LAB VALIDATION REPORT

3PAR 3cV
Virtual Utility Computing

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November, 2008

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ESG Lab Reports

The goal of ESG Lab reports is to educate IT professionals about emerging technologies and products in the storage, data management and information security industries. ESG Lab reports are not meant to replace the evaluation process that should be conducted before making purchasing decisions, but rather to provide insight into these emerging technologies. Our objective is to go over some of the more valuable feature/functions of 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 ESG Lab report was sponsored by 3PAR.

Introduction

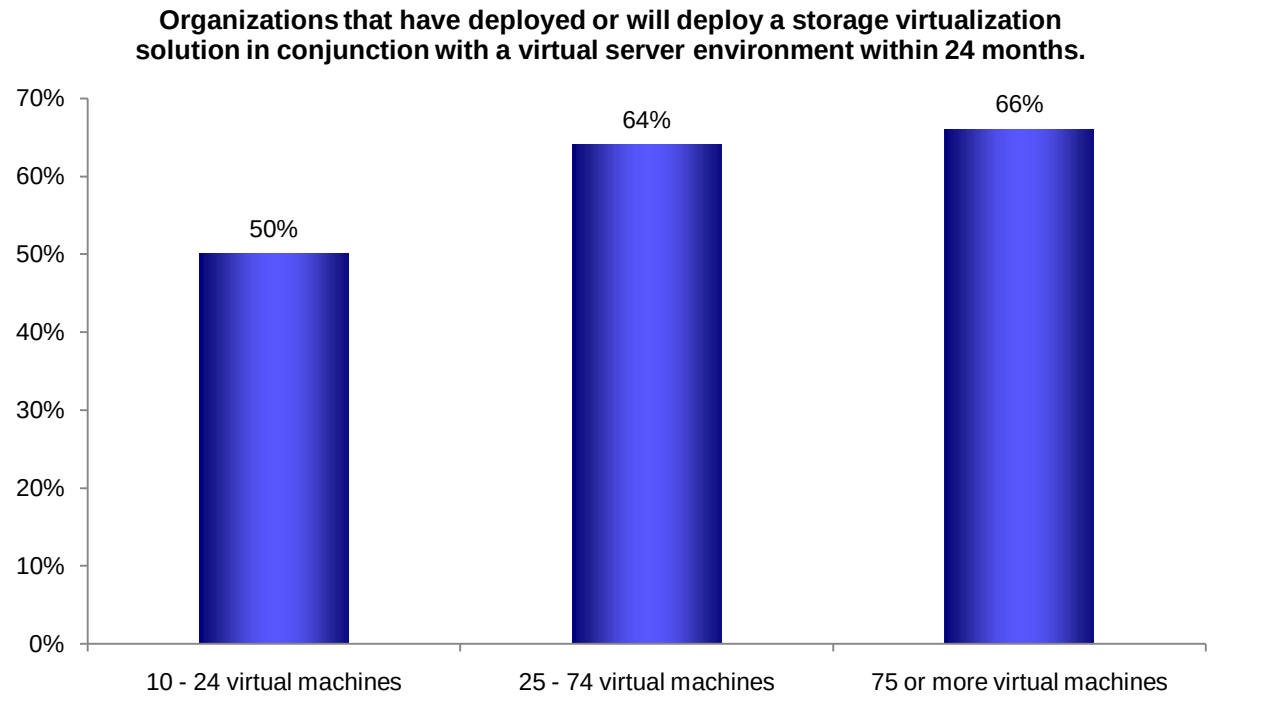
In the real world, IT must combine hardware, software, and technologies from multiple vendors to solve business problems—often with great effort and mixed success. First coined by a mutual customer, 3cV is the combination of 3PAR Utility Storage with HP BladeSystem c-Class servers and VMware Infrastructure. The partnership aims to simplify the implementation and integration of these three products into a single IT infrastructure. ESG Lab examined 3cV and evaluated its suitability as a blueprint for utility computing in today's complex and dynamic IT environments.

Background

Increased demands on IT, coupled with the traditional dedication of physical computing and storage resources, have driven server and storage costs up and led to datacenter sprawl, time-sensitive provisioning, and complex change management. IT managers trying to solve this dilemma have begun to see the benefits of combining server and storage virtualization platforms as the promise of virtualization is its ability to mask the physical complexities of the IT environment from administrators and end-users while reducing IT costs and optimizing efficiency as virtualization proliferates. Server virtualization adopters surveyed by ESG have certainly recognized this opportunity.

ESG research indicates that among organizations—of all sizes—with server virtualization deployments, more than half report that they have deployed or plan to deploy a storage virtualization solution in conjunction with their virtual server environment, as seen in Figure 1.[1] Compared to islands of direct-attached hard drives or non-virtualized SAN storage, utilization is greatly increased when applications share a pool of virtualized storage. Applications are more mobile and available than those deployed on direct-attached hard drives as well.

FIGURE 1. COMBINING SERVER AND STORAGE VIRTUALIZATION



[1] Source: ESG Research Report, *The Impact of Server Virtualization on Storage,* December 2007

The combined use of server and storage virtualization also makes sense from a technology perspective. The primary benefits of server virtualization in the eyes of most users include lower costs, improved resource utilization, and increased availability—all of which are fundamentally enabled by decoupling servers, applications, and data from specific physical assets. Storage virtualization takes those very same benefits and extends them to the underlying storage domain. With no single point of failure at a disk system level capable of bringing down many virtual machines at once, storage virtualization adds yet another layer of protection against failures—extending full hardware independence from the server domain to the storage domain.

The 3cV Blueprint

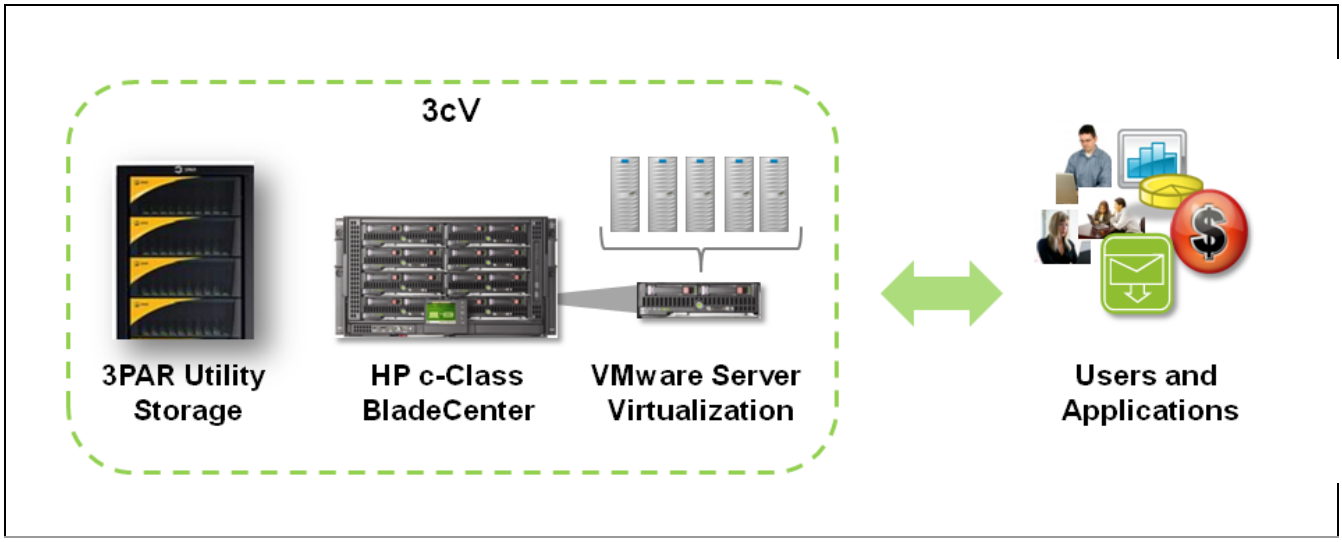
3cV promises to be greater than the sum of its parts, enabling customers to manage and scale their server, storage, and application environments simply and efficiently—lowering acquisition and operational costs while reducing environmental impact, energy consumption, and footprint in the datacenter.

To put the promises of 3cV into perspective, consider ESG's vision for the data center of the future: the datacenter itself becomes a virtual server with a collection of processor and memory systems connected though a storage network to a pool of virtualized storage capacity. The data center of the future reacts to the needs of the business as it controls the flow of electrons to perform tactical operations. As operations complete, resources are automatically released intro their respective pools to meet the next round of business challenges.

While ESG's vision for the data center of the future may seem a bit far off, it's actually closer than you may think. Fundamentally, the ideas are the same whether discussed in the context of a PC, where all the components are enclosed within a small box; or the data center, where all the components are contained within four larger walls (and theoretically, beyond those walls). Users connect to IT infrastructure via an application interface. The only thing users care about is the data required to perform their respective jobs. Everything in between is the IT infrastructure that can and should evolve over time. Years ago, that infrastructure was the mainframe. Then it evolved towards client/server and networked storage topologies. More recently, it has moved towards virtualized servers connected to virtual networks attached to a virtual pool of storage. Today, IT infrastructure is bounded by historical thinking more than anything else. With bounded configurations, we have limited possibilities. When we lift the boundaries of IT infrastructure, then magic can happen.

The magic of the 3cV infrastructure is shown in Figure 2. End-users interact with applications running within virtualized IT infrastructure composed of 3PAR utility storage, HP C-class servers, and VMware server virtualization software.

FIGURE 2. ELEMENTS OF 3CV



Reading from left to right, the elements in a 3cV infrastructure are:

- **The 3PAR InServ Storage Server** – A highly virtualized tiered-storage array built for utility computing. A 3PAR storage server is a utility-class storage system that is extremely easy to manage as it provides cost-effective scalability and reduces the cost of capacity, power, cooling, and space.

- **The HP BladeSystem c-Class** – A blade server infrastructure for data centers of all sizes. HP BladeSystem c-Class minimizes energy, cooling, and space requirements by consolidating powerful physical servers into a dense chassis, while simplifying administration through IO virtualization.

- **VMware Infrastructure** – An infrastructure virtualization suite for industry-standard servers. VMware Infrastructure hosts operating systems and enables efficiency and availability with dynamic server management, movement, availability, and automation capabilities.

This report examines how the combination of these technologies can simplify management, reduce the cost and effort of server and storage administration, and enable new applications and resources to be provisioned on demand and optimized on the fly—all while reducing power, space, and cooling requirements in the data center. Put simply, 3cV enables IT organizations to do more with less.

