Oracle EE</td>
<td>Oracle Enterprise Edition</td>
</tr>
<tr>
<td>Oracle SE</td>
<td>Oracle Standard Edition</td>
</tr>
<tr>
<td>PowerCLI</td>
<td>A Windows PowerShell interface to the VMware vSphere and vCloud APIs</td>
</tr>
<tr>
<td>Reference virtual machine</td>
<td>Represents a unit of measure for a single virtual machine to quantify the compute resources in a VSPEX Proven Infrastructure</td>
</tr>
<tr>
<td>SGA</td>
<td>System global area</td>
</tr>
<tr>
<td>Statspack</td>
<td>Oracle database monitoring and reporting utilities</td>
</tr>
<tr>
<td>TPS</td>
<td>Transactions per second</td>
</tr>
<tr>
<td>VMDK</td>
<td>VMware Virtual Machine Disk</td>
</tr>
<tr>
<td>VMFS</td>
<td>VMware Virtual Machine File System</td>
</tr>
</tbody>
</table>
Chapter 2 Before You Start

This chapter presents the following topics:

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Chapter 2: Before You Start

Deployment workflow

To design and implement your VSPEX for virtualized Oracle Database 11g OLTP solution, refer to the process flow in Table 2.

**Table 2. VSPEX for virtualized Oracle Database 11g OLTP deployment workflow**

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use the VSPEX for Oracle Database 11g OLTP qualification worksheet to collect user requirements. The one-page qualification worksheet is in Appendix A of this Design Guide.</td>
</tr>
<tr>
<td>2</td>
<td>Use the EMC VSPEX Sizing Tool to determine the recommended VSPEX Proven Infrastructure for your Oracle Database 11g OLTP solution, based on the user requirements collected in Step 1. For more information about the Sizing Tool, refer to the VSPEX Sizing Tool on the EMC Business Value Portal. <strong>Note:</strong> You need to register the first time you access the tool. If the VSPEX Sizing Tool is not available, you can manually size the application using the sizing guidelines in Appendix B: Manually sizing a virtualized Oracle Database 11g OLTP for VSPEX.</td>
</tr>
<tr>
<td>3</td>
<td>Use this Design Guide to determine the final design for your VSPEX solution. <strong>Note:</strong> Ensure that all application requirements are considered, not just the requirements for Oracle Database 11g OLTP.</td>
</tr>
<tr>
<td>4</td>
<td>Select and order the right VSPEX Proven Infrastructure. Refer to the appropriate VSPEX Proven Infrastructure document in Essential reading for guidance.</td>
</tr>
<tr>
<td>5</td>
<td>Deploy and test your VSPEX solution. Refer to the appropriate VSPEX Implementation Guide in Essential reading for guidance.</td>
</tr>
</tbody>
</table>
Essential reading

Before implementing the solution described in this document, EMC recommends that you read the following documents, available from the VSPEX space in the EMC Community Network or from EMC.com and VSPEX Partner Portal.

VSPEX Solution Overviews
Refer to the following VSPEX Solution Overview documents:
- EMC VSPEX Server Virtualization for Midmarket Businesses
- EMC VSPEX Server Virtualization for Small and Medium Businesses

VSPEX Implementation Guides
Refer to the following VSPEX Implementation Guide:
- EMC VSPEX for Virtualized Oracle Database 11g OLTP Implementation Guide

VSPEX Proven Infrastructure Guides
Refer to the following VSPEX Proven Infrastructure Guide:
- Reference Architecture: EMC VSPEX Private Cloud VMware vSphere 5.1 for up to 1,000 Virtual Machines

Backup and Recovery
Refer to the following backup and recovery papers:
- White Paper: EMC Avamar Backup for Oracle Environments
- White Paper: EMC Avamar Backup with Data Domain
- White Paper: EMC Backup and Recovery Options for VSPEX for Virtualized Oracle 11gR2 Design and Implementation Guide
Chapter 3  Solution Overview

This chapter presents the following topics:

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Overview

This chapter provides an overview of the VSPEX Proven Infrastructure for Oracle Database 11g and the key technologies used in this solution. The solution described in this Design Guide includes servers, storage, network components, and Oracle Database 11g components.

The solution enables customers to quickly and consistently deploy a virtualized Oracle Database 11g in the VSPEX Proven Infrastructure. The reference architecture will consume the reference virtual machine resources, based on the sizing guidance in the VSPEX Proven Infrastructure, and combine with additional storage for Oracle Database 11g application data.

This Design Guide can help EMC personnel and qualified EMC VSPEX Partners to deploy a simple, effective, and flexible Oracle Database 11g solution on a VSPEX Proven Infrastructure for their customers.

Building a more efficient Oracle infrastructure with EMC VNX

This solution offers users a powerful approach to deploy Oracle databases on EMC VNX systems. By leveraging advanced VNX storage functionality such as FAST VP and FAST Cache, users can archive increased performance and reduce total cost of ownership (TCO) for their Oracle deployments. With these advanced data features, the VNX series not only reduces the initial cost of the Oracle database deployment, but also significantly reduces complexity associated with day-to-day data management by automating the complex and time-consuming storage tiering process.

The EMC VNX with Oracle:

- Automatically delivers the highest IOPS and lowest response times at the lowest cost
- Provides automated storage tiering requiring no manual tuning
- Supports mixed workloads, including block and file (dNFS)
- Provides stronger virtualization integration and lower Oracle licensing costs
- Automates VMware disaster recovery testing, failover, and failback

Solution architecture

Figure 1 shows the architecture that characterizes the infrastructure validated for an Oracle Database 11g overlay on a VSPEX infrastructure. To validate this solution, we¹:

- Deployed all Oracle Database 11g servers as virtual machines on VMware vSphere 5.1.

¹ In this paper, “we” refers to the EMC Solutions engineering team that validated the solution.
• Used the VSPEX sizing tool for Oracle Database 11g to determine the number of, and the detailed compute resources for, each Oracle Database 11g database. Figure 1 displays an example with three Oracle sizing options (small, medium, and large). Use the sizing tools provided with this solution to size your customer’s environment and choose the options that best suit your customer.

• Determined the recommended storage layout for Oracle Database 11g and the virtual infrastructure pool in the VNX series storage arrays (using the VSPEX sizing tool).

Note: The minimum Oracle version for this solution is 11.2.0.3. We refer to this as 11gR2 throughout this document.

Figure 1.  Validated infrastructure architecture
Chapter 3: Solution Overview

Key components

Introduction

This section provides an overview of the key technologies used in this solution:

- EMC VSPEX
- Oracle Database 11g
- VMware vSphere 5.1
- VMware vSphere HA
- vSphere Distributed Resources Scheduler
- VMware vSphere PowerCLI
- EMC VNX series
- EMC Virtual Storage Integrator (VSI)
- Red Hat Enterprise Linux 6.3
- EMC Unisphere
- EMC Avamar
- EMC Data Domain

EMC VSPEX

EMC has joined forces with the industry's leading providers of IT infrastructure to create a complete virtualization solution that accelerates the deployment of private-cloud technologies. Built with best-of-breed technologies, VSPEX enables faster deployment, more simplicity, greater choice, higher efficiency, and lower risk.

VSPEX Proven Infrastructure, as shown in Figure 2, is a modular, virtualized system validated by EMC and delivered by EMC partners. VSPEX includes a virtualization layer, server, network, and storage, designed by EMC to deliver reliable and predictable performance.
VSPEX provides the flexibility to choose the best network, server, and virtualization technologies that fit a customer’s environment to create a complete virtualization solution.

VSPEX provides a virtual infrastructure for customers looking to gain the simplicity of a truly converged infrastructure, while gaining flexibility in individual components of the stack. VSPEX solutions, proven by EMC, are packaged and sold exclusively by EMC channel partners. VSPEX provides channel partners with more opportunity, a faster sales cycle, and end-to-end enablement. By working even more closely together, EMC and its channel partners can now deliver an infrastructure that accelerates the journey to the cloud for even more customers.

Reference virtual machine

To simplify the virtual infrastructure discussion, the VSPEX solution has defined a typical customer workload (described in this section) as a reference virtual machine. For VSPEX solutions, we define the reference virtual machine as a measure unit of a single virtual machine to qualify the compute resources in the VSPEX virtual infrastructure. Table 3 lists the characteristics of this virtual machine.

Table 3. Reference virtual machine characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual processors per virtual machine</td>
<td>1</td>
</tr>
<tr>
<td>RAM per virtual machine</td>
<td>2 GB</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Value</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Available storage capacity per virtual machine</td>
<td>100 GB</td>
</tr>
<tr>
<td>I/O operations per second (IOPS) per virtual machine</td>
<td>25</td>
</tr>
<tr>
<td>I/O pattern</td>
<td>Random</td>
</tr>
<tr>
<td>I/O read/write ratio</td>
<td>2:1</td>
</tr>
</tbody>
</table>

**VSPEX for virtualized Oracle sizing model**

Scale-up testing formed part of the validation process. We used a standard compute-sizing model for Oracle, which simplified and standardized the validation testing. It also enabled us to identify the configuration required to run a TCP-C like OLTP database workload with a 60:40 read/write ratio, yielding acceptable response times.
Table 4 shows how we mapped the Oracle sizing model to the VSPEX reference virtual machine.

**Table 4.** Mapping the Oracle sizing model to the VSPEX Reference Virtual Machine

<table>
<thead>
<tr>
<th>Oracle model</th>
<th>Resources</th>
<th>Equivalent reference virtual machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small—virtual machine for up to 150 users</td>
<td>Compute requirements:</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>• 2 vCPU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 8 GB of memory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage requirements (OS and Oracle binaries):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 100 GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 25 IOPS</td>
<td></td>
</tr>
<tr>
<td>Medium—virtual machine for up to 250 users</td>
<td>Compute requirements:</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>• 4 vCPU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 16 GB of memory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage requirements (OS and Oracle binaries):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 100 GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 25 IOPS</td>
<td></td>
</tr>
<tr>
<td>Large—virtual machine for more than 250 Users</td>
<td>Compute requirements:</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>• 8 vCPU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 32 GB of memory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage requirements (OS and Oracle binaries):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 100 GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 25 IOPS</td>
<td></td>
</tr>
</tbody>
</table>

We calculated the database storage I/O thresholds and capacity separately from those required by the VSPEX reference virtual machine.

