



ESG Lab Validation Report™



Dell/EMC CX3-20 and VMware Virtual Infrastructure 3: Optimizing Virtual Data Centers with iSCSI Storage

**A validation study
by
ESG Lab
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ESG Validation Reports

The goal of ESG Lab Validation reports is to educate customers about various storage and storage-related products, including storage systems, backup-to-disk solutions, storage management applications, backup and recovery software, storage virtualization platforms, etc. ESG Lab reports are not meant to replace the necessary evaluation process that end-users should conduct before making purchasing decisions, but rather to provide insight into these technologies. Our objective is to go over some of the highlighted features/functions of such products, show how they can be used to solve real customer problems, and identify any areas needing improvement. ESG Lab's expert third-party perspective is based on our own hands-on testing as well as on interviews with customers who use these products in production environments. This report was sponsored by Dell Corporation.

Introduction

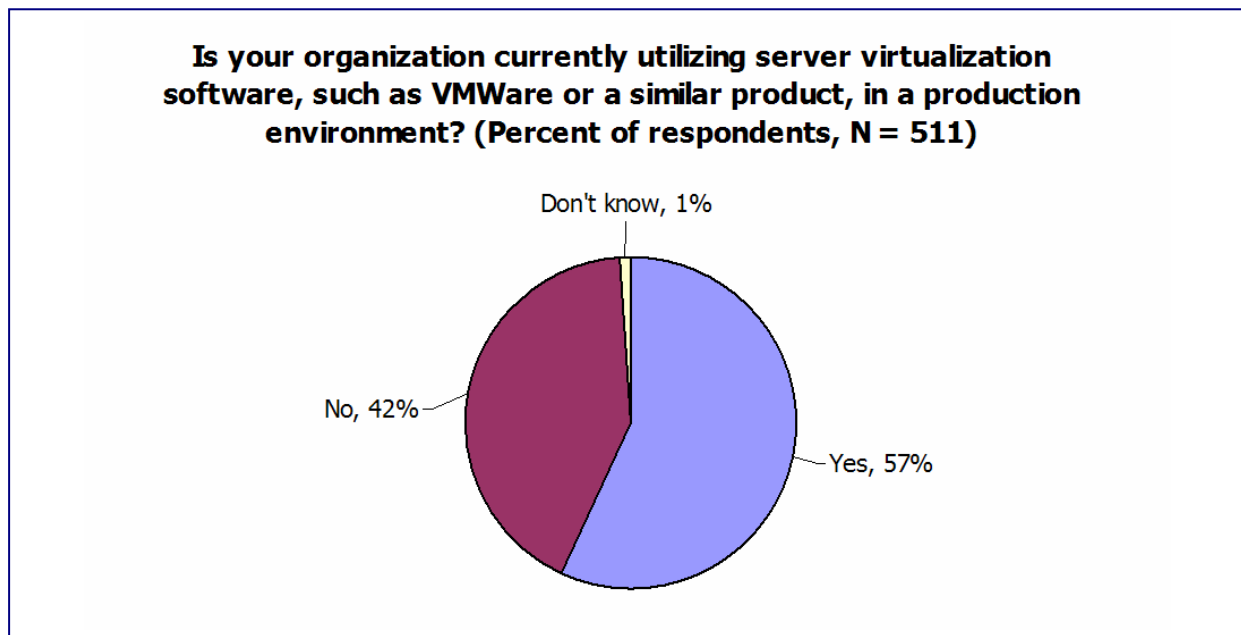
ESG believes that virtual server technology will have a profound impact on storage networking. We have already observed wide and massive adoption of virtual server technology. In addition, we are also seeing wide and growing adoption of Internet SCSI (iSCSI) as a cost effective storage networking technology that works with standard Ethernet. VMware, the leading virtual server vendor, recently added support for iSCSI. Together, we believe that the combination of VMware and iSCSI will drive a new wave of storage networking.

This ESG Lab Validation report documents the results of a hands-on evaluation of virtualized servers and iSCSI attached disk arrays from Dell using VMware Virtual Server Infrastructure version 3. Issues examined include CPU overhead, performance suitability for common business applications and the effects of running the iSCSI initiator in the guest operating system compared to the VMware virtualization layer.

Background

ESG Research indicates that 57% of organizations are utilizing server virtualization software in production environments¹. Given the impressive economic benefits of server virtualization, the glut of affordable and under-utilized processing power and growing power and cooling issues in the data center, ESG predicts that the brisk adoption of server virtualization will continue for the foreseeable future.

Figure One: Percentage of Organizations Utilizing Virtual Server Software in Production



Server virtualization benefits immensely from the use of networked storage. Compared to islands of direct attached hard drives, utilization is greatly increased when applications share a pool of networked storage. Applications deployed on virtual machines sharing a pool of storage are more mobile and available than those deployed on direct attached hard drives. Virtual machines attached to networked storage can be moved between physical servers for enhanced serviceability and flexibility.

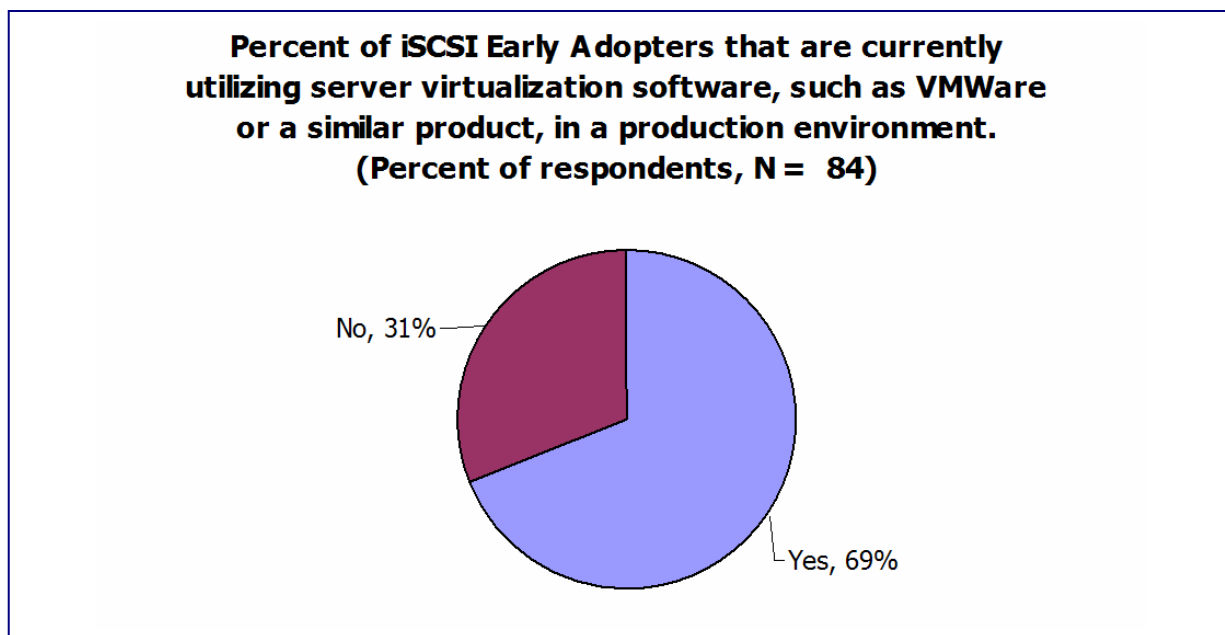
Until recently, the only networked storage option supported for virtual servers was Fibre Channel. iSCSI support was newly introduced in VMware Virtual Infrastructure 3. ESG has been tracking the adoption of iSCSI for a number of years and like server virtualization, it too has entered the early mainstream.

¹ ESG Research: *iSCSI Enter the Mainstream*, December 2006

Recently, ESG asked organizations which networked storage technologies they currently have deployed in production and found that 45% of all organizations classified as Mid Market to Small Enterprise (100 to 4,999 employees) either have deployed or plan to deploy iSCSI in the next 12 to 24 months.

ESG believes that the adoption of server virtualization will in turn drive the adoption of shared iSCSI storage. The benefits of the technologies are similar. Cost effective consolidation leads to increased utilization, availability and efficiency. As a matter of fact, ESG Research indicates that early adopters of iSCSI recognize the combined benefits of these emerging technologies as shown in Figure Two². ESG believes that the momentum will continue to build as virtual server technology drives the adoption of iSCSI.

