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Oracle Special Edition

Server Virtualization

FOR DUMMIES®

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- **Virtualize Oracle SPARC and x86 servers**
- **Recognize deployment scenarios for server virtualization**
- **Manage your physical and virtual infrastructure**

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Server Virtualization FOR DUMMIES®

ORACLE SPECIAL EDITION

by Lawrence C. Miller, CISSP

John Wiley & Sons, Inc.

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Introduction

Server virtualization technologies have experienced tremendous growth in the data center over the past decade. Data center managers deploy virtualization to improve server utilization and increase flexibility in deploying the resources for enterprise applications. Server virtualization enables a more efficient use of server resources, improves application availability, and simplifies application provisioning.

Virtualization's impact on the IT industry has been dramatic. Using virtualization to improve data center operations will continue to drive the deployment of virtualization technologies. However, with so many virtualization options to choose from, selecting the right solution can be difficult. When choosing a virtualization option, it is necessary to take into account application requirements — both business and technical. Virtualization solutions that are integrated with the applications and servers will be the most effective.

The best building blocks for streamlined operations and maximum agility in the data center are comprised of a combination of:

- Hardware
- OS
- Virtualization
- Database
- Applications

- Management
- Support

A comprehensive solution such as this also creates a foundation for future cloud-based deployments. Only Oracle's integrated stack provides a virtualization offering that takes into account the applications, operating systems, and hardware. This "application driven" virtualization can enable deployment of complete solutions — as opposed to just servers and operating systems.

About This Book

This book consists of four short chapters, each written as a stand-alone chapter, so feel free to start reading anywhere and skip around throughout the book!

Chapter 1: Virtualization — What and Why. We start with an overview of virtualization technology and some of the business drivers for server virtualization.

Chapter 2: Virtualization — Where and How. In this chapter, we tell you about the benefits of server virtualization and the risks of inaction.

Chapter 3: Oracle Server Virtualization. Here, we explain some of the many benefits your organization can achieve with Oracle's virtualization technologies.

Chapter 4: Ten Ways Oracle Virtualization Delivers More Value. Here, we tell you how Oracle Virtualization solutions deliver more value than other common industry virtualization products.

Icons Used in This Book

Throughout this book, we occasionally use icons to call attention to important information that is particularly worth noting. Here's what to expect.

This icon points out information that may well be worth committing to your nonvolatile memory, your gray matter, or your noggin' — along with anniversaries and birthdays!

If you're an insufferable insomniac or vying to be the life of a World of Warcraft party, take note. This icon explains the jargon beneath the jargon and is the stuff legends — well, at least nerds — are made of.

Thank you for reading, hope you enjoy the book, please take care of your writers! Seriously, this icon points out helpful suggestions and useful nuggets of information.

Where to Go from Here

With our apologies to Lewis Carroll, Alice, and the Cheshire Cat:

"Would you tell me, please, which way I ought to go from here?"

"That depends a good deal on where you want to get to," said the Cat — er, the Dummies Man.

"I don't much care where . . .," said Alice.

"Then it doesn't matter which way you go!"

That's certainly true of *Server Virtualization For Dummies*, Oracle Special Edition, which, like *Alice in Wonderland*, is also destined to become a timeless classic!

If you don't know where you're going, any chapter will get you there — but Chapter 1 might be a good place to start! However, if you see a particular topic that piques your interest, feel free to jump ahead to that chapter.

Each chapter is individually wrapped (but not packaged for individual sale) and written to stand on its own, so feel free to start reading anywhere and skip around! Read this book in any order that suits you (though we don't recommend upside down or backwards).

We promise that you won't get lost falling down the rabbit hole!

Chapter 1

Virtualization — What and Why

In This Chapter

- Defining server virtualization
- Addressing changing enterprise IT needs
- Understanding the benefits of virtualization
- Exploring Oracle's virtualization portfolio

Successful and market competitive businesses are defined by efficiency, service, and speed. IT is a critical component of these organizations' competitive advantage. With server virtualization, organizations can transform application deployment and management to reduce their total cost of ownership (TCO), increase IT flexibility, and achieve greater business agility.

In this chapter, you find out what virtualization technology is and why it is so important to the modern enterprise, as well as how Oracle delivers the industry's most complete and fully integrated virtualization solutions portfolio.

What Is Virtualization?

Virtualization technology emulates real — or physical — computing resources, such as desktop computers and servers, processors and memory, storage systems, networking, and individual applications. *Server virtualization* creates "virtual environments" that allow multiple applications or server workloads to run on one computer, as if each has its own private computer.

Virtualization is one of the hottest and most disruptive technologies of the past decade and continues to be so today. Yet the basic concept of virtualization originated more than 40 years ago within mainframe computers.

In the 1960s, large and expensive mainframe computers and dumb terminals comprised the enterprise technology landscape, and relatively inexpensive client-server networks with multitasking servers and personal computer (PC) workstations were not even close to becoming a reality. Computer operators used key punches and submitted batch jobs to the mainframe for processing in turn.

The initial foray into virtualization took the form of a time-sharing mainframe system and culminated in the development of the CP-40 operating system. Each user was provided with a virtual machine (VM), which enabled multiple users to access the same mainframe computer simultaneously. A software hypervisor was created to manage memory sharing in the mainframe.

A *hypervisor* — also known as a virtual machine manager (VMM) — allows multiple "guest" operating systems to run concurrently on a single physical host computer. The hypervisor functions between the computer operating system (OS) and the hardware kernel.

The kernel was known as the *supervisor* in mainframes; hence the term *hypervisor* was coined for the software operating above the supervisor.

Two types of hypervisors are defined for server virtualization: Type 1 and Type 2 (see Figure 1-1). A Type 1 hypervisor, also known as a *native* or *bare metal* hypervisor, runs directly on the host computer's hardware. A Type 2 hypervisor, also known as a *hosted* hypervisor, runs within an operating system environment (OSE).

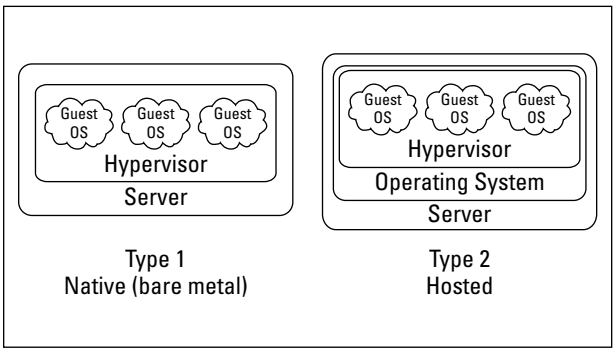

Figure 1-1: Type 1 and Type 2 hypervisors.

Why Virtualize?

Enterprise business requirements are driving a rapidly evolving technology landscape in which:

- Enterprises need greater optimization and efficiency beyond simple consolidation and provisioning of systems

- Data centers are becoming "service centers" that must deliver applications on demand and respond to changing customer requirements with speed and flexibility
- Cloud computing necessitates full stack, integrated application provisioning and management in order to provide users with access to services at any time and from anywhere

Virtualization is a key technology used in data centers to optimize resources. Many companies start their server virtualization journey by consolidating systems to reduce capital expenditures (CAPEX). By focusing their virtualization initiatives on consolidating underutilized resources, many organizations are able to:

- Lower their operating expenses (OPEX), such as energy costs
- Reduce their data center — and carbon — footprint
- Save on capital expenditures for new server equipment
- Provision new systems faster by building standard server operating system images

This strategy works well for file, print, and web server consolidation, where high availability and scalability requirements are often less stringent than for other critical business systems. But too often, such a strategy is limited by its narrow focus on the operating system layer, and therefore lacks integration with applications and other software running in virtual environments.