**Oracle Database 11g**

Oracle Database 11g is available in a variety of editions tailored to meet the business and IT needs of an organization. In this solution we will be considering:

- Oracle Database 11g Release 2 Standard Edition (SE)
- Oracle Database 11g Release 2 Enterprise Edition (EE)

Oracle SE is an affordable, full-featured data management solution that is ideal for all companies. It is available on single or clustered servers and can be licensed on a maximum capacity of four processor sockets, regardless of core count. The SE license includes Oracle Real Application Clusters (RAC) as a standard feature with no additional cost.
Chapter 3: Solution Overview

Oracle Database 11g EE delivers industry-leading performance, scalability, security, and reliability on a choice of clustered or single servers running Windows, Linux, or UNIX. It supports advanced features, either included or as extra-cost options, that are not available with Oracle Database 11g SE. These include security features such as Virtual Private Database and data warehousing options such as partitioning and advanced analytics. Oracle Database 11g Release 2 EE extends the processor-licensing model for multi-core processors and is priced using the following formula:

\[(\text{number of Processors}) \times (\text{number of cores}) \times (\text{Oracle Processor Core Factor})\]

For example, two 10-core Intel Xeon Processor E7-2870s (with an Oracle Processor Core Factor of 0.5) are licensed as follows:

- Oracle Database 11g Release 2 SE: 2 processor socket SE licenses
- Oracle Database 11g Release 2 EE: \(2 \times 10 \times 0.5 = 10\) EE licenses

The Oracle Database 11g R2 edition can affect the licensing cost and the size and number of VMware ESXi clusters you can configure. This affects how you place and manage the virtual machines. For more information on virtualization and Oracle processor licensing, see the section DRS Host Affinity and Oracle processor licensing.

**VMware vSphere 5.1**

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

**VMware vSphere HA**

VMware vSphere High Availability (HA) provides easy-to-use, cost effective high availability for applications running on virtual machines. In the event of a physical server failure, affected virtual machines automatically restart on other production servers with spare capacity.

HA enables you to create a cluster out of multiple ESXi servers, enabling you to protect virtual machines. If one of the hosts in the cluster fails, the impacted virtual machines automatically restart on other ESXi hosts within that same VMware vSphere cluster.

**VMware vSphere Distributed Resource Scheduler**

VMware vSphere Distributed Resource Scheduler (DRS) is an infrastructure service run by VMware vCenter Server (vCenter). DRS aggregates ESXi host resources into clusters and automatically distributes these resources to virtual machines by monitoring utilization and continuously optimizing virtual machine distribution across ESXi hosts. DRS can also use vMotion and Storage vMotion to ensure that the virtual machines have access by rebalancing resource capacity to make room for larger virtual machines. VMware recommends enabling DRS to achieve higher consolidation ratios.

**VMware vSphere PowerCLI**

VMware vSphere PowerCLI provides a Windows PowerShell interface for the users of vSphere 5.1 and above and VMware Infrastructure 4.x and above. VMware vSphere PowerCLI is a powerful command-line tool that lets you automate all aspects of
vSphere management, including network, storage, VM, guest OS and more. PowerCLI is distributed as a Windows PowerShell snap-in, and includes 330 PowerShell cmdlets for managing and automating vSphere and vCloud, along with documentation and samples.

The EMC VNX Flash-optimized unified storage platform delivers innovation and enterprise capabilities for file, block, and object storage in a single, scalable, and easy-to-use solution. Ideal for mixed workloads in physical or virtual environments, VNX combines powerful and flexible hardware with advanced efficiency, management, and protection software to meet the demanding needs of today’s virtualized application environments.

VNX includes many features and enhancements designed and built upon the first generation’s success. These features and enhancements include:

- More capacity with multicore optimization with Multicore Cache, Multicore RAID, and Multicore FAST Cache (MCx)
- Greater efficiency with a Flash-optimized hybrid array
- Better protection by increasing application availability with active/active
- Easier administration and deployment by increasing productivity with new Unisphere Management Suite

VSPEX is built with the next generation of VNX to deliver even greater efficiency, performance, and scale than ever before.

**Flash-optimized hybrid array**

VNX is a Flash-optimized hybrid array that provides automated tiering to deliver the best performance to your critical data, while intelligently moving less frequently accessed data to lower-cost disks.

In this hybrid approach, a small percentage of Flash drives in the overall system can provide a high percentage of the overall IOPS. Flash-optimized VNX takes full advantage of the low latency of Flash to deliver cost-saving optimization and high performance scalability. The EMC Fully Automated Storage Tiering Suite (FAST Cache and FAST VP) tiers both block and file data across heterogeneous drives and boosts the most active data to the flash, ensuring that customers never have to make concessions for cost or performance.

Data is generally accessed most frequently at the time it is created, therefore new data is first stored on flash drives to provide the best performance and latency. As that data ages and becomes less active over time, FAST VP tiers the data from high-performance to high-capacity drives automatically, based on customer-defined policies. This functionality has been enhanced with four times better granularity and with new FAST VP solid-state disks (SSDs) based on enterprise multi-level cell (eMLC) technology to lower the cost per gigabyte. FAST Cache dynamically absorbs unpredicted spikes in system workloads. All VSPEX use cases benefit from the increased efficiency.

VSPEX Proven Infrastructures deliver private cloud, end-user computing, and virtualized application solutions. With VNX, customers can realize an even greater
return on their investment. VNX provides out-of-band, block-based deduplication that can dramatically lower the costs of the Flash tier.

**VNX Intel MCx Code Path Optimization**

The advent of Flash technology has been a catalyst in totally changing the requirements of midrange storage systems. EMC redesigned the midrange storage platform to efficiently optimize multicore CPUs to provide the highest performing storage system at the lowest cost in the market.

MCx distributes all VNX data services across all cores (up to 32), as shown in Figure 3. The VNX series with MCx has dramatically improved the file performance for transactional applications like databases or virtual machines over network-attached storage (NAS).

![Figure 3. Next-Generation VNX with multicore optimization](image)

**Multicore Cache**

The cache is the most valuable asset in the storage subsystem; its efficient use is key to the overall efficiency of the platform in handling variable and changing workloads. The cache engine has been modularized to take advantage of all the cores available in the system.

**Multicore RAID**

Another important part of the MCx redesign is the handling of I/O to the permanent back-end storage—hard disk drives (HDDs) and SSDs. Greatly increased performance improvements in VNX come from the modularization of the back-end data management processing, which enables MCx to seamlessly scale across all processors.

**VNX performance**

VNX storage, enabled with the MCx architecture, is optimized for FLASH 1st and provides unprecedented overall performance, optimizing for transaction performance (cost per IOPS), bandwidth performance (cost per GB/s) with low latency, and providing optimal capacity efficiency (cost per GB).
VNX provides the following performance improvements:

- Up to four times more file transactions when compared with dual controller arrays
- Increased file performance for transactional applications by up to three times with a 60 percent better response time
- Up to four times more Oracle OLTP transactions
- Up to six times more virtual machines

**Active/active array service processors**

The new VNX architecture provides active/active array service processors, as shown in Figure 4, which eliminate application timeouts during path failover because both paths are actively serving I/O.

Load balancing is also improved and applications can achieve an up to two times improvement in performance. Active/active for block is ideal for applications that require the highest levels of availability and performance, but do not require tiering or efficiency services like compression, deduplication, or snapshot.

With this VNX release, VSPEX customers can use virtual Data Movers (VDMs) and VNX Replicator to perform automated and high-speed file system migrations between systems. This process migrates all snaps and settings automatically, and enables the clients to continue operation during the migration. Active/active storage processors only apply to classic LUNs, not to pool LUNs.

![Figure 4. Active/active processors increase performance, resiliency, and efficiency](Image)

**Virtualization management**

**VMware Virtual Storage Integrator**

Virtual Storage Integrator (VSI) is a no-charge VMware vCenter plug-in available to all VMware users with EMC storage. VSPEX customers can use VSI to simplify management of virtualized storage. VMware administrators can gain visibility into their VNX storage using the same familiar vCenter interface to which they are accustomed.
With VSI, IT administrators can do more work in less time. VSI offers unmatched access control that enables you to efficiently manage and delegate storage tasks with confidence. Perform daily management tasks with up to 90 percent fewer clicks and up to 10 times higher productivity.

**VMware vStorage APIs for Array Integration**

VMware vStorage application program interfaces (APIs) for Array Integration (VAAI) offloads VMware storage-related functions from the server to the storage system, enabling more efficient use of server and network resources for increased performance and consolidation.

**VMware vStorage APIs for Storage Awareness**

VMware vStorage APIs for Storage Awareness (VASA) is a VMware-defined API that displays storage information through vCenter. Integration between VASA technology and VNX makes storage management in a virtualized environment a seamless experience.

**EMC Storage Integrator**

EMC Storage Integrator (ESI) is targeted towards the Windows and Application administrator. ESI is easy to use, delivers end-to-end monitoring, and is hypervisor agnostic. Administrators can provision in both virtual and physical environments for a Windows platform, and troubleshoot by viewing the topology of an application from the underlying hypervisor to the storage.

**Unisphere Management Suite**

EMC Unisphere is the central management platform for the VNX series, providing a single, combined view of file and block systems, with all features and functions available through a common interface. Unisphere is optimized for virtual applications and provides industry-leading VMware integration, automatically discovering virtual machines and ESX servers and providing end-to-end, virtual-to-physical mapping. Unisphere also simplifies configuration of FAST Cache and FAST VP on VNX platforms.

The new Unisphere Management Suite extends Unisphere’s easy-to-use, interface to include VNX Monitoring and Reporting for validating performance and anticipating capacity requirements. As shown in Figure 5, the suite also includes Unisphere Remote for centrally managing up to thousands of VNX and VNXe systems with new support for XtremSW Cache.
Red Hat Enterprise Linux 6.3

Red Hat Enterprise Linux is a versatile platform for x86 and x86-64 that can be deployed on physical systems, as a guest on the major hypervisors, or in the cloud. It supports all leading hardware architectures with compatibility across releases. Red Hat Enterprise Linux 6.3 includes enhancements and new capabilities that provide rich functionality, especially the developer tools, virtualization features, security, scalability, file systems, and storage.

EMC backup and recovery solutions

EMC Avamar and EMC Data Domain deliver the protection confidence needed to accelerate deployment of virtualized Oracle. Optimized for virtualized application environments, EMC backup and recovery reduces backup times by 90 percent and increases recovery speeds by 30 times, even offering instant virtual machine access for worry-free protection.

EMC backup also delivers big savings. Our deduplication solutions reduce backup storage by 10 to 30 times, backup management time by 81 percent, and bandwidth by 99 percent for efficient offsite replication, delivering a seven month payback on average.

Furthermore, EMC backup offers a solution with Data Domain systems and DD Boost software that allows for full DBA control of Oracle backup, recovery, and replication while the backup team maintains control of the infrastructure. This eliminates the occurrence of protection silos, increasing efficiency and lowering risk.