Figure Two: Percentage iSCSI Early Adopters Utilizing Virtual Server Software in Production



Consolidating servers and storage using server virtualization and iSCSI storage has a number of benefits:

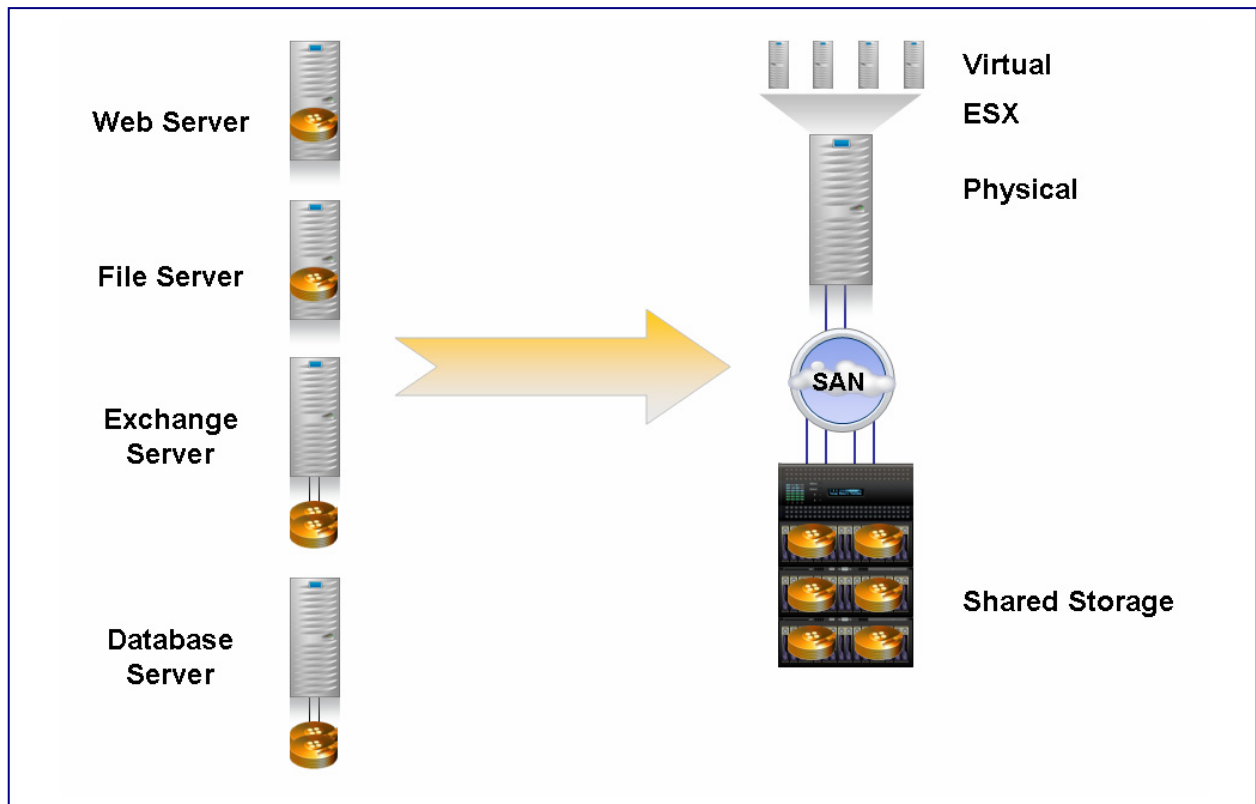
- The number of servers and direct attached hard drives is reduced
- Increased server and storage utilization reduces capital equipment costs
- Space, power and cooling requirements are reduced
- Reduced management complexity by managing many servers from a single user interface
- Virtual machine mobility and a shared pool of storage enhances availability and serviceability

In other words, IT managers can do more with less.

To better understand the value of the combination of virtual servers and iSCSI attached storage, consider the before and after diagram shown in Figure Three. Four servers running Web, File, E-mail and Database applications using internal or direct attached hard drives are consolidated onto a single physical server. VMware ESX software consolidates the four physical servers onto a single physical server. An iSCSI Storage Area Network (SAN) is used to consolidate the four “islands” of direct attached storage onto a single shared storage system.

² ESG Research: *iSCSI Enter the Mainstream*, December 2006

Figure Three: Server and Storage Consolidation



While the benefits of this approach are clear, integrating virtual servers with shared SAN attached storage can be complex. Deploying virtual server technology with traditional Fibre Channel SANs requires specialized switches, adapters and expertise. iSCSI support, new in VMware Virtual Server Infrastructure version 3, provides a cost effective alternative to Fibre Channel using industry standard Ethernet technology.

This ESG Lab Validation report presents the results of hands-on testing of server virtualization software running on servers and SAN attached storage solutions from Dell. Issues explored include the impact of iSCSI on CPU utilization, the performance suitability of iSCSI for common business application workloads and where to run a small, but vital software application: the iSCSI software initiator.

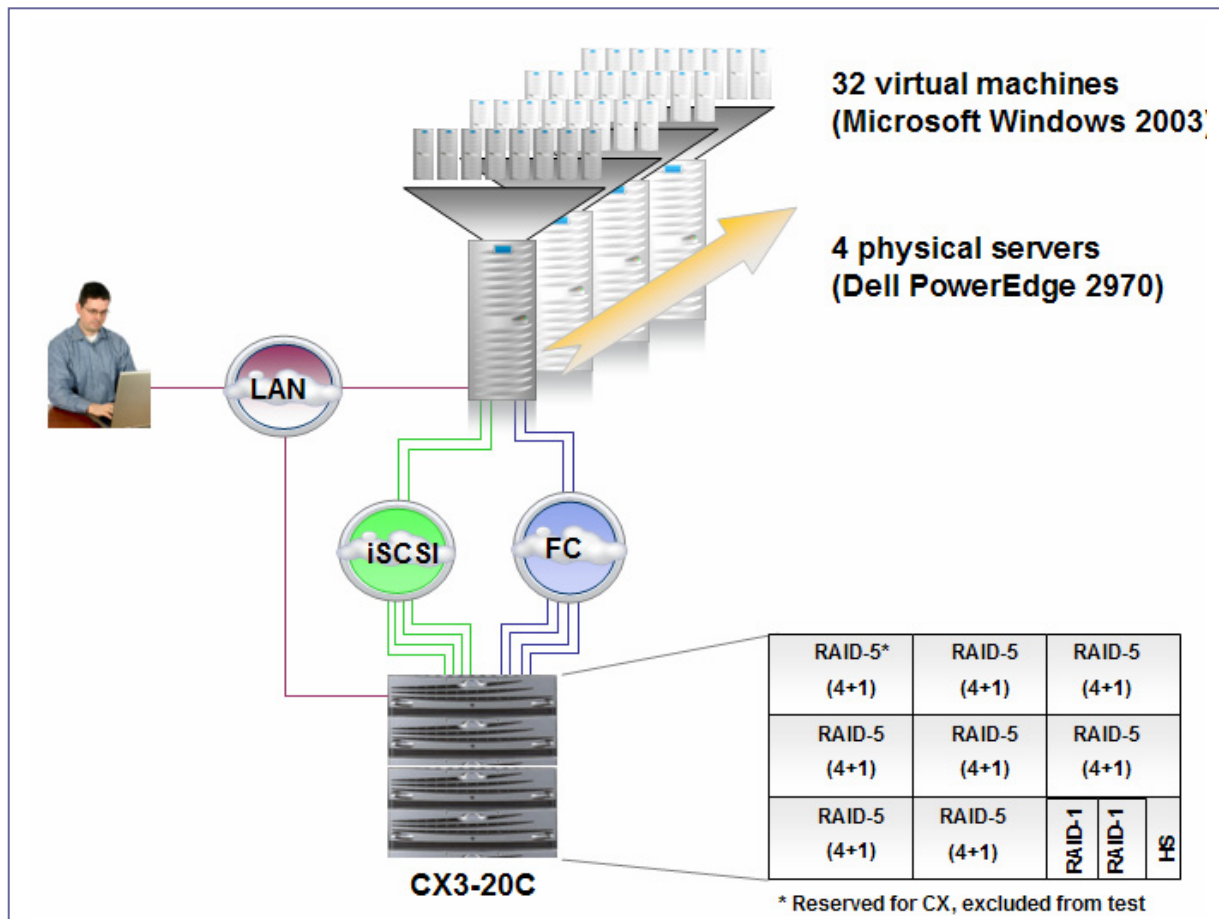
ESG Lab Validation

ESG Lab performed hands-on testing at a Dell facility in Round Rock, Texas using the virtualized environment depicted in Figure Four. This configuration was designed to evaluate the CPU utilization and performance of common business application I/O workloads.