Server consolidation: A real-world example

Most servers that are running only one workload are underutilized in the data center: There are more hardware resources than the workload requires. The result is grossly inefficient use of an organization's assets. Consolidating legacy servers onto newer systems with virtualization technology can help organizations use their resources more efficiently.

For example, replacing 100 Sun Fire V880 systems running Oracle Solaris 8 with 17 Sun SPARC Enterprise T5240s systems running Oracle Solaris 10 would achieve the following benefits:

- Aggregate throughput performance would not change significantly for more workloads. In most cases, a single T5240 can replace six V880s.
- Reduced space: 100 V880s require 50 data center racks, whereas 17 T5240s can fit in a single rack.
- Approximately 660,000 BTUs of heat generation would be removed from the data center.
- Approximately $200,000 would be saved in electricity costs per year (ignoring the cost of cooling).
- Acquisition costs for the new systems would be completely offset by the OPEX savings achieved in the first year.

But as enterprise IT needs continue to evolve toward on-demand services, data center virtualization requirements have gone well beyond simple consolidation and

CAPEX reduction. IT departments must find better ways to integrate, provision, deploy, and manage systems — at a faster pace — without further straining already tight budgets. Greater optimization and efficiency is needed in how software and solutions that power data centers are deployed and managed.

Enterprise users have also become less tolerant of traditional "build-it-yourself" approaches to technology services — simply provisioning and delivering an operating environment falls short. Instead, they expect resources on demand, right when they need them. To satisfy their users' ever-growing appetite for information and services, IT organizations must rapidly deliver services on demand, such as infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS). Everything simply must work together reliably and securely — and always faster!

As a result, virtualization solutions need to mature and facilitate flexibility, agility, and speed in deploying complete application stacks to support the new services-based charter. Traditional virtualization technologies with isolated hypervisors at the operating system level are no longer sufficient to meet business needs.

Virtualization is not a goal by itself. Virtualization is a means to the strategic goal of enabling services-based IT in the enterprise. It is a journey — not a destination.

Why Virtualize with Oracle?

As IT organizations look to deliver on-demand services, virtualization requirements continue to advance — and companies are realizing that server virtualization is only a partial solution. Without the ability to package complete application environments that can be deployed on demand, IT staff must manually customize solutions in order to deliver services. Today's virtualization solutions need to:

- Evolve beyond simple consolidation
- Support comprehensive application environments that meet stringent high availability and scalability requirements
- Integrate with the applications running in the virtual environment
- Make the entire application stack easier to provision, deploy, manage, and support
- Result in greater IT efficiency, agility, and flexibility

Oracle offers the most complete and integrated virtualization solutions portfolio that can virtualize and manage the full hardware and software stack (see Figure 1-2). With its focus on testing from applications to disk and integrated management and support, Oracle's unique approach to virtualization enables IT to rapidly deliver on-demand services to their end-users when they need it.

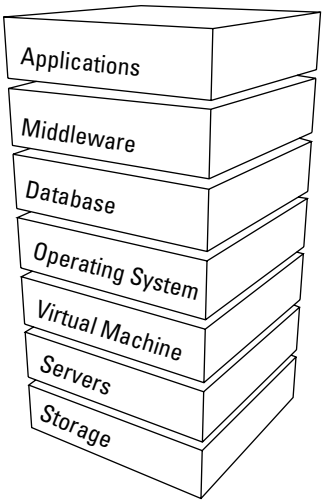

Figure 1-2: Oracle Virtualization from applications to disk.

Server virtualization technologies help organizations create administrative and resource boundaries between applications. This approach provides improved application performance and security, and can also be a vehicle for rapid application provisioning by delivering pre-installed, pre-configured virtual machine images of enterprise software.

Because no two environments have exactly the same needs, Oracle's full range of server virtualization technologies provide varying degrees of isolation, resource

granularity, and flexibility, and can be used separately or together to tackle specific deployment challenges.

Delivering operating system virtualization, virtual machines, and hard partitioning technologies, Oracle's server virtualization solutions can help companies to consolidate applications onto fewer systems to affect better resource utilization, reduce the number of operating system instances to manage, improve security, lower licensing costs, and reduce the time to install and configure software, thereby speeding time to market.

For example, companies can take advantage of **Oracle VM Server for x86**, **Oracle VM Server for SPARC**, and **Oracle Solaris Zones** (also known as **Oracle Solaris Containers**) and **Linux Containers** technology built into **Oracle Linux** to create virtual server environments that can run a wide range of operating systems and take advantage of the latest platform advancements without changing applications, thereby protecting their investments.

In environments requiring bare-metal performance and availability, hard partitioning with **Dynamic Domains** can be used to divide a single system into multiple electrically isolated partitions for the ultimate in workload isolation — software, hardware, and electrical resources that are fully fault isolated.

When rapid software deployment is a key concern, organizations can use the pre-installed and pre-configured software images available in **Oracle VM Templates** (see Figure 1-3) to shorten time to market, eliminate installation and configuration costs, and reduce ongoing maintenance and operational costs.

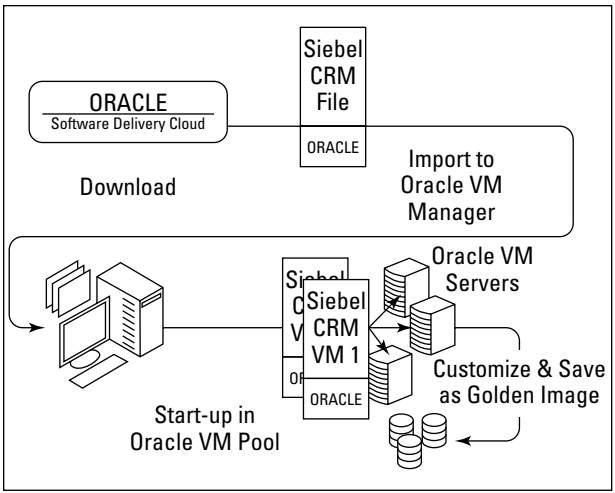

Figure 1-3: Rapid deployment with 90+ Oracle VM Templates.

Finally, **Oracle Enterprise Manager** (see Figure 1-4) integrates with all of Oracle's virtualization offerings to provide end-to-end management in a holistic management framework that supports virtualization in traditional and cloud-based infrastructures. This capability provides IT staff with deep insight into their server, storage, and network infrastructure layers and enables them to manage thousands of systems in a scalable manner.

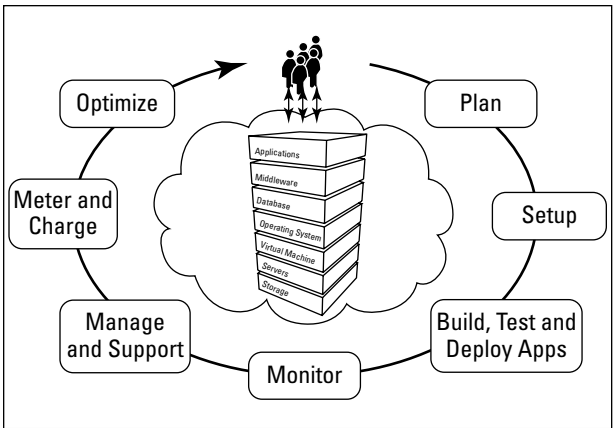

Figure 1-4: Oracle Enterprise Manager provides complete VM and cloud lifecycle management.

Hassle-free deployment with documented best practices

Because the size and complexity of enterprise IT infrastructures can make it difficult to find the right combinations of operating systems, applications, and middleware for optimal performance, Oracle offers two ways to simplify your implementations: Oracle Validated Configurations and Oracle VM Templates.