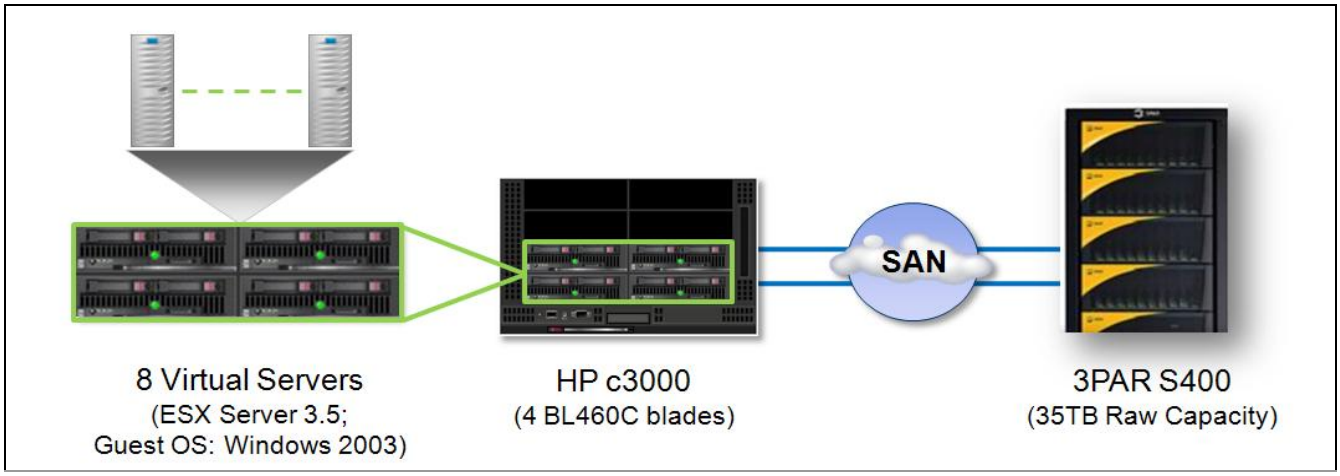
ESG Lab Validation

ESG Lab performed hands-on evaluation and testing of 3cV at 3PAR's facilities in Fremont, California. Testing was designed to validate 3PAR's claims that a 3cV-enabled IT infrastructure is simple, agile, and efficient.

Getting Started

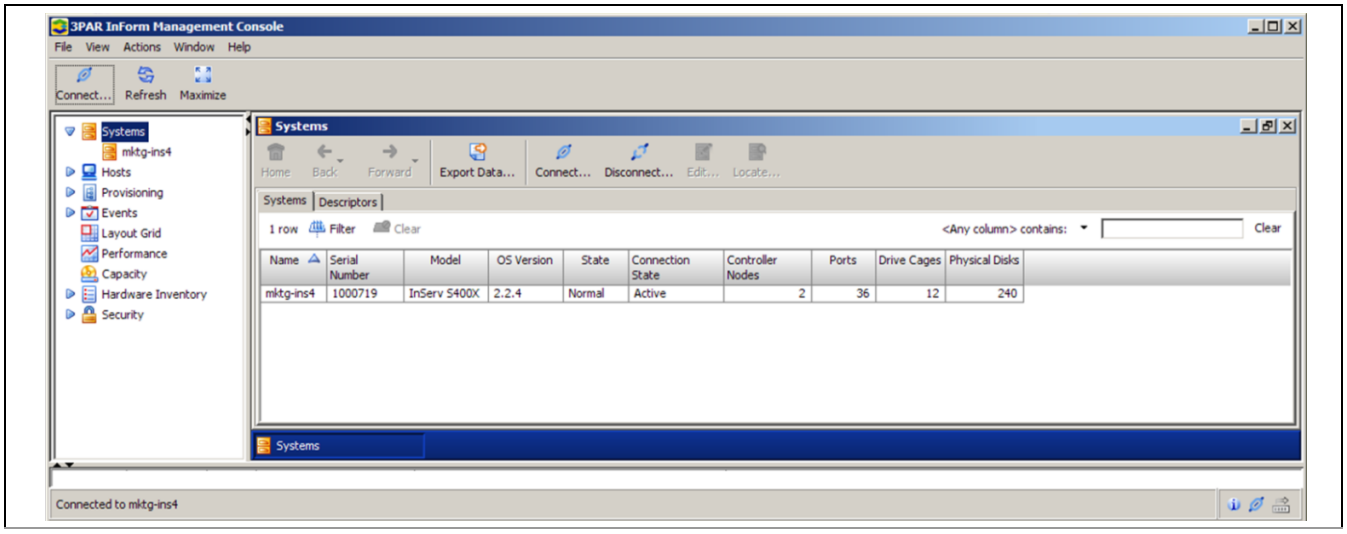
ESG lab started with a pre-wired test bed as displayed in Figure 3. Four HP c-Class BL460 blade servers were installed in an HP c3000 enclosure connected via QLogic Sanbox 5600 FC SAN switches to a 3PAR InServ S400 array. The 3PAR S400 was configured with two controllers and 240 147 GB 10K RPM FC disk drives. Three of the HP Blades were pre-installed with VMware ESX 3.5 with two Windows 2003 virtual machines configured on each.

FIGURE 3. ESG LAB TEST ENVIRONMENT



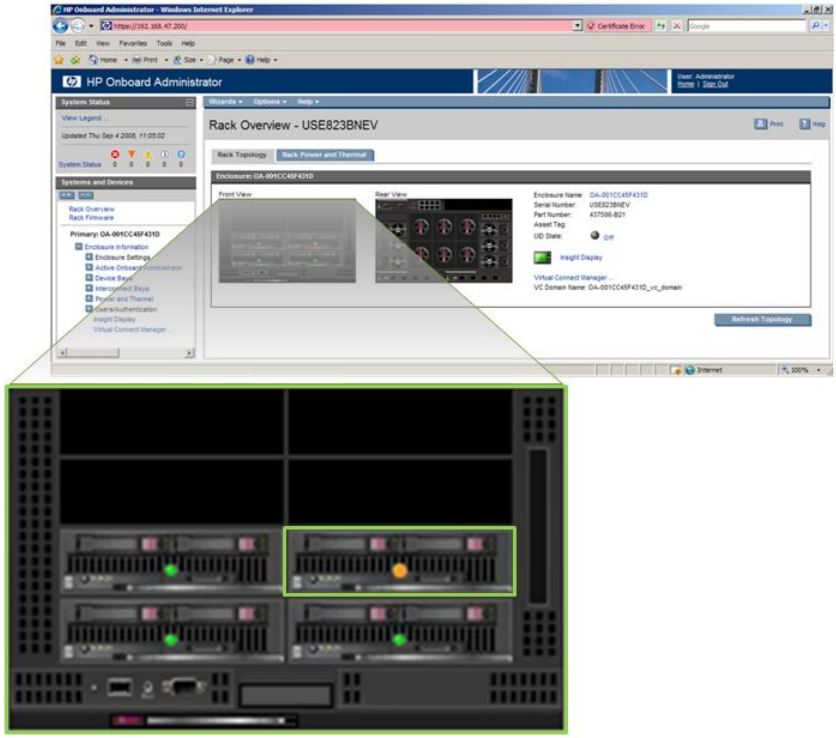
ESG Lab used each offering's native console to configure and manage the environment. The 3PAR InForm Management Console shown in Figure 4 was used to configure and export highly virtualized storage volumes.

FIGURE 4. THE 3PAR INFORM MANAGEMENT CONSOLE



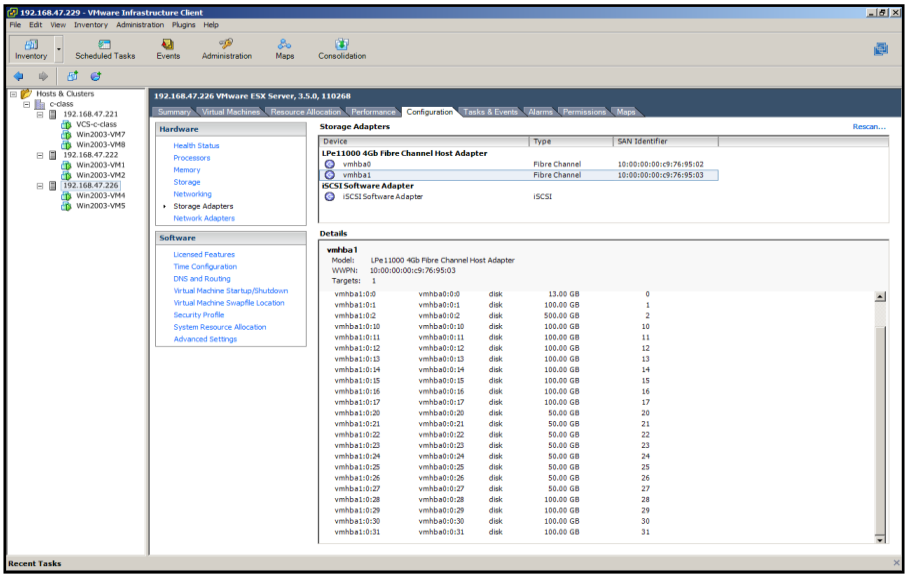
The HP Onboard Administrator was used to configure, monitor, and manage the HP C-class blade server hardware. As seen in Figure 5, the ESG Lab Validation began with the BL460 server powered off.

FIGURE 5. THE HP ONBOARD ADMINISTRATOR



The VMware Virtual Infrastructure Client, as shown in Figure 6, was used to create, monitor, and manage the virtual servers in the test environment.