Four Dell PowerEdge 2970 servers each hosted eight virtual machines for a total of 32 virtual machines using VMware ESX Server version 3.1. Each physical server had two CPU's and eight gigabytes of RAM. Each virtual machine was allocated 1 gigabyte of RAM and access to one CPU. CPU assignment was alternated for the virtual machines so that in the end, each physical server had four virtual machines assigned to each CPU.

The Physical servers were SAN-attached to a Dell/EMC CX3-20c storage array using a pair of 4 Gbps Fibre Channel interfaces and two Gigabit Ethernet interfaces for iSCSI. The CX3-20c had forty-five 73 GB 15k RPM Drives configured in a mixture of RAID5 and RAID1 groups as shown below.

Figure Four: The ESG Lab Test Bed

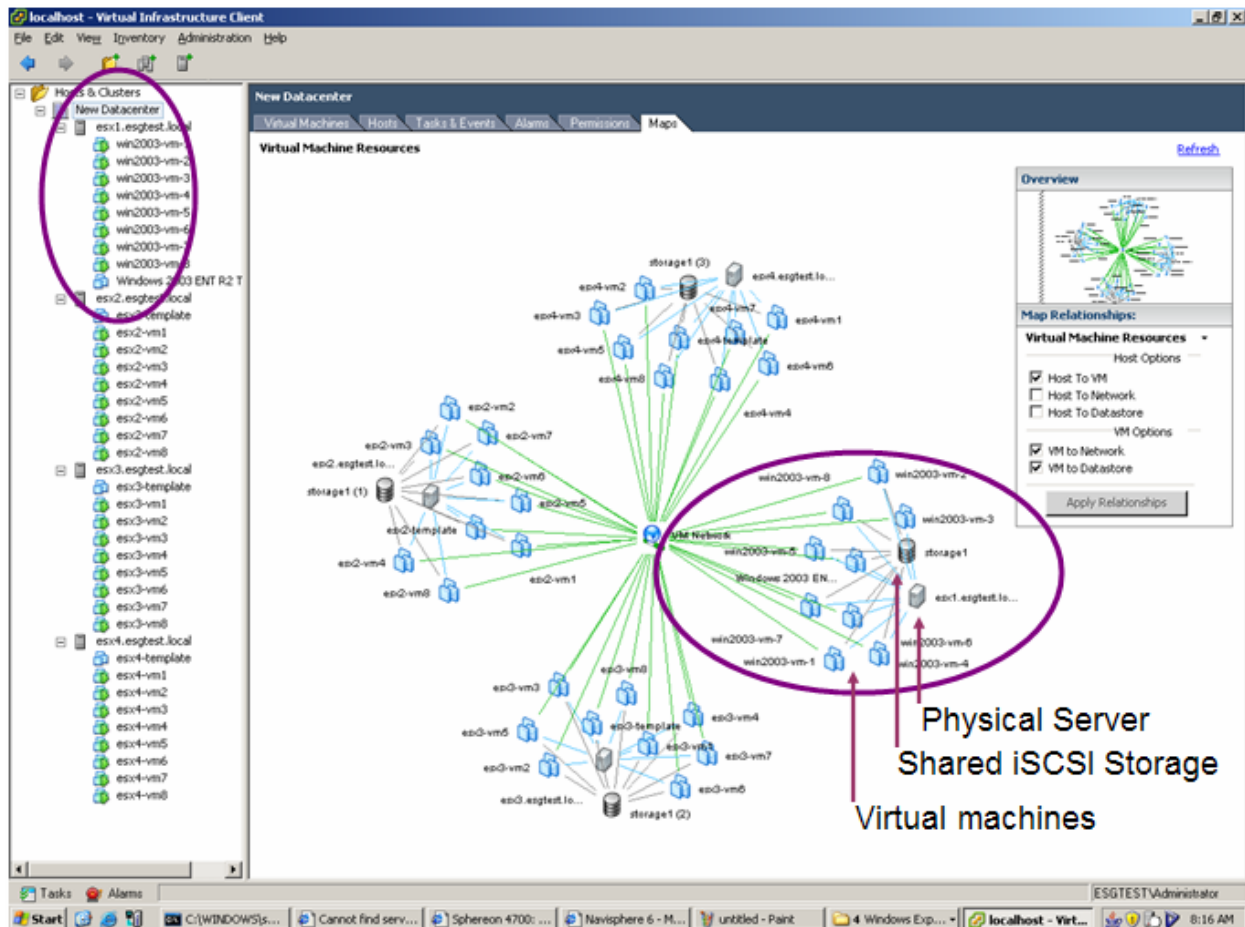


The Windows 2003 operating system and IOMETER were installed on each of the 32 virtual machines³. IOMETER is an industry standard workload generator, used to emulate the I/O workload of common business processes including database, e-mail, file server and a mix of applications.

³ Technically, Windows and IOMETER were installed only on the first machine. That machine (vm1) was then cloned to the remaining 31 machine using a VMware ESX Virtual Machine template

A virtual data center view of the test bed as depicted by the VMware ESX graphical user interface is shown in Figure Five. Each of the four physical servers and 32 virtual machines was managed using this VMware interface during the ESG Lab Validation. The highlighted region on the left shows the eight virtual machines deployed on the first of the four physical servers using the familiar look and feel of an expandable tree menu. The topology map on the right provides connectivity details including the relationship between physical and virtual servers and the connections to shared storage.

Figure Five: The ESG Lab Virtual Server Environment



Why This Matters

Consolidating Dell servers and iSCSI attached storage arrays using VMware Virtual Infrastructure software increases utilization and availability while reducing the amount of equipment that needs to be purchased, managed, powered and cooled. For example, ESG Lab used this test environment to do the work of 32 servers with just four machines and a single iSCSI attached storage array.

ESG Lab found that the VMware Virtual Infrastructure environment is extremely easy to configure and manage. System administrators managing virtual machines can log on, monitor, reboot and power cycle virtual operating systems and applications from a single “pane of glass.” From an application and end-user perspective, VMware server virtualization is totally transparent.

Where to Run the iSCSI Initiator

In this section, we compare the performance of the iSCSI initiator running in the guest operating system and the VMware ESX virtualization layer. One of the concerns here is that TCP/IP and SCSI command overhead running in software may introduce noticeable performance overhead, particularly as the number of virtual machines and software initiators running on a single physical server is increased.

Background

The iSCSI software initiator is a small, but vital piece of software that allows a server (the initiator) to communicate with a storage array (the target). An iSCSI software initiator works with a standard Ethernet connection within a server. The iSCSI software initiator can be deployed in the guest operating system as shown in Figure Six, or within the ESX layer. ESG Lab tested the iSCSI initiator running in the guest OS using the freely available Microsoft iSCSI initiator version 2.04 and the ESX-layer iSCSI initiator that comes standard with ESX.

