Flexible Virtualization with EqualLogic PS Series iSCSI Storage Arrays

The advent of Internet SCSI (iSCSI) technology, combined with the latest in server virtualization software, can offer enhanced capabilities and benefits to enterprises of all sizes. This article provides guidance on building a virtualized infrastructure with EqualLogic® PS Series iSCSI storage arrays and VMware® virtualization software.

Internet SCSI (iSCSI) is a flexible and powerful storage area network (SAN) protocol that can deliver superior capabilities and benefits for enterprises of all sizes. In addition to providing enterprise-class data availability and performance, the iSCSI protocol enables breakthrough virtual storage designs that parallel the advanced designs of server virtualization technologies such as VMware Infrastructure 3.¹

Enterprises of all sizes are building flexible storage infrastructures using iSCSI and advanced virtualization technologies that let them allocate and shift SAN resources dynamically in response to the demands of their virtualized server environments. This article describes a virtualized infrastructure that applies storage and server virtualization technologies to cost-effectively achieve a flexible, high performance, dynamic IT infrastructure that is simple to manage and scale.

**SERVER VIRTUALIZATION AND STORAGE VIRTUALIZATION**

Server virtualization is one of the most significant technology trends in IT today. Managing server hardware and software as separate infrastructure components makes it possible to significantly increase data center operating efficiencies. At a high level, server virtualization works by encapsulating guest operating systems into a set of virtual machine (VM) files. The OS and its unique execution variables and associated data sets are maintained in these files.

Given sufficient memory and disk storage, a single industry-standard server such as a Dell™ PowerEdge™ server running virtualization software can support many guest VMs. Applications and data are processed in exactly the same way as in the physical environment, using the same OS facilities for making system requests. The only difference is that the OS is now a virtualized guest running in a virtual system environment.

VM files can be transparently migrated from one server hardware platform to another, giving administrators the ability to allocate and shift physical server resources in response to changes in application workloads. A scalable, highly resilient, flexible server environment is created, helping increase resource utilization and IT flexibility and reduce operating costs.

Storage virtualization is typically defined as a technology that allows discrete storage systems to operate as a single resource. In light of recent advancements in server virtualization, the concept of storage virtualization is being further refined as a way to create an abstraction layer between the storage hardware and logical data volumes.

Given sufficient protocol support (as with iSCSI), virtual storage products are now being designed that allow data volumes to be located and striped across multiple (and diverse) physical storage resources.

including storage systems, RAID groups, disk types, and controllers. This approach not only helps increase performance and scalability, but also allows data volumes to be transparently moved from one set of resources to another without disruption to the operating systems and applications that are utilizing the data. A scalable, highly resilient, flexible storage environment is formed, helping increase storage utilization rates and significantly reduce operating costs.

**NETWORKED STORAGE WITH VMWARE INFRASTRUCTURE 3**

In a VMware Infrastructure 3 environment, multiple physical servers are networked into a cooperating set of computing resources (see Figure 1). In lieu of a standard Microsoft® Windows® or Linux® OS, each of the x86-based standard servers run a copy of VMware ESX Server, which provides the abstraction layer between the physical servers and guest operating systems. Multiple ESX Server systems are organized into a cluster that can be controlled and coordinated by VMware VirtualCenter, a centralized management system.

Within the virtualized environment, the VM configuration parameters, OS, data sets, and applications are encapsulated in a set of files managed by the VMware Virtual Machine File System (VMFS). VMFS is a cluster file system that coordinates access across ESX Server systems, enabling the migration of live VMs across systems in the ESX Server cluster.

The power of this architecture comes from the ability to run virtually any guest OS, its applications, and its data without modifying the physical servers in the cluster. As the need arises, additional server resources can be nondisruptively added to the ESX Server cluster, and current workloads are load balanced to take advantage of the newly available resources.