- n
Chapter 4: Choosing a VSPEX Proven Infrastructure

This chapter presents the following topics:

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Step 1: Evaluating the customer use case ........................................................................ 31
Step 2: Designing the application architecture .................................................................. 32
Step 3: Choosing the right VSPEX Proven Infrastructure .............................................. 32
Overview

This chapter describes how to design the VSPEX for virtualized Oracle Database 11g OLTP solution and how to choose the right VSPEX Proven Infrastructure on which to layer Oracle Database 11g OLTP. Table 5 outlines the main steps you need to complete when selecting a VSPEX Proven Infrastructure.

Table 5. The VSPEX for virtualized Oracle Database 11g OLTP design process

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Evaluate the customer’s Oracle OLTP workload by using the VSPEX Oracle Database 11g OLTP qualification worksheet. See Step 1: Evaluating the customer use case.</td>
</tr>
<tr>
<td>2</td>
<td>Determine the required infrastructure, Oracle OLTP resources, and architecture using the VSPEX Sizing Tool. See Step 2: Designing the application architecture. <strong>Note:</strong> If the Sizing Tool is not available on the EMC Support website, manually size the application using the guidelines in Appendix B, Manually sizing a virtualized Oracle Database 11g OLTP for VSPEX.</td>
</tr>
<tr>
<td>3</td>
<td>Choose the right VSPEX Proven Infrastructure, based on the recommendations from Step 2. See Step 3: Choosing the right VSPEX Proven Infrastructure.</td>
</tr>
</tbody>
</table>

**Note:** For more information, see the document entitled *Deploying Oracle Database on EMC VNX Unified Storage* available on EMC.com and EMC Online Support.

Step 1: Evaluating the customer use case

Before you choose a VSPEX infrastructure solution, it is important that you understand your customer’s real workload and dataset, based on the business requirement. To help you better understand the customer’s business requirements for the VSPEX infrastructure design, EMC strongly recommends that you use the EMC VSPEX for virtualized Oracle qualification worksheet-sizing tool when evaluating the workload requirements for the VSPEX solution. For more information about the EMC qualification worksheet for this solution, see the VSPEX for Virtualized Oracle OLTP qualification worksheet in Appendix A.

In the VSPEX for virtualized Oracle qualification worksheet, we used some simple questions to understand and describe the customer’s Oracle OLTP workload requirements and usage characteristics.
Step 2: Designing the application architecture

We defined an example customer workload for this VSPEX Proven infrastructure solution. For more information about a reference virtual machine and its characteristics, refer to VSPEX for Virtualized Oracle qualification worksheet example. After you gather the customer’s information and populate the VSPEX for virtualized Oracle qualification worksheet, you can use that information to populate the VSPEX sizing tool located on the EMC Business Value Portal. If the sizing tool is not available on the EMC Support website, use the sizing instructions provided in Appendix B, Manually sizing a virtualized Oracle Database 11g OLTP for VSPEX.

Step 3: Choosing the right VSPEX Proven Infrastructure

The VSPEX program has produced many solutions designed to simplify the deployment of a consolidated virtual infrastructure using VMware vSphere and the EMC VNX family of products. After you confirm the application architecture, you can choose the right VSPEX Proven infrastructure based on the calculated results. For Oracle OLTP, refer to the document entitled EMC VSPEX Private Cloud VMware vSphere 5.1 for up to 1,000 Virtual Machines solution.

EMC recommends that you use the following steps when choosing a VSPEX Proven Infrastructure:

1. Use the VSPEX sizing tool for Oracle 11g OLTP to calculate the total number of reference virtual machines and the suggested storage layout. If this portal is not available, use Appendix B, which describes how to manually size the storage for an environment.

2. Design the other applications’ resource capacity based on business needs. The VSPEX sizing tool calculates the total number of required reference virtual machines and recommended storage layouts for Oracle 11g OLTP.

3. Select your network vendor, hypervisor software vendor, and the VSPEX Proven Infrastructure with number of required reference virtual machines. For more information, visit the VSPEX Proven Infrastructure website.
Chapter 4: Choosing a VSPEX Proven Infrastructure
This chapter presents the following topics:

- **Overview** .......................................................... 35
- Designing the network .............................................. 35
- Designing the storage layout .................................... 38
- Configuring FAST Cache for Oracle .............................. 42
- Configuring FAST VP for Oracle ............................... 43
- Designing the virtualization layer .............................. 44
- Designing the Oracle Database 11gR2 implementation ........ 47
- Designing backup and recovery ............................... 49
Overview

This chapter describes the EMC VSPEX for Virtualized Database 11g OLTP solution design and best practices for the network, storage, virtualization, application, and backup and recovery, and includes the following sections:

- Designing the network
- Designing the storage layout
- Configuring FAST Cache for Oracle
- Configuring FAST VP for Oracle
- Designing the virtualization layer
- Designing the Oracle Database 11gR2
- Designing backup and recovery

Designing the network

Overview

This section describes network details for SAN and IP network configuration, as well as for an ESXi Server network. In this VSPEX Proven Infrastructure for virtualized Oracle Database 11g R2 solution, EMC also recommends that you consider ESX Server advanced settings and network redundancy when designing your network.

SAN best practices

EMC recommends that you use the following SAN best practices:

- Use multiple HBA and FC switches for network redundancy.
- Zone each FC port from the database servers to both storage SP ports for high availability.
- Use path management and dynamic multipathing software, such as PowerPath, on the hosts to enable the failover process to alternate paths and to provide load balancing.

Note: Maximum Transfer Unit (MTU) sizes of greater than 1,500 bytes are referred to as jumbo frames. Jumbo frames require Gigabit Ethernet across the entire network infrastructure, including servers, switches, and database servers.

IP network best practices

EMC recommends that you use the following IP network best practices:

- Use multiple network cards and switches for network redundancy.
- Use 10 Gb Ethernet for network connection if possible.
- Use Virtual local area networks (VLANs) to logically group devices that are on different network segments or sub-networks.
- Enable and configure jumbo frames throughout the physical or virtual stack.
vSphere network best practices

Networking in the virtual world follows the same concepts as networking in the physical world, but some of these concepts are applied in the software instead of using physical cables and switches. Although many of the best practices that apply in the physical world continue to apply in the virtual world, there are additional considerations for traffic segmentation, availability, and throughput.

This solution includes designs to efficiently manage multiple networks and redundancy of network adapters on ESXi hosts. The key best practice guidelines are to:

- Separate infrastructure traffic from virtual machine traffic for security and isolation.
- Use the VMXNET family of Paravirtualized network adapters.
- Take advantage of Network I/O to converge network and storage traffic onto 10 GbE.

For more information on networking with vSphere, follow the instructions in vSphere Networking.

ESXi settings for NFS-specific considerations

One of network examples in this solution includes a redundant pair of switches with all subnets having redundant links as shown in Figure 6.

Aggregate multiple network connections to increase throughput beyond what a single connection can sustain, and to provide redundancy in case one of the links fails. For
example, in the VMware virtualization environment, use two physical NICs per vSwitch and uplink the physical NICs to separate physical switches.

When configuring the NIC teaming settings, it is a best practice to select no for the NIC teaming failback option. If there is some intermittent behavior in the network, this will prevent the NIC cards from flip-flopping.

When setting up VMware High Availability, also set the following ESX Server timeouts and settings under the ESX Server advanced setting tab:

- NFS.HeartbeatFrequency = 12
- NFS.HeartbeatTimeout = 5
- NFS.HeartbeatMaxFailures = 10

To access the NFS advanced options, follow these steps:

1. Log into the VMware vSphere Client.
2. Select the ESXi/ESX host.
3. From the Configuration tab, select Advanced Settings > NFS.

Configure the Oracle 11g Database to use the Oracle 11g dNFS Client ODM disk libraries. This is a one-time operation. After making this setting, the database uses the Oracle-optimized native Oracle dNFS client, rather than the operating system hosted NFS client.

We replaced the standard ODM library with one that supports the dNFS Client. Figure 7 shows the commands that enable the dNFS Client ODM library.

```
[oracle@vspx-ora01 ~]$ cd $ORACLE_HOME/rdbms/lib
[oracle@vspx-ora01 lib]$ make -f make_repos.mk ddfs.cn
rm -f /u01/app/oracle/11.2.0.3/lib/libodm11.so; cp /u01/app/oracle/11.2.0.3/lib/libodm11.so /u01/app/oracle/11.2.0.3/lib/libodn11.so
```

**Figure 7. Enable the dNFS Client ODM library**

For other best practices in network design for the VSPEX Proven Infrastructure, refer to the *EMC VSPEX for Virtualized Oracle Database 11g OLTP Implementation Guide*. 
Designing the storage layout

Overview

This solution details the use of two storage networking technologies with Oracle: Linux Logical Volume Manager (LVM) over Fibre Channel (FC) and Oracle Direct NFS (dNFS) over Internet Protocol (IP). Oracle 11g environments using LVM or dNFS provide options to customers depending on their familiarity and expertise with a chosen protocol, existing architecture, and budgetary constraints.

There are multiple criteria for deciding block, file, or unified (both):

- Existing infrastructure (for example, existing SAN or IP networking)
- Technical knowledge of IT staff
- Ease of use or suitability

It is up to customers to choose the deployment architecture that best fits their specific needs. EMC unified storage provides flexibility and manageability for a storage infrastructure that supports either of these architectures. Unified storage can also offer hybrid architectures that utilize both protocols in a single solution.

High-level architecture

Figure 8 shows the high-level architecture between the Oracle Database 11gR2 components and storage elements validated in the VSPEX Proven Infrastructure for Oracle Database 11gR2 on a VMware vSphere 5.1 virtualization platform. All the Oracle Database 11gR2 volumes are either on network file system storage or on Fibre Channel (FC) storage as the EMC VNX family provides multiprotocol arrays that support block- and file-based storage.

Figure 8. Oracle Database 11gR2 storage elements
In addition to the infrastructure pool for virtual machines, EMC recommends that you use the three additional storage pools in which to store Oracle Database 11gR2 data for different purposes. Table 6 provides an example.

### Table 6. VNX storage layout for Oracle Database

<table>
<thead>
<tr>
<th>Storage pool name</th>
<th>RAID type</th>
<th>Disk type</th>
<th>No. of disks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle Data pool</td>
<td>RAID 5 (4+1)</td>
<td>10,000 rpm SAS disks</td>
<td>25</td>
</tr>
<tr>
<td>Oracle FRA pool</td>
<td>RAID 6 (6+2)</td>
<td>7,200 rpm NL-SAS disks</td>
<td>8</td>
</tr>
<tr>
<td>Oracle Redo pool</td>
<td>RAID 5 (4+1)</td>
<td>10,000 rpm SAS disks</td>
<td>5</td>
</tr>
</tbody>
</table>

Consider the following best practices for storage and layout design in your VSPEX Proven Infrastructure for virtualized Oracle Database 11gR2 solution.