Developed with industry partners, Oracle Validated Configurations are pretested, validated architectures,

(continued)

(continued)

including software, hardware, storage, and networking components, along with documented best practices for deployment. Organizations can now choose from more than 100 Oracle Validated Configurations.

In addition, a catalog of preinstalled and preconfigured Oracle VM Templates can take the guesswork out of deploying a virtual environment. Oracle VM Templates enable organizations to deploy a fully configured software stack of enterprise software, from Oracle Linux to Oracle Database, Oracle Enterprise Manager, Oracle's Siebel Customer Relationship Management, Oracle Fusion Middleware, and more.

The templates are developed after weeks of testing using various combinations of products and versions. Maintenance is also simple with the templates. Within each template, Oracle software is structured the same as it would be if it were installed and patched manually, and the package and patch inventories are standard and up-to-date so that no changes to normal Oracle operations procedures are required to maintain the instances over time.

Organizations can choose from more than 90 templates, and more are on the way. With Oracle Linux JeOS (Just Enough OS) a secure, minimized OS that is freely redistributable and backed by enterprise-class support — developers and independent software vendors can also create their own Oracle VM Templates.

In Chapter 2, you find out about the different virtualization use cases and deployment models.

Chapter 2

Virtualization — Where and How

In This Chapter

- Managing different workloads
- Migrating virtual servers
- Choosing flexibility or isolation in virtual models

In this chapter, we help you to identify where you should virtualize in your data center (through use cases) and how best to virtualize for your unique business requirements (through virtualization models).

Exploring Use Cases

In order to realize the business benefits of virtualization (discussed in Chapter 1), you need to understand the various use cases that are appropriate for specific scenarios within your data center. In the following sections, you learn about seven common use cases for server virtualization.

Consolidated workloads

The trend within the software industry to design enterprise applications that run on dedicated, purpose-built servers for maximum performance and stability has led to server sprawl in the data center. Virtualization technology allows enterprises to consolidate multiple, often unrelated workloads from multiple servers to a single physical server, running multiple virtual environments (VEs).

In virtualization, *workload* is generally used to describe the operating system and application components of a physical server or host.

Virtualization allows multiple applications to be run on a single physical server in different VEs, creating the effect of a purpose-built server for each of the applications running on the server. This approach avoids potential interoperability issues between applications running in a mixed environment.

Asynchronous workloads

Many enterprise workloads are active at certain times during a typical day, but use few system resources at other times. For example, an organization's customer relationship management (CRM) system may see heavy use during normal business hours, but their enterprise resource planning (ERP) system may not peak until the second and third shifts in its distribution center. Peak utilization for each of these systems may require as much as 60 to 80 percent of server resources (typically processor and memory), but the average utilization may be less than 30 percent for each system.

Virtualization allows you to take advantage of these asynchronous workloads by combining both systems on a single physical server to maximize the overall utilization of the physical server. Virtualization technologies such as resource controls, resource scheduling, and VE migrations (discussed later in this chapter) can be used to help you prevent resource contention issues.

Bursty workloads

Many workloads are characterized by bursts of intense activity, followed by periods of little or no activity.

For example, software developers typically require lots of processing and memory resources while compiling new software code. For this reason, developers often use very powerful computers to do their work. But most of the time, their computer resources are relatively idle, and those same software developers instead require lots of highly caffeinated liquid resources!

Virtualization allows multiple developers to use the same hardware resources. You can build one VE and allocate the appropriate computing resources, then allow each of your developers to connect remotely in order to compile code in turn, as needed.

Relieving scalability constraints

Scalability is always a concern for IT staff when deploying new systems or upgrading existing systems. When you purchase computer equipment — particularly servers — you must anticipate your organization's future growth and user demand. You also must estimate the maximum resource capacity (such as processors, memory, and storage) that will be needed over

the life of the system — typically five to seven years. These complex and sophisticated calculations produce a very precise SWAG — a scientific, wild-uhh . . . academic guess. And the typical result of many SWAGs is that businesses purchase systems that are too expensive and too large (in terms of capacity), hoping they will not outgrow their investment too quickly. Inevitably,

- A new server will initially have excess capacity and therefore be underutilized. Given the general trend that computer hardware costs drop dramatically with each successive technology improvement (such as processor speed), you will almost certainly pay too much for excess capacity far in advance of when you actually need it — and the cost of that same technology will have fallen significantly by the time you need it!
- The workload will eventually outgrow the resource capacity of the server — whether due to business growth, greater user demand, software upgrades, or server obsolescence. When that happens, the entire cycle repeats itself, beginning with yet another SWAG! The operating system and application will then need to be re-installed and configured on the new server — a time-consuming and often error-prone process.

With virtualization, an enterprise can purchase and deploy many smaller servers, then just simply migrate a VE workload to a larger server when it outgrows its original server.

Alternatively, an enterprise can purchase fewer larger servers and install multiple VE workloads on each server to fully utilize its total capacity. When a

workload's resource requirements exceed the capacity of the host server, you can either migrate the VE to a different server, or migrate other VE's to a different server to free additional resources on the server.

Migration is the process of moving a VE from one physical server to another. This operation is possible because of the separation (or containment) that virtualization technology creates between a workload and its server hardware.

Simplified workload mobility

In the preceding section, you learned about VE migration, which is one example of simplified workload mobility. But there are many more use cases for workload mobility. Workload mobility enables you to:

- Perform hardware maintenance or upgrades while minimizing costly downtime by simply moving your VEs to another physical host server while you replace a faulty power supply or add memory in the original host server, for example.
- Proactively manage server resources by automatically migrating unusually busy workloads (see the previous sections on asynchronous and bursty workloads) to less busy physical hosts.
- Maintain business continuity when an outage or disaster occurs by moving workloads to other physical hosts within a data center (for example, to circumvent an isolated outage), or between data centers (for example, in the event of a widespread disaster).

Three migration types are defined for virtualization technology: cold, warm, and live. Each migration type is characterized by the amount of time during which the workload is not available, and by the amount of workload state (for example, active sessions or open transactions) that is lost during the migration process. See Table 2-1 for a summary of the differences between these migration types.

Table 2-1 Virtual Migration Types

Type	*Outage Duration*	*Stateful Transfer*
Cold	Minutes to hours	No
Warm	Tens of seconds	Yes
Live	Less than one second	Yes

The *cold migration process* requires the following three steps:

1. Orderly halting of the original physical host and its workload(s).
2. Transfer of data files from the old storage to new storage, or reconfiguration of shared storage.
3. Start-up on the new physical host and the migrated workloads.

P2V and V2V conversions are two common examples of cold migrations. A P2V (physical-to-virtual) conversion involves converting an existing *physical* server workload to a *virtual* environment (VE) on a host server. A V2V (virtual-to-virtual) conversion involves converting servers and their associated workloads from one

virtualization technology to another (for example, moving from VMware to Oracle VM, or moving an Oracle Solaris 10 Zone from a Oracle Solaris 10 machine to a Oracle Solaris 11 machine).

V2P (virtual-to-physical) conversions, while uncommon, are also possible. For example, after virtualizing a mission-critical online transaction processing (OLTP) application, you may discover that the performance of the virtualized system is unsatisfactory (you should have used Oracle virtualization solutions instead!).

A *warm migration* does not require halting and rebooting of the VE. Unlike a cold migration, active processes on the VE are not shut down during a warm migration, so current state information is maintained. However, a warm migration requires a noticeable service outage, usually on the order of tens of seconds. During that time, the virtualization technology performs the following three steps:

1. Pauses the VE and its processes on the original system.
2. Creates a copy of the VE on the destination (or target) system.
3. Copies a memory image of the related processes from the original VE to the new VE.

The VE processes then continue their execution on the target system and the original memory image is erased.

