

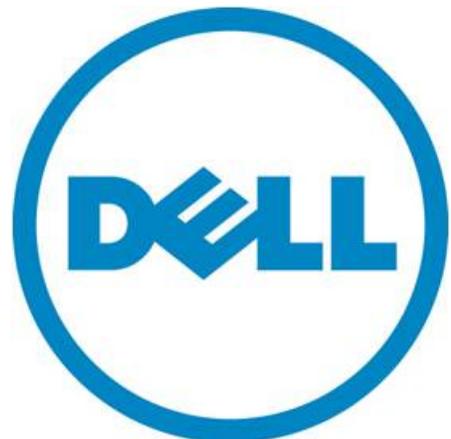
Dell EqualLogic FS7500 – Unified block and file storage for virtual workloads

A Dell Technical White Paper

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ABSTRACT:

This white paper examines the common storage challenges faced by IT for virtualized application workloads and describes why the Dell™ EqualLogic™ FS7500 unified block and file storage is an ideal solution for hosting a VMware environment with virtual workloads. Using results from testing conducted at Dell Labs, this white paper also provides a performance-based proof point for hosting multiple virtual workloads on EqualLogic FS7500 over NFS.



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Introduction

Today datacenter administrators in businesses of all sizes are facing an efficiency challenge. Due to the rapid growth of collaboration and e-business applications and regulatory compliance requirements, server and storage needs are continually growing while IT budgets are either stagnant or shrinking. To address the server side efficiency issues, virtualization solutions, such as those from VMware®, Microsoft® and Citrix® where resources of a single physical server are shared across multiple virtual machines, deliver high asset utilization and eliminate the problems that result from having to maintain and manage large numbers of underutilized physical servers. As virtualized application workloads expand to more than a few physical servers, beyond the limits of direct-attached storage (DAS) expansion, some IT organizations have consolidated their storage on networked storage devices. However, many organizations still continue to use DAS for their virtual workloads. While they have taken advantage of server consolidation, they have not yet extended the consolidation benefits to storage. The problem of underutilization of storage resources associated with DAS is dramatically reduced with networked storage. This is particularly important for a virtual environment because the only way to take full advantage of server virtualization is with consolidated storage pools; for example, the ability to move live virtual machines is only enabled with shared storage devices. DAS architectures can support this function only to a limited number of servers that are directly attached to the storage device, making your virtual server implementation less flexible.

Many companies that have implemented networked storage solutions in an attempt to avoid the inefficiencies of DAS have struggled with the complexity and support costs of those solutions. Hypervisors, such as those from VMware, Microsoft®, and Citrix, support both networked storage options—storage area network (SAN¹) and network attached storage (NAS). Over time many datacenters may end up with multiple islands of SAN and NAS with separate vendor-specific storage management consoles that are not easy to use.

This white paper provides an overview of storage options for VMware virtualization and describes the benefits you can gain from using the EqualLogic FS7500 in conjunction with VMware. It also provides a performance-based proof point that the EqualLogic FS7500 can meet the demanding I/O needs of multiple virtual workloads running in VMware environments over the NFS protocol.

Audience

This white paper is intended for customers who have evaluated the EqualLogic unified storage value proposition and want to explore the use of the EqualLogic FS7500 for their virtual environments. These customers are looking for a performance-based proof point for running multiple virtual workloads over the NFS protocol in VMware environments. This white paper *does not* provide design considerations and best practices for setting up their virtual infrastructures with VMware over NFS using the EqualLogic FS7500.

¹ Fibre Channel, iSCSI, or FCoE are storage networking protocols for SANs

Sections

This white paper contains the following sections:

- Storage Options for VMware
- The Dell EqualLogic FS7500 storage solution for VMware
- Storage Performance
- Test Methodology
- Test Results

Storage Options for VMware

The VMware® vSphere™ suite provides a hypervisor that supports full operating system virtualization within a virtual machine (VM). A VM operates exactly like a physical server; it has its own virtual hardware including processor(s), memory, hard disks, and network interfaces. Each VM runs its own operating system, whether it is Windows™ ® or Linux, just like a physical server. Most major applications and databases, for example Microsoft® Exchange®, Microsoft® SQL Server®, Microsoft® SharePoint® and Oracle® 11g, are fully supported in VMware virtual environments. Application performance is just as important in a virtual environment as it is in a physical environment. The storage option you choose to host your virtualized application workloads is critically important for a good end-user experience.

VMware offers a variety of storage options in the vSphere product suite to host virtual workloads. These storage options are available to host both the VMware hypervisor including the VMs and the user data for the application running within the virtual machine. These storage options include:

1. **Direct Attached Storage (DAS):** A typical DAS system consists of one or more data storage devices directly connected to a computer through a host bus adapter (HBA). These devices can be housed in the server enclosure or in an external enclosure that is directly connected to one or more servers. A DAS environment does not have network devices like hubs, switches, or routers. DAS connections primarily use ATA, SATA or SAS block-based protocols². VMware DAS environments typically leverage the VMFS file system.
2. **Storage Area Network (SAN):** A typical SAN consists of a dedicated network of storage devices that serves one or more consolidated logical units (also known as LUNs) such that the LUNs appear as locally attached storage devices to the server operating system. A SAN typically has a dedicated switching fabric independent from the client local area network (LAN). A SAN provides only block-level abstraction of storage devices. Shared file systems on a SAN use block-level operations to access the host operating system, or user data. Examples include the Microsoft Windows NT file system (NTFS) and the Linux third extended file system (ext3). SAN connections primarily use Fibre Channel (FC), FC over Ethernet (FCoE) or iSCSI block-based storage networking protocols. VMware SAN environments typically leverage the VMFS file system.
3. **Network Attached Storage (NAS):** A typical NAS is a storage device that uses file-based protocols such as NFS or SMB/CIFS and provides file-level abstraction of storage to the network clients. Unlike SANs, NAS systems share the client LAN. Applications running on physical or virtual environments that are connected to NAS devices use file level operations to provide access to user data. VMware can host virtual workloads on NAS devices using the NFS protocol.