**Oracle Database 11gR2 data pool**

Use SAS disks with RAID 5 (4+1) protection for the Oracle data and temp file systems. This combination of RAID protection and disk type provides high capacity utilization along with good I/O performance at a low cost, while at the same time ensuring data availability in the event of a drive failure.

**Oracle Database 11gR2 redo log pool**

In this solution, we configured the file system for redo logs on the same physical pool protected by RAID5 on SAS disks. For highly write-intensive workloads, or workloads for which random read response times are more important, you should consider a separate pool for redo file systems on physically separate disks.

**Oracle Database 11gR2 FRA pool**

Considering that backup has relatively low client access and the main design factor is the capacity, we used NL-SAS drives for the Oracle FRA. EMC recommends that when using high capacity NL-SAS drives, you should use RAID 6 protection.

**Customization**

EMC recommends that customers work with vendors to estimate the capacity and IOPS requirements for the storage layout. Make sure to consider future growth when laying out the storage, and include projected growth as input to the VSPEX sizing tool.

Administrators can choose to manually create pools for file systems or use the Automated Volume Management function from Unisphere. If the administrator chooses to manually layout the storage pool LUNs, they should consult the document entitled *EMC VNX Unified Best Practices for Performance*.

**Additional performance requirements for FAST Suite**

The EMC FAST Suite—FAST VP and FAST Cache—provides two key technologies available on the VNX series that enable extreme performance in an automated fashion, when and where needed. For more information on FAST Suite for VSPEX Proven Infrastructures, see the [VSPEX Proven Infrastructure](#) website.
Enabling FAST Cache is a transparent operation to Oracle Database 11gR2 and no reconfiguration or downtime to the database is necessary. EMC recommends that you only use FAST Cache on the storage pool or LUNs that require it. FAST Cache is best for light random I/O where there is an uneven data distribution.

Users can create blended storage pools composed of various disk types (Flash, SAS, and NL_SAS). The data migration in this highly consolidated virtualized environment produces the highest storage efficiency, both from a performance and capacity perspective.

If you enable FAST Suite technology on the Oracle Database 11gR2, the response times, read/write throughput, and latencies will improve the Oracle Database 11gR2 user experience. This also eases the burden on storage and database administrators when determining the most efficient storage layout for their customers.
This section describes the VNX storage layouts in this VSPEX Proven Infrastructure for virtualized Oracle Database 11g R2 based on the VSPEX private cloud. This example follows the best practice and design considerations as previously discussed.

Figure 9 shows a storage layout for an example Oracle Database 11gR2 of the VNX series.

![VSPEX storage layout example](image)

**Figure 9. Example virtualized Oracle storage layout for VSPEX**

**Note:** This is only one example of a storage layout. To plan and design your own storage layouts for Oracle Database 11gR2 on an EMC VSPEX stack, follow the guidance in the VSPEX Sizing Tool and the best practices in Designing the storage layout on page 38.
Configuring FAST Cache for Oracle

Overview

FAST Cache uses Enterprise Flash drives to add an extra layer of cache between dynamic random access memory (DRAM) cache and rotating disk drives, thereby creating a faster medium for storing frequently accessed data. FAST Cache is an extendable, read/write cache. It boosts application performance by ensuring that the most active data is served from high-performing flash drives and can reside on this faster medium for as long as is needed.

FAST Cache tracks data activity at a granularity of 64 KB and promotes hot data into FAST Cache by copying it from the HDDs to the flash drives assigned to FAST Cache. Subsequent I/O access to that data is handled by the flash drives and is serviced at flash drive response times—this ensures very low latency for the data. As data ages and becomes less active, it is flushed from FAST Cache to be replaced by more active data.

A small number of flash drives implemented as FAST Cache provides a greater performance increase than a large number of short-stroked HDDs.

FAST Cache is particularly suited to applications that randomly access storage with high frequency, such as Oracle OLTP databases. In addition, OLTP databases have inherent locality of reference with varied I/O patterns. Applications with these characteristics benefit most from deploying FAST Cache. The optimal use of FAST Cache happens when the working dataset can fit within the FAST Cache.

FAST Cache best practices

EMC recommends the following best practices:

- Only enable FAST Cache on pool/LUNs that require it
- Size FAST Cache appropriately, depending on the application’s active dataset
- Disable FAST Cache on pool/LUNs where Oracle online redo logs reside
- Never enable FAST Cache on archive logs because these files are never overwritten and are rarely read back (unless you need to recover the database)

EMC recommends that you enable FAST Cache for the Oracle data files only. Oracle archive files and redo log files have a predictable workload composed mainly of sequential writes. The array’s write cache and assigned HDDs can efficiently handle these archive files and redo log files. Enabling FAST Cache on these files is neither beneficial nor cost effective.
Configuring FAST VP for Oracle

Overview

FAST VP is a “game-changing” technology that provides compelling advantages over traditional tiering options. It combines the advantages of automated storage tiering with Virtual Provisioning to optimize performance and cost while radically simplifying storage management and increasing storage efficiency.

Like FAST Cache, FAST VP works best on datasets that exhibit a high degree of skew. FAST VP is very flexible and supports several tiered configurations, such as single tiered, multi-tiered, with or without a flash tier, and FAST Cache support. Adding a flash tier can locate “hot data” on flash storage in 256 MB slices.

FAST VP can be used to aggressively reduce TCO and/or to increase performance. A target workload that requires a large number of performance tier drives can be serviced with a mix of tiers, and a much lower drive count. In some cases, you can achieve an almost two-thirds reduction in drive count. In other cases, performance throughput can double by adding less than 10 percent of a pool's total capacity in flash drives.

A common strategy is to use FAST VP to gain TCO benefits while using FAST Cache to boost overall system performance. This paper discusses considerations for an optimal deployment of these technologies.

For further information on FAST VP algorithm and policies, see *EMC FAST VP for Unified Storage Systems*.

FAST VP best practices

EMC recommends that you follow these FAST VP best practices:

- Use flash in FAST Cache first before using flash in the tier when limited hard disk space is available (the granularity of FAST Cache data management will provide improved efficiency per GB of hard disk compared to FAST VP).
- Use flash drives with RAID 5 (4+1) protection for the Extreme Performance (flash) Tier.
- Use SAS disks with RAID 5 (4+1) protection for the Performance (SAS) Tier.
- Use RAID 6 (6+2) configuration for the Capacity (NL-SAS) Tier.
- Use automated storage tiering.
- Distribute flash drives across all available buses and avoid using enclosure 0_0.
- Schedule your system relocations for off-hours so that the primary workload does not conflict with the relocation activity.
- Enable FAST VP on a pool, even if the pool has only one tier, to provide ongoing load balancing of LUNs across different drives.
- Leave at least 5 percent of your storage unallocated to facilitate slice relocation activity.
The best practices for leveraging FAST VP with file data are to:

- Use only thick pool LUNs for file.
- Use the entire pool for file capacity.
- Apply the same tiering policy to all LUNs in the pool.
- Create one LUN for every four drives, in multiples of 10. For example, 50 physical drives/4 =12.5 LUNs, rounded up to nearest 10=20 LUNs. This applies to the number of drives used for pool creation or pool expansion.
- When expanding a pool, do not create new LUNs for file data until the rebalance activity is complete.
- Use Thin-enabled file systems. A thin file system is configured with a starting size and a max size and goes through repeated file system auto-extensions as it reaches a high water mark. The auto-extension capacity is typically between 5 and 10 percent.

Designing the virtualization layer

Overview
Oracle Database 11gR2 is fully supported when you deploy it in a virtual environment with VMware vSphere ESXi technology. The following sections describe the best practices and design considerations for Oracle Database 11gR2 virtualization.

Virtualization best practices
In this VSPEX Proven Infrastructure for Oracle Database, EMC recommends that you consider implementing best practices for managing the following resources in your virtualization design:

- Compute resources
- Network resources
- VMware features
- VMware vCenter

Compute resources
EMC recommends that you implement the following compute resource best practices:

- Enable hyper-threading. Hyper-threading technology allows a single physical processor to execute multiple independent threads simultaneously. ESXi is designed to make use of hyper threading by controlling the placement of logical processors on the same core and intelligently managing processor time to guarantee that load is spread evenly across all physical cores in the system.
- Use Hardware-Assisted MMU Virtualization (Intel EPT and AMD RVI) to reduce memory consumption and speed up workloads that cause guest operating systems to modify page tables too frequently.
- Use Non-Uniform Memory Access (NUMA), a computer architecture in which memory located closer to a particular processor is accessed with less delay than memory located farther from that processor.
Chapter 5: Solution Design Considerations and Best Practices

- Allocate Virtual machine memory (vRAM) in a virtual machine to be less than the local memory accessed by NUMA node (processor).
- Schedule the vCPU to use the fewest sockets required using the virtual machine parameter `numa.vcpu.preferHT=TRUE`.
- Install VMware Tools, including several utilities that enhance the performance of the virtual machine's guest operating system and improve the ability to manage the virtual machine.
- Allocate vRAM to be at least twice the size of the Oracle System Global Area (SGA)
- Configure the virtual machine memory reservations to be, at a minimum, the size of the Oracle SGA

**Network resource**

EMC recommends that you implement the following network resource best practices:

- Use the most recent paravirtualized virtual network device from VMware, currently VMXNET Generation 3 (VMXNET3), which supports 10 GbE.
- Use vLANs to separate vSphere infrastructure traffic from virtual machine traffic for security and isolation.
- Enable and configure Jumbo frames throughout the virtual and physical stack for the vMotion and the IP storage networks.
- Use an In-guest NFS mount from an Oracle DNFS client within the virtual machine rather than VMDK on an NFS datastore.

**VMware features**

EMC recommends that you implement the following VMware features:

- **vSphere HA**—This feature uses multiple ESXi hosts, configured as a cluster, to provide rapid recovery from outages and provides cost-effective highly available systems for applications running in virtual machines. vSphere HA protects applications against:
  - A server failure by restarting the virtual machines on other ESXi servers within the cluster
  - Application failure by continuously monitoring a virtual machine and resetting it in the event of a guest OS failure

- **VMware DRS**—This feature automatically balances the workload between the hosts using the vMotion function when migrating virtual machines. When Oracle Database workloads increase, DRS automatically moves a bottlenecked virtual machine to another host with more available resources, without downtime.

- **DRS Affinity rules**—This feature controls the placement of virtual machines on hosts within a cluster. DRS provides two types of affinity rules:
  - A virtual machine-Host affinity rule, which specifies an affinity relationship between a group of virtual machines and a group of hosts
A virtual machine-virtual machine affinity rule, which specifies whether particular virtual machines should run on the same host or be kept on separate hosts.

