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OPTIMIZED SOLUTIONS

Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure

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Introduction

Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure addresses key challenges in deploying a virtualized cloud infrastructure—reducing time to deployment, lowering costs, and eliminating risk. IT organizations typically spend multiple weeks to plan, architect, troubleshoot, and deploy a full multivendor solution. Deployment teams must assemble and integrate a wide range of hardware and software components (for example, servers, storage, network, virtualization software, and operating systems). The process is not only time-consuming, but also can be error-prone, delaying implementation and making it hard to achieve a timely and profitable return on investment.

Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure offers a much simpler approach that speeds deployment, reduces risk, and lowers the total cost of ownership. It is a single-vendor solution for the entire hardware and software stack—from application to disk—that can be deployed in hours rather than weeks. The solution stack has gone through extensive testing at Oracle, resulting in a pretested, preoptimized, and validated configuration that can significantly reduce the time-consuming efforts of determining a stable configuration and testing for compatibility.

This paper describes the solution and provides recommendations and best practices for optimizing a virtualized cloud infrastructure when deploying Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure. It discusses software, hardware, storage, and network components and is intended to serve as a practical guide to help IT organizations get up and running quickly while maximizing the benefits of built-in virtualization technologies and the massive thread-scale of Oracle's SPARC servers.

Solution Overview

Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure addresses every layer of the virtualization stack with Oracle hardware and software components (Figure 1). The solution makes use of a broad selection of Oracle hardware and software components, including the following:

» Oracle's SPARC T7, SPARC S7-2L, and SPARC T5 servers as the deployment platforms (specifically, the SPARC T7-1, SPARC T7-2, SPARC T7-4, SPARC S7-2L, and SPARC T5-2servers are qualified)

» Oracle VM Server for SPARC, which defines logical domains (or LDoms) that behave as fully isolated virtual SPARC processor-based servers

» The Oracle Solaris operating system, which includes the Oracle Solaris Zones feature to provide fine-grained, lightweight virtual environments within an Oracle Solaris instance

» Oracle's 10 GbE network switches as a virtual backbone

» Oracle ZFS Storage Appliance as shared storage for the virtual environments

» Oracle Enterprise Manager Ops Center 12*c* as the management framework and interface to build, monitor, and manage virtual environments

Oracle has conducted validation testing of multiple configurations and has prepared this and other documentation to illustrate best practices and recommended operational processes. Customers are assured of a validated configuration, so the entire virtualized cloud infrastructure can be up and running in hours without worrying about firmware, software, or patch version compatibility between the various components.

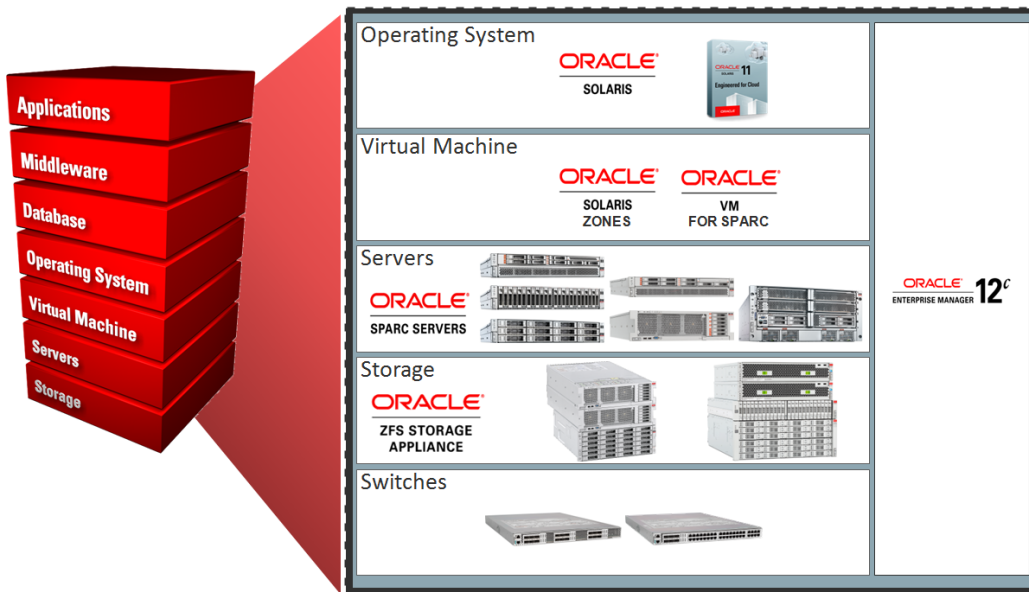## Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure

Figure 1. Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure provides a complete hardware and software stack that can accelerate deployment and reduce the risk of errors.

Solution Components

Table 1 lists tested components in the solution along with relevant configuration details.

TABLE 1. COMPONENTS OF ORACLE OPTIMIZED SOLUTION FOR SECURE ENTERPRISE CLOUD INFRASTRUCTURE

Stack Layer	Recommended Oracle Product	Configuration Description
Operating system	Oracle Solaris	Oracle Solaris 10 and Oracle Solaris 11.
Virtualization	Oracle VM Server for SPARC	Oracle VM Server for SPARC configures LDoms on each virtualization server.
	Oracle Solaris Zones	Oracle Solaris Zones is another layer of virtualization within each logical domain.
Management	Oracle Enterprise Manager Ops Center 12*c*	Oracle Enterprise Manager Ops Center 12*c* runs on a separate SPARC T7-1 or SPARC S7-2L system.
Server hardware	SPARC T7-1 servers SPARC S7-2L servers	Up to 13x virtualization servers per rack: » *Up to 13x SPARC T7-1 servers (recommended)* » *Up to 13x SPARC S7-2L servers (recommended)* » *Up to 9x SPARC T7-2 servers* » *Up to 5x SPARC T7-4 servers*
	SPARC T7-1 or SPARC S7-2L server (management server)	One management server per rack.
Networking	Oracle Ethernet Switch ES2-72	Two 72-port 10 GbE top-of-rack switches act as an interconnect for the distribution network layer.
	Oracle Ethernet Switch ES2-64	Two 64-port 1 GbE/10 GbE switches act as an interconnect for the access network layer.
Storage	Oracle ZFS Storage Appliance: » *Oracle ZFS Storage ZS3-2* » *Oracle ZFS Storage ZS4-4*	» *Available in different configurations to meet a variety of needs for capacity, price, and performance.* » *Use NFS over high-speed 10 Gb Ethernet interfaces for domains and zones to access shared storage.* » *Use iSCSI or FC for block storage.*

The SPARC T7-1 and SPARC S7-2L Servers—An Optimal Virtualization Platform

Oracle's SPARC T7-1 and SPARC S7-2L servers are ideal platforms for cloud infrastructure deployments that consolidate and virtualize systems to improve operating efficiency, reduce data center overhead, and lower cost and complexity. Because the SPARC T7-1 and SPARC S7-2L servers offer faster performance, a smaller form factor, and greater virtualization capabilities than previous-generation servers, they are a superb choice for Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure.