² Although Fiber Channel protocol can be used in a DAS device, it is primarily used in a SAN device.

Both NAS and SAN infrastructures offer viable alternatives for network storage that may be appropriate for hosting multiple virtual workloads in VMware environments. So how do you know which consolidated storage solution is best for you? It depends upon the application, your workload characteristics, and your datacenter circumstances. The key is to look for flexibility in your storage solution.

There are two key features that your shared storage solution should provide: scalability and a unified storage platform. The way a storage solution implements these two features defines whether it will meet your needs for hosting multiple VMware virtual workloads.

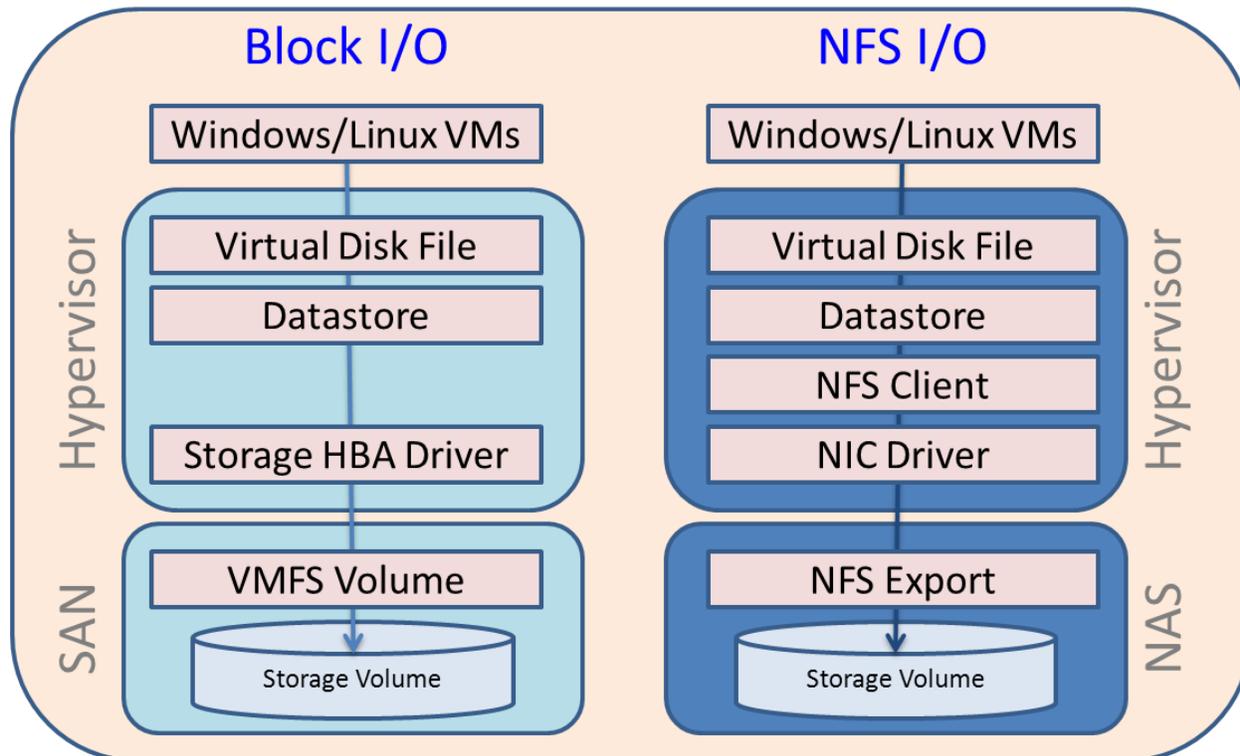
First, a highly scalable storage device can handle a growing virtual implementation simply and easily without disruptive “forklift upgrades.” That is, expansion should be possible without replacing existing storage devices with new generation higher-capacity devices and migrating data to the new generation devices. Multiple generations of storage systems should be able to come together to provide a single storage pool with easy expansion or evacuation of capacity as needed. It should also scale performance along with capacity, so that growth doesn’t lead to performance degradation.

Second, a unified storage system—that is, a system that supports both SAN and NAS storage needs—simplifies storage and virtualization management. A consolidated management approach to storage enables IT administrators to easily manage storage needs of all virtual workloads using a single storage management console. Instead of having to choose between SAN and NAS up front, you are assured that over time you can remain flexible; choosing the most appropriate networked storage type based on your application needs.

VMware I/O stacks

VMware virtualized workloads can be hosted on SAN devices using iSCSI, Fibre Channel, or Fibre Channel over Ethernet (FCoE) block I/O protocol; they can also be hosted on a NAS device using NFS I/O protocol. The key elements in each of the I/O stacks for these technologies are shown below in Figure 1.