**DRS Host Affinity and Oracle processor licensing**

The Oracle processor licensing option is based on the interaction of the software with hardware. For Oracle EE, this is based on the number of *physical cores* that are available to the installed Oracle software. For Oracle SE, this is based on the number of *processor sockets* that are available to the installed Oracle software. Oracle does not permit the soft partitioning of CPUs as a means to calculate or limit the number of software licenses required for a physical server. Oracle regards VMware vSphere technology as soft partitioning. In a vSphere environment, you must license all hosts where the Oracle executable files are installed and/or running.

This means that the design and size of the vSphere ESXi cluster, along with placement and movement of virtual machines hosting the Oracle executable files, are essential to minimize Oracle licensing costs.

When a customer’s Oracle requirements do not justify a dedicated VMware cluster, that customer can license a subset of servers in the VMware cluster for Oracle Database 11g EE. In this case, use DRS Host Affinity rules to appropriately restrict the movement of virtual machines within the cluster, including during an HA event. DRS Host Affinity is a clustering technology and is not a mechanism for soft or hard partitioning within a given server. (See *Understanding Oracle Certification Support and Licensing in VMware – Environments*).

**VMware templates**

In VMware terms, a template is a master copy of a virtual machine that you can use to quickly create and provision virtual machines. By using a template, you can install a guest OS onto a virtual machine with application users and software configured and ready for use with minimal user intervention. Templates minimize deployment time and automate repetitive installation and configuration tasks for each virtual machine that is required.

Customization specifications stored in vCenter further simplify the rollout of virtual machines. A deployment wizard, automation tool, or script can use these templates to automatically create or amend server settings (such as server name, time zone, and network configuration) before building the new virtual machine.

**Monitoring the VSPEX Proven Infrastructure regularly**

Make sure you monitor the performance of the VSPEX Proven infrastructure regularly. Monitoring performance not only happens at the virtual machine level, but also at the hypervisor level. For example, with an ESXi hypervisor, you can use performance monitoring within the Oracle Database machine to ensure that the virtual machine or Oracle Database performs as expected. Meanwhile, at the hypervisor level, you can use esxtop to monitor host performance.
## Designing the Oracle Database 11gR2 implementation

### Overview

Design considerations for Oracle Database 11gR2 involve many aspects. The best practice and design considerations in this section provide guidelines for the most common and important ones to follow.

### File system Configuration

Redhat 6.3 supports multiple and various file systems, like VFAT, ext2, ext3, ext4, and Reiser file systems. Oracle generally does not certify file systems or operating systems, but Linux is a specific exception. Oracle’s current support includes ext2, ext3, and ext4 (Oracle Linux 5.6 and later).

Ext4 is the default file system in this solution. Ext4 file systems are robust and are fully supported by Oracle. For more information, see My Oracle Support, Note ID 236826.1 and Note ID 1476869.1.

### Configuring the Oracle dNFS Client

Enable the Oracle dNFS client. It provides both resiliency and performance over an OS-hosted NFS with the ability to automatically failover on the 10 G Ethernet fabric. It also performs concurrent I/O that bypasses any operating system caches and OS write-order locks.

dNFS also performs asynchronous I/O that allows processing to continue while the I/O request is submitted and processed.

### Managing automatic shared memory

Automatic Shared Memory Management (ASMM) is a standard method of dynamically managing memory in Oracle 11g databases and has been available since Oracle Database 10g. This method is compatible with Linux HugePages. EMC recommends that you implement ASMM to automate the management of the following shared memory structures:

- `DB_CACHE_SIZE`
- `SHARED_POOL_SIZE`
- `LARGE_POOL_SIZE`
- `JAVA_POOL_SIZE`
- `STREAMS_POOL_SIZE`

To implement this feature, the following initialization parameters must be set:

- `SGA_TARGET` set to a nonzero value
- `STATISTICS_LEVEL=TYPICAL` (or ALL)

**Note:** Do not use Oracle Automatic Memory Management (AMM) because AMM is incompatible with HugePages. If you want to use HugePages, make sure that both `MEMORY_TARGET` / `MEMORY_MAX_TARGET` initialization parameters are not set.

For more information, see My Oracle Support, Note ID 749851.1.
HugePages is crucial for faster Oracle database performance on Linux if you have a large RAM and SGA. If your combined database SGAs are large (more than 8 GB), you need to configure HugePages. The size of the SGA matters.

The advantages of enabling HugePages include:

- Larger page size and fewer pages
- Better overall memory performance
- No swapping

For more information on enabling and tuning HugePages, see My Oracle Support, Note ID 361323.1.

Set DISK_ASYNC_IO= true. Async I/O is now recommended on all the storage protocols. The default value is true in Oracle 11.2.0.3.

Set FILESYSTEMIO_OPTIONS=SETALL. This setting enables both direct I/O and async I/O. With async I/O, processing continues while the I/O request is submitted and processed.

Direct NFS does not depend on the value of FILESYSTEMIO_OPTIONS. Direct NFS always issues async and direct I/O, as it does not depend on OS support. However, you can always fall back to the OS NFS client in the case of misconfiguration. As a precaution, set the filesystemio_options parameter to SETALL if the OS supports it.

For more information, see My Oracle Support, Note ID 120697.1.

EMC recommends that you create the different storage pools for different Oracle data types, such as data files, online redo log files, and FRA files. However, the traditional method of creating smaller pools or isolated sets of application-centric RAID groups increases the complexity of storage deployment. FAST VP, with its various configuration options, can solve this problem and ease storage deployment complexity. You can also enable FAST Cache when appropriate, depending on the data type. The exact layout requirements will change from deployment to deployment based on the customer’s requirements.

Figure 7 shows one of database layout examples in which the FAST VP storage pools are created on the I/O type of different oracle data types. There are three distinct pools and some simple provisioning policies are defined to guarantee service-level agreements (SLAs) to database administrators and application owners.

### Table 7. Example database layout for a consolidated Oracle environment

<table>
<thead>
<tr>
<th>Application</th>
<th>Redo pool</th>
<th>Data pool</th>
<th>FRA pool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Type</td>
<td>Redo Logs</td>
<td>Data files</td>
<td>FRA files</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FAST Suite policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAST Cache</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>
### Designing backup and recovery

#### Overview
Design considerations for backing up Oracle Database 11gR2 involve many aspects. For information about the best practices and design considerations necessary to back up and recover an Oracle 11gR2 Database, refer to the document entitled *EMC Backup and Recovery Options for VSPEX for Virtualized Oracle 11gR2 Design and Implementation Guides* available on EMC’s online support.

<table>
<thead>
<tr>
<th></th>
<th>Redo pool</th>
<th>Data pool</th>
<th>FRA pool</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAST Policies</td>
<td>No</td>
<td>Auto Tier</td>
<td>No</td>
</tr>
</tbody>
</table>
Chapter 6 Solution Verification Methodologies

This chapter presents the following topics:

- Verifying the solution.................................................................52
- Creating the test environment.....................................................53
- Populating the test database.........................................................53
- Implementing your solution .........................................................54
Verifying the solution

EMC recommends that you test the new VSPEX for Oracle Database 11gR2 application overlay proven architecture before deploying it to the production environment. This confirms that your design achieves the required performance and capacity targets and enables you to identify and optimize potential bottlenecks before they impact users in a live deployment. This section gives a summary description of the high-level steps we performed when verifying this solution.

Before verifying the Oracle Database 11gR2 performance in the VSPEX Proven Infrastructure, make sure you have deployed Oracle Database 11gR2 in your VSPEX Proven Infrastructure based on the Implementation Guides for Oracle Database 11gR2.

Table 8 describes the high-level steps required before you can implement the Oracle Database 11gR2 environment in production.

Table 8. High-level steps for application verification

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Define the test scenario (as noted in the VSPEX sizing tool) to demonstrate a common business workload scenario.</td>
<td>Creating the test environment</td>
</tr>
<tr>
<td>2</td>
<td>Understand the key metrics of your Oracle Database 11gR2 environment to achieve performance and capacity that meet your business requirements.</td>
<td>Step 1: Evaluating the customer use case</td>
</tr>
<tr>
<td>3</td>
<td>Use the VSPEX Sizing Tool for Oracle Database 11gR2 to determine the architecture and resources required by your VSPEX Proven Infrastructure implementation</td>
<td>EMC VSPEX website</td>
</tr>
<tr>
<td>4</td>
<td>Design and build the Oracle Database 11gR2 solution on VSPEX Proven Infrastructure.</td>
<td>Implementation Guide for Oracle Database 11gR2 OLTP</td>
</tr>
<tr>
<td>5</td>
<td>Populate the data using a test tool that simulates a real environment.</td>
<td>Use Swingbench to create and populate database Order Entry schema.</td>
</tr>
<tr>
<td>6</td>
<td>Run the tests, analyze the results, and optimize your VSPEX architecture.</td>
<td>Use Swingbench for sample Oracle Database 11gR2 performance</td>
</tr>
</tbody>
</table>
In addition to the test scenario, it is important to understand the goal of the Oracle Database 11g R2 testing to make it easier to decide which metrics to capture and which thresholds you need to meet for each metric when running the Oracle Database 11g R2 validation tests. To verify the VSPEX for Virtualized Oracle Database 11g R2 solution, consider the following key metrics:

- Transactions per second (TPS)
- Change rate
- Average wait time for User I/O
- Average wait time for Commit

The VSPEX sizing tool helps you to define the basic metrics and thresholds to meet your customer’s business requirements. For more information about using the VSPEX sizing tool, refer to VSPEX Sizing Tool for Oracle Database 11g R2 available on the EMC VSPEX website.

Creating the test environment

After you have determined test objectives, defined the measurements, and calculated the capacity requirements for your database, the next step is to design and create the test environment for the VSPEX for Virtualized Oracle Database 11g R2 solution. The test database should duplicate the production environment as closely as possible. Consider all the features previously described, including storage layout, network load balance, and networking.

In the VSPEX for Virtualized Oracle Database 11g R2 solution, we used Swingbench to simulate a common Oracle Database 11g R2 scenario.

When you set up your test environment, you need to create a plan for the servers and the Oracle Database, as well as for the machines needed to execute the tests. Use one of the machines as the Swingbench server. The Swingbench server will stress the database by simulating a workload of user-defined transactions, and issue requests to the Oracle Database 11g R2 Database. Store the test results on an Oracle Database.

In addition to the test environment and test tool, you may also need to use other tools to prepare a complete test environment for Oracle Database 11g R2. For more information, refer to the Oracle Technology Network (TechNet) article (www.oracle.com/technetwork/index.html) on this topic.