The SPARC T7-1 server's density—with the same number of cores, threads, and memory capacity as the SPARC T5-2 server, but with smaller rack space and greater processor speed and I/O bandwidth—helps customers efficiently transition to an enterprise cloud architecture with less hardware and a lower TCO. Table 2 summarizes the features of Oracle's SPARC T7-1 server and compares them to features of the previous-generation SPARC T5-2 servers.

TABLE 2. SPARC T5-2 AND SPARC T7-1 SERVER FEATURES

	Sparc T5-2 Servers	Sparc T7-1 Servers	Sparc S7-2l Servers
Size (units)	3U	2U	2U
Processor	» *Two SPARC T5 processors at 3.6 GHz* » *32 cores, 256 threads*	» *One SPARC M7 processor at 4.1 GHz* » *32 cores, 256 threads*	» *Two SPARC S7 processors at 4.27 GHz* » *16 cores, 128 threads*
Max. memory	512 GB (using 16 GB DIMMs)	1 TB GB (using 64 GB DIMMs)	1 TB (using 64 GB DIMMs)
I/O capabilities	6 drive bays, 8 PCIe 3.0 slots, 4x 10 GbE ports	8 drive bays, 6 PCIe 3.0 slots, 4x 10 GbE ports	8x 2.5", 24x 2.5", or 12x 3.5" drive bays, 6 PCIe 3.0 slots, 4x 10 GbE ports
Service processor	Oracle Integrated Lights Out Manager (Oracle ILOM)	Oracle ILOM	Oracle ILOM
Operating system	Oracle Solaris 11.3 or Oracle Solaris 10 1/13	Oracle Solaris 11.3 or Oracle Solaris 10 1/13	Oracle Solaris 11.3 or Oracle Solaris 10 1/13
Key reliability, availability, and serviceability (RAS) features	» *Dynamic voltage frequency scaling (DVFS)* » *Oracle ILOM, RAID 0/1, ECC correction* » *Redundant, hot-pluggable fans and power supplies*	» *Dynamic voltage frequency scaling (DVFS)* » *Oracle ILOM, RAID 0/1, ECC correction* » *Redundant, hot-pluggable fans and power supplies*	» *Dynamic voltage frequency scaling (DVFS)* » *Oracle ILOM, RAID 0/1, ECC correction* » *Redundant, hot-pluggable fans and power supplies*

Oracle's SPARC M7 processor and the SPARC S7 processor leverage the high-throughput design of Oracle's SPARC S4 core architecture, increasing the clock frequency and a much larger Layer 3 cache size greatly increases the performance of the chip. The SPARC S7 processor maintains the same core count as the SPARC T5 processor while the SPARC M7 processor doubles the number of cores and available threads per processor in comparison to the SPARC T5 CPU.

The SPARC S7 and SPARC M7 processors also provide unparalleled security on chip. Each of the cores in the SPARC S7 and SPARC M7 processors include a crypto instruction accelerator with direct support for 15 industry-standard cryptographic algorithms plus random number generation. Accelerated cryptography is supported through the Cryptographic Framework feature of Oracle Solaris.

The SPARC S7 and SPARC M7 processors permit access to cryptographic cypher hardware implementations with supported algorithms that include AES, Camellia, CRC32c, DES, 3DES, DH, DSA, ECC, MD5, RSA, SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512. The cyphers are implemented within the appropriate pipeline itself rather than as a coprocessor. This approach yields a more efficient implementation of the hardware-based cyphers as well as no privilege-level changes, resulting in a large increase in efficiency in cryptographic algorithm calculations. In addition, database operations can make much more efficient use of the various cryptographic cyphers that are implemented within the instruction pipeline itself. Using the built-in encryption on the SPARC S7 and SPARC M7 processors across all layers of the Oracle stack provides greater data security with almost no loss in performance.

A new security feature introduced with the SPARC S7 and SPARC M7 processors is Silicon Secured Memory. Silicon Secured Memory provides real-time data integrity checking to guard against pointer-related software errors and malware, replacing very costly software instrumentation with low-overhead hardware monitoring. Silicon Secured Memory enables applications to identify erroneous or unauthorized memory access, diagnose the cause, and take appropriate recovery actions.

In addition to performance, scalability, and security enhancements, the SPARC S7 and SPARC M7 processor-based servers also provide significant price-performance advantages over key competitors. Lower acquisition costs (CapEx) and lower operating costs (OpEx) result in a cost-effective platform for Oracle applications in the cloud, including Oracle Database. (For more information on business benefits and TCO advantages, see the companion business paper, "Reduce Complexity and Accelerate Enterprise Cloud Infrastructure," posted on the solution's website.)

Built-in Server Virtualization Technologies

Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure helps to increase service levels and business agility through its use of virtualization technologies. Recognizing the strategic importance of virtualization when constructing a cloud-based services delivery model, Oracle integrates virtualization technologies into its servers and the Oracle Solaris operating system at no additional cost. With the latest SPARC T7 and SPARC S7-2L servers, memory capacity stays the same 1 TB (using 64 GB dual inline memory modules [DIMMs]) while consuming less rack space, thus significantly increasing the virtualization capacity. Figure 2 depicts the virtualization capabilities that this solution puts into practice:

» Oracle VM Server for SPARC (formerly called Oracle's Sun Logical Domains) provides logical domains (LDoms), which are available in all of Oracle's SPARC servers, including the SPARC T5, SPARC S7, and SPARC M7 processor–based servers.
» Oracle Solaris Zones technology (known as Oracle Solaris Containers in Oracle Solaris 10 and previous versions) is available in the Oracle Solaris 11 operating system.
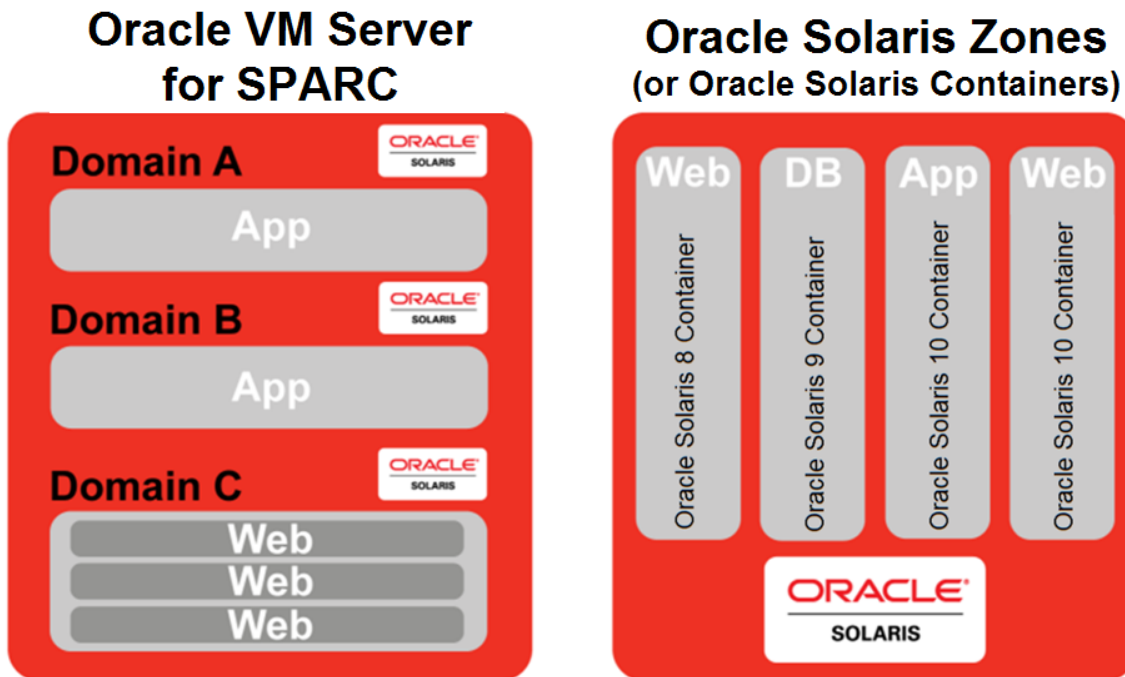

Figure 2. Built-in virtualization technologies.

In this solution, these virtualization capabilities can be combined and effectively used together. Administrators can create Oracle Solaris Zones on top of Oracle VM Server for SPARC logical domains to further optimize deployment flexibility and allocate system resources with fine-grained control and to enforce more stringent security requirements. As shown in Figure 2, Oracle Solaris Containers on Oracle Solaris 10 servers help to facilitate the consolidation of applications running on legacy systems. Applications running on the Oracle Solaris 8, Oracle Solaris 9, or Oracle Solaris 10 releases can be consolidated on the latest systems using containers, or branded zones, on Oracle Solaris 10, enabling savings on power, space, cooling, administrative, and support costs by eliminating aging systems that run those legacy releases.

Managing Virtual Environments in the Solution

To simplify deployments and manage virtual environments effectively, Oracle Enterprise Manager Ops Center 12*c*—Oracle's flagship product for systems management—provides an administrator-friendly interface for the solution and its virtualization capabilities. The management platform uses Oracle Database as its management repository, which typically can be installed on the management server or on a separate database server. It offers a single integrated console for testing, deploying, patching, operating, monitoring, diagnosing, and troubleshooting Oracle systems in complex IT environments.

Oracle Enterprise Manager Ops Center 12*c* provides a simple, scalable solution for managing the solution stack. It allows administrators to manage all components of the solution, including physical servers, firmware, the Oracle VM Server for SPARC hypervisor and logical domains, Oracle Solaris operating systems, Oracle Solaris Zones, and the storage infrastructure. Oracle offers several options, management packs, management plugins, and other products to enhance the capabilities of the Oracle Enterprise Manager management framework. For cloud management capabilities, Oracle Enterprise Manager Cloud Control 12*c* is designed to manage the full lifecycle of cloud services, and it can be added. Other separately licensed Oracle Enterprise Manager 12*c* modules enable comprehensive control of Oracle middleware, Oracle Database instances, and Oracle applications, enabling end-to-end cloud infrastructure management from applications to disk. An Oracle representative can provide more information.

Oracle VM Server for SPARC—Key Concepts

The solution consists of Oracle VM Server for SPARC logical domains running on multiple SPARC servers, managed by Oracle Enterprise Manager Ops Center 12*c* hosted on a separate SPARC T7-1 or SPARC S7-2L management server.

Oracle VM Server for SPARC relies on a SPARC hypervisor, a small firmware layer that subdivides and partitions server resources (CPUs, memory, I/O, and storage) among defined virtual machines (VMs) called logical domains. A domain's operating system is permitted to access only those resources allocated to it by the Oracle VM Server for SPARC hypervisor. CPU threads are exclusively allocated and are not time-sliced, so compute operations achieve native performance—there is no context switching or privileged instruction emulation as there is in other virtual machine implementations. In addition, since this is a built-in enterprise virtualization technology that is certified and fully supported by Oracle, it enables a comprehensive virtualized infrastructure while avoiding the complexity of dealing with multiple vendors for support.

As shown in Figure 3, Oracle VM Server for SPARC installs directly on SPARC server hardware and enables each domain to run its own instance of Oracle Solaris 10 or Oracle Solaris 11.
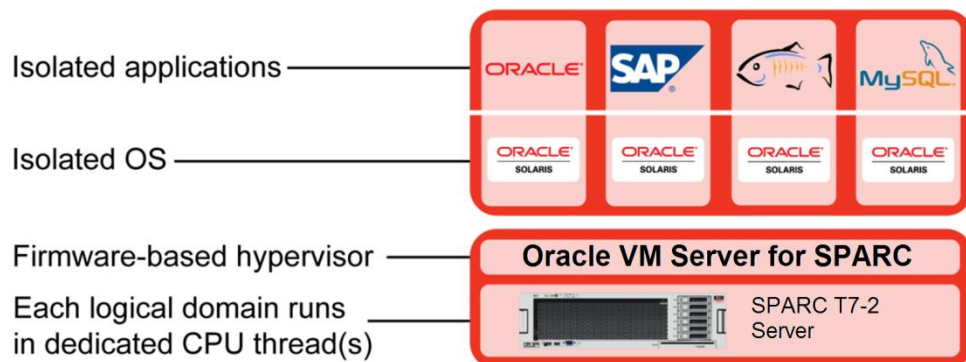
Figure 3. Each Oracle VM Server for SPARC domain runs a separate Oracle Solaris operating system instance.

Each logical domain is a full virtual machine that runs an independent operating system instance and contains allocated or virtualized CPUs (depending on the virtualization technology chosen), memory, storage, network, console, and cryptographic devices. Administrators can allocate resources into logical groupings and create multiple, completely independent discrete domains, each with their own identity within a single physical server. Each domain can be started, stopped, or rebooted independently.