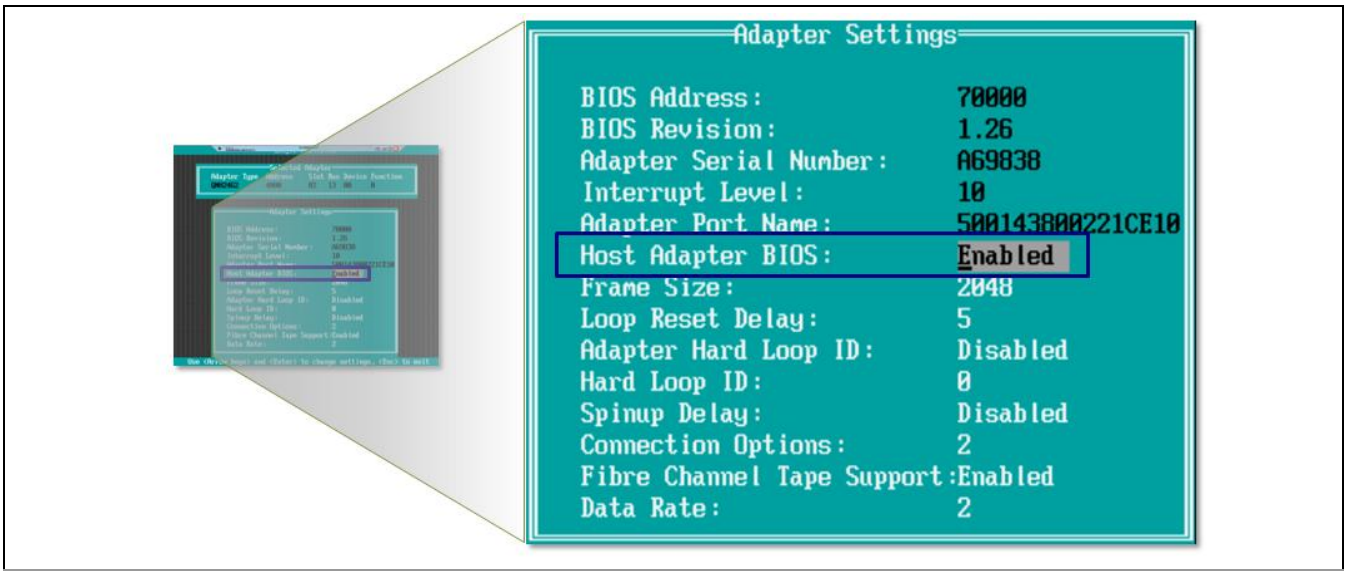
FIGURE 6. THE VMWARE VIRTUAL INFRASTRUCTURE MANAGER



Simple

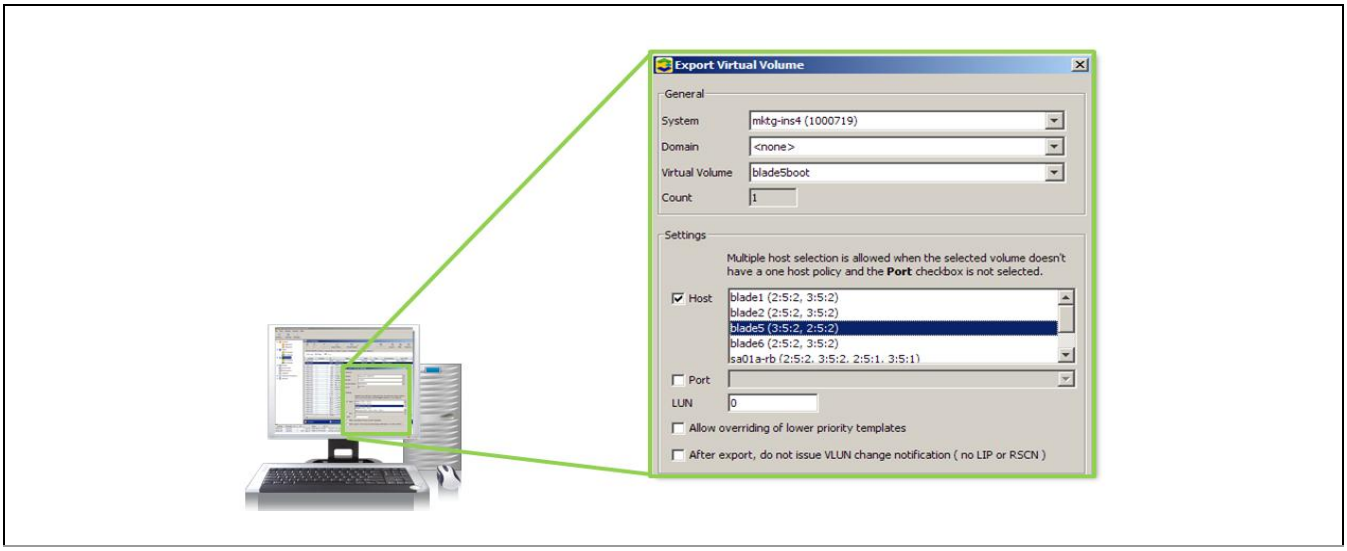
First, ESG Lab powered the fourth blade server on and accessed the BIOS to enable the FC Host bus adapters for SAN boot. This was a multi-step process, but extremely straightforward. The administrator selects the HBA to enable, then enables the BIOS of the HBA, as seen in Figure 7. The last step is to enable 'Selectable Boot' or boot from SAN. The server was rebooted to apply the changes.

FIGURE 7. HP C-CLASS FC ADAPTER BIOS CONFIGURATION



After the server had rebooted, ESG Lab could see the HBA port's WWNs in the QLogic SANbox GUI. Zones were created between the FC HBA ports in the server chassis and the 3PAR controllers. Next, ESG Lab used the 3PAR console shown in Figure 8 to create a 15 GB fully provisioned boot volume.[2]

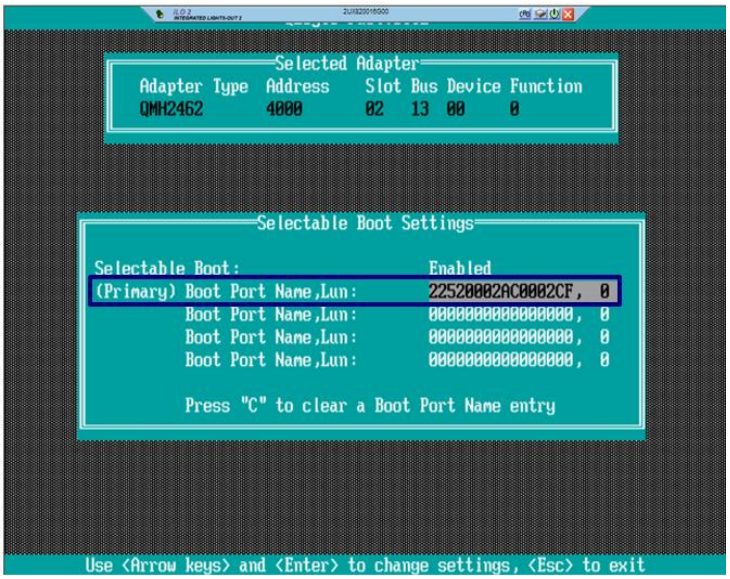
FIGURE 8. EXPORTING VIRTUAL VOLUMES



[2] Since VMware boot images are a known size and static in capacity, thin provisioning is not necessary for these boot volumes. Thin provisioning will be explored in detail later in this report.

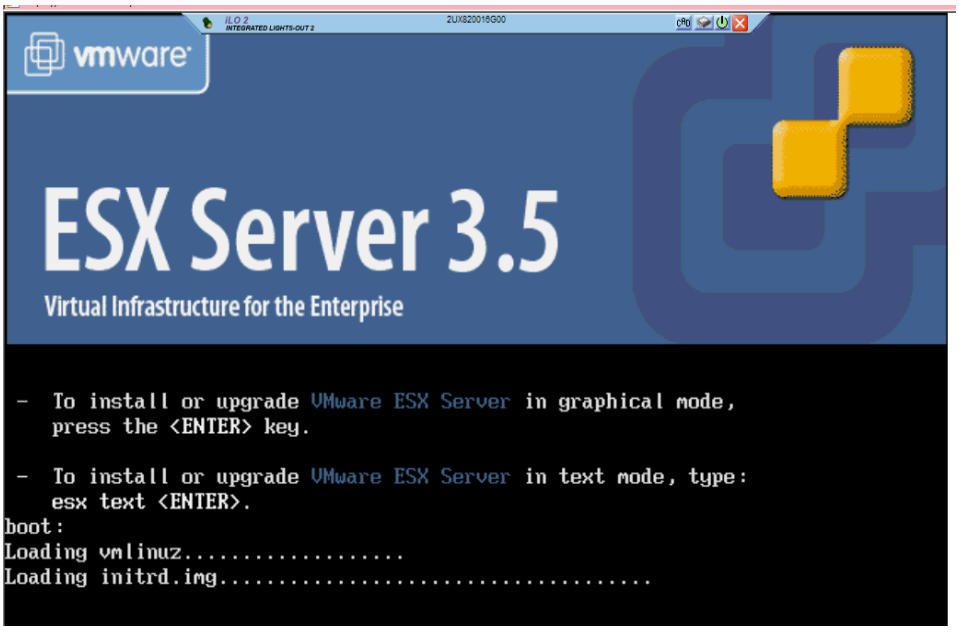
The last step of hardware setup was a rescan of the blade server's FC Adapters, as shown in Figure 9. The elapsed time from powering up the blade server to this point was 20 minutes.

FIGURE 9. HP C-CLASS FC ADAPTER BIOS CONFIGURATION



ESG Lab began the installation of ESX on the blade server. This was accomplished by booting the blade server over the network from an ISO image of the ESX 3.5 installation CD as shown in Figure 10. The installation completed in approximately 30 minutes.

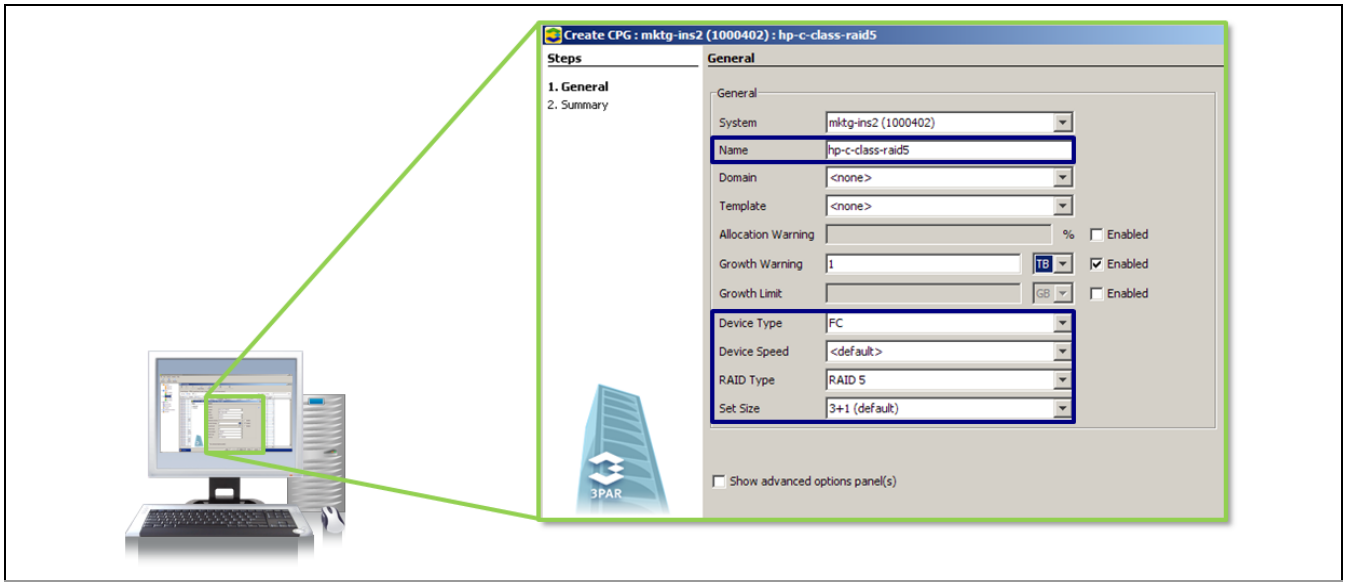
FIGURE 10. INSTALLING ESX VIRTUAL INFRASTRUCTURE



While ESX was installing, ESG Lab returned to the 3PAR InForm Management Console and provisioned storage for the virtual servers to be hosted on the new ESX Server. First, ESG Lab configured a Common Provisioning

Group (CPG). A CPG is a definition or template on how storage will be drawn when creating traditional or thin provisioned volumes with similar characteristics. As seen in Figure 11, to create a CPG, ESG Lab selected the type of disk (i.e., 15K RPM FC or 7.2K RPM SATA) and the RAID protection to be applied to the data (RAID 1 or RAID 5).