Figure 1. VMware I/O stacks



In a SAN, when the VMware hypervisor is using the block-based FC, FCoE, or iSCSI protocol, it creates a VMFS file system on a storage volume (shown as VMFS Volume in Figure 1) to organize and store VMware files. The VMFS file system logic runs on the VMware server.

Unlike SAN, in a FS7500 NAS, when the VMware hypervisor is using the NFS protocol, the NFS services running on the FS7500 controllers are responsible for running the file system logic.

NFS is a file-based protocol that can be used to establish a client-server relationship between VMware vSphere hosts and a NAS storage system. NFS services running on the NAS device are responsible for managing the layout and structure of the files and directories on physical storage (shown as NFS Export in Figure 1). NFS services are also used for coordinating simultaneous storage access from multiple servers. vSphere hosts use these services to provide shared access for VMware VMs similar to that provided by VMFS when used with block storage.

VMware has built full NFS support into the vSphere disk virtualization layer. VMware supports all major features such as VMotion™, VMware snapshot, VMware HA, and VMware DRS using NFS exports, at parity with VMFS volumes. This white paper is primarily concerned with NFS.

From a technical perspective, the VMware hypervisor typically abstracts the I/O operations generated by the VM and processes them in a virtual disk file known as a VMDK file. This VMDK file is stored in a datastore presented to the ESXi host server. A datastore is a storage volume or file system repository that may contain the configuration and data files of one or more VMs. These datastores may either be block-based VMFS volumes (using iSCSI/FC/FCoE protocol) or file-based NFS exports (using the NFS protocol). In either case, from a functional point of view the VM is unaware of the underlying storage mechanism because the hypervisor handles all the I/O processing on the virtual machine's behalf.

As storage I/O requests are received, the hypervisor either leverages the storage subsystem drivers or the network subsystem drivers to establish and maintain a connection to the datastore. In the case of block-based storage, the hypervisor uses the storage Host Bus adapter³ (HBA) driver to connect to the block-based SAN storage device. This may be iSCSI HBAs, Fibre Channel HBAs, or even Converged Network Adapters running FCoE.

In file-based storage environments, the hypervisor leverages the Network Interface Card (NIC) driver because the storage traffic flows over the IP network. Traffic destined for the NAS device is processed by the NFS client in the hypervisor, and then sent over the IP network where it is handled by the NAS device.

Other differences also exist between the two VMware I/O stacks. As we noted above, in a block-based storage environment, the hypervisor formats the raw storage device with the VMFS file system. NAS-based datastores are not formatted by the hypervisor; instead they are managed entirely by the NAS device. This means the NAS device maintains the formatting, and ultimately controls the maximum size of the volumes presented to the ESXi hosts. While VMFS is limited to 2TB per volume in vSphere 4.x, and 64TB per volume in vSphere 5, the Dell EqualLogic FS7500 may enable you to exceed these boundaries to provide substantially more contiguous space than block-based solutions. At present, the EqualLogic FS7500 has been tested with volumes up to 509TB in size.

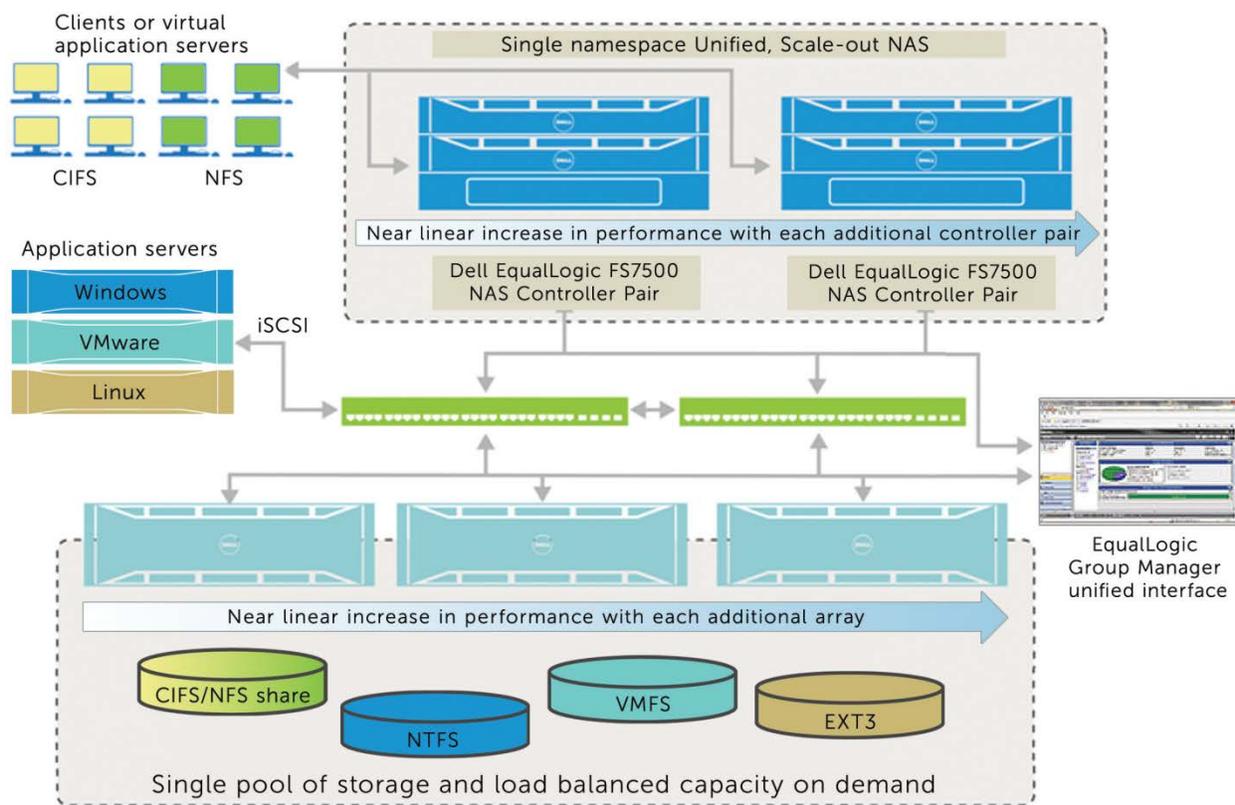
The Dell EqualLogic FS7500 storage solution for VMware