Similar to a warm migration, a *live migration* does not require halting and rebooting of the VE. But unlike a warm migration, the service outage associated with a live migration is too short (usually less than one second) for most users to notice and any applications

running on the VE are not affected by the outage. The live migration method performs these four steps:

1. Creates a copy of the VE on the destination (or target) system while the VE is still running.
2. Copies a memory image of the related processes from the original VE to the new VE.
3. Pauses the VE and its processes on the original system and transfers a final set of data to the new VE.
4. Passes control of the VE from the original system to the new system.

Flexible, rapid provisioning

Provisioning traditional systems is an expensive and time-consuming process for any organization, which can take days or weeks. Virtualization tools provide IT organizations with a rapid, flexible provisioning capability to support their enterprise requirements. Because virtualized OS environments have a very small disk footprint, IT staff can easily create and clone master OS images for use in virtually (ouch!) any deployment scenario.

Provisioning a new system with virtualization tools takes minutes instead of days and simply involves selecting and fine-tuning (for example, configuring a system name and IP address) the appropriate OS image, then booting it up on the new host server!

Testing and staging

Many test environments are configured for a specific purpose, for example to test a new application or a

modification to an existing application. But these test environments are often underutilized because testing is not typically performed every day or on a regular basis.

Most functional testing of systems and applications can be performed today in a virtualized environment without significantly affecting the outcome of the tests. This allows organizations to consolidate their testing environments and run individual tests on separate VEs. VEs can be quickly provisioned and configured to test specifications and easily decommissioned or re-purposed when the test is concluded.

Virtualization is best used for functional testing rather than performance or scalability testing. Performance testing in virtualized environments is appropriate only if the production workload will be deployed in a VE.

Understanding System Virtualization Models

Three models for system virtualization are commonly used: hardware partitioning, virtual machines, and operating system (OS) virtualization. Each model can be described in terms of two characteristics that have an inverse relationship — flexibility and isolation (see Figure 2-1). Typically, as more isolation is required between VEs, less flexibility is provided in resource allocation. Conversely, flexibility requires resource sharing, which reduces isolation between VEs.

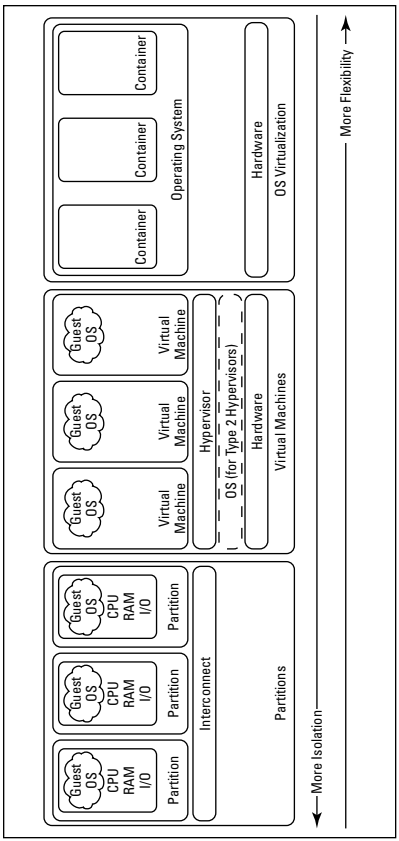

Figure 2-1: Flexibility versus isolation in system virtualization models.

Hardware partitioning

Hardware partitions offer the most isolation but the least flexibility. Hardware partitioning ensures complete electrical segregation of computer hardware resources — CPUs, RAM, and I/O components — to create multiple independent computers within one computer. Each isolated grouping of hardware is called a *partition* or *domain*.

A partition runs its own copy of an operating system and has complete control over its hardware. The OS runs directly on the hardware just as in a traditional physical (nonvirtualized) environment. However, any single failure — whether in hardware or software — in a component of one VE cannot affect another VE in the same physical server.

Partitions are most appropriate for business-critical workloads where service availability is the most important factor.

Virtual machines

The most popular virtualization model is the *virtual machine*. This model mimics multiple servers or workloads — virtual environments (VEs) — on a single physical (or host) system, each running its own OS. Each of these VEs is called a virtual machine. Virtual OS instances are managed by software or firmware — or a combination of both — which also provides multiplexed access to the hardware. This supporting layer of firmware/software — the hypervisor — gives this model its flexibility, but also adds performance overhead while performing its various virtualization functions. For more about the hypervisor, refer to Chapter 1.

Fault isolation varies among different implementations of hypervisors. Each shared resource in the virtual machine model is a potential single point of failure, including the hypervisor itself.

Virtual machines typically represent a middle ground between the isolation of hard partitions (discussed in the preceding section) and the flexibility of operating system virtualization, or OSV (discussed in the following section). The additional isolation of separate OS instances compared to OSV allows for the consolidation of completely different operating systems. The hypervisor layer also provides a convenient point of separation between VEs, thereby facilitating and simplifying VE mobility.

Operating System Virtualization (OSV)

The ability to provide multiple isolated execution environments in one operating system (OS) instance is called *operating system virtualization* (OSV).

Hardware partitioning and virtual machine technologies share a common trait: Each VE contains an instance of an operating system. Most of those technologies allow different operating systems to run concurrently.

In contrast, operating system virtualizations, also known as *zones* or *containers*, use features of the operating system to create VEs that are not separate copies of an operating system. This approach provides the appearance of an individual operating system instance for each VE. Most OSV implementations provide the same OS types as the hosting OS. Others, such as Oracle Solaris Zones, also have the ability to behave as another operating system.

Among the virtualization models, OSVs provide the maximum flexibility but the least isolation between VEs. Isolation in OSVs is enforced by the OS kernel, rather than by a hypervisor (as in VMs) or hardware (as in partitions). All processes share the same OS kernel, which must provide a robust mechanism to prevent two different VEs from interacting directly. Without this isolation, one VE could affect the operation of another VE. The kernel must be modified so that the typical inter-process communication (IPC) mechanisms do not work between processes in different VEs.

OSV implementations usually require little disk space, consume minimal RAM, and add very little CPU overhead.

System virtualization models include hardware partitioning, virtual machines, and operating system (OS) virtualization. Chapter 3 talks about Oracle's virtualization solutions for each of these models.

Chapter 3

Oracle Server Virtualization

In This Chapter

- Unveiling Oracle VM Server for x86
- Looking at Oracle VM Server for SPARC
- Deploying Oracle Solaris Zones
- Understanding Dynamic Domains
- Managing your virtualized environment

Virtualization is moving beyond isolated projects in the data center and fundamentally changing the nature of enterprise IT organizations. By deploying virtualization solutions, IT organizations can improve enterprise applications management.

In this chapter, you find out about Oracle's virtualization solutions portfolio, including Oracle VM for Sun x86 servers and Sun T-Series servers, Dynamic Domains (hardware partitioning) for Oracle M-Series servers, and Oracle Solaris Zones (OS virtualization) for any SPARC or x86 server running Oracle Solaris.

Oracle VM Server for x86

Oracle VM is an enterprise-class server virtualization solution comprised of Oracle VM Server for x86 and Oracle VM Manager (see Figure 3-1).

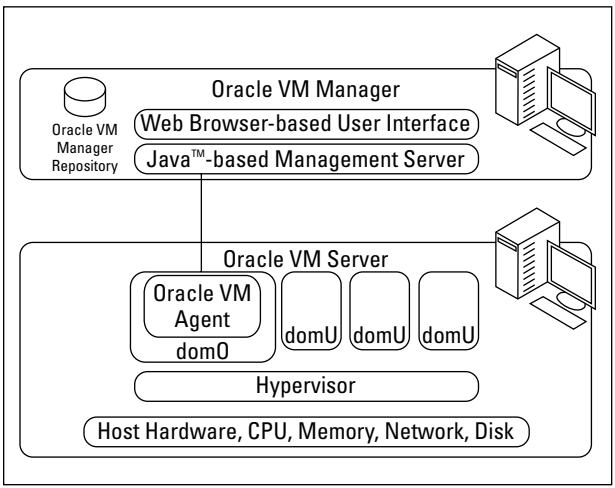

Figure 3-1: Oracle VM components.