FIGURE 11. CREATING A COMMON PROVISIONING GROUP



Next, a Virtual Volume, or VV, was created drawing capacity from the newly created CPG. Finally, the new volumes (as well as volumes on the existing ESX servers) were assigned to the new blade using the export screen previously shown in Figure 8. This entire process took less than five minutes.

Once the ESX installation completed, ESG Lab moved two existing virtual machines from an existing blade server to the new blade server using the VMware Virtual Infrastructure Client. One server was moved in a powered-down state (cold migrate) and the second machine was moved while up and running using VMotion. Both virtual server moves occurred flawlessly, with zero impact to the running machine as it was transferred with VMotion.

The total time elapsed from the first power up of the HP BL460c server to a live ESX Server hosting live virtual machines was just over one hour. ESG Lab was impressed with the smooth installation and easy integration of the solution.

Why This Matters

ESG research has found that among organizations that use or plan to use networked storage to support virtual server environments, increased simplicity of implementation and management is consistently among the top drivers for doing so.[3]

The components of the 3cV solution were easy to configure, implement, and manage. In ESG Lab testing, new physical and virtual servers were installed, configured, and ready to run applications in just over an hour using intuitive tools and procedures. The InForm Management Console required only a handful of intuitive, well-supported actions for complete functionality and system administration. With 3cV, organizations have the potential to significantly reduce administration complexity and cost.

[3] Source: ESG Research Report, *The Impact of Server Virtualization on Storage*, December 2007

Agile

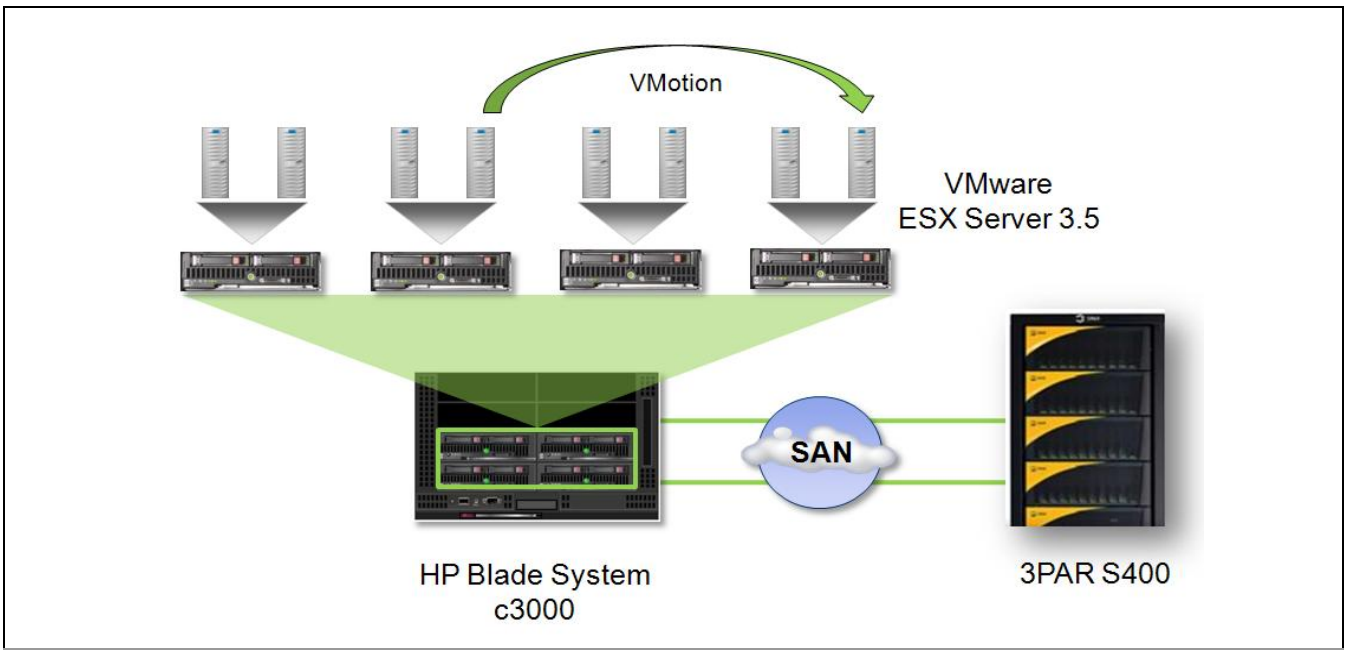
Virtualization is quickly becoming the norm in data centers. The ability to host several operating systems and applications on a single server reduces capital costs for new equipment as well as the operational costs associated with power, cooling, data center space, and the administrative effort expended to maintain the infrastructure. Similarly, the ability to optimize storage service levels online and non-disruptively also helps to reduce capital and operational costs.

ESG believes that virtualized, networked storage is essential if organizations are going to unlock the full potential of server virtualization solutions. The ability to move virtual machines between physical servers for utilization, availability, and data protection purposes is essential for a number of reasons. Virtual storage mobility can be used to change the underlying storage attributes such as RAID level, drive type, or degree of resource utilization to match performance and availability to the requirements of the application or dataset.

3PAR Dynamic Optimization modifies a volume's underlying properties, including RAID level, drive type, stripe width, or radial placement to align data service levels with business requirements non-disruptively and on demand. VMware VMotion enables the live migration of running virtual machines from one physical server to another with zero downtime, continuous service availability, and complete transaction integrity.

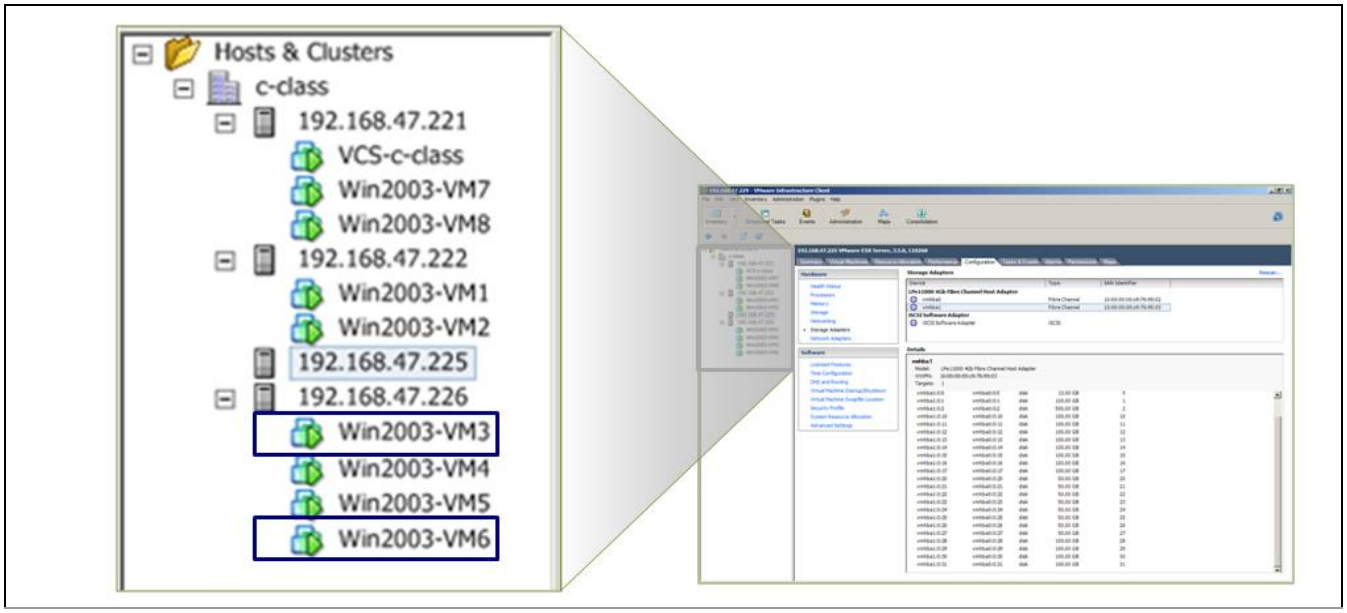
ESG Lab Testing
ESG Lab used VMotion to move two entire virtual machines—consisting of operating systems, applications, and data—running on one physical server to another physical server in the HP c-Class enclosure, as shown in Figure 12. Simultaneously, ESG lab used Dynamic Optimization to move the data volumes in use by these servers to a different level of RAID protection.