Figure Six: iSCSI initiator running in the Guest OS

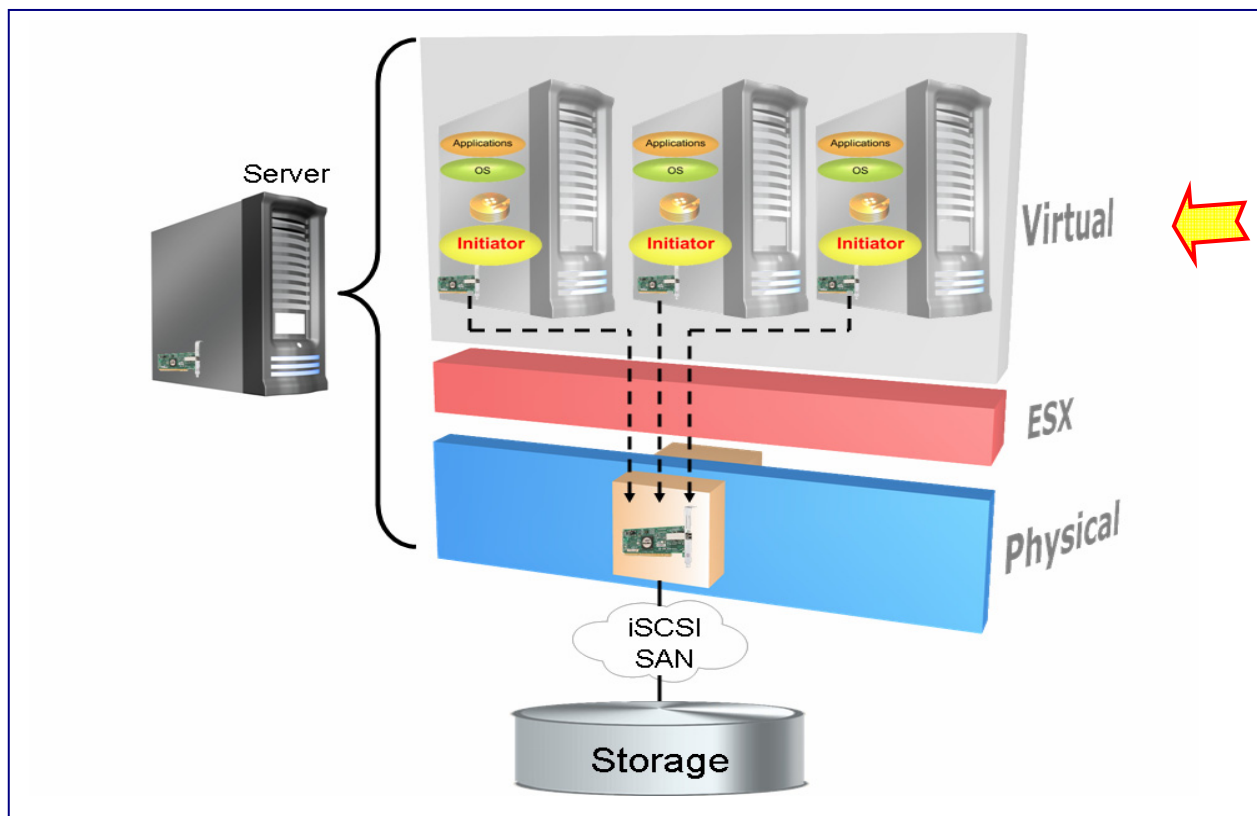
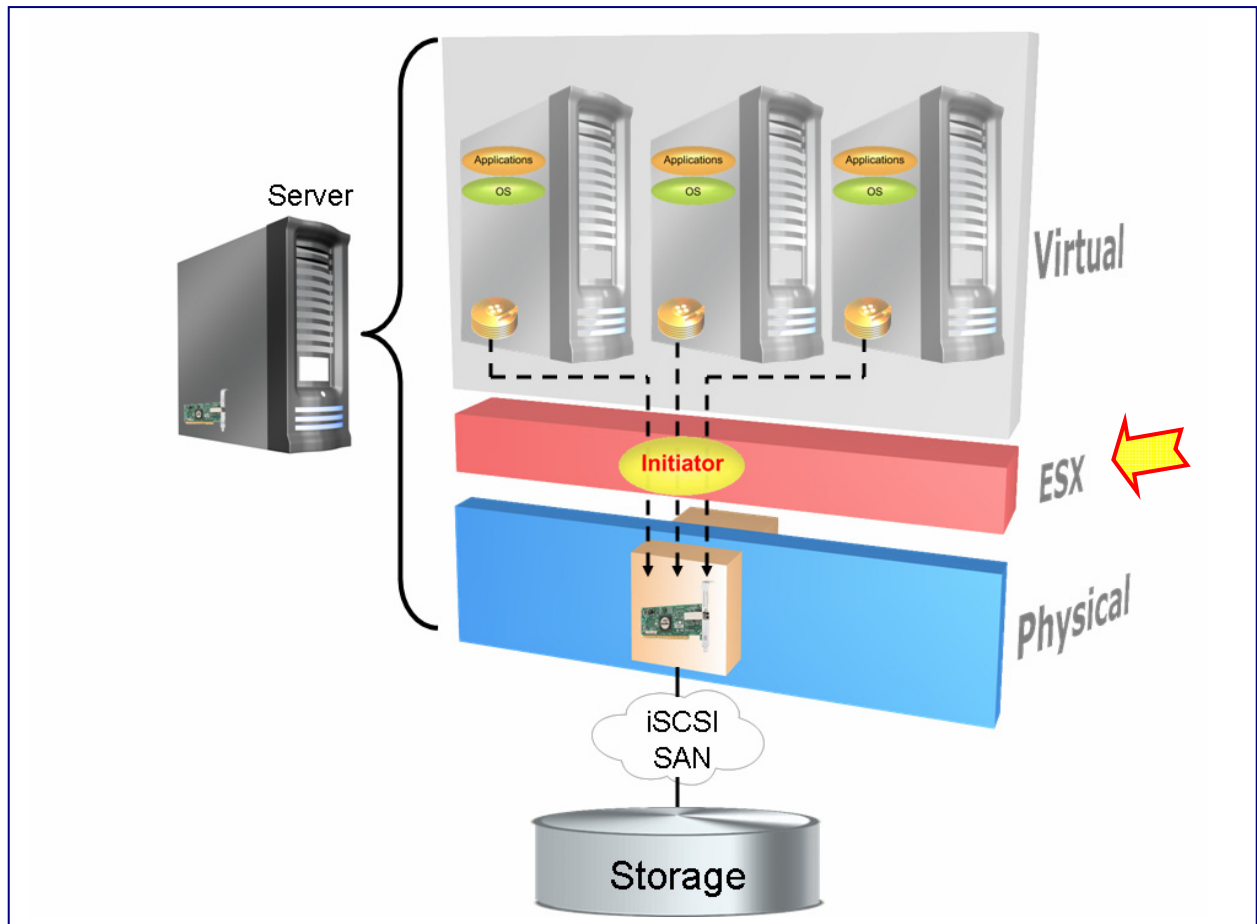


Figure Seven depicts the iSCSI software initiator running in the ESX layer as tested by ESG Lab. In this case, the ESX server presented the iSCSI storage array as locally attached devices using a method referred to as Raw Device Mapping (RDM). From the view of the Windows 2003 operating system installed within each virtual machine, the iSCSI devices appeared just like a local hard drive.

Figure Seven: iSCSI initiator running in ESX



The major difference between the two methods is defined by what ESX arbitrates. With the iSCSI initiator running in the guest OS, ESX only arbitrates network access. With iSCSI running in the ESX layer, ESX arbitrates access to the software initiator, which serves as a virtual SCSI HBA to the virtual machines.

ESG Lab Testing

ESG Lab ran IOMETER workloads across an increasing numbers of virtual machines per physical server. The following workload definitions, provided by the Dell Storage Performance Analysis (SPA) team, were used during ESG Lab testing⁴:

- **File Server** - a shared file system (e.g. a shared network drive in Microsoft Windows)
- **Database** - an interactive on-line database application (e.g. Microsoft SQL server)
- **Mail Server** - a messaging server (e.g. Microsoft Exchange)
- **Logging** - the logging device for a database or mail server (e.g. the Microsoft Exchange .LOG file)
- **Video on Demand** - multiple clients viewing video content
- **Mixed** - a mix of simulated application workloads that closely approximate real-world I/O.⁵

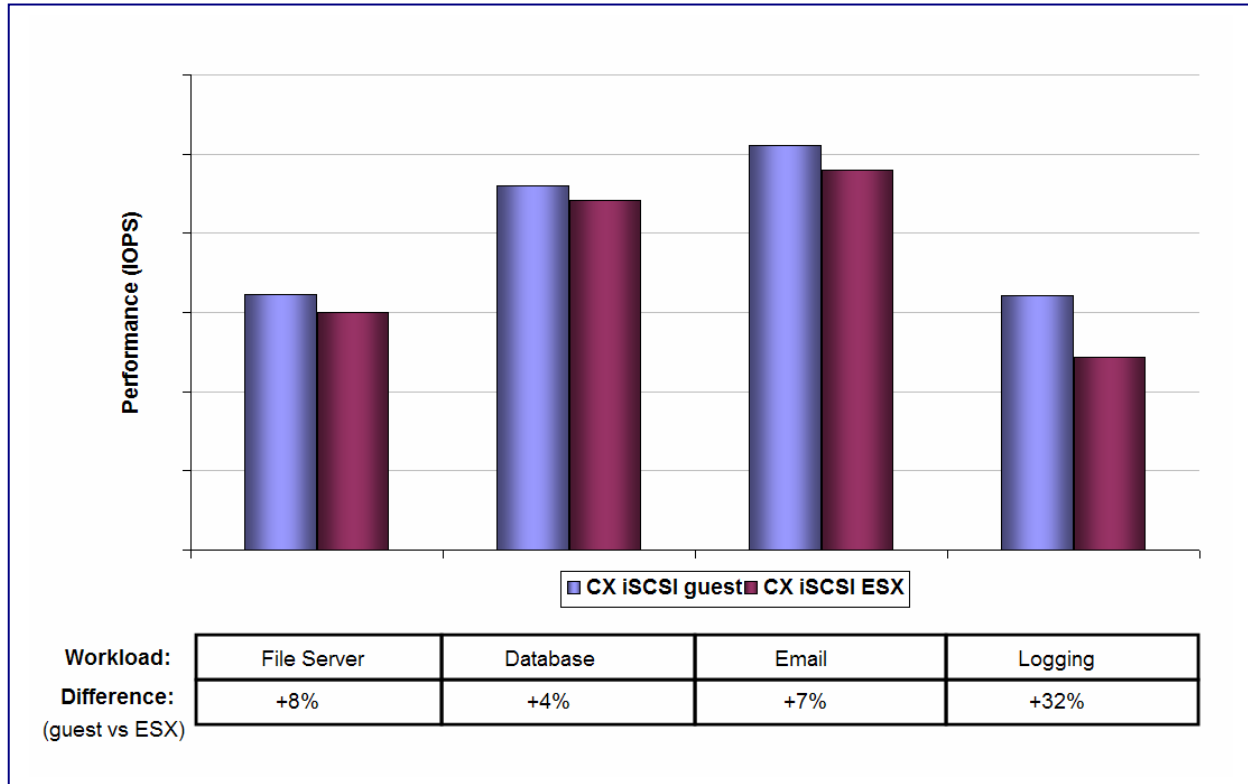
⁴ The Dell workloads listed in the Appendix yielded similar results to previously published ESG Lab IOMETER Workloads (+/- 3%). The freely available open source IOMETER utility is available at <http://www.sourceforge.net/projects/iometer>.