Effective VMware virtualization deployments depend on shared access to storage—in other words, a SAN. SANs help ensure that each ESX Server system has ready access to the data sets of other VMs, enabling virtually immediate re-hosting of the VM. This capability helps eliminate the time-consuming necessity of copying VM files, applications, and data from one ESX Server system to another.

Networked storage (iSCSI or Fibre Channel) is required to enable powerful features within VirtualCenter, like VMware VMotion™ technology, which enables the online migration of active VMs without interruption, and Distributed Resource Scheduler, which monitors and automatically migrates VMs to help balance workloads across resources within an ESX Server cluster. VMware High Availability (VMware HA), which also requires networked storage, monitors the functioning of ESX Server systems within the cluster, and in case of a system failure, can re-host and restart VMs affected by the failure on another ESX Server system within the cluster.

In addition to the requirement for networked storage, a virtualized environment heightens the need for high-performance, highly available, resilient storage to help meet the needs of the aggregated workloads. As critical applications, production workloads, and data assets are consolidated into relatively few resources, the need for high performance, nondisruptive scalability, and continuous availability of the storage assets increases. Enterprise-class storage designed for mission-critical deployments is a basic requirement when building a virtualized IT infrastructure.

In particular, purpose-built storage architectures should be deployed that include mirrored memory write caches, fully redundant hot-pluggable components, online hot-spare disks, environmental monitoring, and enterprise-class disk drives with RAID protection. Furthermore, advanced availability features, including storage controller and I/O path failover, are required to help guarantee data access even in the case of component failure.

Consideration should also be given to evaluating the data protection software features enabled within the storage system. Storage consolidation within a SAN enables the consistent application of data protection and disaster recovery, assuming the basic SAN-based tools are available and enabled. Space-efficient, nonintrusive, snapshot-based point-in-time copies as well as efficient array-based replication tools should be considered basic requirements of the storage infrastructure for a virtualized environment. Multiple use cases exist for the application of these tools in virtualized environments, including disaster recovery, online backup and quick recovery of VMs, simple extraction of lost or corrupted data files, rapid VM and data set provisioning using snapshots and clones for production and temporary use, and server-less tape and disk-based backup and recovery of the organization’s data assets.

A thorough evaluation of the storage platform should be made prior to deployment, reflecting not only on the robustness and feature set, but also on the total cost of ownership over its useful life, with particular consideration of the required system growth in terms of both performance and capacity.

![Figure 1. VMware ESX Server cluster with SAN storage](image)
**iSCSI and VMware Infrastructure 3**

With the advent of VMware Infrastructure 3, iSCSI initiators are integrated into the ESX Server kernel, allowing native access to iSCSI storage directly from ESX Server systems. Both hardware initiators and software initiators are available. Network interface card teaming (multiplexing a single logical connection across multiple interfaces) is supported with the software initiator. The hardware initiator includes support for multipathing as well as boot from SAN.

iSCSI support broadens the potential for full-fledged VMware virtualization deployments in small and medium businesses by helping remove the need for a costly and complex Fibre Channel-based SAN deployment. The acquisition, implementation, and operational costs of an iSCSI-based SAN are intrinsically lower than those of a Fibre Channel-based SAN, helping remove an economic barrier to the adoption of server virtualization technologies. Advanced iSCSI-based system architectures can help dramatically change enterprise expectations for large deployments as well. A truly flexible iSCSI-based virtualized environment can help not only reduce costs, but also simplify deployment, provide comprehensive storage management and data protection functionality, and enable seamless VM mobility between hosts.

The addition of iSCSI protocol interfaces to classic storage system designs does not fully exploit the potential of the iSCSI protocol and, in turn, does not adequately solve the storage management challenges faced today by IT managers. Even with the introduction of iSCSI, storage administrators using classic storage systems typically require a ratified level of knowledge for configuring and tuning storage arrays, RAID geometries and data layout considerations, application workload analysis, forced data migration, and complex system upgrades.