Populating the test database

After creating the test environment, determine what type of data you are going to run. For this solution, we applied a simulated OLTP workload by scaling users with the Swingbench tool, populating a 250 GB database. We then accessed the database using different sessions generated by Swingbench server.
Implementing your solution

After you have designed your VSPEX infrastructure, refer to the EMC VSPEX for Virtualized Oracle Database 11g OLTP Implementation Guide (the companion to this document) for information on how to implement the solution.
This chapter presents the following topics:

EMC documentation ...............................................................56
Other documentation .............................................................56
Chapter 7: Reference Documentation

**EMC documentation**

The following documents, available from the [EMC Online Support](http://www.emc.com) or [EMC.com](http://www.emc.com) websites, provide additional information. If you do not have access to a document, contact your EMC representative.

- *Deploying Oracle Database on EMC VNX Unified Storage*
- *EMC Cost-Efficient Infrastructure for Oracle*
- *Maximize Operational Efficiency for Oracle RAC with EMC Symmetrix FAST VP (Automated Tiering) and VMware vSphere - An Architectural Overview*
- *EMC VNX7500 Scaling Performance for Oracle 11g R2 on VMware vSphere 5.1*
- *VNX Family*
- *VNX Series Documentation on EMC Online Support site*
- *White Paper: EMC Backup and Recovery Options for VSPEX for Virtualized Oracle 11gR2 Design and Implementation Guide*

**Other documentation**

**Oracle white papers**

Refer to the following Oracle white papers, which are relevant to this solution:

- *Oracle Edition Comparisons*
- *Oracle Software Investment Guide*
- *Oracle Database Licensing*
- *Oracle Processor Core Factor Table*
- *Installing and Using Standby Statspack in 11g [ID 454848.1]*
- *How to Tell if the IO of the Database is Slow [Article ID 1275596.1]*
- *HugePages on Linux: What It Is... and What It Is Not... [ID 361323.1]*
  [https://support.oracle.com](https://support.oracle.com) (Requires Login)

**Oracle product documentation**

Refer to the following Oracle product documentation relevant to this solution:

- *Oracle Database 11g Documentation Library 11g Release 2 (11.2)*
- *Oracle Edition Comparisons*
- *Oracle Software Investment Guide*
- *Database Licensing*
- *Oracle Processor Core Factor Table*
- *Understanding Oracle Certification Support and Licensing in VMware – Environments*
Chapter 7: Reference Documentation

**VMware documentation**

Refer to the following VMware white papers relevant to this solution:

- [Understanding Oracle Certification Support and Licensing in VMware – Environments](#)
- [Oracle Databases on VMware Best Practices Guide](#)
- [Best Practices for running VMware vSphere on NFS](#)
- [Performance Best Practices for VMware vSphere™ 5.0](#)

**VMware product documentation**

Refer to the following VMware product documentation relevant to this solution:

- [VMware vSphere Documentation](#)
- [vSphere PowerCLI Documentation](#)
- [Best Practices for running VMware vSphere on NFS](#)
- [Performance Best Practices for VMware vSphere™ 5.0](#)
- [Oracle Databases on VMware Best Practices Guide](#)
- [Understanding Oracle Certification Support and Licensing in VMware – Environments](#)
- [VMware vSphere 5.1 Clustering Deepdive](#) by Duncan Epping and Frank Denneman

**Swingbench documentation**

Refer to the [Swingbench](#) website for information on how to use the product.

---

**Note:** The links provided were working correctly at the time of publication.
This appendix presents the following topic:

VSPEX for Virtualized Oracle OLTP qualification worksheet ........................................60
VSPEX for Virtualized Oracle qualification worksheet example ........................................60
Printing the qualification worksheet ........................................................................63
Appendix A: Qualification Worksheet

VSPEX for Virtualized Oracle OLTP qualification worksheet

Before sizing the VSPEX solution, gather the information from the customer’s Oracle databases using the qualification worksheet shown in Figure 10. This worksheet is appropriate for qualifying multiple databases.

<table>
<thead>
<tr>
<th>Database SID</th>
<th>Memory</th>
<th>Storage</th>
<th>Avg wait (ms)²</th>
<th>Forecast Yearly growth %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SGA (MB)</td>
<td>PGA (MB)</td>
<td>READ IOPS¹</td>
<td>WRITE IOPS¹</td>
</tr>
</tbody>
</table>

Figure 10. Qualification worksheet for EMC VSPEX for Oracle 11g OLTP

You can use the Oracle Automatic Workload Repository or Statspack Reports to obtain this information as described in the Oracle Database Performance Tuning Guide 11g Release 2 (11.2) documentation available at: http://docs.oracle.com/cd/E11882_01/server.112/e16638/toc.htm

VSPEX for Virtualized Oracle qualification worksheet example

You can obtain the information required to populate the EMC Oracle qualification worksheet from each Oracle database from the Automatic Workload Repository (AWR). The Automatic Workload Repository (AWR) and the Statspack Repository each provide key statistics on database performance, load, and resources (both internal and external). You can access this data using standard Oracle supplied scripts. You can obtain the remaining information from the customer or by using the simple queries provided in this appendix.

Database memory settings

Use the init.ora Parameters section of the AWR report to calculate the System Global Area (SGA) and Program Global Area (PGA) values as shown in Figure 11

init.ora Parameters

Figure 11. The init.ora Parameters from the AWR Report
Many customers will know the numbers of users connected to their system. However, you can use the SQL query shown in Figure 12 to confirm the maximum number of users connecting to the database concurrently.

```
SQL> select SESSIONS_CURRENT, SESSIONS_HIGHWATER from v$license;

SESSIONS_CURRENT   SESSIONS_HIGHWATER
------------------------------------------
        5               249
1 row selected.
```

**Figure 12. Querying the user session high watermark**

Use the data and temporary file sizes used to populate the **DB Size (MB)** column and calculate the total as shown in Figure 13.

```
SQL> select ltrim(to_char(sum(bytes)/(1024*1024))) as "Total size (M)"
from (select sum(bytes) as bytes from v$datafile union select bytes from v$tempfile);

Total size (M)
----------------------------------------
 256000
1 row selected.
```

**Figure 13. Calculating the database size using a SQL query**

You can obtain the READ IOPS, WRITE IOPS, and Change Rate (MB/s) columns in the "IOStat by Function summary" section of the AWR report. Figure 14 shows these columns.

**IOStat by Function summary**

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Reads: Data</th>
<th>Reqs per sec</th>
<th>Data per sec</th>
<th>Writes: Data</th>
<th>Reqs per sec</th>
<th>Data per sec</th>
<th>Waits: Count</th>
<th>Avg Time(ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer Cache Reads</td>
<td>18.5G</td>
<td>1341.43</td>
<td>10.5056</td>
<td>0M</td>
<td>0.00</td>
<td>0M</td>
<td>2440.7K</td>
<td>5.33</td>
</tr>
<tr>
<td>DBWR</td>
<td>0M</td>
<td>0.00</td>
<td>0M</td>
<td>11.1G</td>
<td>607.95</td>
<td>823702</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>2.6G</td>
<td>3.56</td>
<td>142744</td>
<td>2.6G</td>
<td>1.97</td>
<td>140155</td>
<td>662</td>
<td>0.43</td>
</tr>
<tr>
<td>LGWR</td>
<td>4M</td>
<td>0.16</td>
<td>000203</td>
<td>2.4G</td>
<td>830.26</td>
<td>134988</td>
<td>666.1K</td>
<td>0.24</td>
</tr>
<tr>
<td>Direct Reads</td>
<td>2M</td>
<td>0.14</td>
<td>001101</td>
<td>0M</td>
<td>0.81</td>
<td>0M</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Direct Writes</td>
<td>0M</td>
<td>0.00</td>
<td>0M</td>
<td>2M</td>
<td>0.14</td>
<td>001101</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>21.2G</td>
<td>1341.35</td>
<td>11.9363</td>
<td>15.9G</td>
<td>1140.82</td>
<td>6.96035</td>
<td>3400.9K</td>
<td>3.69</td>
</tr>
</tbody>
</table>

**Figure 14. IOStat by function summary from the AWR Report**
Appendix A: Qualification Worksheet

Obtaining user I/O time and commit time

The following Oracle wait events (shown in Figure 15) provide key response time statistics for the Oracle database.

- **Use** `db file sequential read` **to populate the User I/O column.** Oracle recommends that this value is under 20 ms.
- **Use** `log file sync` **to populate the Commit column.** Oracle recommends that this value be under 15 ms.

![Figure 15. Foreground Wait Event from the AWR](image)

Transactions in the Load Profile from the AWR report

You can obtain the value used to populate the TPS column of the worksheet from transactions in the Load Profile as shown in Figure 16.

![Figure 16. Transactions in a load profile from the AWR report](image)

2 Reference: My Oracle Support: How to Tell if the IO of the Database is Slow [ID 1275596.1]
Printing the qualification worksheet

A standalone copy of the qualification worksheet is attached to this document in PDF format. To view and print the worksheet:

1. In Adobe Reader, open the Attachments panel as follows:
   - Select View > Show/Hide > Navigation Panes > Attachments.
   - or
   - Click the Attachments icon as shown in Figure 17.

![Figure 17. Printable qualification worksheet](image)

2. In the Attachments panel, double-click the attached file to open and print the qualification worksheet.
Appendix B: Manually Sizing Your Solution

This appendix presents the following topic:

**Manually sizing a virtualized Oracle Database 11g OLTP for VSPEX**

65
Manually sizing a virtualized Oracle Database 11g OLTP for VSPEX

Overview

This section describes how to calculate the resources required in a VSPEX proven infrastructure for Oracle Database 11g OLTP. We use three working examples that demonstrate how the Oracle manual sizing methodology. You can apply the methodology used in these examples to homogeneous provisioning pools with or without configuring FAST VP or FAST Cache.

The flow of these examples is to:

1. Complete the VSPEX for Virtualized Oracle OLTP qualification worksheet as shown in Appendix A.
2. Determine the user count from the completed qualification worksheet, mapped to the virtual machine resources and VSPEX reference virtual machines.
3. Calculate the storage requirement for Oracle Database 11g.

Example one: Homogenous pool without FAST

This sizing example involves the following five steps.

Step 1: Determine the workload

Understanding the workload is always the first thing you need to know for host/storage system configuration. The workload consists first of calculating the number of drives for performance, and then calculating the right number of drives for capacity.

Using a completed EMC Oracle Qualification Worksheet (see Table 9), you can estimate the resources required for vCPU, memory, and storage for your Oracle Database 11g OLTP environment.

Note: Use these instructions to manually determine the approximate size of a single application if the VSPEX Sizing Tool website is not available. EMC recommends that you use the VSPEX Sizing Tool, with its multi-application, multi-instance capability, as the preferred sizing approach.