FIGURE 12. MOVING VIRTUAL SERVERS BETWEEN PHYSICAL SERVERS



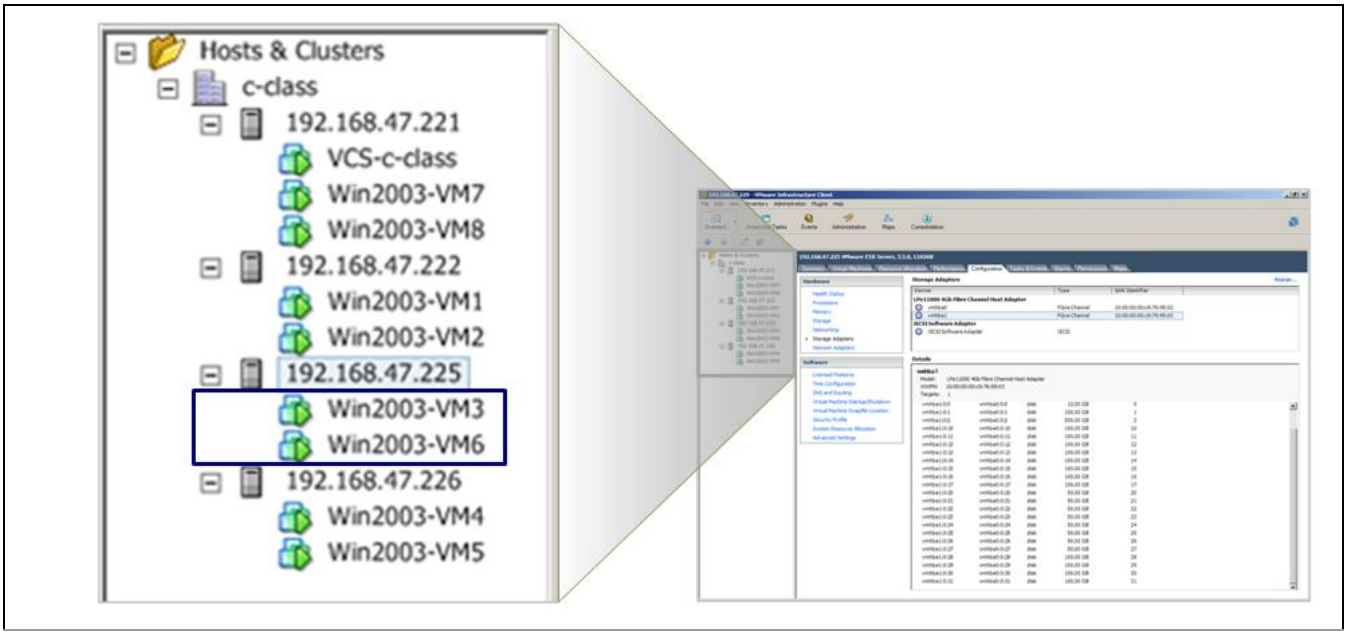
A running application was simulated on the virtual machines using the Iometer workload generation utility. Iometer is a software tool that creates IO traffic and measures the performance capabilities of a storage system. A workload combining random read and write IO was started on virtual machines VM3 and VM6, which were hosted on ESX Server 192.168.47.226 as seen in Figure 13. ESG Lab used the 3PAR InForm CLI to issue one command against each server volume to change the underlying RAID protection from RAID5 to RAID1.

FIGURE 13. MOVING VIRTUAL SERVERS WITH VMOTION - BEFORE



Next, ESG Lab clicked on the running virtual machines VM3 and VM6 in the VMware Virtual Infrastructure Client and used VMotion to move them over to ESX Server 192.168.47.225. Within a few seconds, the virtual machines had moved to the target ESX server, as seen in Figure 14. Iometer continued to function without error.

FIGURE 14. MOVING VIRTUAL SERVERS WITH VMOTION - AFTER



Finally, ESG Lab verified that the volumes belonging to VM3 and VM6 had been re-provisioned to RAID1 storage. The entire process, from first click to final confirmation, took less than three minutes.

Why This Matters

Without the ability to move virtual servers and change storage service levels online, administrators are forced to use error-prone, manual migration techniques, often resulting in applications and data being unavailable during the migration in addition to the consumption significant resources. ESG research indicates that the majority of migration efforts exceed originally planned estimates, including planning, staging, actual migration, and validation.[4] Staff time is often underestimated, with 69% of respondents exceeding estimates during a migration. Additionally, 21% stated that they always exceeded planned staff time.

Moving applications between servers, as well as the ability to change storage service levels online, provide a number of important benefits and are essential for the management of virtualization environments. Virtual machine and storage mobility are key capabilities that add core value to server virtualization environments—providing the ability to upgrade servers, bring new applications online quickly, and enable automated failover and performance load balancing. ESG Lab found that VMotion in the 3cV environment allowed a virtual server to be seamlessly moved from one physical server to another with no application downtime and no perceivable performance impact. ESG lab used Dynamic Optimization to move a volume to new physical storage with one command, online and nearly instantly. Applications (including VMotion) continued reading and writing without interruption.

Efficient

ESG Lab examined 3cV with two different types of efficiency in mind: capacity efficiency (thin provisioning) and power and cooling efficiency (blades and consolidation). Capacity efficiency is provided by 3PAR thin provisioning technology, which can dramatically reduce the capacity associated with an application's storage needs. HP, VMware, and 3PAR work together in a 3cV consolidated infrastructure to increase power and cooling efficiency by reducing the number of servers and disk drives needed to meet the needs of the business.

Capacity Efficient

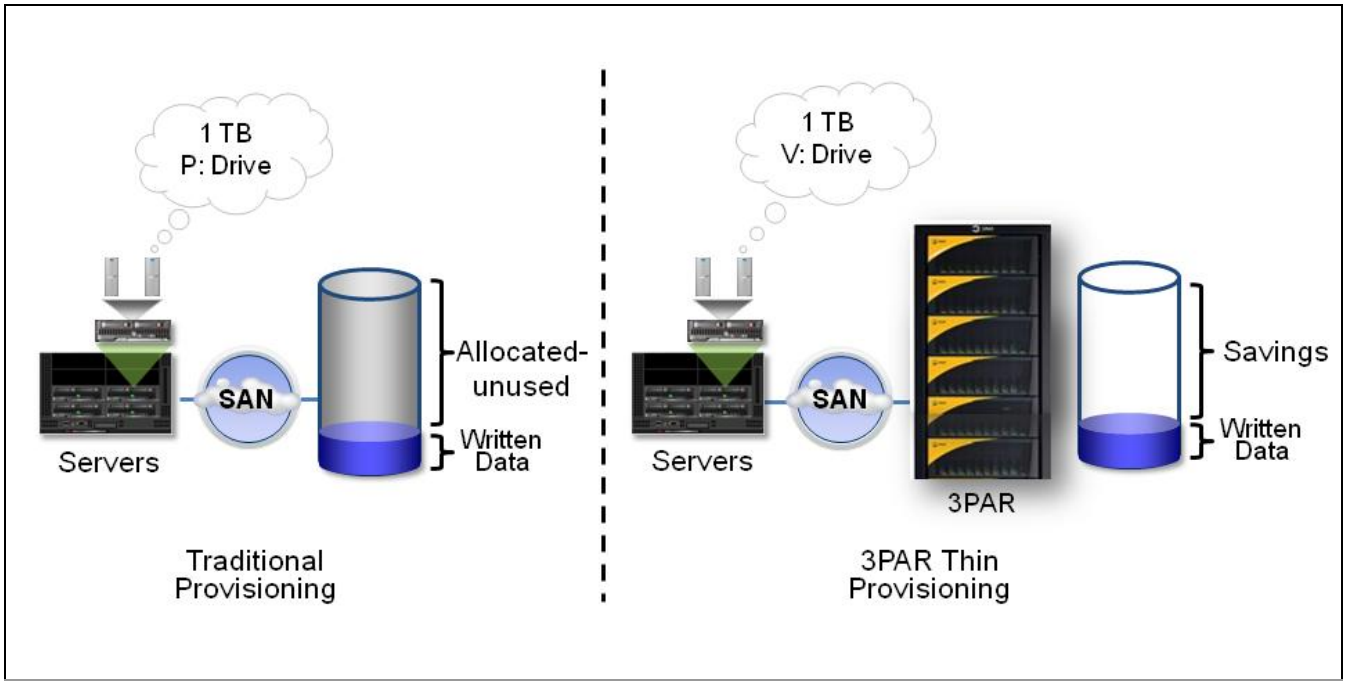
With thin provisioning, physical disk capacity is allocated in a controlled manner on an as-needed basis. Capacity becomes highly utilized and additional applications are able to leverage and share the capacity of one storage system rather than implementing several storage systems for multiple solutions with low disk utilization rates.

3PAR uses the term Thin Provisioned Virtual Volume (TPVV) to describe thin provisioned disk presented to a host. Figure 15 compares traditional provisioning with 3PAR's implementation. When provisioning a volume for a host in the traditional manner, the amount of physical disk allocated is equal to the size of the volume presented to the host.

In the example shown in Figure 15, a server running a mission-critical online application has a storage capacity requirement of 100 GB, but over time, its storage requirement is projected to grow to 1 TB. With traditional provisioning, 1 TB is pre-allocated to the application. This means that 90% of the physical storage assigned to this volume would be unused and, importantly, unavailable to other applications.

[4] Source: ESG Research Report, *Data Migrations*, April 2006, N=550

FIGURE 15. TRADITIONAL VS. THIN PROVISIONING



With 3PAR thin provisioning, the administrator creates a TPVV and specifies its virtual capacity only. This is the maximum capacity that the volume may consume on disk. Physical disk space is consumed only as data is written to the thin provisioned volume.

It's important to note that unlike some thin provisioning implementations, 3PAR does not require a user to pre-dedicate storage to a thin provisioned volume at the outset. 3PAR Thin Provisioning minimizes manual effort by automatically allocating capacity in fine increments from a single pool with no pre-dedication of any kind while volumes benefit from the wide-striping of data across the entire system.

ESG Lab Testing

ESG Lab validated 3PAR's thin provisioning capabilities by creating a thin provisioned virtual volume and exporting it to a virtual server, as an administrator would do when setting up a new application server.

Figure 16 shows the Create Virtual Volume dialog box. ESG Lab found the procedure to create thin provisioned volumes to be straightforward and simple. The only required information is the volume name, the size to be presented to the server, and the Common Provisioning group to provision capacity from as data is written to the volume.