Oracle VM Server for x86 3.0 is the most scalable x86 server virtualization solution in the market today. It has been tested to handle mission-critical enterprise workloads with support for up to 160 physical CPUs and 2TB (terabytes) of memory. For virtual machines, Oracle VM 3.0 can support up to 128 virtual CPUs and 1TB of memory per guest VM. Oracle VM supports

industry standard x86 operating systems and servers from Oracle and other third party vendors, and it supports a broad range of network and storage devices, making it easy to integrate into your environment.

Oracle VM Server for x86 installs directly on server hardware with x86 Intel processors and does not require a host operating system. An Oracle VM Server is comprised of a hypervisor and privileged domain (Dom0) that allows multiple domains or virtual machines on different operating systems (such as Linux, Solaris, and Windows) to run on one physical machine. The Dom0 runs a process called Oracle VM Agent.

Oracle VM Manager 3.0 provides an easy-to-use centralized management environment for configuring and operating your server, network, and storage infrastructure from a browser-based interface (no Java client required), and it is accessible from just about anywhere. Users leverage the virtualization manager for creating management policies, as well as cloning, sharing, configuring, booting, and migrating VMs. Oracle VM helps customers improve server utilization, achieve higher availability, and achieve better performance while reducing costs.

Oracle VM Manager controls the virtualization environment, creating and monitoring Oracle VM servers and virtual machines, and serves as the only administrative interface to the Oracle VM servers.

For its management repository, Oracle VM Manager uses an Oracle Database that can be installed either on the same management server or on a separate server.

Oracle VM for x86 is recognized as a "hard partition" with regards to Oracle per core software licensing.

Beyond the virtualization layer, Oracle offers solutions such as Oracle VM Templates and Oracle Virtual Assembly Builder that leverage Oracle VM and enable application-driven virtualization.

Oracle VM Templates

Oracle VM Templates provide the ability to rapidly and easily deploy a single pre-built, pre-configured, pre-optimized, and pre-patched guest virtual machine (or multiple machines depending on the application).

The guest VM can contain a complete Oracle software solution along with the operating system and related software infrastructure. These guest VMs, called Oracle VM Templates (see Figure 3-2), are available from Oracle's E-Delivery website (`edelivery.oracle.com`) and are ready to download and deploy. Already configured for production use, Oracle VM Templates can save IT staff days or weeks learning to install and configure a sophisticated product such as Siebel CRM or Oracle Enterprise Manager Grid Control. Instead, users can simply download and start the VM to begin using it right away.

Within these Templates, Oracle software is automatically configured in the same manner as if the software had been installed and patched manually. The exact same directories and Oracle "homes" are used, and the package and patch inventories are completely standard and up-to-date so that no changes to operational procedures are required to maintain the instances over time. Accordingly, Oracle VM Templates can also be fully customized post-install and then re-saved as "golden image" templates in Oracle VM. Such templates can serve as a user's enterprise deployment standard to minimize risks and variation across multiple instance deployments.

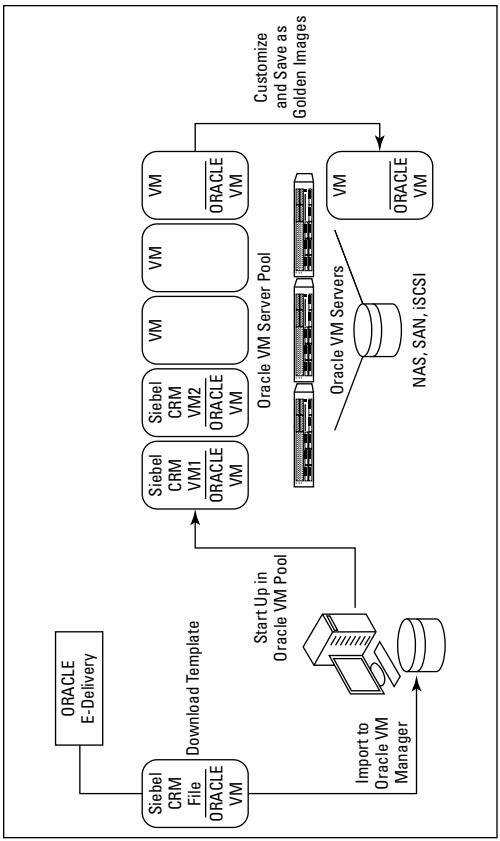

Figure 3-2: Oracle VM Templates can be used to replicate entire enterprise application stacks to virtual environments.

Oracle Virtual Assembly Builder

Combined with Oracle VM, Oracle Virtual Assembly Builder helps organizations quickly create and configure entire multi-tier application topologies and provision them onto virtualized resources. It enables IT organizations to take multi-tier enterprise applications — for example, a web server, application server, and database — and package them into self-contained, single-purpose virtual machines called software appliances. Oracle Virtual Assembly Builder structures the process of combining these appliances into cohesive, reusable units known as *assemblies*.

Oracle Virtual Assembly Builder (see Figure 3-3) is a sophisticated development tool for introspecting the current application environment and creating assemblies or collections of VMs, along with all their critical configuration parameters. This allows you to move your applications to a virtual environment, or to replicate easily and quickly within an existing environment.

An application "assembly" is very similar to an Oracle VM Template except that an additional set of configuration information and management policies are packaged along with the set of multiple virtual machines, their virtual disks, and the interconnectivity between them. These assemblies are packaged using the industry-standard Open Virtualization Format (OVF).

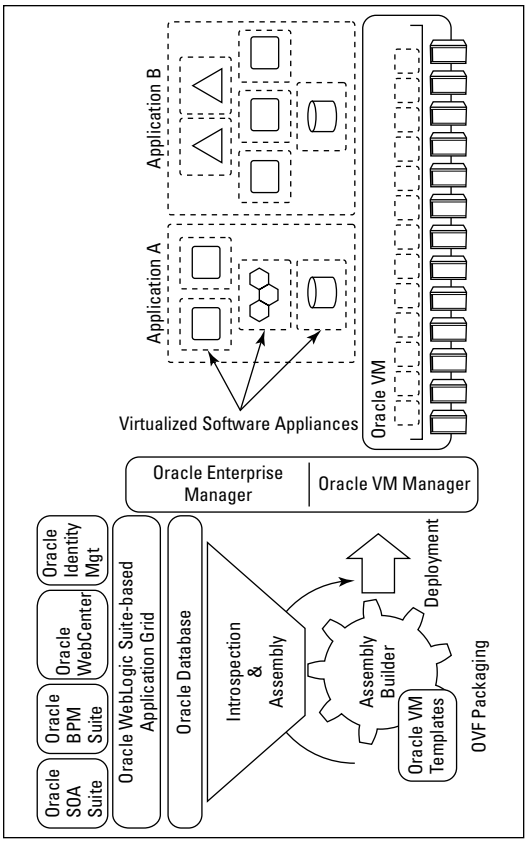

Figure 3-3: Oracle Virtual Assembly Builder.

Oracle VM Server for SPARC

Virtual machines (refer to Chapter 2) are implemented with Oracle VM Server for SPARC and Oracle VM Server for x86. Oracle VM Server for SPARC, previously called Sun Logical Domains, provides highly efficient, enterprise-class virtualization capabilities for Oracle's SPARC T-Series servers and SPARC SuperCluster (see Figure 3-4). This virtualization solution fully optimizes Oracle Solaris and Oracle SPARC servers for your enterprise server workloads, and provides the flexibility to deploy multiple Oracle Solaris Operating Systems simultaneously on a single server.