⁵ The E-mail and file server workloads were run against RAID-5 devices and the logging and database workloads were run against RAID-1 devices. Mixing of workloads sharing the same LUN using a weighted average was not attempted. Each of the four LUNs handled a single workload

ESG Lab Testing

ESG Lab ran IOMETER workloads across an increasing numbers of virtual machines per physical server. The same four servers and storage system were used for each of these tests. The only change was the location of the iSCSI initiator. The results for a single virtual machine running on each of the four physical servers are shown in Figure Eight.

Figure Eight: iSCSI Guest vs. ESX, One Virtual Machine per Server

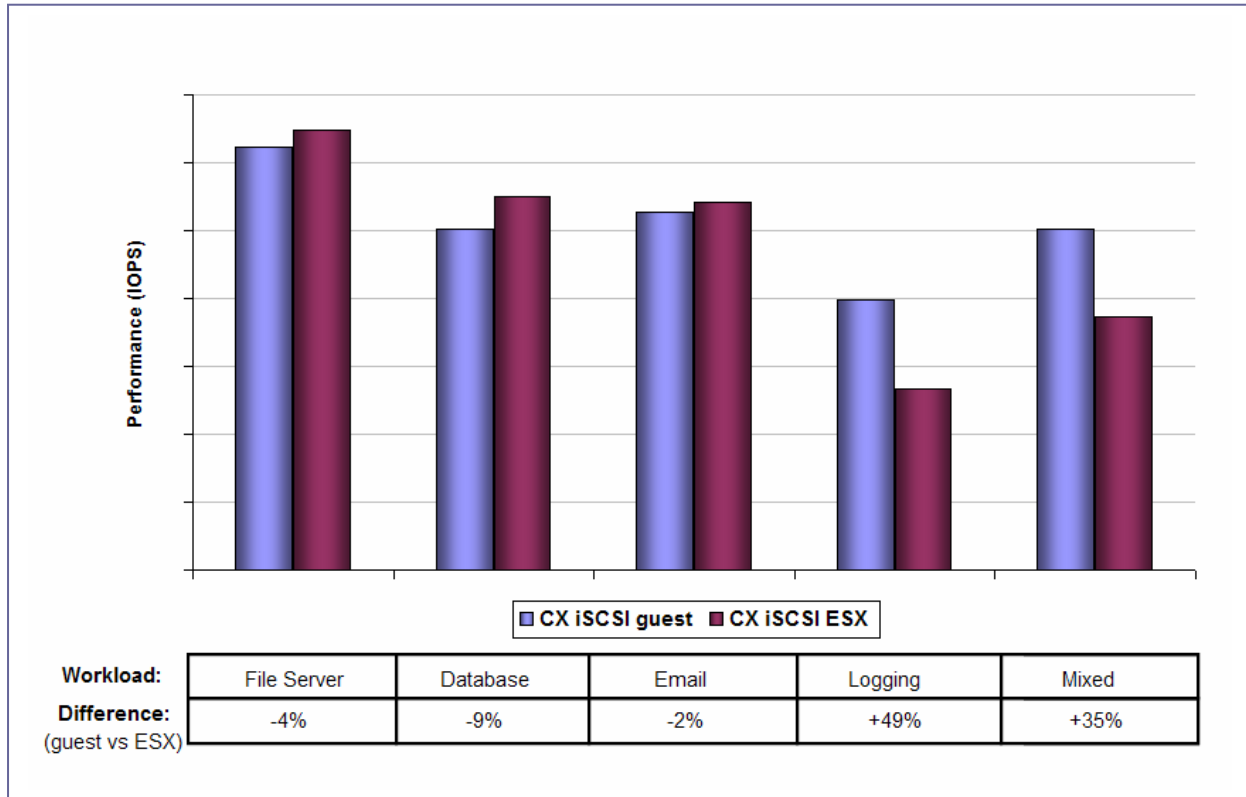


What the Numbers Mean

- Absolute performance results have been omitted to focus on the relative difference between iSCSI configuration options while avoiding an out-of-context comparison with different storage system and server configurations.
- iSCSI running in the guest O/S is between 4% and 8% faster than iSCSI ESX for mostly random File Server, Database and E-mail workloads.
- iSCSI running in the guest O/S is 32% faster for the write-intensive sequential logging workload.
- In general, for one virtual machine running in one physical server, the iSCSI initiator running the Guest O/S performs slightly better.

Next, ESG Lab examined what happens when the number of virtual machine is increased. Figure Nine shows the results as 32 virtual machines ran within four physical servers.