FIGURE 16. CREATING A THIN PROVISIONED VIRTUAL VOLUME

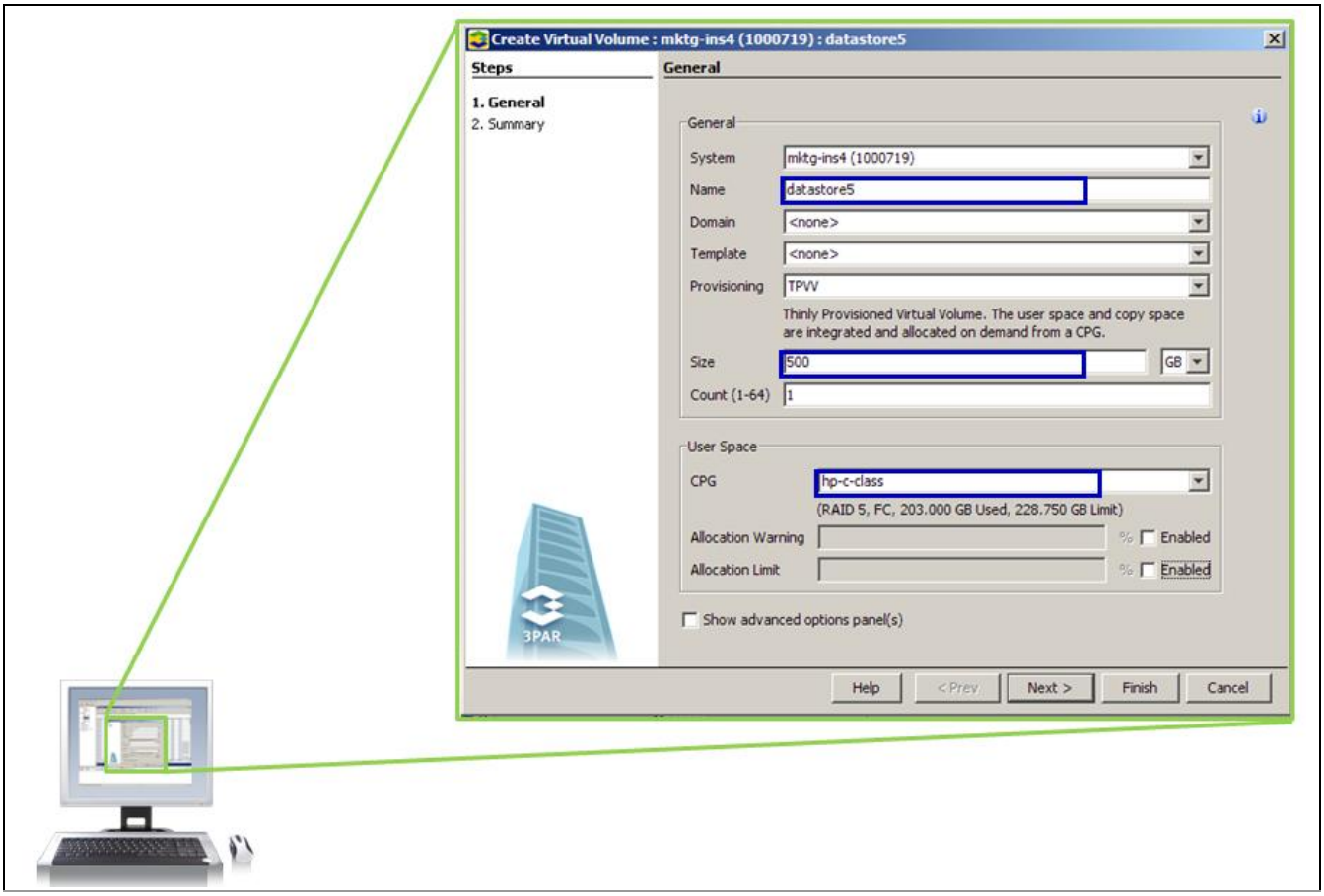
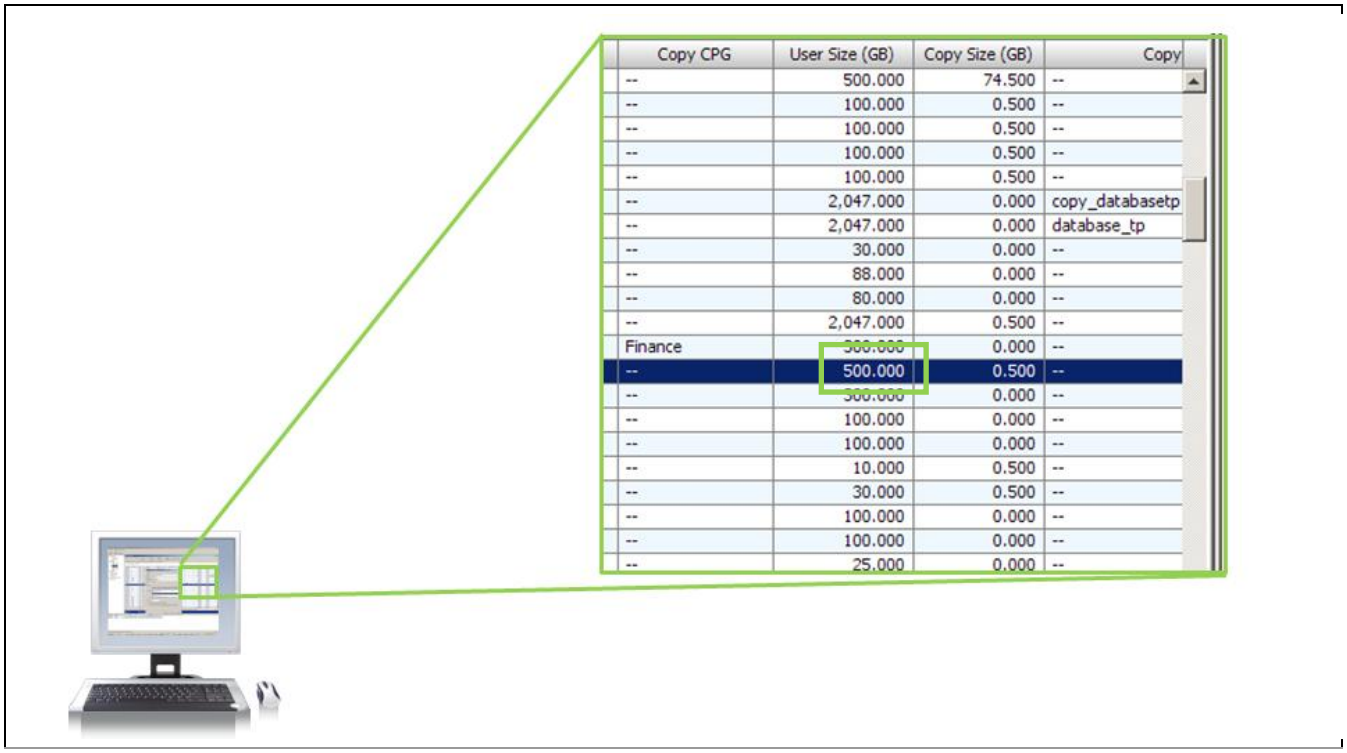


Figure 17 shows the exported storage (User Size) for the 500 GB TPVV just created from the InForm Management Console. Using the InServ command line utility, ESG Lab confirmed that the total storage automatically allocated for the 500 GB TPVV was just 640 MB. This number included allocation for the TPVV itself as well as the pointer and metadata for snapshots.

FIGURE 17. CREATING A THIN PROVISIONED VIRTUAL VOLUME



When an organization is supporting many applications and systems using a self-managing, virtualized system like the 3PAR InServ, an administrator needs to be alerted when allocated capacity approaches the limits of the physical storage in the system. The ability to control the growth of allocated capacity is also crucial.

With 3PAR, allocation warnings and limits can be specified independently for CPGs and TPVVs. ESG Lab tested this functionality by creating a CPG with an allocation warning set to 1 GB. Next, a 1 TB TPVV was created using the 1 GB CPG. Finally, the 1 TB TPVV was exported to a virtual machine and files were copied into the volume. As soon as the capacity of the volume exceeded the 1 GB allocation warning, an alert was logged in the InForm Management Console and a message was sent to the administrator's e-mail account as well as to 3PAR Customer Services.

Why This Matters

ESG has found that end-users often acquire and implement new storage systems when they have allocated but unused storage capacity. In a recent survey of enterprise storage administrators, more than half reported that up to 50% of their purchased storage capacity was stranded and unused. Eighty percent stated that storage provisioning had a significant negative impact on IT time and resources. Thin provisioning can reduce or eliminate these potentially major costs. With thin provisioning, less physical storage is required since the amount of stranded storage is significantly reduced. Purchase of new storage systems can often be deferred based on reclaiming stranded storage.

ESG Lab has validated that 3PAR thin provisioning is easy to manage and extremely capacity efficient. Provisioning additional storage capacity happens behind the scenes while the application and file system remain unaware of any changes. The storage system automatically provisions additional capacity as needed without any manual intervention. Compared to traditional provisioning methods, ESG Lab is confident that 3PAR thin provisioning can be used to reduce the cost of storage capacity by 50% or more.