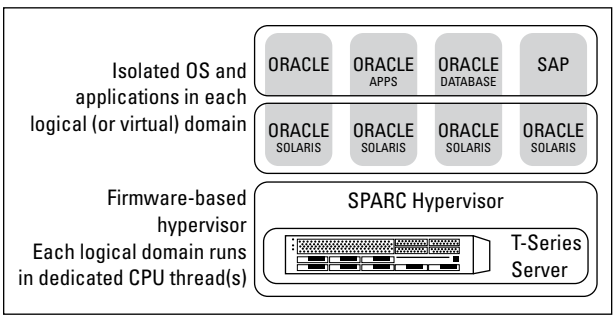

Figure 3-4: Oracle VM Server for SPARC — for your enterprise server workloads.

Oracle VM Server for SPARC leverages a built-in hypervisor to subdivide system resources (CPUs, memory, network, and storage) by creating partitions called *logical domains* (LDoms). Each logical domain can run a

complete Oracle Solaris Operating System instance. Oracle VM LDoms have a granularity of a single processor thread and are dynamic.

Live migration is now available on Oracle's SPARC T-Series systems, including SPARC SuperCluster, SPARC T4, SPARC T3, UltraSPARC T2 Plus, and UltraSPARC T2 servers. This capability enables IT administrators to migrate an active LDom from one T-Series server to another T-Series server while maintaining application availability. The SPARC T-Series on-chip cryptographic accelerators deliver secure, wire-speed encryption capabilities for live migrations — without additional hardware. Other virtualization products require a dedicated network connection for live migrations and transfer VM data in the clear, leaving sensitive data — such as passwords, personal information, and financial data — vulnerable.

Starting with the SPARC T4 processor and Oracle VM Server for SPARC 2.1, you can use dynamic CPU threading controls to optimize workload performance on SPARC T4 and SPARC SuperCluster systems. These threading controls enable you to specify the number of hardware threads to be activated per core. CPU performance can be optimized for CPU-bound workloads by tuning CPU cores to maximize the number of instructions per cycle (IPC). Or, CPU performance can be optimized for maximum throughput by tuning CPU cores to use a maximum number of CPU threads. By default, the CPU is tuned for maximum throughput. Oracle VM for SPARC is recognized as a "hard partition" with regards to Oracle per core software licensing.

Oracle helps NaviSite expand its virtualization platform

NaviSite (www.navisite.com), a Time Warner Cable Company, is a leading worldwide provider of enterprise-class, cloud-enabled hosting, managed applications, and services.

"We needed to expand our existing virtualization platform to meet the growing infrastructure demands of our customers, so it was natural to consider Oracle Sun gear, based on our previous good experiences implementing the UltraSPARC system for systems that required high levels of performance, reliability, and security."

Wm. Wallace Abbott, Senior Director, Technical Operations, NaviSite

Oracle Solaris Zones

Operating System Virtualization, or OSV (refer to Chapter 2), is implemented with Oracle Solaris Zones (also known as Oracle Solaris Containers) to provide virtualization for Oracle SPARC or any x86 servers running Oracle Solaris (see Figure 3-5).

Oracle Solaris Zones are a software-partitioning solution that provides a software environment, which appears to be a complete OS instance on the physical server.

Despite being a software-based technology, zones are considered "hard partitions" with regards to Oracle per core software licensing.

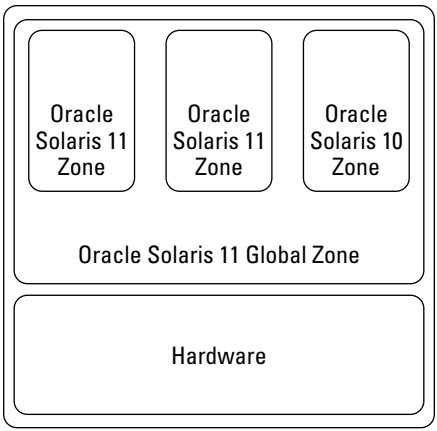

Figure 3-5: Oracle Solaris Zones.

Although zones and containers are the same thing, they use different names. In Oracle Solaris 10, this software partitioning capability is called Oracle Solaris 10 Containers; in Oracle Solaris 11, it is called Oracle Solaris 11 Zones.

Oracle Solaris Zones offer rich features and capabilities, including

- Configurable isolation and security boundaries
- Multiple namespaces — one per zone
- Software packaging, deployment, and flexible file system assignments

- Resource management controls and usage reporting
- Network access
- Optional access to devices
- Centralized or localized software lifecycle management
- Management of zones (such as configure, boot, halt, or migrate)

With Oracle Solaris Zones, you can maintain the one-application-per-partition deployment model while consolidating those applications onto shared hardware resources. An integral part of the Oracle Solaris OS, Oracle Solaris Zones isolate software applications and services using flexible, software-defined boundaries and allow many private execution environments to be created within a single instance of the Oracle Solaris OS.

You can also run your Oracle Solaris 8 and Oracle Solaris 9 applications on Oracle Solaris 10 by deploying them in Oracle Solaris 8 and Oracle Solaris 9 branded containers. This means that you can take advantage of the latest server hardware that may require Oracle Solaris 10. In other words, you can upgrade to the latest hardware without having to upgrade to the latest version of Oracle Solaris. With the release of Oracle Solaris 11, you can run Oracle Solaris 10 applications in Oracle Solaris 10 branded zones.

For organizations already running their applications either in zones or on bare metal hardware on Oracle Solaris 10 systems, virtual-to-virtual (V2V) and

physical-to-virtual (P2V) migration tools are provided to help you transition to an Oracle Solaris 10 Container.

An Oracle Solaris 10 Container can have a shared IP stack with the global zone, or an exclusive IP stack. Oracle Solaris 10 Containers provide a proven, tested, and fully supported option for quick adoption of Oracle Solaris 11. This allows administrators to benefit immediately from all the new features available within Oracle Solaris 11 while providing an easy application migration path.

New management tools in Oracle Solaris 11 facilitate monitoring of system resources consumed by Oracle Solaris Zones. More specifically, administrators can observe memory and CPU utilization, utilization of resource control limits, total utilization, and per-zone utilization over specified time periods.

Finally, with Oracle Solaris 11, the administration of Oracle Solaris Zones is much more flexible. You have the ability to delegate common administration tasks for specific zones to different administrators using Role-Based Access Control (RBAC). With delegated administration for each zone, a user or set of users may be identified with the permissions to log in, manage, or clone that zone.

Oracle Solaris Zones provide the benefits of consolidation and business agility in data centers today. Oracle Solaris Zones isolate software applications and services using flexible, software-defined boundaries, allowing multiple private execution environments to run side by side within a single instance of the Oracle Solaris OS. With each environment having its own identity, separate from the underlying hardware, it behaves as if it's running on its own system — making

consolidation simple, safe, and secure. Oracle Solaris Zones are included in all instances of Oracle Solaris — free of charge. Whether you're running Oracle Sun x86 or Oracle SPARC, you'll have access to Oracle Solaris Zones.

Dynamic Domains

Hardware partitions (refer to Chapter 2) are implemented with Dynamic Domains on Oracle SPARC Enterprise M-Series servers running Oracle Solaris. Dynamic Domains create electrically isolated partitions that provide complete isolation. A *domain* is an independent partition composed of memory, processors, and I/O slots, running its own copy of the Oracle Solaris Operating System. Domains divide a system's total resources into separate units that are not affected by the operations of the other units. A hardware or software fault in one domain does not affect any other domain. Each domain can run different Oracle Solaris 10 or Oracle Solaris 11 versions. Software changes, reboots, user actions, and faults in one domain do not affect applications running in other domains. A Dynamic Domain can be shut down and completely reconfigured or serviced without affecting any other Dynamic Domains in an M-Series server.