Table 9. EMC Oracle Qualification Worksheet example

<table>
<thead>
<tr>
<th>Database SID</th>
<th>Memory</th>
<th>Storage</th>
<th>Avg. wait (ms)</th>
<th>Forecast yearly growth %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SGA (MB)</td>
<td>PGA (MB)</td>
<td>Users</td>
<td>DB size (MB)</td>
</tr>
<tr>
<td>VSPEX1S</td>
<td>4,096</td>
<td>787</td>
<td>150</td>
<td>256,000</td>
</tr>
<tr>
<td>VSPEX1M</td>
<td>8,192</td>
<td>787</td>
<td>250</td>
<td>256,000</td>
</tr>
</tbody>
</table>
Step 2: Determine the virtual machine resources

Taking the user count for VSPEX1S and VSPEX1M from Table 9, and referencing Table 10, we can obtain the size of the virtual machine required and the number of VSPEX reference virtual machines.

<table>
<thead>
<tr>
<th>Oracle model (S/M/L)</th>
<th>Virtual machine resources</th>
<th>VSPEX reference virtual machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 150 users (small)</td>
<td>2 vCPUs and 8 GB memory</td>
<td>4</td>
</tr>
<tr>
<td>Up to 250 users (medium)</td>
<td>4 vCPUs and 16 GB of memory</td>
<td>8</td>
</tr>
<tr>
<td>For more than 250 users (large)</td>
<td>8 vCPUs and 32 GB of memory</td>
<td>16</td>
</tr>
</tbody>
</table>

VSPEX1S has 150 users and an SGA of 4,096. This requires a Small Oracle Model with two vCPUs and 8 GB memory, and maps to four VSPEX reference virtual machines.

VSPEX1M has 250 users and an SGA of 8,192. This requires a virtual machine with four vCPUs and 16 GB of memory, and maps to eight VSPEX reference virtual machines.

This configuration, therefore, requires a total of 12 VSPEX reference virtual machines used for calculating the required VSPEX virtual Infrastructure pool size.

Step 3: Determine the I/O drive load and the number of drives for performance

The performance calculation itself consists of two sub-steps:

- Calculating the correct number of drives for IOPS or bandwidth
- Calculating the correct model storage system to support the drive’s performance

As described in Designing the storage layout, when calculating the storage requirement for a database, consider both I/O performance and capacity. First, determine the RAID type of the pool and drive-group size. In this solution, all data and redo files should reside on RAID5 storage while the Oracle FRA files placed on RAID6.

You calculate the storage requirements for each database using the values collected in the Qualification Worksheet and the information provided in Table 11 and Table 12.

For example, the database entry VSPEX1S (in Table 9) has the following storage profile:

- Database size of 256,000 MB (250 GB)
- Five percent annual growth gives a three-year capacity of 296 GB
- The database has 595 read and 256 write IOPS
- The redo change rate is 0.59 MB/s
Appendix B: Manually Sizing Your Solution

Table 11. RAID type and write penalty and capacity utilization

<table>
<thead>
<tr>
<th>RAID</th>
<th>Capacity utilization</th>
<th>Multiple of</th>
<th>Write penalty</th>
<th>Active drives</th>
<th>Parity drives</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAID 5 (4+1)</td>
<td>0.80</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>RAID 6 (6+2)</td>
<td>0.75</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 12. Random disk IOPS and bandwidth by drive type

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>IOPS</th>
<th>Bandwidth (MB/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 K SAS</td>
<td>180</td>
<td>60</td>
</tr>
<tr>
<td>10 K SAS</td>
<td>140</td>
<td>30</td>
</tr>
<tr>
<td>NL-SAS</td>
<td>90</td>
<td>20</td>
</tr>
<tr>
<td>SSD</td>
<td>3,000</td>
<td>100</td>
</tr>
</tbody>
</table>

To calculate the storage array IOPS, take the database read and write IOPS, and apply the following formula:

\[
\text{Array IOPS} = \text{read IOPS} + (\text{write IOPS} \times \text{RAID write penalty})
\]

For example, you calculate the drive load for database VSPEX1M as follows:

RAID 5(4+1): \( 595 + (256 \times 4) = 1619 \) IOPS

For this workload, the total IOPS of both databases is:

RAID 5(4+1): \( 595 + (256 \times 4) + 464 + (211 \times 4) = 2927 \) IOPS

In Table 9:

- The data pool uses a 900 GB 10 K SAS drive with a random read/write workload. Table 12 shows that this drive supports 140 random IOPS.
- The redo pool also uses a 900 GB 10 K SAS drive with a sequential write workload. A conservative value of 30 MB/s per drive is used for sustained writes.
- The FRA pool is made up of 3 TB 7.2 k NL-SAS drives with a sequential write workload. A conservative value of 20 MB/s per drive is used for these sustained writes.
## Table 13. Storage pool calculation example

<table>
<thead>
<tr>
<th>Storage pool</th>
<th>Number of drives</th>
<th>Total capacity (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle data pool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAID 5</td>
<td>25 drives</td>
<td>900 GB x 25 x 0.8 = 18,000</td>
</tr>
<tr>
<td></td>
<td>21 = 2927/140</td>
<td>Round up to a multiple of 5 to allow for RAID 5 (4+1)= 45 drives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oracle redo pool</td>
<td>5 drives</td>
<td>900 GB x 5 x 0.8 = 3,600</td>
</tr>
<tr>
<td>RAID 5</td>
<td></td>
<td>1 = ((0.42+0.59+1.18)MB/s * 4) / 30 MB/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Round up to a multiple of 5 to allow for RAID 5 (4+1)=5 drives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oracle FRA pool</td>
<td>8 drives</td>
<td>3 000 GB x 8 x 0.75 = 18,000</td>
</tr>
<tr>
<td>RAID 6</td>
<td></td>
<td>Round up to a multiple of 8 to allow for RAID 8 (6+2)=8 drives</td>
</tr>
</tbody>
</table>

### Step 4: Determine the capacity

The number of drives in a storage system is determined by both the performance and capacity needs. The method described previously calculates the minimum number of drives needed to meet performance requirements. Also, the number of drives needs to be resolved to meet the storage capacity requirement.

Unless a database is unusually large, the storage requirement for performance usually determines the number of data drivers. In this example, the storage solution using the fewest number of drives that was calculated previously meets the capacity requirements.

Make sure to plan for future growth. It is important to have enough storage capacity and performance to satisfy the workload’s near-future requirements. In this example, we do calculate the 5 percent annual growth.

### Step 5: Select the right VSPEX Proven Infrastructure

Refer to the appropriate EMC VSPEX Proven Infrastructure and calculate the number of disks number required for the VSPEX private cloud pool using the virtual infrastructure building block methodology.

**OS capacity sizing**

One Oracle 11.1g Database instance will have one OS volume, and the capacity is fixed at 100 GB. For more information on capacity sizing, refer to the Virtualization Infrastructure documents available on EMC Online Support.

**OS IOPS sizing**

The OS IOPS is fixed at 25 IOPS for each OS volume. For more information on OS IOPS sizing, refer to Virtualization Infrastructure documents available on EMC Online Support.
Table 14. Mapping reference virtual servers to the virtual infrastructure pool

<table>
<thead>
<tr>
<th>Virtual servers</th>
<th>Flash drives</th>
<th>SAS drives</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>26</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>39</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>52</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>65</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>78</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>91</td>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>104</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>117</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>125</td>
<td>2</td>
<td>45*</td>
</tr>
</tbody>
</table>

Note: Due to increased efficiency with larger stripes, the building block with 45 SAS drives can support up to 125 virtual servers. To grow the environment beyond 125 virtual servers, create another storage pool using the building block method described here.

To calculate the appropriate VSPEX Proven Infrastructure type for your solution, use the following steps:

1. Use the previously described manual sizing procedure to obtain the total number of reference virtual machines and any additional suggested storage layout for the application. For this example:
   - OracleRVM = Number of reference virtual machines required for VSPEX1M (8) + number of reference virtual machines required for VSPEX1S (4) = 12 reference virtual machines
   - VIPool=12 reference virtual machines = 7 drives (see Table 14)
   - Total OracleDrives suggested for both Oracle 11g OLTP databases (VSPEX1S/VSPEX1M) = 25+5+8=38
   - Total drive count = VIPool + OracleDrives (7 + 38) = 45 drives
   - For this solution, we have a requirement for 12 reference virtual machines and 45 drives.
2. Use Table 15 to select the VSPEX private cloud with VMware solution model.

<table>
<thead>
<tr>
<th>VSPEX Proven Infrastructure model</th>
<th>Maximum supported reference virtual machine</th>
<th>Supported storage array</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 300 virtual machines</td>
<td>300</td>
<td>VNX5400</td>
</tr>
<tr>
<td>Up to 600 virtual machines</td>
<td>600</td>
<td>VNX5600</td>
</tr>
<tr>
<td>Up to 1,000 virtual machines</td>
<td>1,000</td>
<td>VNX5800</td>
</tr>
</tbody>
</table>

**Note:** To determine the number of reference virtual machines to use in your environment, refer to the document entitled *EMC VSPEX Private Cloud VMware vSphere 5.1 for up to 1,000 Virtual Machines*.

**Example two: Sizing for a FAST VP pool**

This example uses the procedures above to create a virtual provisioning pool using the FAST VP feature to calculate the number of drives required to meet both the performance and capacity requirements.

To create tiered pools, you must enable FAST VP, and then follow the five steps below.

**Step 1: Determine the workload**

This example uses the data from the previous example.

**Step 2: Determine the required I/O load of the top tier and drive estimate**

Next, we allocate the pool resources. In this example, we use a three-tiered FAST VP pool, which includes Flash, SAS, and NL_SAS drives. The top tier consists of Flash drives, while other tiers include the SAS and NL_SAS drives.

Ideally, the most conservative approach is to assume the top tier will handle the greater portion of the performance. However, not all of the host IOPS really need to be handled by the highest tier. The calculations were previously performed and are captured in Table 9 storage pool calculation example. However, we need to adjust the performance to account for the locality.

Locality is a statement on the statistical distribution of your most frequently accessed capacity to infrequently accessed capacity. The most frequently accessed data goes on the highest performing storage devices. Occasionally, less frequently accessed data will be read or written. This I/O will have a longer host response time than more frequently accessed data located on higher performing storage devices. The accuracy of your locality data determines how variable the host response time shall be. The more accurate, the lower the average host response time.

To leverage the FAST VP feature, you need locality of reference information. The locality information is used to estimate the division of drive capacity and I/O load between the tiers.
In this example, we assumed a locality of 10, which means that about 10 percent of the data is used most frequently.