Figure Nine: iSCSI Guest vs. ESX, Eight Virtual Machines per Server

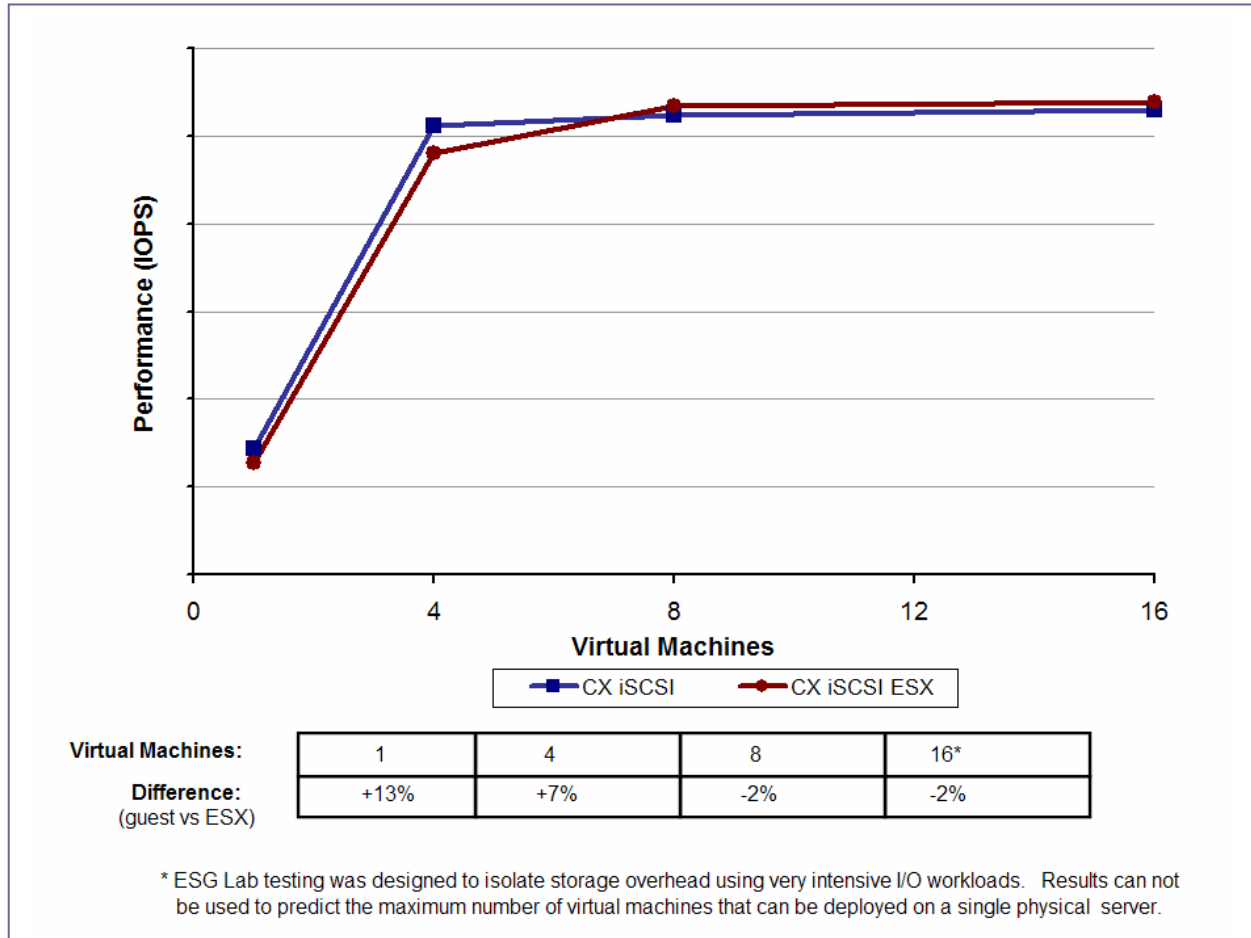


What the Numbers Mean

- The ESX iSCSI initiator is between 2 and 9% faster than guest O/S for mostly random business workloads.
- As in the single virtual machine test, iSCSI running in the guest O/S performs better during the logging workload (49% faster).
- When running a mixed workload likely to be found in many environments (Database, E-mail, File Serving and Logging), iSCSI in the guest O/S performed better (35% faster).
- While the results are varied, the mixed workload results indicate that the guest O/S method is currently the better choice for a mix of many application workloads running on the same server—particularly when one or more of the applications has peaks of activity that may be sensitive to logging performance.

Figure Ten depicts the difference in performance between iSCSI running in the guest O/S and ESX as the number of virtual machines scales from one to 16.

Figure Ten: CX iSCSI Guest vs. ESX, E-mail Database Workload



What the Numbers Mean

- The guest operating system option performs faster at first (+13% faster for a single VM), and then slightly slower as the number of virtual machines per physical server is increased (-2%).
- Beyond 8 total virtual machines (2 per physical server), performance hit a plateau with ESX retaining a very small advantage. This plateau is likely due to reaching the limits of the disk array configuration tested.
- The difference in performance between the two options is relatively insignificant for a workload simulating thousands of heavy Microsoft Exchange e-mail users.

There are number of issues to be considered besides CPU utilization and performance when determining where to implement the iSCSI software initiator in a VMware enabled virtual server environment:

- **The maturity of the driver stack.** The Microsoft software initiator has been generally available since 2003 and the iSCSI driver running within VMware ESX was introduced recently in Virtual Infrastructure 3.0.
- **How well it works with array based services** (e.g. VSS enabled snapshots and remote replication). The guest O/S method requires no changes. The ESX method requires changes if you are not using raw device mapping.
- **How easy it is to migrate to and from physical servers and virtual machines.** The guest O/S method is easier because it introduces less change when moving from physical to virtual.
- **Multi-path support.** The Microsoft MPIO guest O/S initiator supports active/active load balancing and failover. As of the writing of this report, the ESX initiator supports only active/passive failover.
- **Non-disruptive volume removal.** This is a seldom performed procedure in most production environments, but ESG Lab noticed that a virtual machine must be rebooted to remove a volume using the ESX method. This reboot is not required for the guest O/S method.
- **The number of iSCSI initiators to install and manage.** With the ESX method, there is only one driver to install and configure. With the guest O/S method, the driver needs to be installed and configured on each virtual machine. This is generally done only once during initial configuration and can be simplified with the use of VMware clone images for standardized software initiator distribution and the centralized VMware console to perform one-time iSCSI log on and configuration.
- **Both methods eliminate the cost and complexity of Fibre Channel.**
- **Both methods can be used to leverage the mobility and high availability capabilities of VMware.**
- There are a number of references published by Dell to assist with this decision, including the following PowerSolutions article: <http://www.dell.com/downloads/global/power/ps3q07-20070401-Baker.pdf>
- Given that the performance and CPU utilization of iSCSI is adequate for your application, iSCSI is a better choice than Fibre Channel as it is more flexible, easier to implement and lower cost.

Why This Matters

There are two options for deploying a cost-effective software-based iSCSI initiator in VMware Virtual Infrastructure environments. ESG Lab testing, which indicates that neither option has a clear performance advantage, suggests that the choice should be made based on factors besides performance. ESG Lab currently recommends the use of the iSCSI initiator in the guest operating system for a number of reasons—including the trusted maturity and active/active load balancing of the Microsoft MPIO driver as well as the transparent preservation of existing array-based copy and replication services.

CPU Utilization

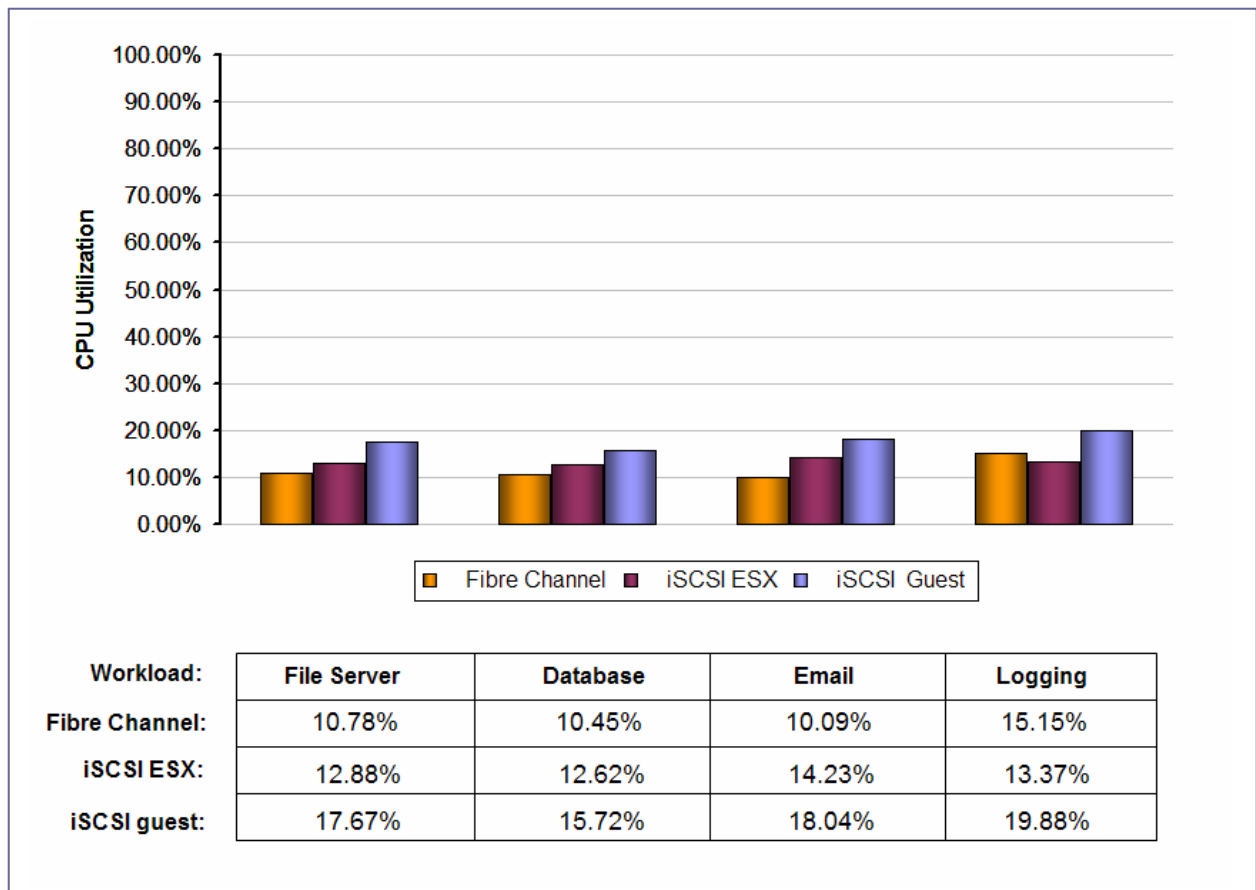
Understanding the CPU requirements of applications and storage systems is a vital consideration when planning the deployment of virtual machines in the data center. Too many CPU intensive applications deployed on a single server will impact performance. Similarly, if a storage system requires too much CPU, it can starve applications and impact performance. In this report, we focus on the CPU utilization of the storage system—specifically the CPU impact of iSCSI.

Over the years, there has been a lot of confusion regarding the CPU impact of iSCSI. Because iSCSI utilizes the TCP/IP stack on the server, there is a concern that TCP/IP processing will consume too much CPU. ESG Lab has tested a number of iSCSI storage systems over the past four years and has found that CPU utilization on modern servers is manageably low (less than 15%) for common business applications. While specialized TCP/IP offload Engines (TOE) engines and iSCSI host bus adapters are available for use in environments with little CPU to spare, ESG Research⁶ indicates that the vast majority of early iSCSI adopters are using industry standard Ethernet adapters within servers and that CPU utilization is not an issue.