**ADVANCED VIRTUALIZATION WITH THE EQUALLOGIC PS SERIES**

Storage virtualization, a key feature of EqualLogic PS Series arrays, can help simplify provisioning and ongoing management, increase storage utilization, provide virtually unlimited scalability in capacity and performance, and enable online migration of data sets among controllers and storage tiers. By consolidating network-based storage into a simple, flexible, consolidated pool of storage designed to grow in capacity and performance (as in an EqualLogic storage environment), storage virtualization can help provide an exceptional virtualization deployment.

Historically, the adoption of storage virtualization technologies in SAN environments has been limited to enterprise data centers needing a tool for online data migration between heterogeneous storage environments. This add-on design allows for heterogeneous storage and data movement, but does not simplify management of the configuration. Most of these designs have been implemented as external appliances sitting within the SAN. These devices generally add complexity to an already complex environment—introducing additional points of management within the SAN, masking value-added features of the attached arrays, and limiting the performance and scalability of the consolidated SAN storage pool to a single gateway hosting the back-end storage.

Advanced storage virtualization technologies, like those available with PS Series arrays, offer the ability to virtualize storage at the storage device level. This approach helps achieve scalable performance and capacity and reduce overall management by aggregating multiple controllers into a cooperating set of resources—that is, by virtualizing volumes not only across disks within a controller but also across storage systems in a SAN.

EqualLogic PS Series iSCSI storage arrays are an excellent example of such a “scale-out” architectural design. Despite their powerful simplicity, such designs are virtually nonexistent in the Fibre Channel-based SAN world, primarily because of architectural constraints inherent in Fibre Channel network deployments.

For example, devices in a Fibre Channel-based SAN are attached to the network via a World Wide Name (WWN), a physical port address specifically assigned and encoded within the device hardware or firmware. WWNs are assigned for all devices within the SAN, including each physical port within each host server and each physical port within the storage controllers. Furthermore, data paths between the hosts and the storage array are statically set when the host is added to the SAN.

Herein lies the inflexibility of Fibre Channel-based SANs. The topology of the SAN is intrinsically hard coded into the environment, making changes within the infrastructure burdensome, time-consuming, and error prone. Expansion of resources in the host, fabric, or storage layer propagates changes throughout the infrastructure, causing intrusive downtime to the applications and infrastructure.

In contrast, TCP/IP networks support virtual addressing and dynamic routing, whereby paths through the network are not statically defined. With Dynamic Host Configuration Protocol (DHCP), addresses can be dynamically assigned, or through address proxying, physical addresses can be virtualized, making it possible for devices in the network to transparently act on behalf of other devices on the network. If the IP address of the resource being accessed is known from within the network, the entity (such as a SAN initiator) requesting access can find the resource dynamically without prior knowledge of the paths or the resource’s physical address.

IP address proxying helps make storage access fully virtualized across multiple EqualLogic PS Series storage controllers. In an EqualLogic group, for example, each member array has 3 active physical Gigabit Ethernet ports; a four-member group has a total of 12 active Gigabit Ethernet ports, providing 12 Gbps of peak bandwidth. Each of these Ethernet ports is assigned an IP address. The members within the group are aware of and coordinate use of these multiple IP addresses and the underlying physical resources. External access to the group by all hosts within the SAN is exclusively addressed through the SAN.
through the group IP address, a unique IP address that transcends all of the underlying member IP addresses. The only IP address known by the attached hosts in the SAN infrastructure is the group IP address. I/Os may be serviced by any physical Gigabit Ethernet port.

Shielding host systems within the SAN from being aware of the physical topology of the storage serving its data is vitally important, particularly in a virtualized server environment. By virtualizing the physical I/O ports, a flexible storage utility is created. Pooling storage assets within the SAN is now possible, enabling a rich set of features to help maximize storage utilization and effectiveness, extending beyond the limitations of a single physical end-to-end connection to a single storage controller.