Dynamic Domains can be as small as a single processor (the granularity of a Dynamic Domain is a single processor socket) or as large as an entire M-Series server, and they can be resized while applications are running. Processors, memory, and I/O slots can be moved from one Dynamic Domain to another with no application downtime. If the Oracle database is running in any of the domains that are resized, the database can

dynamically resize itself to account for the change in memory and processor resources.

Dynamic Domains allow organizations to customize and adjust the compute capacity of Oracle SPARC Enterprise M-Series servers to meet specific enterprise needs. For example, a SPARC Enterprise M9000 server can be configured as a single domain with up to 64 processors in order to host an exceptionally compute-intensive application. Alternatively, an organization with multiple databases that require isolation from one another might divide a single SPARC Enterprise M9000 server into as many as 24 domains.

Typical configurations involve three or four Dynamic Domains in a single server.

Dynamic Domains provide not only maximum flexibility for different enterprise needs, but also different enterprise needs *at different times!*

For example, an e-commerce retailer with data centers in Europe, North America, and Asia could configure its e-commerce servers to "follow the sun" (see Figure 3-6). During peak shopping hours for each region, a domain (Domain A) with 16 processors is dedicated to compute-intensive OLTP (online transaction processing) e-commerce applications, while a second domain (Domain B) uses only 4 processors for sales analysis and ERP (enterprise resource planning) integration. During off-peak hours Dynamic Reconfiguration can be used to re-configure the domains — with no down time for the applications or servers — so that more processors are dedicated to Domain B for batch processing of sales data and ERP operations.

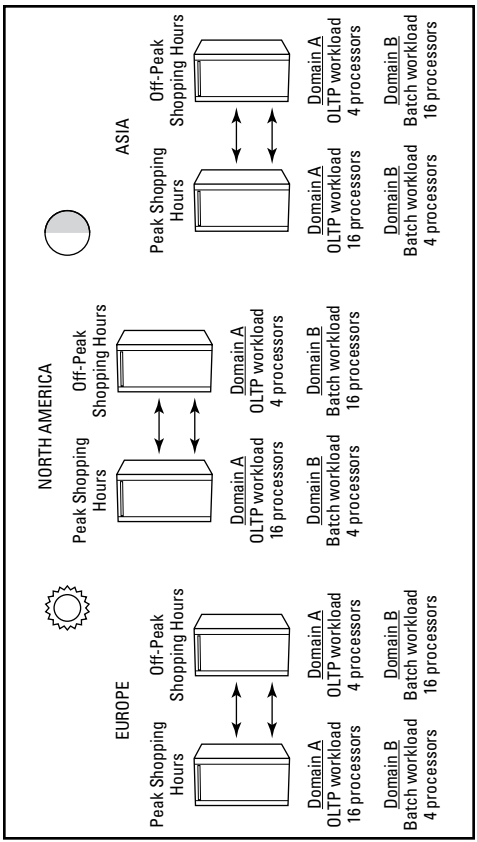

Figure 3-6: Dynamic Domains maximize resource utilization for demanding workloads.

The Oracle SPARC Enterprise M-Series server uses an embedded computer called the eXtended System Control Facility (XSCF) to configure the system and set up the domains. The very nature of hard partitions means elements such as security and data isolation are even more tightly integrated than with other virtualization technologies.

Each Dynamic Domain can run its own instance of Oracle Solaris with no added performance overhead. Dynamic Domains are recognized by Oracle as a "hard partition" with regards to Oracle per core software licensing. This means that an end user running Oracle software that is priced per core in a Dynamic Domain is charged only for the processor cores inside that Dynamic Domain.

Oracle Enterprise Manager

Oracle Enterprise Manager is comprised of Oracle Enterprise Manager 12c and Oracle Enterprise Manager Ops Center.

Oracle Enterprise Manager 12c

Oracle Enterprise Manager is designed to manage your full hardware and software stack from applications to disk. Fully integrated with Oracle VM Manager, Oracle Enterprise Manager provides a complete view into the virtualized apps and infrastructure with a single tool. Not only does Oracle Enterprise Manager 12c allow you to set management policies, as well as clone, share, configure, boot, and migrate VMs, but it also helps you to manage, diagnose, and fix issues with applications running inside the virtual machine.

Oracle Enterprise Manager Ops Center

Oracle Enterprise Manager Ops Center, a key component of the Oracle Enterprise Manager portfolio, is Oracle's comprehensive solution for managing both the physical and virtual infrastructure in your data center. It can discover and provision both physical and virtual servers, storage, and networking. It monitors and manages the health of these systems and can take proactive corrective actions where appropriate — including initiating service calls. Oracle Enterprise Manager Ops Center is included at no extra charge on any Oracle server that has an Oracle Premier support contract.

Oracle Enterprise Manager Ops Center provides full lifecycle management of virtual guests, including Oracle VM Server for SPARC and Oracle Solaris Zones. It helps you streamline operations and reduce downtime, and provides an end-to-end management solution for physical and virtual systems through a single web-based console. This solution automates the lifecycle management of physical and virtual systems and is the most effective systems management solution. With Oracle Enterprise Manager Ops Center, you can

- **Streamline operations.** Double the number of servers that existing staff can manage with Ops Center's integrated management console and outstanding ease of use.
- **Minimize downtime.** Reduce time to apply security patches by up to 90 percent, and virtually eliminate failed patch jobs with Ops Center's world-class intelligent patch management.

- **Speed new deployments.** Cut provisioning time in half and get new services delivered faster with Ops Center's automated, end-to-end deployment plans and rapid scalability.
- **Maximize return on investment.** Based on a recent study, Ops Center delivered an ROI of 139 percent by eliminating multiple management tools, increasing productivity, and reducing system downtime.

Chapter 4

Ten Ways Oracle Virtualization Delivers More Value

In This Chapter

- Discovering the advantages of Oracle virtualization

Oracle delivers the most complete and integrated virtualization solutions for maximum enterprise value. In this chapter, we explain how Oracle delivers more value than other virtualization technologies.

Application-driven

Oracle offers all components of an enterprise application deployment including storage, servers, networking, operating system, middleware, database, and business applications. Virtualization is fully integrated in all layers of the full application stack. Oracle's virtualization management solutions are aware of what's running inside virtual environments and can provision and manage the applications, middleware, and databases in the virtual environments. Other virtualization technologies

are not able to manage the database, middleware, and applications running inside their virtual environments.

Accelerating Application Deployment

Instead of virtual environments provided via a community "marketplace" that is not vendor supported, Oracle VM includes

- **Oracle VM Templates.** Deploy in full production environments, within minutes and hours rather than days and weeks with pre-installed, preconfigured virtual machines of mission-critical enterprise software, including customer relationship management (CRM), enterprise resource planning (ERP), clustering, and management.
- **Oracle Virtual Assembly Builder.** Package multi-tier applications and deploy them with the click of a button.

APL simplifies system deployment with Oracle Templates

"We can use existing Oracle VM Templates to build fully-blown, fully-installed, fully-configured environments to support specific new technologies or development requirements. We can simply grab a template and have a fully deployable system very quickly."

Raymond Payne, Principal Systems Architect, Johns Hopkins Applied Physics Lab

Parks Victoria provisions servers in minutes, not weeks, with Oracle VM

"In the past, it used to take 6 to 10 weeks to provision a physical server. With Oracle VM, we can have a virtual machine up and running in 35 minutes."