ESG Lab Testing

CPU utilization was monitored using ESX and compared to the CPU utilization reported by IOMETER. The results for one physical server with eight active virtual machines are presented in Figure Eleven.

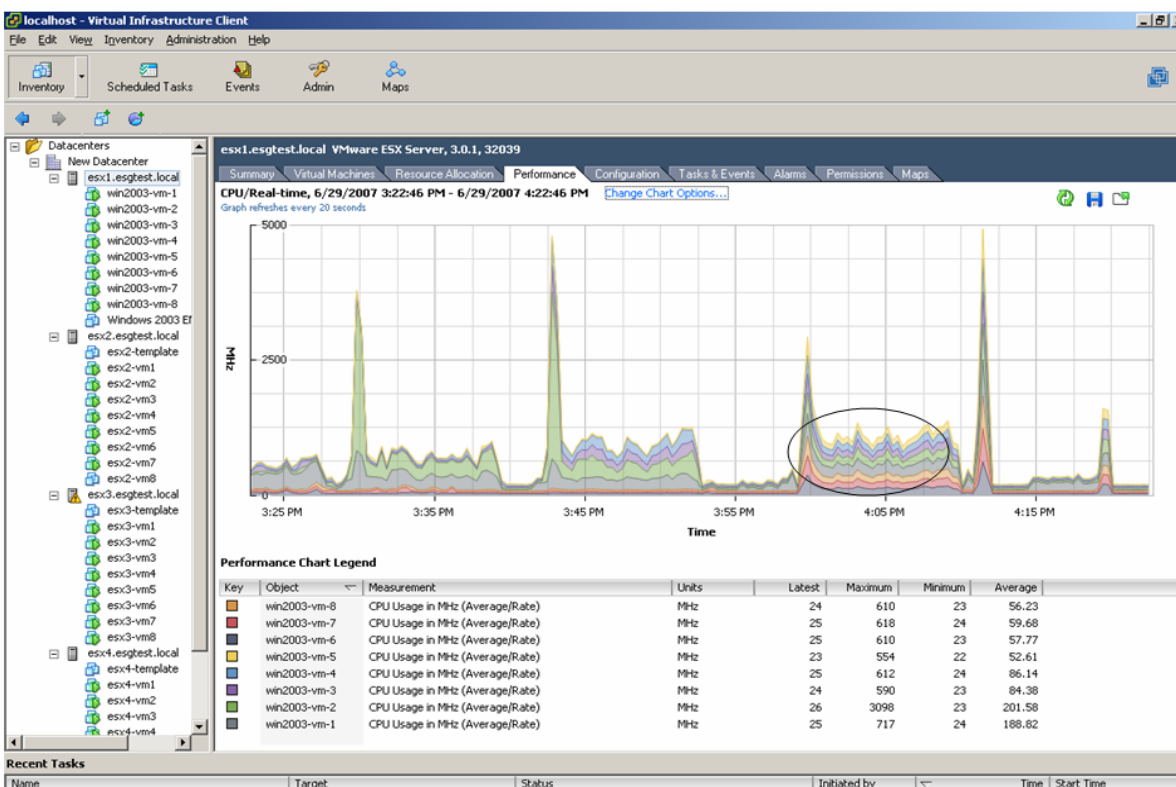
Figure Eleven: CPU Utilization of Eight Virtual Machines on One Physical Server



⁶ ESG Research: *iSCSI Enter the Mainstream*, December 2006

An ESX view of CPU utilization for the iSCSI guest configuration is shown in Figure Twelve. This view shows CPU utilization for one physical server as performance characterization tests ran on one, two, four and then eight virtual machines. The highlighted section shows CPU utilization for common business workloads running on eight virtual machines hovering around 18%. The peaks above 18% were observed during an engineering-level stress test (e.g. one block sequential operations out of cache).

Figure Twelve: An ESX View of CPU Utilization (iSCSI Guest)



What the numbers mean

- There is only a minor difference in CPU utilization between the guest O/S method—which performs TCP/IP and SCSI processing in each VM—and the ESX method, which does it all in one stack.
- In general, the Fibre Channel method has lower CPU utilization than iSCSI.
- Regardless of the method chosen, the CPU utilization attributable to SAN attached storage ranges from manageably low to moderate (10-20%) for common business workloads.
- Modern CPUs and the stateless TCP/IP acceleration built into Dell GigE NICs do a good job at reducing the TCP/IP overhead when running common business workloads over iSCSI from virtual machines.

Why This Matters

As organizations consolidate multiple applications on fewer physical servers, contention for resources becomes a key concern. Users have expressed concern to ESG that iSCSI, living higher in the protocol stack than Fibre Channel, will consume excessive CPU resources in highly virtualized environments. ESG Lab found that while Fibre Channel has a mild advantage, iSCSI running on Dell PowerEdge 2970 servers does not consume significantly more CPU than Fibre Channel. CPU utilization is only one of many factors to be considered when choosing between Fibre Channel and iSCSI or deciding where to run the iSCSI initiator. With proper planning and monitoring as virtual deployments grow in size and complexity, ESG is confident that the CPU utilization attributed to iSCSI leaves room for applications to run comfortably.

iSCSI vs. Fibre Channel

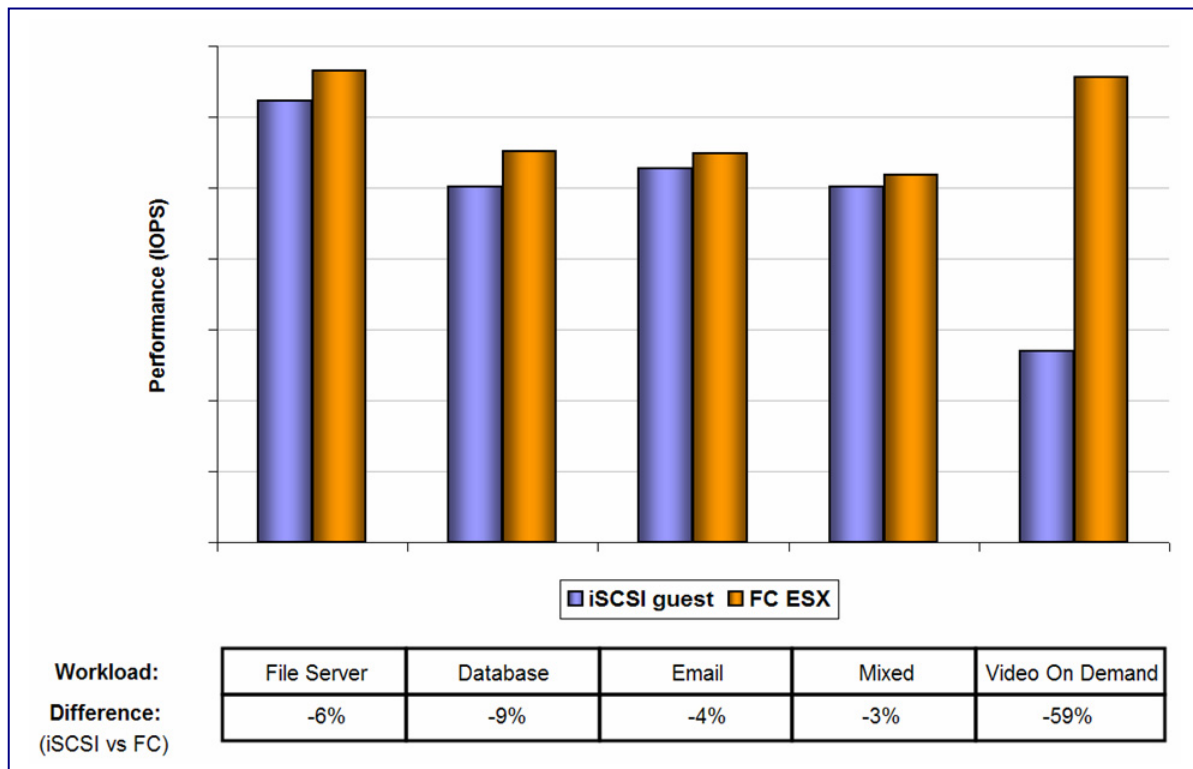
There has been a lot of confusion regarding iSCSI performance over the years. The concerns include the overhead of TCP/IP and SCSI processing as well as the difference in bandwidth between Fibre Channel and iSCSI. The bandwidth issue in particular has caused the most confusion. Fibre Channel running over a 4 Gbps interface has four times the bandwidth of iSCSI running over a gigabit Ethernet interface. While this difference matters for bandwidth intensive sequential workloads like video editing, more bandwidth doesn't necessarily translate into significantly faster performance for common business application workloads that are mostly random in nature.