Data is accessed by the host without intimate knowledge of where in the storage utility the data is stored, providing the opportunity for data volumes to span controller boundaries and exploit the combined resources of multiple controllers. Controllers coordinate among themselves to help balance workloads and optimize storage resource utilization.

Changes in storage infrastructure can be achieved seamlessly, without affecting host connectivity or data access. The iSCSI-based infrastructure can be scaled nondisruptively, automatically applying the resources of the additional controllers and disks to help extend performance and capacity. Multiple tiers of storage can be seamlessly integrated in the utility, providing for automatic placement of data within a volume to the appropriate tier based on the volume’s access patterns.

A flexible storage architecture is particularly appealing in a virtualized server environment because the scale-out architectures of both server and storage infrastructures complement each other, providing an end-to-end virtualized infrastructure. By deploying both virtualized servers and virtualized storage together, IT managers achieve an infrastructure that is particularly adaptable to changing business requirements by providing nondisruptive workload migration and balancing across all physical resources (both storage and server resources) as well as online resource expansion that can immediately apply to preexisting server and storage workloads without intervention and tuning. For more information on the advantages of this type of environment, see the "Integrating server and storage virtualization" sidebar in this article.

**EqualLogic virtualized iSCSI-based SANs**

A virtualized iSCSI-based SAN complements a VMware ESX Server farm. The foundation of an EqualLogic virtualized iSCSI-based SAN is the PS Series storage array (see Figure 2). Each array is designed to be fully redundant, containing disks, multiple high-performance network interfaces, redundant controllers with mirrored battery-backed caches, and other advanced features. The disks can be automatically protected with RAID (RAID-5, RAID-10, or RAID-50) and hot spares. Multiple models of arrays exist, leveraging high-performance 10,000 rpm and 15,000 rpm Serial Attached SCSI (SAS) drives or cost-effective, high-density Serial ATA (SATA) II drives.

A PS Series storage group comprises a single array or multiple arrays. A group is a virtualized resource, appearing to ESX Server systems as a single entity that offers network storage access to a single large pool of storage—a SAN composed of a single virtually scalable, high-performance storage system. Unlike a conventional SAN, in which multiple controllers appear as independently managed islands of storage, each group member in an EqualLogic SAN can cooperate with other members to automate resource provisioning and performance optimization.

ESX Server administrators can create data volumes from within the EqualLogic group storage pool. The group exports its volumes as iSCSI targets protected with security measures that include authentication and authorization. Upon connection, ESX Server systems work with EqualLogic volumes as VMFS data stores, which contain multiple VMs and virtual disks. A variation on this is a raw device map in which the SAN-resident volume is mapped directly to a corresponding virtual disk within the ESX Server environment, circumventing the VMFS data store. A third alternative is to employ the native iSCSI software initiator of the individual guest OS to connect directly to the SAN-resident volume. This last option allows administrators to use all array-based functionality and allows seamless integration with high-level applications, particularly backup applications that use Microsoft Volume Shadow Copy Service (VSS) or Virtual Disk Service (VDS) as an underlying protocol.

**Figure 2. EqualLogic virtualized iSCSI-based SAN**
Automatic load balancing
Volumes are distributed among the PS Series group’s member arrays, with data placement and access continually adjusted for optimal performance as resources are added or workloads change. When an array is added as a group member, its disk space is added to the group’s storage pool. Volumes can be automatically re-striped and distributed across the members of the storage pool. Controller resources are also dynamically adjusted based on the workloads being generated by the ESX Server farm. Data and network I/O to the group can be automatically load balanced across the group members’ resources.

A key feature of PS Series arrays that sets them apart from traditional storage is their dynamic scalability and automated configuration, enabling administrators to flexibly meet changing needs while maintaining availability. As capacity and performance requirements increase, a group can be scaled linearly in both capacity and performance—all while online. New members “learn” configuration and performance information from the group—with no manual intervention. Data and client connection load balancing can occur automatically as the group scales. I/O activity is monitored, and data and network connections are adjusted as needed.