One of the most powerful capabilities of Oracle VM Server for SPARC technology is live migration. This capability migrates an active domain to another physical machine while application services continue to run. In the SPARC servers, on-chip cryptographic accelerators enable secure wire-speed encryption—without any additional system hardware—allowing logical domains (and any sensitive data they contain) to be migrated securely, even across public networks.

Other key features and advantages of Oracle VM Server for SPARC include:

» Full virtualization capabilities for SPARC servers at no charge.
» Built-in hypervisor virtualization software included in Oracle Solaris 11, or free to download and install on SPARC hosts running Oracle Solaris 10.
» Full virtual machine OS image isolation and separation.
» A proven virtualization technology with enterprise quality support and real-world deployment testing.
» Ability to consolidate and virtualize legacy SPARC servers. A physical to virtual (P2V) migration tool permits the conversion of an existing physical system to a virtual server running in a virtualized Oracle Solaris 10 image. For legacy servers running Oracle Solaris 8, Oracle Solaris 9, or Oracle Solaris 10 releases, the P2V tool installs the system image in compatible branded zones running on the Oracle Solaris 10 operating system.
» Support for interoperability across the stack, including with the optional Oracle Solaris Cluster software for high availability.

Oracle Solaris Zones—Key Concepts

Available in Oracle Solaris 10 and Oracle Solaris 11 releases, Oracle Solaris Zones (known as Oracle Solaris Containers in Oracle Solaris 10 and earlier releases) technology is a lightweight, near-zero overhead, virtualization technology that creates multiple private execution environments within a single Oracle Solaris instance. Applications running within zones are completely isolated, preventing processes in one zone from affecting processes running in another. Organizations that must safeguard access and protect sensitive data, such as governments, financial institutions, and HR departments, can safely segregate workloads and control resources that are allocated to virtual environments.

Oracle Solaris Zones provides flexibility in deployment and simplify system resource configuration changes. These virtual environments permit reassignment of resources to handle peak or seasonal workloads, providing fine-grained control of system compute, memory, networking, and I/O assets. Oracle Solaris Zones features extremely fast initialization, and it can be configured to instantly start, stop, or restart application or database services after reconfiguration.

Combining Virtualization Technologies

Using Oracle Solaris Zones and Oracle VM Server for SPARC together is a common strategy to consolidate and virtualize workloads safely within a single platform. These technologies provide a foundation for efficiently and securely consolidating applications on a single machine, enabling secure multitenancy, flexible resource management, and fast virtual machine cloning for enterprise cloud deployments.

Key Solution Deployment Concepts

From a deployment perspective, multiple Oracle VM Server for SPARC domains or instances of Oracle Solaris Zones can be grouped into server pools, as shown in Figure 4. Every VM in a given pool has access to shared network and storage assets (NFS- or Fibre Channel SAN–based storage). This flexibility increases service levels by making it possible for VMs associated with a given pool to start and run on any physical server within the pool.

Deployment plans established by the administrator determine the server in the pool on which the VM runs. Typically this is the server that has the most resources available, or the server that most closely matches the resource requirements of the VM. Given uniform access to shared storage mounted from the solution's Oracle ZFS Storage Appliance, VMs also can be securely moved (via live migration) or automatically started or restarted across any servers in their respective pools. (In contrast, Oracle Solaris Zones is cold migrated.) In this solution, Oracle ZFS Storage Appliance offers simple high-speed 10 GbE interfaces over which SPARC servers can share storage and enable domain migrations at high speed.
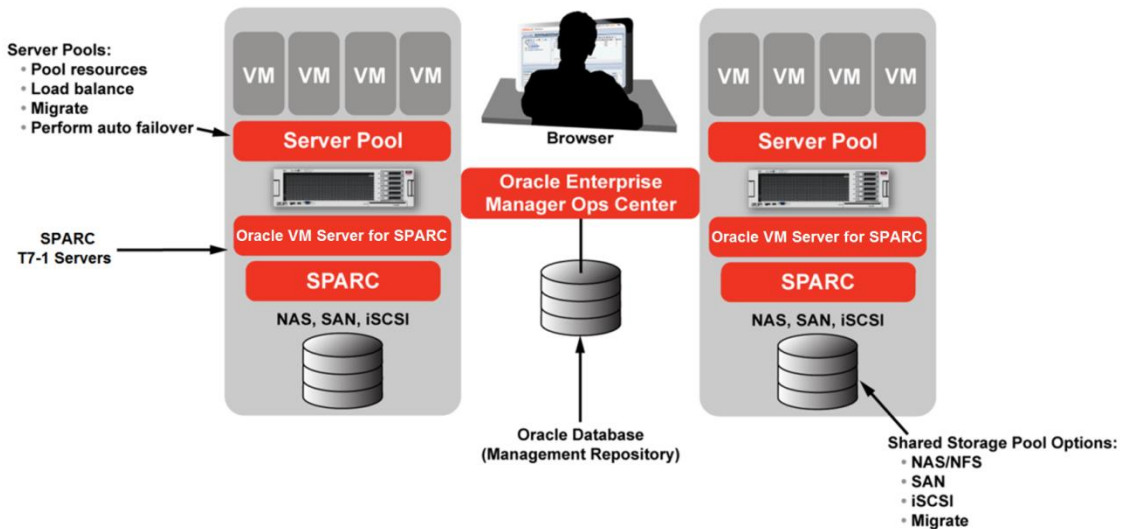

Figure 4. VM deployment using Oracle VM Server for SPARC and Oracle Enterprise Manager Ops Center.

VMs are associated with a given server in the pool. VM resource consumption, including memory and CPUs, is defined upon VM creation. When a virtual pool is created, VM placement and automatic load balancing polices are defined, and they can be edited at any time later.

The placement policy determines the preferred server host for new VMs within the virtual pool, and how the virtual pool is balanced. The following placement policy best practices are recommended:

» Place the VM on the server with the lowest relative load, based on the lowest memory and CPU utilization. The calculation is based on a combination of the average load during one hour, one day, and three weeks.
» Place the VM on the server with the lowest allocated CPU and memory resources across all guests on the host. The resource allocation is the sum of the number of virtual CPUs and virtual memory specified for each guest.
» Place the VM on the server that is consuming the least power.

As a result of this architecture, VMs can easily start up, power off, migrate, and/or restart without being blocked by the failure of any individual server or by the failure of multiple servers. A new VM can be started as long as there are adequate resources in the pool to support the requirements for all VMs to run concurrently.