The Dell EqualLogic FS7500 is a unified, scale-out NAS solution that works with EqualLogic PS Series arrays to combine both NAS and SAN storage in a single, flexible architecture designed to optimize both performance and capacity. While many storage solutions tend to experience performance degradations as you increase their capacity, the FS7500 offers almost linear scalability; that is, as you increase the number of controller pairs or EqualLogic PS Series arrays, the FS7500 delivers a proportional increase in storage performance. This is a key feature because consolidating virtual workloads can cause unexpected demand bursts in your storage capacity and performance. The scalability of performance with capacity eases this common stumbling block.

The FS7500 system can be quickly added to an existing EqualLogic SAN environment to create a NAS service. Because workloads in virtual environments can be deployed or moved quickly to meet business needs, it is not uncommon to experience high volatility in storage demand. As a result, the ability to add or move NAS or SAN storage quickly and easily, without disrupting operations, is a great advantage—especially as more and more applications are virtualized.

³ Assuming a hardware initiator is used for FC/iSCSI/FCoE block access.

Figure 2. Unified Scale-out Dell EqualLogic FS7500 Storage System



With the FS7500, you can scale both capacity and performance easily online; controllers and arrays are automatically discovered and added to the resource pool. When you need more storage capacity or I/O performance, you can add Dell EqualLogic PS Series storage arrays; these are automatically added to the storage pool and data is load-balanced across all the disks in the pool. To increase NAS performance, you can add FS7500 controllers; I/O is then spread across all available controllers to maximize performance. Whether you use the NFS or CIFS protocol, NAS performance scales in an almost linear fashion as you add controllers.

While many traditional NAS systems have limitations on scalability and file system size based on architecture, the Dell EqualLogic FS7500 has no such restrictions. It can scale to the limit of the backend storage arrays in a single namespace; currently tested up to 509 TB of usable NAS space. This means you can surpass the limitations of traditional file systems, providing contiguous space for even your most demanding applications.

NAS datastores can even simplify the implementation and management of a VMware virtual environment because NAS storage volumes can be simpler to deploy and manage than traditional SAN volumes. The NAS device is responsible for the provisioning and allocation of the storage. The hypervisor essentially maps a network drive to the NAS device; much in the same way users would connect to their home folders. This greatly simplifies the administrative tasks required by virtualization administrators because connecting an ESX host to a NAS-based storage requires no specialized training in storage administration. In addition, NAS-based datastores in a VMware environment provide nearly all the major features of block-based storage volumes, but without the complexities involved in managing a traditional SAN storage network.

Finally, through the use of VMware's Storage vMotion, the FS7500 enables administrators to leverage multiple storage tiers for each virtual machine depending upon the application needs. While some storage may remain on block-based iSCSI volumes, other workloads with more unpredictable storage needs may be migrated to the NFS volumes where they can be easily expanded. Likewise, new virtual workloads may be provisioned initially on NFS volumes, and then later migrated to alternative storage on block based iSCSI volumes, if required. In addition, applications with multi-tiered datasets, like OLTP and VDI applications, when implemented in virtual environments using either block or file storage pools, can also benefit from the auto-tiering capabilities of EqualLogic PS Series arrays.

The unified nature of the FS7500 solution provides an opportunity to improve productivity and streamline infrastructure management. It offers high performance and scalability for both new and existing Dell EqualLogic storage arrays to manage storage traffic over iSCSI, CIFS, and NFS protocols. This enables you to configure and manage storage for both block-based and file-based applications from a single management interface. The EqualLogic Group Manager can be used for configuration of storage pools and volumes, to create or expand CIFS shares or NFS exports, and to set up authentication, quotas, snapshots, and NDMP backups. Automated features such as load balancing across disks, RAID sets, connections, cache, and controllers help to minimize the amount of administration that IT must perform for both SAN and NAS services.

As with all Dell EqualLogic products, advanced features like wizard-based installation, automated setup and configuration, native support for Active Directory, LDAP and NIS, and high availability features are all included in the base price of the FS7500 system. File-based snapshots (separate from iSCSI snapshots), enable users to restore their own files without IT involvement. As with all EqualLogic products today, all future EqualLogic firmware enhancements are available at no cost to customers with valid support contracts.

Virtual server environments are delivering tremendous capital and operational cost benefits, but require consolidated storage pools to take advantage of their full functionality. As more storage is required, the volumes hosted by the FS7500 may be expanded without reconfiguring the VMware hypervisor; thus simplifying the management of a large virtualization environment. With the Dell EqualLogic FS7500, your virtualized infrastructure gains the flexibility of a unified SAN and NAS storage system, centralized management, and near linear scaling of performance and capacity.