Nondisruptive scalability
The scalability model allows for automated, online expansion across storage dimensions, and the EqualLogic PS Series architecture helps nearly eliminate down-time caused by expanding or managing a storage system. Because capacity can be added so easily, IT managers need to buy only the storage necessary for today’s applications, helping ease budget constraints caused by excessive purchases.

Additional advantages of the virtualized SAN environment include the transparent application of storage tiers. EqualLogic storage groups can use multiple storage tiers contained within the storage pool and automatically optimize data placement based on workload. Alternatively, storage tiers may be segmented into independent resource pools to help guarantee specific resources to specific workloads, concurrently maintaining the flexibility to migrate volumes online from one tier to another, transparently to the ESX Server hosts.

Quick, intelligent provisioning
Within the EqualLogic environment, storage is quickly provisioned simply and easily with the click of a button. The key functions needed to configure, manage, and scale storage are automated, helping cut administration tasks for volume and capacity growth. Given the intelligence built into the PS Series software, decisions with respect to RAID type and data layout can be made automatically at the time of provisioning, and optimized as workload patterns for the newly provisioned storage evolve. As new resources become available, the resources can be automatically applied where and when they are needed. By helping eliminate complex tasks and
enabling fast and flexible storage provisioning, PS Series solutions can help dramatically reduce acquisition and ongoing operational costs and make enterprise-class shared block storage practical for organizations of all sizes, from small businesses to large enterprises. Thin provisioning extends existing EqualLogic provisioning features, helping make the “buy-as-you-grow” storage model of the modular PS Series seamless for servers and applications. Thin provisioning is an important advanced feature that enables the automatic addition of physical capacity on demand up to preset limits. With advanced thin provisioning, buy-as-you-grow storage management and virtualization are made seamless for servers and applications. When a volume is created, it can be sized for the long-term needs of the application without initially allocating the full amount of physical storage. Instead, as the application needs additional storage, capacity is allocated to the volume from a free pool. EqualLogic thin-provisioning capabilities help provide extensive flexibility and user safety controls. These include the ability to turn thin provisioning on and off as needed for any volume, allowing users to cost-effectively test the most suitable applications and volumes for thin provisioning, with the knowledge that they can return to “normal” provisioning online. EqualLogic implementation of thin provisioning also provides enhanced alerts and controls—with proactive, user-defined threshold alarms and controls, administrators can depend on automatic space allocation without worrying about reaching allocation limits or unexpected depletion of physical storage.

**Automated management**
The PS Series architecture is designed to simplify storage management in several ways. RAID configuration and hot sparing is automated, and dynamic storage and network I/O load balancing can occur automatically as resources and performance metrics change. No longer must administrators manually map application data to specific physical devices and controllers.

A primary advantage of this automated virtual storage system is that storage administration remains stable as the group is expanded. All administration is performed at the group level, through the EqualLogic PS Group Manager, an intuitive, single-pane administrative console. Because the group is managed as a single logical system, the ongoing operational costs of storage management can remain fixed even as storage grows.

**SIMPLE, COST-EFFECTIVE, DYNAMIC IT ENVIRONMENT**

Virtualized iSCSI-based SANs, such as those enabled by EqualLogic PS Series arrays, are changing enterprise expectations of how simple a storage infrastructure can be to deploy, manage, and grow. As Figure 3 illustrates, complementary server and storage virtualization built on iSCSI-based SANs create a fully abstracted pool of physical resources—one that can provide higher performance, scalability, ease of use, and flexibility compared with classic storage array architectures. EqualLogic PS Series iSCSI arrays are designed to reduce technical complexity and cost barriers imposed by classic SAN architectures without compromising performance, scalability, or resiliency. In enterprise data centers, a virtualized SAN utilizing PS Series arrays offers a cost-effective, comprehensive solution to help reduce both management complexity and total cost of ownership. To learn more, visit www.equallogic.com.

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