Virtual Server Pool Planning

There are a large number of design considerations for planning a virtualized enterprise cloud infrastructure—one size does not fit all and virtualization architects must take site and workload factors into account. This section provides some guidelines for the development of a design plan for a virtual server pool that is well suited to site and organizational requirements.

It may be helpful to think of the server pool as if it were one big server with an aggregate amount of CPU, memory, storage, and network bandwidth. As such, planning for deploying VMs into a pool is much like planning for a server consolidation. It involves deciding how much aggregate capacity is needed to support normal and peak workloads as well as what types of workloads are appropriate to share resources in the pool or server. Workload profiles should be taken into account in addition to how predictable or unpredictable the workloads may be.

There are also some significant similarities between server pool planning and physical server planning with regards to physical server size versus overall pool size. For example, in some cases it is better to have relatively fewer but larger VMs in a pool. In other cases, a greater number of relatively small VMs can be a better fit. Both deployments may provide the same aggregate CPU, memory, storage, and bandwidth, but the implications of the deployment in a pool can be different.

For the current Oracle VM Server for SPARC release, each server pool must have its own shared storage resources that can be accessed by VMs within the same pool. A separate server pool must have its own separate shared storage.

High Availability Planning

Oracle VM Server for SPARC provides the following features to optimize uptime for VMs running in server pools:

» **Guest VM High Availability (HA)**. Auto-restart on server or VM failure. This requires the optional Oracle Solaris Cluster software.
» **Secure live migration**. Move domains off of servers that are undergoing planned maintenance. Since Oracle Solaris Zones is cold-migrated, using the live migration capabilities of Oracle VM Server for SPARC can help to minimize downtime.
» **Automatic pool load balancing**. Use the automatic load balancing policy to schedule load balancing within a virtual pool. The automatic balancing can be scheduled to occur weekly, daily, or hourly on a specific day and time of the week, and this can be based on a predefined schedule or done manually. Auto-balancing changes the allocation of resources defined by the placement policy. The load is balanced by migrating a guest to a different virtual host in the same virtual pool. The automatic load balancing policy is set for each virtual pool.

Recommendations for Deploying Highly Available Server Pools

The following steps are recommended to achieve high availability:

» Deploy the optional Oracle Solaris Cluster software, which provides protection from failure, management of resource dependencies, and cluster load balancing for domains, either at the application level or at the virtual guest level. When a logical domain is configured as a standard cluster node, Oracle Solaris Cluster provides failover and management of the applications running within the virtual guest. When a logical domain is configured as a failover resource, it is failed over automatically in case of failure. Upon request it also can be moved across servers using live migration. Oracle Solaris Cluster also provides full service protection for zones, through fine-grained monitoring of applications, policy-based restart, and failover within zone virtual clusters. It also enhances availability of zone deployments through load balancing and prioritization.

» Plan to use the secure live migration to migrate domains in support of planned downtime events like server maintenance, preventing service outages.

» Plan for enough excess capacity in aggregate across the pool to support running all VMs at appropriate service levels, even when one or more servers in the pool are out of service.

Pool Capacity, Performance, and Scalability

Capacity planning for a server pool is similar to capacity planning for a physical server. However, the following additional considerations are also important when planning capacity for a server pool:

» **Plan extra capacity to support guest HA/auto-restart**. There should be sufficient capacity to support hosting additional VMs on relatively fewer machines in the event that one or more of the servers fails and its VMs are restarted on the remaining healthy servers—even if this occurs only temporarily.

» **Plan for extra capacity to support migration of VMs during planned events**. When performing maintenance on servers in the pool, live migration allows administrators to migrate domains to another server in the pool without interrupting service. To take advantage of this capability, there should be enough excess capacity in aggregate across the pool so that a server can be taken offline (after migrating its domains) without inappropriately impacting service levels.

Determining How Many Servers or VMs a Pool Should Contain

The number of servers or VMs that is ideal for a pool depends on a number of factors that can vary greatly between data centers and deployments. There is no one correct configuration, but there are several factors that should influence this decision. Typical considerations are described below.

Storage Topologies, Performance, and Implementation

For this solution, virtual server pools require that all servers in the pool have shared access to the same storage so that VMs can be migrated easily. This means that server pools must use shared storage such as NFS-based storage. In Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure, Oracle ZFS Storage Appliance systems are used to provide NFS shared storage. Both the physical makeup of the storage devices and the scalability of the file systems used dictate how many servers are practical for a given shared storage pool without adversely affecting I/O performance.

When evaluating the number of servers to share a given storage topology, the following questions should be considered:

» How much I/O will each server generate, and can throughput and latency needs be accommodated through the designated network interface card (NIC) or HBA ports?

» How much I/O can the storage device or devices support?

» What are the HA multipathing needs?

» Are there any application requirements for directly accessed storage?

The answers to these storage-related questions depend on the I/O environment. Is the application I/O-intensive? What is the average size of an I/O request?

Workload Profile

The nature of the workload is also a consideration. Is the workload flat and stable, or variable and peaky? Tighter consolidation can be achieved for VMs with relatively low utilization that run flat and stable workloads with minimal peaks. Such workloads are very predictable, so they require little excess capacity or headroom to accommodate unexpected peaks. This often enables consolidation of a large number of VMs per server.

The next best scenario occurs when consolidating multiple VMs that have peaks, but the peaks are very predictable in both timing and magnitude. For instance, some VMs may contain applications that always peak at the end of the week or end of the month. If these VMs can be consolidated with other VMs that peak at exactly the opposite time—workloads that peak at the beginning of the week or month—they potentially can be packed together fairly tightly to maximize the number of VMs per server and per pool.

The worst-case scenario is when the VMs are highly variable in load and in timing. In this situation, it is likely that a comparatively large amount of extra headroom will be needed on the servers. Thus fewer VMs will be able to be accommodated per server and per pool.

Service Level Support Strategy

Sometimes service level objectives may dictate that there is enough planned excess capacity to support normal service levels even if all the VMs peak at the same time. This is the most conservative option, but also the most expensive since it requires extra hardware that may not be utilized much of the time. Another alternative is to plan for the average load and accept any performance hit based on resource contention if there is too much of a peak. This certainly reduces hardware expense, but might not provide acceptable service levels if the workloads are too unpredictable or are mission-critical. As a result, many data centers plan their capacity to support some percentage of the aggregate peak load. For example, they may plan for 40 to 60 percent of the peak above average. This is often a good compromise between meeting service levels and having reasonable hardware utilization. However, it clearly depends on how critical service levels are for the given workloads.