Storage Performance Metrics

There are two primary metrics of storage performance:

1. **Throughput:** This is the quantity of data passed from the host to the target. It is expressed in two ways depending on the size of the I/O payload being measured.
 - a. For small data payloads, throughput is often expressed in I/O operations per second (IOPS) because each storage request may contain all its data in a single storage packet, and we are interested in how quickly each transaction can be processed.
 - b. For larger data payloads, throughput is often expressed in megabytes per second (MBPS) because a given payload may be broken into smaller fragments, making IOPS information not very useful. The goal is to determine how much data can be moved in a given time period.
2. **I/O Latency:** This is the round-trip delay between the source and target expressed in milliseconds. This number represents how long a given storage request takes to go from the host to the target storage device and back again (the round trip). Storage devices with high I/O latency are not suitable for response time sensitive applications like email and e-commerce.

Together these metrics can be used to quantify performance at the application level. Both of these performance metrics are related to each other. When the storage system reaches its performance limits, the transactional performance and latency values are often found to be in an inverse relationship. As latency increases, transactional performance decreases because of the increased time required to process each I/O. However, when the system is underutilized, transactional performance can increase without dramatically affecting latency. As a result, when assessing the performance of a storage system near saturation, it is sufficient to measure the application transactional performance at an acceptable quality of service (QoS) level that is typically defined by a maximum application transaction response time.

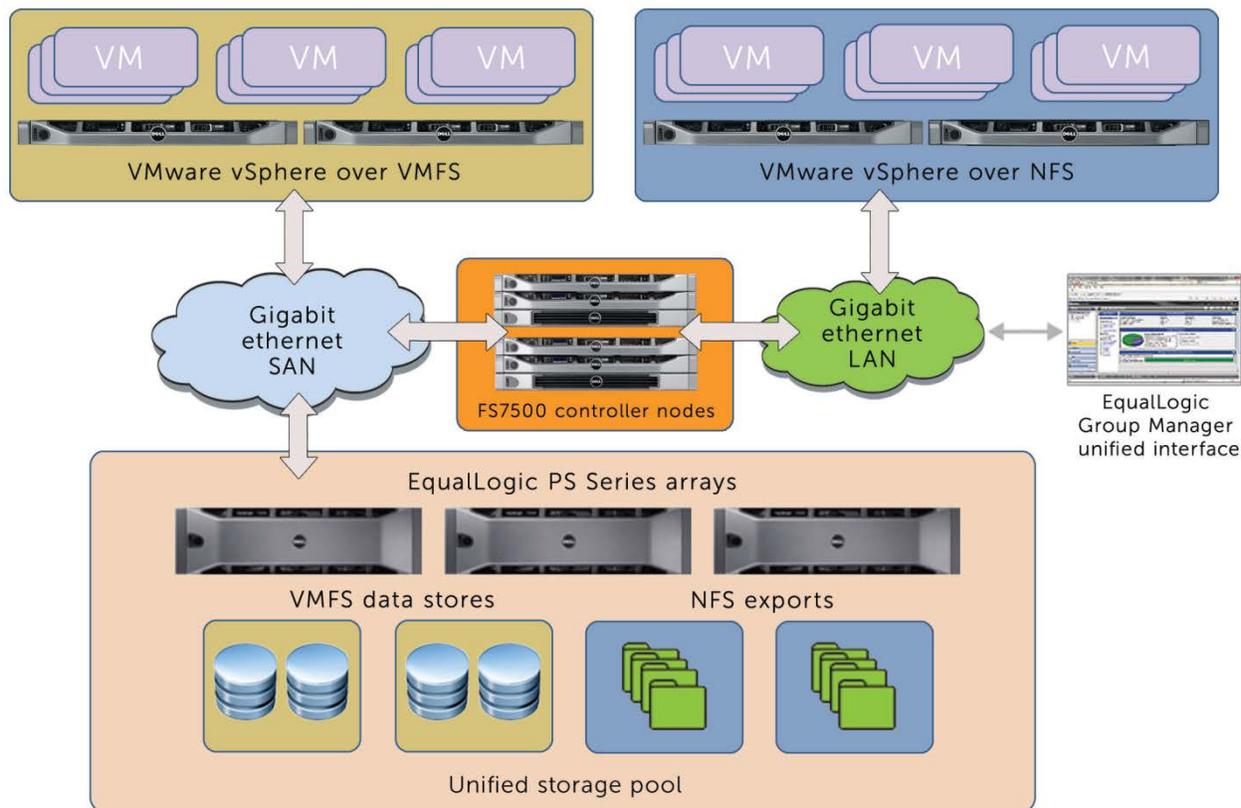
Test Methodology

Our test environment was structured to provide insight into the scalability of VMware virtual environments supporting multiple simultaneous workloads and VMware-specific virtual infrastructure operations.

In this test environment, we deployed a pair of FS7500 controllers and the VM host servers with sufficient CPU, memory and network resources to avoid any bottlenecks in these subsystems. In terms of hardware, we varied only the storage configuration to understand the impact of increasing storage capacity in the configuration. For each storage configuration, we increased the workload and noted the application transaction throughputs and response times. In our test results, we focused on quantifying application transactional performance while maintaining a steady virtualization infrastructure activity as well as maintaining an acceptable application QoS.