Christine Varga, Business Systems Analyst, Parks Victoria

Architected for Efficiency

Oracle Virtualization solutions are architected for low overhead so that they don't introduce a performance penalty when virtualizing. Oracle's virtualization solutions are aggressively tested using real database and application workloads. Oracle Solaris Zones and Dynamic Domains are built into the operating system and the server, providing optimized performance and reliability. Oracle has a single engineering team for Linux and Oracle VM, leading to better optimization between Xen and Linux.

Comprehensive Platform Support

Oracle VM is available for both x86 and SPARC architectures including SPARC SuperCluster. Other third-party virtualization technologies only support the x86 platform.

Oracle Solaris Zones are also available for both SPARC and x86 architectures.

High Availability

Unlike other virtualization technologies that only provide high availability at the hypervisor level and are completely unaware of application needs, Oracle offers high availability for the entire stack. Oracle sees clustering and virtualization as complementary technologies. Oracle customers can achieve additional high availability with Oracle Clusterware, Oracle Solaris Cluster, Zone Clusters, and Oracle Real Application Clusters (Oracle RAC).

Integrated Management

Oracle provides full stack management, enabling you to manage the hypervisor, physical server, and the applications running in it, with a single tool. Other virtualization technologies require multiple vendor tools to manage the hypervisor and what's running inside them.

Oracle Enterprise Manager Ops Center can be used to manage both the physical servers and the virtual servers created by Dynamic Domains, Oracle VM for SPARC, and Solaris Zones.

Integrated Support

With Oracle VM for x86, Oracle VM for SPARC, Dynamic Domains, and Oracle Solaris Zones, Oracle's full application stack is certified and supported. This means that you make one call to Oracle — there's no finger pointing at other vendors so you get faster resolution of issues.

Lower Cost

The total cost of ownership (TCO) for many popular virtualization solutions includes complex licensing and high license, support, and management costs. Oracle VM is free to download, use, and distribute, support fees are affordable, and licensing is simple. Oracle VM for SPARC, Dynamic Domains, and Solaris Zones are included with the Oracle SPARC server. Free virtualization and management solutions greatly lower the cost of deploying and managing Oracle virtualization.

Use Oracle's TCO Calculator (`www.oracle.com/us/media/calculator/vm/index.html`) to compare Oracle VM and VMware costs.

Scalability

With support for up to 128 vCPUs in each virtual machine, Oracle VM is four times more scalable than other x86 hypervisor-based virtualization technologies that only support 32 vCPUs per virtual machine. Oracle VM for SPARC supports up to 128 virtual environments in SPARC T-Series servers. Solaris Zones support thousands of partitions in any server running Solaris and M-Series SPARC servers can be used to deploy up to 24 Dynamic Domains. Unmatched performance and scalability can be achieved with Oracle's low-overhead virtualization solutions. This level of scalability is useful for virtualizing heavy-duty database and application workloads.

Built-in Virtualization

Oracle offers virtualization built into its hardware for optimum performance. Oracle VM for SPARC, built into

SPARC T-Series servers and SPARC SuperCluster allows multiple applications to be run on a single system. Dynamic Domains are built into SPARC Enterprise M-Series servers, enabling greater hardware utilization and providing a high level of isolation from other domains.

Glossary

bare metal hypervisor: See **Type 1 hypervisor.**

cold migration: A migration process that requires halting of the original physical host and its workload, transfer of data files, and startup of the new physical host and migrated workloads. Cold migrations typically cause a service outage lasting minutes to hours. See **P2V conversions** and **V2V conversions**.

Containers: In Oracle Solaris 10, Oracle Solaris Containers are software partitions used to implement Operating System Virtualization (OSV). Containers are known as Oracle Solaris Zones (see **Zones**) in Oracle Solaris 11.

Customer Relationship Management (CRM): CRM software is used to help an organization manage its interactions with customers, clients, and sales prospects.

Dom0: A privileged domain in Oracle VM Server that allows multiple domains or virtual machines on different operating systems to run on one physical machine.

Dynamic Domains: Used to implement hardware partitions on Oracle SPARC Enterprise M-Series servers running Oracle Solaris. A domain is an independent partition composed of memory, processors, and I/O slots, running its own copy of the Oracle Solaris Operating System (OS).

Enterprise Resource Planning (ERP): ERP systems integrate accounting and finance, CRM, distribution, inventory control, manufacturing, sales and service, and other cross-disciplinary functions across an organization.

hosted hypervisor: See **Type 2 hypervisor**.

hypervisor: Also known as a virtual machine manager (VMM), the hypervisor allows multiple "guest" operating systems to run concurrently on a single physical host computer. The hypervisor functions between the computer operating system (OS) and the hardware kernel.

Inter-process communication (IPC): An operating system (OS) capability that allows multiple processes to communicate with one another on the same computer or multiple computers across a network.

live migration: A migration process that does not require halting and rebooting of the VE. Active processes on the VE are not shut down so current state information is maintained and no noticeable service outage occurs.

Logical Domains (LDoms): A built-in hypervisor used in Oracle VM Server for SPARC to subdivide system resources (CPUs, memory, network, and storage) by creating separate partitions that can each run a complete Oracle Solaris Operating System (OS) instance.

migration: The process of moving a virtual environment (VE) from one physical server to another. See **cold-, warm-,** and **live migration**.

native hypervisor: See **Type 1 hypervisor**.

Online Transaction Processing (OLTP): Systems that manage high-volume transaction-oriented applications, such as large databases.

Open Virtualization Format (OVF): An open industry standard for packaging and distributing virtual appliances.

P2V migration: A physical-to-virtual conversion that involves converting an existing physical server workload to a virtual environment (VE) on a host server.

role-based access control (RBAC): A method for implementing discretionary access controls in which access decisions are based on group membership, according to organizational or functional roles.

Type 1 hypervisor: Also known as a native or bare metal hypervisor, a Type 1 hypervisor runs directly on the host computer's hardware.

Type 2 hypervisor: Also known as a hosted hypervisor, a Type 2 hypervisor runs within an operating system environment (OSE).

V2V migration: A virtual-to-virtual conversion that involves converting existing virtual servers and their workloads from one virtualization technology to another.

Virtual Machine Manager (VMM): See **hypervisor**.

warm migration: A migration process that does not require halting and rebooting of the VE. Active processes on the VE are not shut down so current state information is maintained, but a noticeable service outage typically lasting tens of seconds occurs.

workload: In virtualization, workload is generally used to describe the operating system (OS) and application components of a physical server or host.

XSCF (eXtended System Control Facility): An embedded computer on Oracle SPARC Enterprise M-Series servers used to configure the system and set up the domains.

Zones: In Oracle Solaris 11, Oracle Solaris Zones are software partitions used to implement Operating System Virtualization (OSV). Zones are known as Oracle Solaris Containers (see **Containers**) in Oracle Solaris 10.

Realize the true potential of server virtualization!

Oracle offers the industry's most complete and integrated virtualization solutions, from desktop to data center. Oracle virtualization solutions provide better system utilization, lower administrative overhead, and the ability to consolidate servers to save on energy and data center space.

- ***Recognize the benefits of virtualization — including consolidation, provisioning, and workload mobility***
- ***Deploy Oracle virtualization solutions — explore Oracle VM for SPARC and x86, Oracle Solaris Zones, and Dynamic Domains to deploy virtualization solutions that are efficient and optimized for performance***
- ***Understand Oracle virtualization technologies — Oracle's unique application-driven virtualization accelerates application deployment, streamlines, and reduces costly support cycles***

Open the book and find:

- **The benefits of application-driven virtualization in the data center**
- **How to rapidly deploy software with virtualization templates**
- **Why Oracle virtualization solutions deliver more value than other virtualization technologies**
- **How to streamline operations, minimize downtime, and maximize ROI with virtualization**

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