Dynamic Server Pools

Since domains can be moved around within the pool, depending on HA events or live migration, the capacity plan needs to be at the pool level and not at the individual server level. For this reason, it may be best to consider keeping highly volatile domains in their own pool or restricting them to a subset of the pool where a relatively large amount of excess capacity can be maintained for handling unpredictable peaks.

Conversely, highly predictable VMs should be restricted to a separate pool where the resources can be very tightly planned for high utilization without the need for much excess capacity.

Recommendations for Designing the Server Pool

The following guidelines are recommended for designing and sizing the server pool:

» Plan for excess resource capacity at the pool level to support advanced features such as domain live migration and guest VM HA.
» Consider storage topologies and their characteristics as well as network requirements, workload characteristics, and HA needs when determining the number of servers in a server pool.
» Plan for excess capacity according to business requirements for meeting peak loads versus only a proportion of the peak load.
» Memory capacity is the most critical resource. I/O capacity and then CPU capacity are the second and third priorities, respectively. CPU and I/O should be balanced given that I/O activity is often CPU-intensive.
» The amount of memory required for all running VMs can never exceed the amount of physically available memory on the server(s) in the pool.

- » CPU over-commitment is not supported (e.g., having more virtual CPUs configured than are physically present).
- » CPU policies can be prioritized to help ensure that important domains obtain preferential access to resources. They also can be enabled or disabled manually or based on time of day for different prime shift and off-hours policies. For example, one domain may have the highest resource needs and priority during the daytime, while a domain running batch work may operate in a more resource-intensive manner at night.
- » Use identically configured server nodes throughout the pool to support consistent performance and feature sets regardless of individual server failure(s). This approach ensures that no matter where live migration or restart occurs, the same performance and features are uniformly available.

Security Configuration and Best Practices

Customers place high trust in the organizations with which they do business, trust that their information will be safe, and trust that the systems they rely on will be available when needed. Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure leverages extensive security and availability features to meet these requirements.

Hardening was an objective throughout the design of the solution. Steps were taken, and called out in the solution's collateral, to ensure that the solution is capable of being a secure multitenant private cloud environment. The solution is able to take advantage of the built-in security aspects that Oracle's SPARC servers, Oracle Solaris 11.3, and Oracle Enterprise Manager Ops Center 12.3 provide. This includes things such as role-based access control (RBAC) that can integrate with existing data center LDAP directory services, virtual machine network isolation using VLAN network segmentation, and ZFS data encryption. Security is built into the infrastructure as well by further isolating management networks from storage networks and virtual machine data traffic, limiting the potential of network intrusion to the cloud infrastructure, and management components. Small things, such as changing the default factory passwords on each component, are made so that simple security is not overlooked. In addition, the solution is built on a high availability (HA) architecture that is tested and validated to ensure organizations that they aren't the first organizations to piece this environment together.

Network Configuration and Best Practices

The control domain (Dom0) for Oracle VM Server for SPARC has direct access to the physical devices. It exports virtual instances of the system devices to guest domains (DomU). A virtual device driver (also known as a front-end driver) appears to the guest operating system as a real device. Guest network devices will look like a regular host with a MAC address, IP address, etc. Oracle Solaris comes with para-virtualized I/O drivers for improved network throughput and higher disk I/O using these virtualized devices.

The network configuration should provide enterprise-grade redundancy and failover. Each server is connected via redundant network switches to the Oracle ZFS Storage Appliance cluster. This design leverages the bandwidth of 10 GbE networking while ensuring no single point of failure.

IP network multipathing (IPMP) and datalink multipathing (DLMP) in Oracle Solaris provides increased reliability, availability, and network performance for systems with multiple physical interfaces. IPMP and DLMP provide physical interface failure detection and transparent network access failover for a system with multiple interfaces on the same IP network link.

By using IPMP, administrators can configure one or more physical interfaces into an IP multipathing group, or IPMP group. After configuring IPMP, the system automatically monitors the interfaces in the IPMP group for failure. If an interface in the group fails or is removed for maintenance, IPMP automatically migrates, or fails over, the failed interface's IP addresses. The recipient of these addresses is a functioning interface in the failed interface's IPMP group. The failover feature of IPMP preserves connectivity and prevents disruption of any existing connections.

Additionally, IPMP improves overall network performance by automatically spreading out network traffic across the set of interfaces in the IPMP group. This improves the network throughput and thereby the efficiency of the server.

DLMP provides features similar to IPMP such as support of link-based port failure for high availability, but they are implemented at different layers of the network stack.

Storage Configuration and Best Practices

Oracle ZFS Storage Appliance systems support multiple protocols such as NFS, Common Internet File System (CIFS), Internet Small Computer System Interface (iSCSI), and InfiniBand (IB). NFS offers the utmost simplicity in attaching storage in Oracle VM Server for SPARC virtualization environments over Ethernet. NFS on Oracle ZFS Storage Appliance scales to many concurrent I/O threads due to the innovative architecture design of the appliances. This high I/O throughput enables more VM stacks to perform I/O without sacrificing service levels.

Oracle ZFS Storage Appliance offers many choices in terms of RAID layout to address capacity, protection, and performance. Mirrored or triple-mirrored protection is the recommended RAID layout for VM storage repository and user data. However, depending on capacity requirements and the service level agreements, RAID Z2 (double parity RAID) also can be deployed for storage repositories.

The high-performance storage capability in this configuration results from using solid-state drives (SSDs) in some Oracle ZFS Storage Appliance models. SSDs enable rapid write capabilities for fast data placement in the storage pool. They optimize I/O rates by providing a fast buffer for reads and/or writes. Both Oracle ZFS Storage ZS4-4 and Oracle ZFS Storage ZS3-2 models have read-optimized and write-optimized SSDs, which enable excellent response times and throughput for demanding virtualized environments. SSD or flash memory technology can significantly boost VM cache performance because of the low latency and higher performance possible. These platforms also have clustering capabilities to provide high availability for storage access.

To address the synchronous write performance of VMs, it is strongly recommended to have two or more write-optimized flash devices per storage pool. To fully utilize the Hybrid Storage Pool feature of Oracle ZFS Storage Appliance with shorter read response times, it is further recommended to use two or more read-optimized flash devices per storage pool.

On Oracle ZFS Storage Appliance systems, all file systems and LUNs are grouped into projects. A project defines a common administrative control point for managing shares. All shares within a project can share common settings, and quotas can be enforced at the project level in addition to the share level. Projects also can be used solely for grouping logically related shares together, so their common attributes (such as accumulated space) can be accessed from a single point.

One project per virtual server pool with dedicated storage repository is recommended. The shared VM storage repository (/export) can be a file system or a LUN that is seen from the VM servers in the virtual server pool.