Figure 3 depicts a VMware environment with multiple virtual workloads hosted on an EqualLogic FS7500. This is the overall layout of the test environment.

Figure 3. Multiple Virtual Workloads in a VMware environment on Dell EqualLogic FS7500



Test Hardware Configurations

The test hardware configuration consisted of two ESXi servers with 128GB of RAM, quad-socket, 12-core processors yielding 48 logical CPUs. Both servers were running VMware vSphere v4.1 Update 1 hypervisor.

Two Dell PowerConnect 6248 Gigabit Ethernet switches were used for the front-end and back-end connectivity; segmented internally via VLANs. While this is usually not a recommended best practice for production networks, it provided the connectivity we needed for this test environment.

The EqualLogic FS7500 consisted of one pair of controllers and up to three EqualLogic PS6000XV arrays operating under a single group address. Each EqualLogic PS Series array contained 14 600GB 15K RPM SAS drives in a RAID 10 configuration with approximately 3.66TB of usable space each. Arrays were added one at a time to test performance scalability.

Six shared datastores were configured on each ESXi server; three were using NFS exports on the FS7500 and the other three were using block I/O using VMFS.

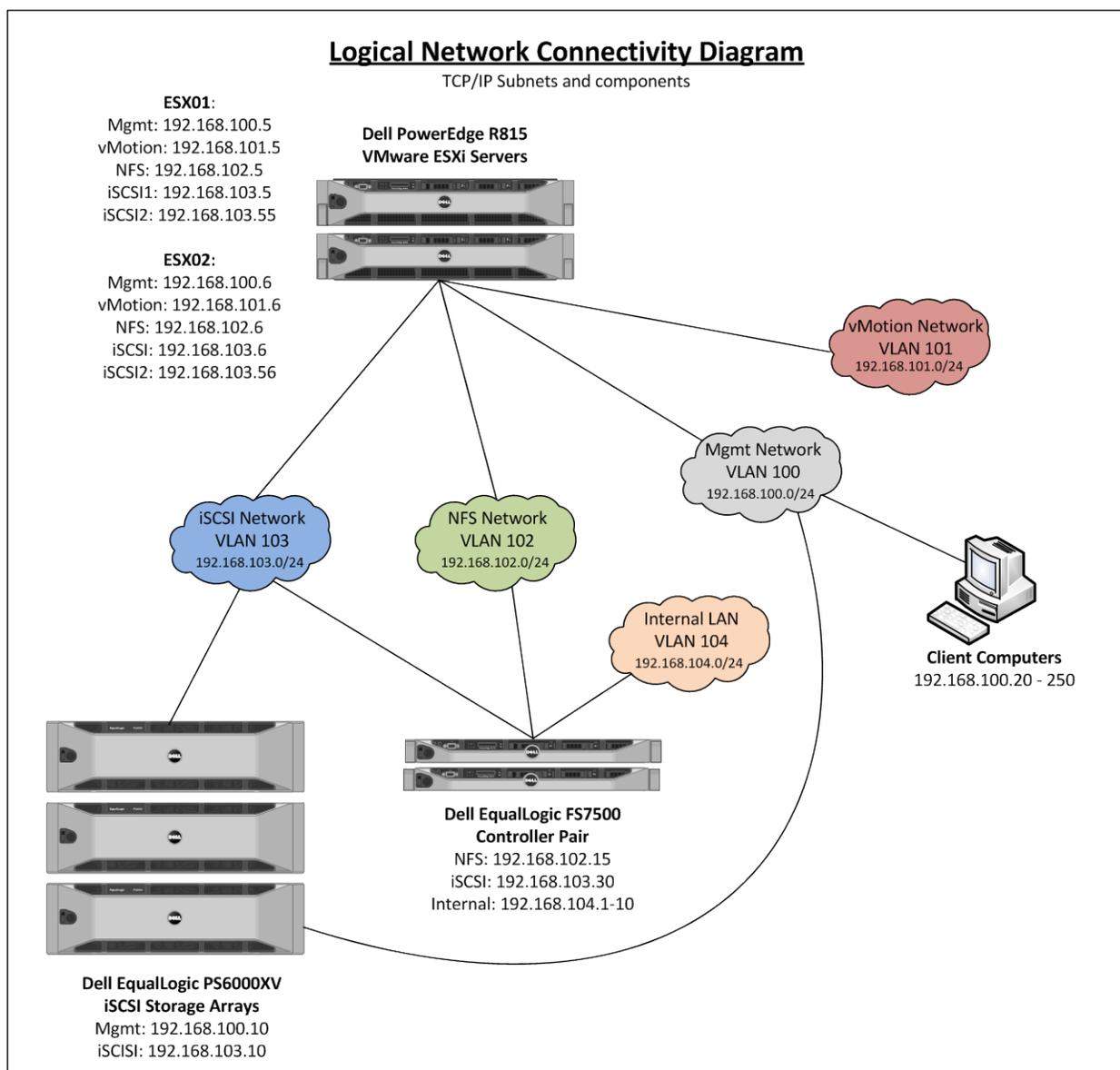
The test began by utilizing only one PS Series array. As the tests progressed, additional arrays were incorporated into the storage pool. Testing progressed only after the PS6000XV arrays had completely balanced the existing data across the newly added array.

Test Network Configuration

The network configuration consisted of two dedicated Dell PowerConnect 6248 Gigabit Ethernet switches. The iSCSI and NFS traffic was isolated and differentiated from the VM traffic through the use of VLANs and physical switch segmentation. Once again, while this is usually not a recommended best practice for production networks, it provided the connectivity we needed for this test environment.