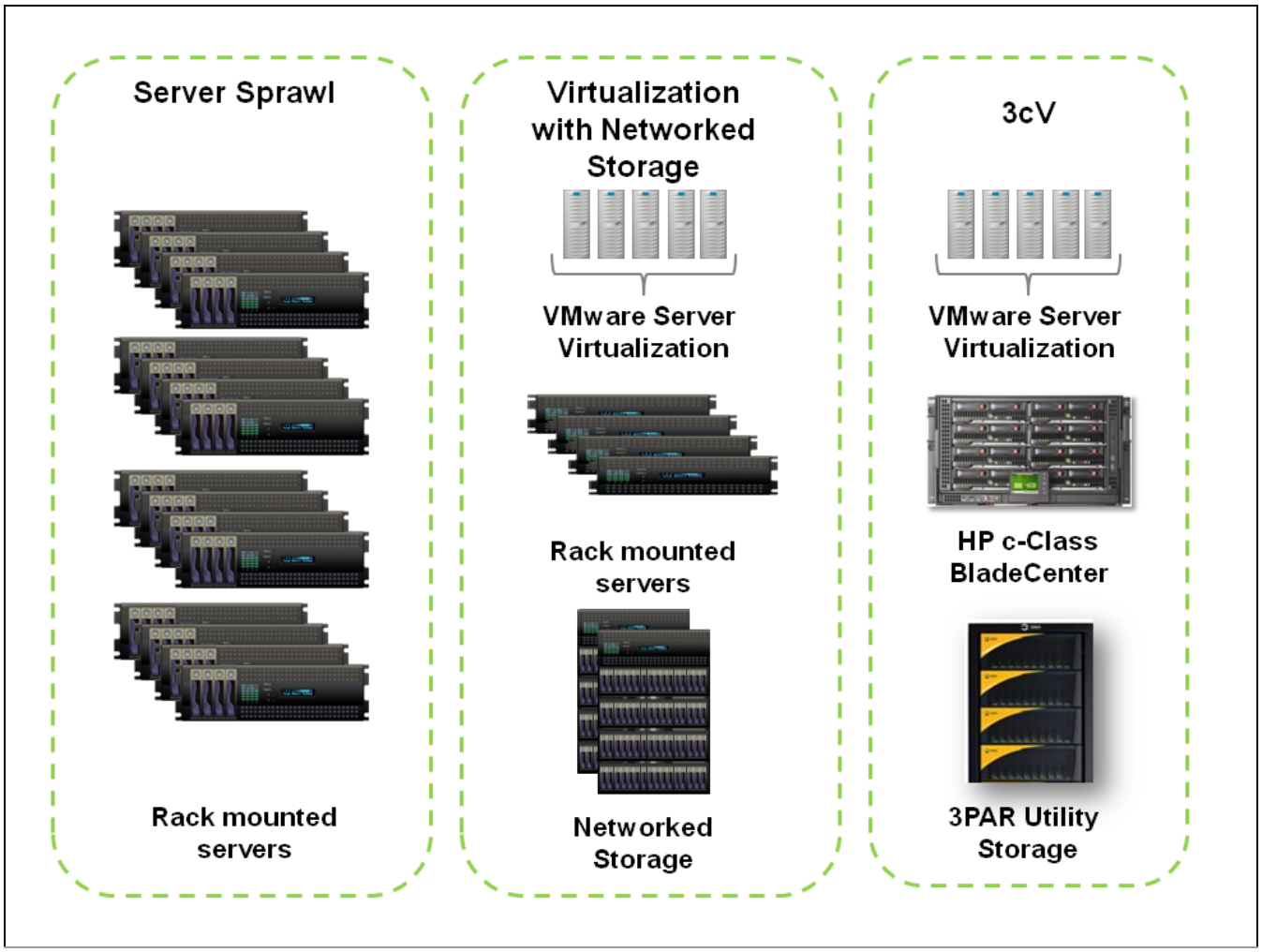
Power Efficient

ESG lab measured the power consumption of the system under test and compared it with more traditional IT infrastructure configurations to determine the power savings that can be achieved with a highly virtualized and consolidated 3cV infrastructure. The configurations used for comparison were chosen to mimic the evolution of server and storage infrastructure that is happening within data centers around the world: from server sprawl through server virtualization with networked storage to a 3cV-enabled IT infrastructure with highly virtualized blade servers and 3PAR utility storage.

As shown in Figure 18, the server sprawl configuration was built using 16 HP DL580 servers, each with its own island of internal storage. The virtualization with networked storage configuration was built using four HP DL360 G5 servers running VMware server virtualization software attached to a traditional modular storage array. The 3cV configuration was built as described earlier in this report and documented in the Appendix.

ESG Lab used the peak power consumption reported by the HP c-Class server during testing to simulate a system running at approximately 70% utilization. Power consumption for the discrete and rack mounted estimates were obtained using HP's ProLiant Power Calculator utility.[5]

FIGURE 18. SERVER SPRAWL AND VIRTUALIZATION EXAMPLES



[5] http://h30099.www3.hp.com/configurator/powercalcs.asp

Configuration details and results are shown in Table 1. Note how a VMware-enabled server consolidation factor of 4:1 was used to reduce the number of servers from sixteen to four. The average cost of commercial power of 9.71 cents per kilowatt-hour in 2008, as reported by the US Department of Energy,[6] was used to calculate the cost of power per hour. The average cost of cooling in a data center is 60% of the cost of power. These metrics were used to calculate the cost of power and cooling over three years.

TABLE 1. POWER REQUIREMENTS FOR TRADITIONAL VS. 3CV INFRASTRUCTURE

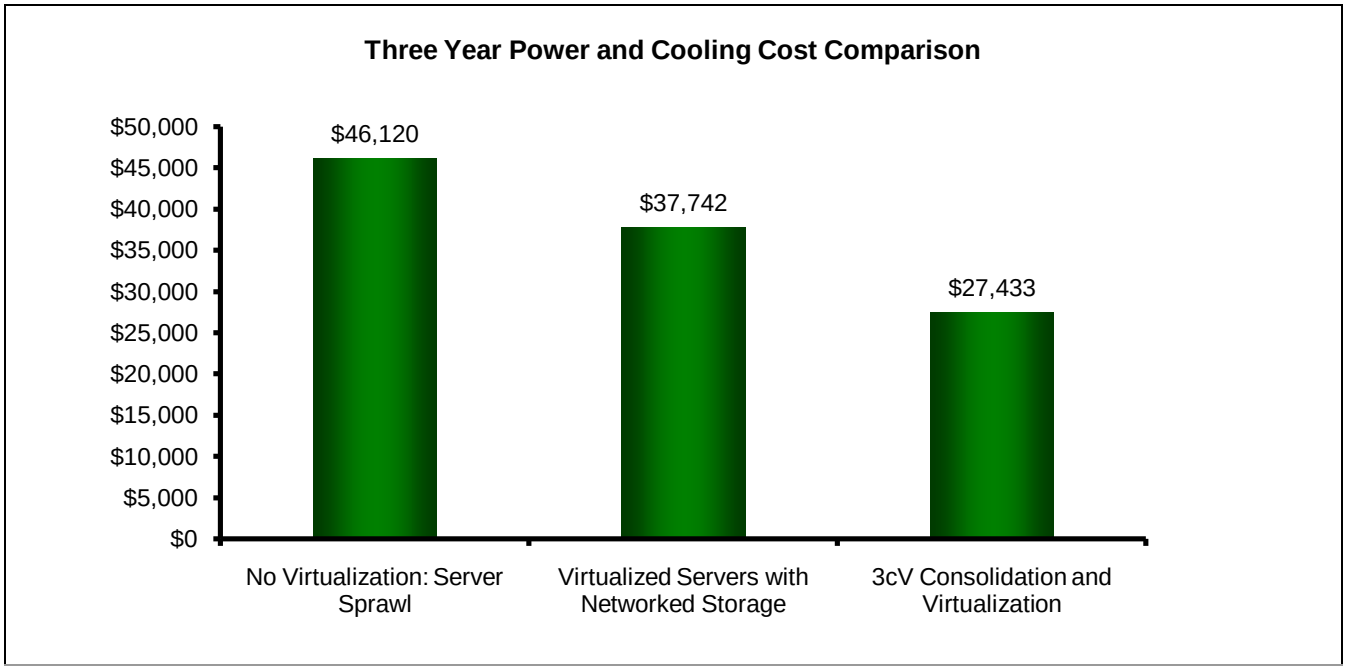
	Server Sprawl	Virtualization with Networked Storage	3cV
Servers	16	4	4
Storage Capacity	37 TB	35 TB	35 TB
Wattage Consumed	11,296	9,244	6,719
BTU/Hour	38,595	31,584	22,957
Power Cost in $/Hour	1.0968	.8976	.6524
Cooling Cost in $/Hour	.6581	.5386	.3914
Total Cost over 3 Years	$46,120	$37,742	$27,433

As shown in Figure 19, the cost savings over three years for power and cooling to be gained by moving from a fully physical, direct attached storage environment to a 3cV utility computing environment are estimated at $18,637 (more than 40%) for a relatively small configuration.

Note that the drive configurations shown in Table 1 were chosen so that the number of physical drives and storage capacity were nearly identical for each configuration—even though less capacity could have been used for the 3cV configuration due to the benefits of thin provisioning. It should also be noted that a 3cV customer typically deploys several times the capacity shown in Table 1. Taken together, these conservative assumptions indicate that a typical 3cV customer realizes savings well in excess of those summarized in Figure 19.

[6] http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html

FIGURE 19. POWER AND COOLING COST OVER 3 YEARS



Why This Matters

Power, cooling, and data center efficiency are of increasing concern for data center managers. As server, storage, and connectivity densities increase, so too do power requirements. While the rising cost of power has become a serious concern for a growing number of data center managers, many have simply run out of power or cooling capacity and must defer new implementations until resources in the data center can be reclaimed.

ESG asked Enterprise IT managers to indicate which technologies were included in current or planned efforts to reduce data center power and cooling requirements. The top three responses were: server virtualization (85%), power efficient servers (79%), and power efficient storage systems (73%).[7]

Based on hands-on testing, audit, and simulations, ESG Lab believes that the complementary technologies of 3cV can deliver significant power, cooling, and footprint savings through both hardware design efficiencies and by reducing the amount of hardware required to support a given organizations applications.

[7] Source: ESG Research Report, *Power and Cooling Concerns Impact Secondary Storage Purchases*, March 2008

Performance

In order to ensure optimized storage performance for virtualized applications, an organization must establish a link from the virtualized to the physical environment. What is needed is the ability to correlate applications to storage and be able to not only view, but collect and act upon performance data to ensure smooth operation of applications. It's a challenge in non-virtualized environments, but with multiple applications running on a single physical server, this kind of detailed analysis is critical for identifying high-growth applications and resolving performance issues. With this in mind, ESG Lab performed a series of storage performance tests in a 3cV enabled virtual infrastructure.

ESG Lab testing

ESG Lab performed hands-on testing to compare the real-world performance of different application workloads. The performance of different 3PAR RAID protection schemes and industry-audited SPC-1 benchmark results were examined as well.

The industry standard, open source Iometer utility was used to create application workloads and measure storage performance during this phase of testing.[8] Iometer uses a configuration file to describe IO and application workloads used during performance testing. The ESG Lab Iometer workload configuration file used during this phase of testing has been developed based on more than ten years of hands-on experience developing and testing storage systems. The majority of the ESG Lab workloads are designed to mimic the behavior of real-world applications.[9]

ESG Lab tested two application workloads: a media streaming workload, which stressed the throughput capabilities of the 3cV infrastructure, and the response-time sensitive transactional performance of a simulated Microsoft Exchange e-mail and messaging environment.

Testing began with the media streaming workload. This workload was used to simulate the effect of many users within a company accessing videos stored on a centrally managed 3PAR InServ storage system. This workload was created after observing the IO generated when low to medium resolution videos are viewed with Windows Media Player. Each stream was observed performing 32 KB sequential reads at a rate of 1.5 IOs per second. The results are shown in Table 2.