**Table 16. Example workload for a three-tier FAST VP pool capacity**

<table>
<thead>
<tr>
<th>Database SID</th>
<th>Database size (GB)</th>
<th>Percent locality</th>
<th>Top tier capacity(GB)</th>
<th>Other tier capacity(GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSPEX1S</td>
<td>250</td>
<td>10</td>
<td>25</td>
<td>225</td>
</tr>
<tr>
<td>VSPEX1M</td>
<td>250</td>
<td>10</td>
<td>25</td>
<td>225</td>
</tr>
</tbody>
</table>

The locality allocated the majority of the IOPS to the top tier:

- VSPEX1S: \((464 + (211*4)) * 0.9 = 1178\) IOPS
- VSPEX1M: \((595 + (256*4)) * 0.9 = 1458\) IOPS
- The total IOPS for the top tier will be \(1178 + 1458 = 2636\) IOPS

Next, calculate the number of drives needed for the RAID levels to satisfy the top tier's performance requirements. Using Table 12, Random disk IOPS and bandwidth by drive type, calculate the number of IOPS of flash drive as follows:

**RAID 5(4+1):** \(2636/3000 = 1\) drive total

Provision the top tier with the flash RAID group. In this example, RAID 5(4+1) is default raid type for top tier, which results in five flash drives.

**Step 3: Determine the required I/O load of the other tiers and drive estimate**

Not all host IOPS must be handled by the highest tier. The lower tier has a performance margin that can also be productive. Using the workload captured in Table 9, subtract the FAST VP top tier to get an estimate of the IOPS load on the lower tier using the following calculation:

\[ 595 + (256*4) + 464 + (211*4) - 2636 = 2927 - 2636 = 291 \text{ IOPS} \]

You should always check that the lower tier is able to sustain the IOPS load required of it. In this case, a RAID 5 SAS group has about 700 IOPS, which will result in low host response times for data on the lower tier.

In addition, a RAID 6 NL-SAS RAID group has about 450 IOPS. A single NL_SAS RAID group in the lower tier might have low IOPS, but it results in high capacity for data on this tier.

**Step 4: Determine the capacity of FAST VP pool**

You calculate the FAST VP pool storage capacity by summing the capacity of the usable drive space of all the data drives in the tiers. In this example, we use the 900 GB capacity SAS drives and 3 TB capacity NL_SAS drives. We also selected the 200 GB flash drives. You can substitute the other capacity or speed drives in the calculation.

**Note:** Database redo logs and FRA files have a very predictable sequential write workload, and this type of activity does not benefit significantly from tiering up to flash. EMC recommends that you pin them to their existing tier.
Appendix B: Manually Sizing Your Solution

Table 17. Storage pool calculation for Example Two

<table>
<thead>
<tr>
<th>Storage pool</th>
<th>Number of drives</th>
<th>Total capacity (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle data FAST VP pool</td>
<td>18 drives</td>
<td>200 GB x 5 x 0.8 + 900 GB x 5 x 0.8 + 3000 GB x 8 x 0.75 = 22,400 GB</td>
</tr>
<tr>
<td></td>
<td>5 flash drives (RAID 5) + 5 SAS drives (RAID 5) + 8 NL_SAS drives (RAID 6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Round up to a multiple of 5 to allow for RAID 5 (4 +1) = 5 drives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Round up to a multiple of 8 to allow for RAID 8 (6+2)=8 drives</td>
<td></td>
</tr>
<tr>
<td>Oracle redo pool RAID 5</td>
<td>5 drives</td>
<td>900 GB x 5 x 0.8 = 3,600 GB</td>
</tr>
<tr>
<td></td>
<td>1 = ((0.42+0.59+1.18)MB/s * 4) / 30 MB/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Round up to a multiple of 5 to allow for RAID 5 (4 +1)=5 drives</td>
<td></td>
</tr>
<tr>
<td>Oracle FRA pool RAID 6</td>
<td>8 drives</td>
<td>3 TB x 8 x 0.75 = 18,432 GB</td>
</tr>
<tr>
<td></td>
<td>Round up to a multiple of 8 to allow for RAID 8 (6+2)=8 drives</td>
<td></td>
</tr>
</tbody>
</table>

Generally, the storage solution using the fewest number of drives that meets the performance and capacity requirement is the best solution. However, a more reasonable solution would match the additional workload and expected annual data growth. In this example, while we applied careful consideration to the reliability of the locality information, flash drives with RAID 5 would be a good candidate, which fits the requirements and uses fewer drives. In addition, the lower tier’s performance, which includes SAS RAID 5 and NL_SAS RAID 6, is compatible with extended load.

**Step 5: Select the right VSPEX Proven Infrastructure**

This example uses the same procedure above to calculate the appropriate VSPEX Proven Infrastructure type for your solution:

1. Use the previously described manual sizing procedure to obtain the number of reference virtual machines required, and any additional suggested storage layout for the application. For this example:
   - OracleRVM = the number of reference virtual machines required for VSPEX1M (8) + the number of reference virtual machines required for VSPEX1S (4) = 12 reference virtual machines
   - VIPool=12 reference virtual machines = 7 drives (see Table 14 on page 69)
   - OracleDrives suggested for both Oracle 11g OLTP databases (VSPEX1S/VSPEX1M) = 5+5+8+5+8=31
   - Total drive count = VIPool + OracleDrives (7 + 31) = 38 drives
   For this solution, we have a requirement for 12 reference virtual machines and 38 drives.

2. Use Table 15 on page 70 to select the VSPEX private cloud with VMware solution model.
**Example three: Sizing with FAST Cache**

This example uses the procedure above to size a workload for a data pool supplemented by a FAST Cache. To configure FAST Cache, complete the following five steps.

**Step 1: Determine the workload**

This example uses the data from the previous example.

**Step 2: Size the FAST Cache**

FAST Cache reduces the load on the storage devices by directly reducing the IOPS serviced by mechanical hard drives. The FAST Cache feature leverages the same locality of referenced information that is needed for a FAST VP pool estimate. Estimate the capacity of the FAST Cache based on the ratio of the high locality capacity to the total pool capacity.

In this example, we implemented a two 200 GB Flash drive FAST Cache as RAID 1. For the calculation purposes, we used a more conservative 50 percent cache hit rate, which means that there is a 50 percent chance that FAST Cache will handle the I/O.

This estimate is based cache that has been “warmed up” or in place and running for a while. Initially, before the cache has a chance to “warm up,” the hit rate is lower. For the calculation purposes, we used a more conservative 50 percent cache hit rate, which means there is potential for 50 percent of the I/O to be handled by the FAST Cache.

Adjust the host IOPS served by mechanical drives by reducing them by the FAST Cache hit rate percentage. Table 18 summarizes the calculations performed.

**Table 18. FAST Cache hit rate and workload calculations**

<table>
<thead>
<tr>
<th>Database SID</th>
<th>Database Size(GB)</th>
<th>Host IOPS</th>
<th>FAST Cache hit rate percent</th>
<th>Host IOPS after FAST Cache</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSPEX1S</td>
<td>250</td>
<td>1,308</td>
<td>50</td>
<td>654</td>
</tr>
<tr>
<td>VSPEX1M</td>
<td>250</td>
<td>1,619</td>
<td>50</td>
<td>810</td>
</tr>
<tr>
<td>Total FAST Cache IOPS</td>
<td></td>
<td></td>
<td></td>
<td>1,464</td>
</tr>
</tbody>
</table>

Next, calculate the number of drives needed for the RAID levels to serve the required IOPS. Using Table 12, random disk IOPS, and bandwidth by drive type, calculate the number of IOPS of flash drive.

RAID 1(1+1): $1,464/3,000= 1$ drive total

In this example, RAID 1(1+1) is default RAID type for FAST Cache, which results in two flash drives.

**Step 3: Determine the required I/O load for non-flash drives**

To calculate the required IOPS served by non-flash drives, apply the following formula:

\[
\text{Non-flash IOPS} = \text{total IOPS} - \text{FAST Cache IOPS}
\]
For example, you calculate the drive load for databases VSPEX1S and VSPEX1M as follows:

\[ 1,308 + 1,619 - 1,464 = 1,463 \text{ IOPS} \]

**Note:** EMC recommends that you only use FAST Cache on the storage pool or LUNs that require it. FAST Cache is best for small random I/O where data has skew.

<table>
<thead>
<tr>
<th>Storage pool</th>
<th>Number of drives</th>
<th>Total capacity (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle data pool RAID 5</td>
<td>15 drives</td>
<td>900 GB x 15 x 0.8 = 10,800</td>
</tr>
<tr>
<td></td>
<td>11 = 1463/140</td>
<td>Round up to a multiple of 5 to allow for RAID 5 (4 +1)= 15 drives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>900 GB x 15 x 0.8 = 10,800</td>
</tr>
<tr>
<td>Oracle redo pool RAID 5</td>
<td>5 drives</td>
<td>900 GB x 5 x 0.8 = 3,600</td>
</tr>
<tr>
<td></td>
<td>1 = ((0.42+0.59+1.18)MB/s * 4) / 30 MB/s</td>
<td>Round up to a multiple of 5 to allow for RAID 5 (4 +1)=5 drives</td>
</tr>
<tr>
<td>Oracle FRA pool RAID 6</td>
<td>8 drives</td>
<td>3000 GB x 8 x 0.75 = 18,000</td>
</tr>
<tr>
<td></td>
<td>Round up to a multiple of 8 to allow for RAID 8 (6+2)=8 drives</td>
<td>3000 GB x 8 x 0.75 = 18,000</td>
</tr>
</tbody>
</table>

**Step 4: Determine the capacity**

The capacity remains the same as in the previous example. See example One: homogenous pool without FAST, **Step 4: Determine the capacity** on page 68.

**Step 5: Select the right VSPEX Proven Infrastructure**

This example uses the same procedure above to calculate the appropriate VSPEX Proven Infrastructure type for your solution.

1. Use the previously described manual sizing procedure to obtain the total number of reference virtual machines and any additional suggested storage layout for the application. For this example:
   - OracleRVM = the number of reference virtual machines required for VSPEX1M (8) + the number of reference virtual machines required for VSPEX1S (4) = 12 reference virtual machines
   - VIPool=12 reference virtual machines = 7 drives (see Table 14 on page 69)
   - Total OracleDrives suggested for both Oracle 11g OLTP databases (VSPEX1S/VSPEX1M) = 2+15+5+8=30
   - Total drive count = VIPool + OracleDrives (7 + 30) = 37 drives

   This example uses up to 12 reference virtual machines and 37 drives as the minimum VSPEX Proven Infrastructure.

2. Use Table 15 on page 70 to select the VSPEX private cloud with VMware solution model.