Each ESXi host server was configured with eight (8) 1 Gbit NICs to produce a typical highly available configuration with separation between management, vMotion, iSCSI, and NFS connections. All outbound connections used the default port-based load distribution model in standard virtual switches. The Maximum Transmission Unit (MTU) size was increased on the IP storage connections and the PowerConnect switches from 1500 to 9000 to support Jumbo Frames.

Figure 4. Logical Network Connectivity Diagram of the Test Environment



Virtual Workload Description

To ensure that we simulated a real life situation for our performance measurement, we chose to run a virtual workload mix based on a set of typical datacenter workloads including business applications as well as operations associated with managing the virtual environment. We used workloads suggested by VMware's VMmark 2 benchmark, as these workloads are representative of popular applications commonly run in the datacenter. However, individual loads were modified to saturate the storage system in the test environment while making sure that other subsystems were not becoming a bottleneck. We used a mix of the following three application workloads:

Mail server operations using Microsoft Exchange

The workload emulates 1000 heavy profile users with a fixed mailbox size and measures the transaction capability of the email server based on number of completed email transactions.

Social networking operations using Olio, Web 2.0 based applications

The Olio workload is fixed at 400 concurrent users and the completed operations per minute reflect its performance.

E-commerce transactional operations using DVDstore and MySQL databases

The workload simulates customer shopping activity including browsing catalogs, shopping, and checkout with number of transactions per minutes reflecting the performance achieved.

In addition to the above application workloads, in parallel we also ran nominal virtualization infrastructure activities like vMotion, Storage vMotion and VM creation in each run. For each underlying benchmark, the application transaction counts were gathered at an acceptable quality of service (QoS) represented by a maximum allowable transaction response time⁴. In all tested configurations the storage environment was near saturation with sufficient headroom in CPU, memory, and network resources. The table below shows a consolidated view of the workload mix.

⁴ These response time values were measured at the application using Windows PerfMon.

Table 1. Virtual Workload Configurations Tested on FS7500 over NFS

Virtual Workload Configurations Tested on FS7500 NFS								
Workload Name	Application	Workload Config.	Virtual Machine Platform	Virtual Machine Configuration			Performance Metric	QoS
Mail server	Exchange 2007	1000 Heavy Profile Users	Windows 2008 64-bit	4 vCPU	8GB RAM	80GB disk	No of Transactions Executed by Mail Server	<500ms Transaction response time
Web 2.0	Olio	Two-Tier Java based; 400 Concurrent Users	Back end: MySQL database on Novell SLES ⁵ 11 64-bit	2 vCPU	2GB RAM	16GB disk	Total completed operations per minute	<600ms Operation response time
			Front end: Tomcat based tc Server on Novell SLES 11 64-bit	4 vCPU	8GB RAM	68GB disk		
E-Commerce	DVD Store 2	Two-Tier Three Webservers and One Database Server	Back end: MySQL database on Novell SLES 11 64-bit	4 vCPU	4GB RAM	49GB disk	No of Transactions Executed per minute	<700ms Transaction response time
			Front end (3): SLES 11 64-bit	2 vCPU	4GB RAM	14GB disk		

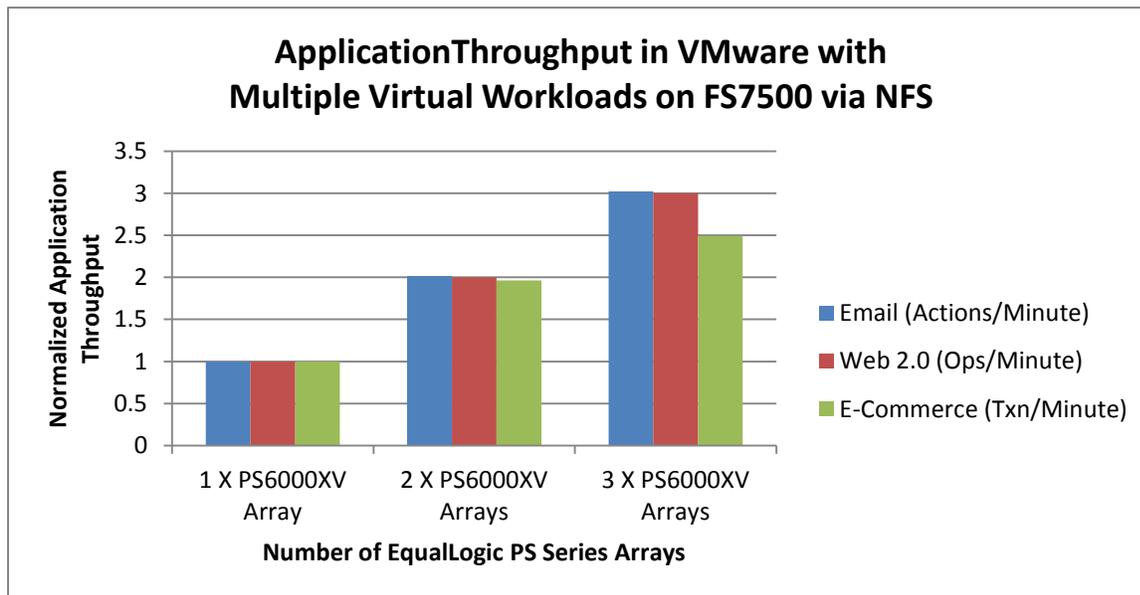
Test Results

The simulations were designed to be highly reproducible, meaning that we could reproduce test results if identical circumstances were provided. In each configuration we held everything else constant except the number of EqualLogic PS6000XV arrays. We used the various application throughputs from a single PS6000XV array configuration as the baseline. The test results from the other two configurations were then compared to the baseline to determine the performance of each configuration relative to the baseline. This comparison allowed us to show the performance improvements in each configuration as we added additional PS6000XV arrays to the storage pool.