ESG Lab Testing

ESG Lab ran IOMETER workloads on virtual machines accessing shared storage over an iSCSI and Fibre Channel SAN. The only parameter changed was the connectivity to the disk array. The same four servers and disk array were used for all tests. The relative performance between iSCSI and Fibre Channel with 32 virtual machines running on four physical servers is shown in Figure Thirteen.

Note that the absolute performance results have been omitted to focus on the relative difference between iSCSI and Fibre Channel while avoiding an out-of-context comparison with different storage system and server configurations.

Figure Thirteen: iSCSI Guest vs. Fibre Channel



What the Numbers Mean

- FC is slightly faster for mostly random business workloads (3-9%), which would not be noticeable to users or applications.
- For a mix of common business workloads including bandwidth intensive sequential write logging, iSCSI performance is just 3% less than that of Fibre Channel.
- This validates that for non-bandwidth intensive workloads, there is no real performance difference between iSCSI and FC in a VMware environment.
- As expected, FC was significantly faster than iSCSI for bandwidth intensive workloads due to the 4X bandwidth difference between 4 Gb FC and 1 Gb Ethernet.
- Assuming that the performance and CPU utilization of iSCSI is adequate for your application, iSCSI is a better choice than Fibre Channel as it is more flexible, easier to implement and lower cost.

Why This Matters

Achieving the full benefits of server virtualization requires networked (SAN) storage. Before iSCSI, this meant Fibre Channel. iSCSI support, new in VMware Virtual Infrastructure 3, provides a cost effective alternative to Fibre Channel that is well suited to virtualized server environments.

ESG Lab has performed many performance tests and analyses of iSCSI disk arrays and has repeatedly proved that iSCSI is an efficient protocol that performs close to FC for common business applications. Recent testing by ESG Lab indicates that the conclusions are the same in a VMware enabled virtual server environment. When used as directed for common business applications, iSCSI attached storage arrays from Dell provide excellent performance that differs marginally from Fibre Channel.

ESG Lab Validation Highlights

- ☑ VMware ESX version 3.1 provided an excellent and intuitive user interface for the configuration and management for 32 virtual machines running on four physical servers.
- ☑ CPU utilization in virtualized iSCSI environments was manageably low (less than 20%) for common business applications workloads running on up to eight virtual machines.
- ☑ The performance of virtualized iSCSI was comparable to Fibre Channel (3 to 9%) for common business workloads and negligible for mixed workloads (3%).
- ☑ The iSCSI initiator running in the guest O/S generally performed slightly better on a single virtual machine and ESX generally did slightly better as the number of virtual machines was scaled to eight. For logging and mixed workloads, the iSCSI guest option performed better (49% and 35% respectively).

Issues to Consider

- ☑ The ESX iSCSI initiator required a reboot to remove an iSCSI volume from a virtual machine. This is not required by the guest O/S initiator and should be addressed in a future release of ESX.
- ☑ The ESX iSCSI initiator does not yet support active-active load balancing for iSCSI. As tested for this report, there was no significant performance penalty, but when scaling up to more powerful server and storage configurations, this may become an issue.
- ☑ While configuring iSCSI storage systems from Dell removes the cost and complexity of Fibre Channel switches and host bus adapters, it's still complex. Configuring a Dell disk array for iSCSI requires a level of storage and networking expertise that may be beyond the capabilities of system administrators accustomed to managing internal hard drives within servers. Customers new to iSCSI are encouraged to consider planning, training and installation services from Dell. Dell is encouraged to continue its efforts in streamlining iSCSI installation procedures and enhancing self-guided wizards.
- ☑ When choosing between FC and iSCSI in a VMware ESX environment, there is a subtle visibility and control issue that was not examined in this report, but should be considered. Fibre Channel SANs deployed to date in environments supporting VMotion require each of the physical servers to have access to the same storage LUN. This allows VMotion to provide transparent migration and failover of virtual machines.. This can raise concerns about data integrity due to administrator misconfiguration. A new Fibre Channel standard called NPIV has recently emerged to address this issue and will be supported in a future release of ESX. iSCSI does not have this problem.
- ☑ The results presented in this report should not be used to project CPU utilization with real-world applications (e.g. Microsoft Exchange) or as a guideline for the number and type of applications that can be consolidated on a single server. The CPU utilization reported here is attributed entirely to I/O operations. In the real-world, applications consume CPU at a variety of levels aside from the storage stack. Besides the I/O CPU utilization issue, IT managers are encouraged to assess the current and projected CPU utilization of existing applications when planning for VMware consolidation.

ESG Lab's View

ESG Lab felt it was important to focus on iSCSI with VMware because we are seeing growing market interest in these two technologies working together. We feel that iSCSI performance is on par with FC in all use cases—with the exception of bandwidth intensive workloads. This is not a concern because most SAN infrastructures never come close to saturating their network bandwidth. Last year, an ESG Research Report on iSCSI revealed that end-users never exceeded 10% bandwidth utilization. Additionally, end-users can aggregate 1 Gb Ethernet connections to increase bandwidth in the extreme case, if necessary. Microsoft also provides native capabilities for Windows. Over time, this issue will be off the table as 10 Gb Ethernet becomes pervasive. ESG Lab—based on this analysis and other testing we have done—states with confidence that we feel iSCSI performance within a VMware environment is excellent. However, since performance is based on a number of variables, it is important to consider each of the factors in your environment that may have an effect on application performance. Rest assured that the iSCSI protocol itself is more than up to the task.

Another top concern for many end-users is CPU utilization and storage resource contention when considering VMware and iSCSI. As more servers are consolidated onto a single physical server using virtual machines, there will be greater demand placed on the processor(s) within that server. ESG testing confirmed that CPU utilization in virtualized iSCSI environments running on servers and storage from Dell is low to moderate—ranging between 8-20%—in our testing with eight virtual machines. While CPU utilization was not an issue during ESG Lab testing, end-users should monitor CPU utilization to consider whether using a Fibre Channel array will enable the consolidation of more applications and users as their VMware and iSCSI environments grow.

As an industry, we are just at the beginning of our analysis and development of best practices concerning the integration of virtual machines and storage. We are learning more every day about this especially important topic. Where to run the iSCSI software initiator is an example. While a centralized approach within ESX may make sense in years to come, ESG recommends that the best bet is the guest operating system option for the time being. This leverages the maturity and active/active load balancing of the Microsoft MPIO driver and preserves existing array-based snapshot and replication procedures.

ESG has confirmed that cost efficient iSCSI disk arrays from Dell enhance the virtual machine mobility of VMware Virtual Infrastructure. If you're looking at server and storage consolidation to optimize your infrastructure and save money, ESG recommends that you consider the power of VMware Virtual Infrastructure and cost effective iSCSI attached disk arrays from Dell.

Appendix

ESG Lab Configuration Details

Storage Configuration	
Dell/EMC CX3-20	Flare rev: 3.24.020.5.011 w/ 1 Disk Processor Enclosure and & (2) Disk Array Enclosures, 45 15K RPM FC drives
RAID Configuration	7 Raid 5 groups w/ 5 Drives Each, 2 Raid 1 groups w/ 2 Drives Each, One hot spare.
Server Configuration	
Physical Servers	(4) Dell PowerEdge 2970 with Dual 2.8 GHz dual core AMD processors, 8GB RAM, dual Broadcom 5708 GigE NICs.
VMWare ESX Server	Version 3.0.1
Virtual Machines	8 VM's per physical Server (32 total) each configured with 1GB of RAM and assigned to alternating CPU's
Microsoft iSCSI Software Initiator	2.04
Network Configuration	
Fibre Channel	(1) McData 4700 4Gb FC Switch
Gigabit Ethernet	(2) Dell Power Connect 6224 GigE Switches
IOMETER Workload Characterizations	
IOMETER Workload Generator Software	2006.07.27
File Server workload	8KB IO, 90% Read, 75% Random
OLTP Workload	8KB IO, 67% Read, 100% Random
Exchange Database workload	4KB IO, 67% Read, 100% Random
Log workload	64KB IO, 100% Write, 100% Sequential
Video on Demand	512 KB IO, 100% Read, 100% Sequential
Mixed workload (Run across 32 VM's)	16 Workers running File Server and Exchange DB workloads against RAID5 protected LUNs; 16 Workers running sequential Log workloads against RAID1 protected LUNs.