For storing structured user data such as databases that are accessed from the VMs, it is recommended to match the share record size with the application block size for optimal performance (for example, 8 kB for OLTP databases). Unstructured data and binary files can be stored on shares with a block size of 128 kB.

Storage Appliance Data Protection Features

Oracle ZFS Storage Appliance includes a set of comprehensive data protection features that provide instant snapshots, cloning, rollback, and remote replication—making data protection and maintenance tasks easyand fast restores. These features are recommended to provide advanced data protection in the following ways:

» **Snapshots**. Snapshots are point-in-time copies of data and are recommended as a simple means to backup VM images on the shared storage. An unlimited number of snapshots can be taken from the source. The snapshot mechanism uses a copy-on-write method and does not occupy additional space until new data is written. As new data is written, the old copy is maintained in the snapshot to maintain the point-in-time copy. Each snapshot can be made visible and can be accessed read-only.

» **Cloning**. A clone is a read-write copy of the snapshot. Clones can be created from a snapshot and can be cloned many times, allowing domain boot images or user data in a ZFS share to be accessed and changed by multiple different user environments. Snapshots and clones don't require additional space allocation when they are created, but they will start consuming space when the data is changed.

» **Rollback**. As a faster mechanism for restores, shares can be rolled back from snapshots—bringing all data in the share back to the point in time when the snapshot was taken. Cloning and rollback of OS images in the VM environment are an excellent use of this feature.

» **Remote replication for disaster recovery or development and test**. For environments that include mission-critical data, remote replication for disaster recovery is highly recommended. The remote replication feature in Oracle ZFS Storage Appliance simplifies this requirement. Data is asynchronously replicated from one Oracle ZFS Storage Appliance system (source) to one or more remote sites (targets) for the purpose of disaster recovery. This feature allows for easy failover, role reversal, and failback operations as well as the ability to use target sites for test or development in addition to backup purposes.

In addition, Oracle ZFS Storage Appliance includes built-in compression and deduplication capabilities that help to conserve disk space at no additional cost.

Example Deployment Scenario

This section provides an example deployment scenario of Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure. This is a typical enterprise deployment model that uses high-end SPARC servers and NFS shared storage (based on Oracle ZFS Storage Appliance) to support Oracle applications, middleware, and Oracle Database services.

The example configuration illustrated in Figure 5 offers high performance, availability, reliability, and manageability. While these requirements can be met in numerous ways, this configuration implements an optimal approach. The following sections detail the server components, virtual machine allocation, storage configuration, and project allocations with a clustered Oracle ZFS Storage ZS3-2 appliance configuration.

In this example, up to 14 SPARC T7-1 servers in a single rack can be used to run a virtualized infrastructure in a large, highly available configuration. A separate SPARC T7-1 system is configured to run the Oracle Enterprise Manager Ops Center 12*c* software. In solution testing by Oracle engineers, each SPARC T7-1 server featured a single SPARC M7 CPU with 32 cores and eight hardware threads (vCPUs) per core. The servers were configured with 512 GB of memory and 6x 600 GB/900 GB internal SAS disks. Recommended VM configurations for various types of workloads are included in the subsection that follows.

Each SPARC T7-1 server features four 10 GbE ports. Two 10 GbE interfaces are used by VMs to access storage on the Oracle ZFS Storage ZS3-2 appliance via NFS. These two 10 GbE interfaces supply plenty of bandwidth and cable aggregation for the virtual machine data.

Each server is attached to a clustered pair of Oracle ZFS Storage Appliance systems accessed using NFS (or via an iSCSI LUN). This approach enables additional capabilities such as live migration, high availability, and distributed resource scheduling to be used for the VMs in the server pool. Configuring sets of servers in a similar way is recommended if they are identified as part of a single server pool so that the service level agreements can be met during failovers or migration.
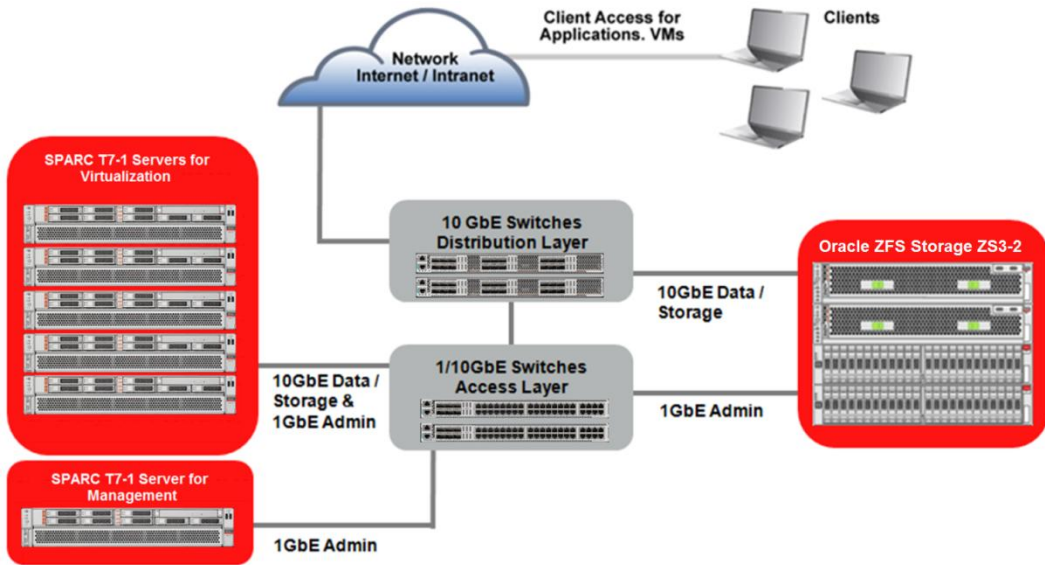
Figure 5. Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure—example deployment.

Recommended VM Configurations

The largest validated configuration of Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure features 13 SPARC T7-1 servers per rack, although a minimum of two servers is acceptable. This section describes recommended minimum configurations for the VMs (using both Oracle VM Server for SPARC domains and Oracle Solaris Zones) deployed within the cloud infrastructure.

TABLE 3. MINIMUM RECOMMENDED CONFIGURATIONS

VM Type	Compute	Memory
Oracle Solaris Zones	1 vCPU (1 thread)	2 GB
Oracle VM Server for SPARC domains	8 vCPUs (1 core)	16 GB

Best practice is to follow these recommended minimum configurations, although these are not absolute limits and can be adjusted based upon workloads and VM technology capabilities.