Figure 5 shows the simulation test results for three hardware configurations where the CPU, memory, and network subsystems were kept constant and only the storage capacity in the EqualLogic FS7500 was increased by adding additional PS6000XV arrays. The height of each bar in this chart shows the normalized application throughput in a VMware environment via NFS. These test results clearly show that in a VMware environment, with multiple virtual applications running on an EqualLogic unified scale-out NAS, a near linear increase in application transactional performance is achieved when additional storage capacity is added. We were easily able to provision additional capacity in the EqualLogic FS7500. Each time the PS series array was automatically discovered and added to the storage pool, and data was load-balanced across all the disks in the pool while the applications were running. As we increased the workloads, the application performance increased at a near-linear rate with capacity.

⁵ SUSE Linux Enterprise Server

Figure 5. Performance of Multiple Virtual Workloads in VMware using FS7500 over NFS



Conclusion

Most organizations cannot accurately estimate their workload growth, especially in a virtualized environment. With multiple increasing workloads, they need a storage platform that can easily scale in capacity and performance without any disruptions in the production environment and without any fork-lift upgrades. Because virtual workloads can be hosted on both SAN and NAS devices, using either Windows or Linux operating systems, such a storage platform must also provide a consolidated storage pool with a single unified management interface. Dell EqualLogic FS7500 with PS Series arrays provides unmatched capabilities for such a storage platform. Dell Labs simulation tests illustrated that as we increased multiple virtual application workloads in a VMware environment, the FS7500 was able to scale transactional performance near linearly with capacity, such that we experienced little degradation in application performance as we added additional storage arrays to accommodate the increase in workloads. Unlike traditional storage architectures where application performance increase starts to diminish with increasing capacity, especially near saturation performance, each additional array in FS7500 increased storage capacity with proportional increase in application transactional performance. The FS7500 unified scale-out storage system is easy to install, use, and manage. Instead of having to choose between SAN and NAS or block and NFS up front, you can remain flexible to choose the right storage type for your application needs over time.

This flexibility means that whether your company expands into new ventures or simply adds more users, your storage can scale with you when using the EqualLogic FS7500. The Dell EqualLogic FS7500 enables you to start small and grow as required; without taking a hit in your operations or efficiency.

Appendix A

Test System Components

The hardware configuration used in the testing process is outlined below:

Hostname	Mgmt IP	Version	CPUs	RAM
ESX01	192.168.100.5	VMware ESXi Installable 4.1.0 348481 (update 1)	Quad Socket, 12-cores each (48 LCPUs)	128GB
ESX02	192.168.100.6		Quad Socket, 12-cores each (48 LCPUs)	128GB

The datastore configuration on each ESXi server is outlined below:

Datastore	Type	Size	Purpose	Storage Port type	Storage Connection
BlockDS01	VMFS	800GB	Future use for Block I/O Applications	iSCSI Software initiator	192.168.103.10 (iSCSI)
BlockDS02	VMFS	800GB			
BlockDS03	VMFS	200GB	Storage vMotion		
NFS-DS01	NFS	808GB	NFS I/O Applications	NAS/NFS3	192.168.102.15/NFS_DS01
NFS-DS02	NFS	808GB		NAS/NFS3	192.168.102.15/NFS_DS02
NFS-DS03	NFS	200GB	Storage vMotion	NAS/NFS3	192.168.102.15/NFS_DS03

IP and Subnet Information

The test environment network configuration was arranged using dedicated Gigabit Ethernet switches (Dell PowerConnect 6248). The subnet configuration is shown below:

Subnet	Purpose
192.168.100.0 / 24	Management and Clients
192.168.101.0 / 24	vMotion
192.168.102.0 / 24	Front-end Storage (FS7500)
192.168.103.0 / 24	Backend storage (PS6000)
192.168.104.0 / 24	FS7500 Internal Network

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There were 8 1 Gbit NICs in each ESXi host server as outlined below:

VMNIC	vSwitch	Subnet(s)	MTU	Purpose	Upstream Port type	Upstream Connection
vmnic0	vSwitch0	192.168.100.0/24 192.168.101.0/24	1500	Management, Clients, Applications, vMotion	TRUNK	(Switch #2) VLAN 100: Management, Clients, and Applications (Switch #2) VLAN 101: vMotion
vmnic1					TRUNK	
vmnic2					TRUNK	
vmnic3					TRUNK	
vmnic4	vSwitch1	192.168.102.0/24	9000	NFS to FS7500	ACCESS	(Switch #1) Front-end portgroup
vmnic5					ACCESS	
vmnic6	vSwitch2	192.168.103.0/24	9000	iSCSI HBA33	ACCESS	(Switch #1) Back-end portgroup
vmnic7	vSwitch3	192.168.103.0/24	9000	iSCSI HBA34	ACCESS	(Switch #1) Back-end portgroup