In an example deployment scenario that supports Oracle applications, middleware, and Oracle Database services, a minimum of 32 GB and one CPU core can be configured for each of the middleware and application domains. For the domain that hosts the database, 48 GB of memory and four CPU cores can be allocated. Note that the number of virtual CPUs and allocated memory for each domain can be tuned in a live system.

While several more domains can be configured per server than what is shown here, the type of workload and the resource requirements of the applications run by each domain will ultimately determine the number of domains that can be supported on each SPARC T7-1 server. If the CPUs are approaching maximum utilization while running multiple domains on the same host, the administrator can add additional virtual CPUs to the server or live migrate domains to a server with more capacity in the pool. Optionally, this migration can be configured to occur automatically by creating workload policies.

Recommended Storage Configuration

For high availability and optimal performance, a pair of clustered Oracle ZFS Storage ZS3-2 appliances is used as the storage platform. Table 4 shows the recommended configuration of four distinct storage pools and the purpose of each pool. Further details about the recommended pools are provided below.

TABLE 4. STORAGE CONFIGURATION FOR HIGH PERFORMANCE WITH ORACLE VM FOR SPARC

Pool Name	RAID COnfiguration	Oracle ZFS Storage ZS3-2 Cluster Head	System/VM	Purpose
pool-0	RAID Z2	HEAD-1	Dom0	For storing the VM storage repository. This pool is accessed from domain 0 and contains the OS images from which the virtual machines are launched.
pool-1	Mirrored	HEAD-1	Virtual machines that run the database	For storing database files and database binaries. One or more projects are created to cater to each database instance.
pool-2	Mirrored or RAID Z2	HEAD-2	Virtual machines that run Oracle Fusion Middleware	For storing the middleware components, including binaries and configuration files.
pool-3	Mirrored or RAID Z2	HEAD-2	Virtual machines that run Oracle applications	For storing the application layer components including binaries and configuration files.

Each storage head is set to be active for two pools. This enables both load-sharing and high availability for all storage pools. In the event of a failure in HEAD-1, HEAD-2 takes over ownership of pool-0 and pool-1 as well as continuing to serve the clients.

» **Pool-0**. One Oracle VM for SPARC project is created in pool-0 to store the VM storage repositories. This is accessed from Dom0 of the Oracle VM Server for SPARC server.

» **Pool-1**. One project is created to share the ORACLE_HOME across the various database instances. Additionally, one project per database is created. Compared to the rest of the pools, a greater number of disks are to be allocated for this pool. This is because the random reads (database sequential reads) benefit from more disks when there is a read miss from the cache.

» **Pool-2**. One or more projects are created for storing the various middleware components. Projects might be dedicated to items such as a web server, SOA binaries, logs, admin binaries, and so on.

» **Pool-3**. One or more projects are created for storing the various application binaries and configurations for Oracle E-Business Suite; Oracle's PeopleSoft and Siebel Customer Relationship Manager (Siebel CRM) applications; and so forth.

The shares (file systems) created under these projects are mounted from the various virtual machines. For security purposes, access to certain projects and file systems can be restricted to specific virtual machine clients.

In this example architecture, all domains are active and the various applications can access the clustered Oracle ZFS Storage ZS3-2 appliances via redundant data paths. This high-availability architecture provides a high-performance infrastructure for demanding enterprise virtualization needs.

Software Description

Table 5 details the software that was installed in this sample configuration.

TABLE 5. SOFTWARE COMPONENTS

System Component	Software Component
Virtualization platform	» *Oracle VM Server for SPARC 3.4* » *Download from Oracle Technology Network*
Deployment management	» *Oracle Enterprise Manager Ops Center 12c* » *Includes Oracle Database*
Operating systems	» *Oracle Solaris 10, Oracle Solaris 11* » *Download from oracle.com/us/products/servers-storage/solaris/overview/index.html*
Storage node	Oracle ZFS Storage ZS3-2 version 2013.06.05.6.7,1-1.2

Conclusion

Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure accelerates the transition to a cloud-based services delivery model while helping to consolidate legacy systems, improve utilization, conserve power and space, and reduce TCO. This solution seamlessly incorporates new and innovative SPARC servers from Oracle with high core counts, memory capacity, and thread scale compared to previous SPARC servers. The dense system design promotes data center efficiencies and the new multicore/multithreaded processors support the extensive scalability needed to support large-scale virtualized environments for cloud deployments.

This solution is a fully designed, documented, and validated blueprint for building a virtualized cloud infrastructure, speeding time-to-deployment while reducing risk. Under real-world workloads, Oracle engineers extensively subjected the solution to fault injection, stress, regression, performance, and scalability testing to predefine configurations and best practices that optimize application response times and availability.

By following the best practice recommendations and guidelines in this paper, IT organizations can take full advantage of the solution to realize a fast return on investment, and at the same time move to a state-of-the-art virtualized infrastructure for cloud services. Additional best practices can be found in the implementation guide, which an Oracle sales representative can provide.

References

For more information, visit the resources listed below.

TABLE 6. RESOURCES FOR MORE INFORMATION

Web Resources	Web URL
Oracle Optimized Solution for Secure Enterprise Cloud Infrastructure	oracle.com/us/solutions/oos/enterprise-cloud-infrastructure/overview/index.html
SPARC servers	https://www.oracle.com/servers/sparc/index.html
Oracle Solaris	oracle.com/solaris
Oracle VM Server for SPARC	oracle.com/us/technologies/virtualization/oraclevm/oracle-vm-server-for-sparc-068923.html
Oracle ZFS Storage Appliance	oracle.com/us/products/servers-storage/storage/unified-storage/
Oracle networking products	oracle.com/us/products/servers-storage/networking/
Oracle Enterprise Manager	oracle.com/us/products/enterprise-manager/
Oracle Enterprise Manager Ops Center	oracle.com/technetwork/oem/ops-center/ops-center-085184.html
Oracle Premier Support	oracle.com/us/support/systems/premier/

White Papers and Data Sheets	Web URL
"Modernize Cloud Infrastructure with Oracle SPARC Servers"	oracle.com/us/products/servers-storage/servers/sparc/sparc-modernize-cloud-brief-2298566.pdf
"Oracle VM Server for SPARC Technology Primer"	oracle.com/technetwork/articles/systems-hardware-architecture/oracle-vm-server-sparc-primer-163874.pdf
"Increasing Application Availability by Using the Oracle VM Server for SPARC Live Migration Feature: An Oracle Database Example"	oracle.com/technetwork/server-storage/vm/ovm-sparc-livemigration-1522412.pdf
"Oracle VM Server for SPARC: Enabling A Flexible, Efficient IT Infrastructure"	oracle.com/us/oraclevm-sparc-wp-073442.pdf

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