TABLE 2. WINDOWS MEDIA SERVER SCALABILITY

Physical	Virtual	IOPS	MB/Sec	Streams
1	1	6,490	203	4,327
2	4	11,175	349	7,450
4	8	20,462	639	13,641

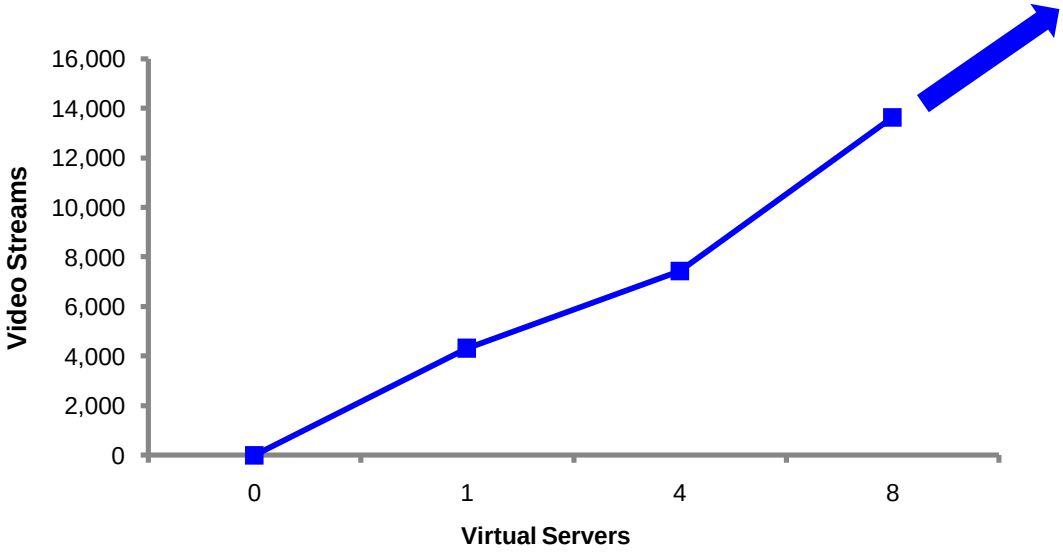
What the Numbers Mean

- Using VMware on HP c-Class blade servers in combination with the 3PAR InServ Storage Server, a single physical server was able to support 4,327 simultaneous video streams.
- The 3PAR InServ was able to efficiently stripe across all disks and sustain maximum performance with just three physical machines and did not suffer a performance penalty when spreading the load across more physical and virtual servers.

[8] Iometer is an open source IO workload generator and performance measurement tool that is freely available at iometer.org.

[9] The ESG Lab defined workloads used to test the 3cV systems can be found in the Appendix.

FIGURE 20. MEDIA SERVER IOMETER RESULTS

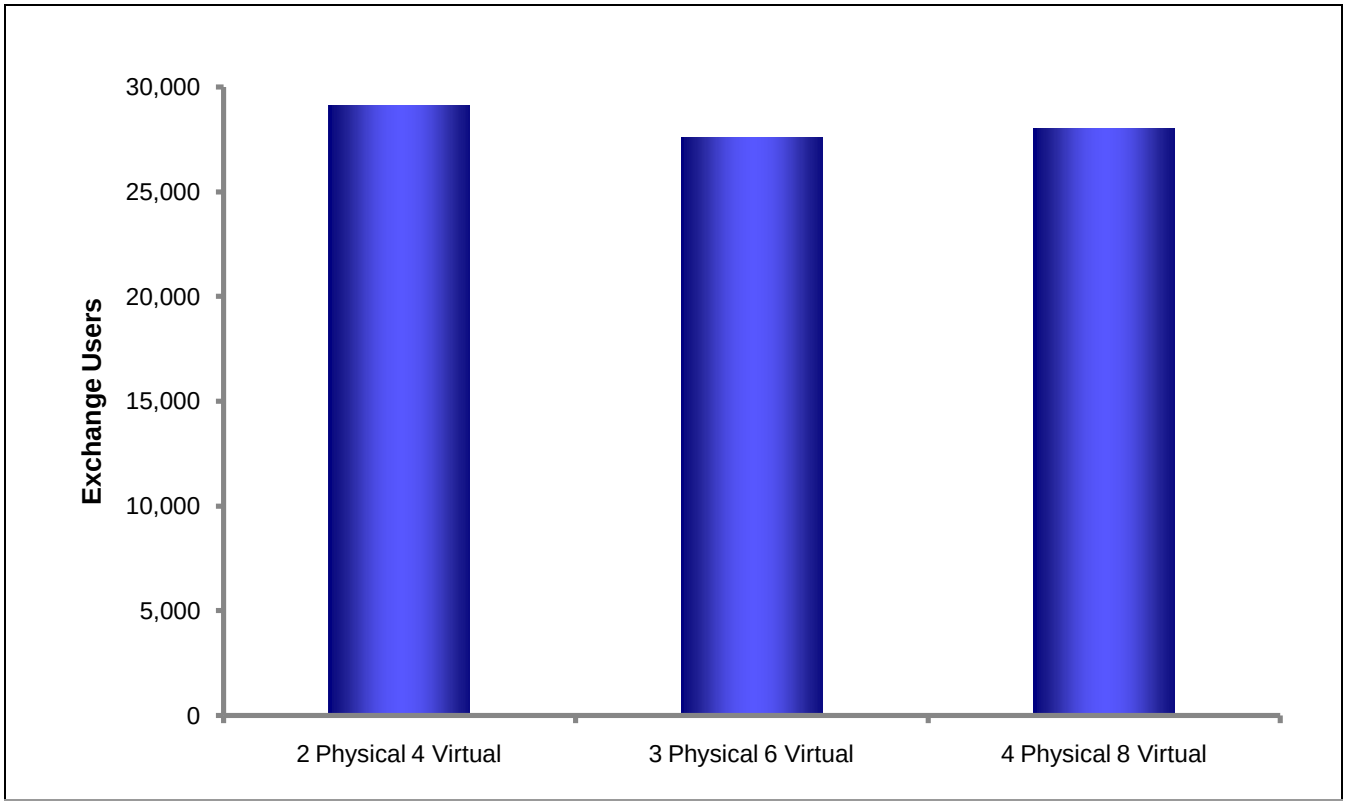


The Media Server results in Figure 20 show that as the number of virtual servers is increased, the combined resources of the 3cV solution also scale in a near linear fashion: up to 13,641 simultaneous simulated video streams on an InServ S400 with two controllers. Based on audited performance testing of the high-end T800 system, ESG Lab is confident that performance should scale in a linear fashion as more controllers and disk drives are added to the system.

The ESG Lab Exchange 2007 workload for Iometer was used to drive a simulated e-mail test using multiple physical and virtual machines. ESG Lab used the Microsoft Exchange 2007 Mailbox Server Storage Design guidelines to interpret the results, where a Heavy Exchange user is defined as generating an average of .32 IOPS.[10] The 3cV test bed was able to sustain sufficient IOPS to support approximately 30,000 'Heavy' Exchange users, as displayed in Figure 21.

[10] http://technet.microsoft.com/en-us/library/bb738147(EXCHG.80).aspx

FIGURE 21. HEAVY EXCHANGE USER SIMULATION

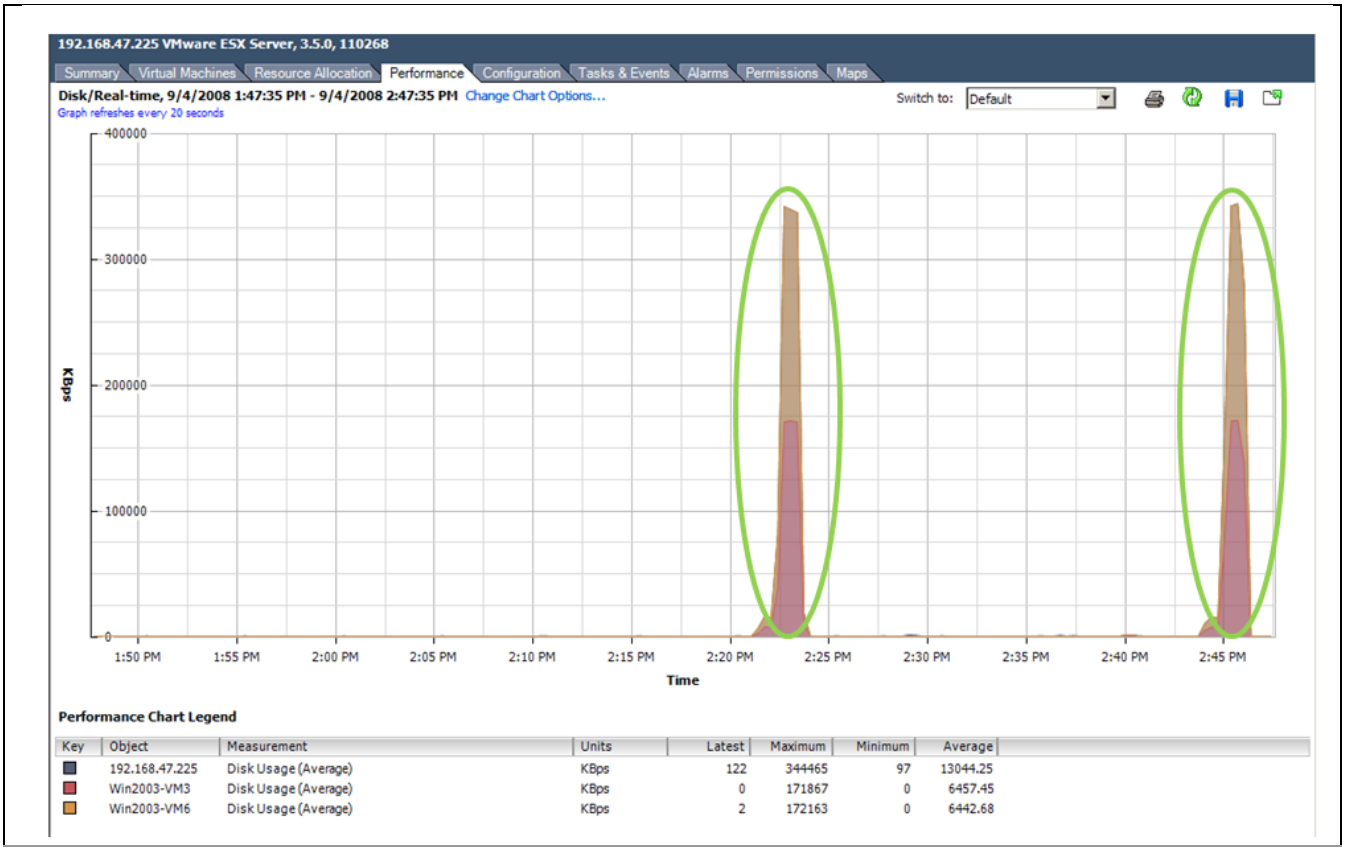


What the Numbers Mean

- Using VMware on HP c-Class blade servers in combination with the 3PAR InServ Storage Server, a single physical server was able to support nearly 15,000 Exchange users.
- The 3PAR InServ was able to efficiently stripe across all disks and sustain maximum performance with just two physical machines and did not suffer a performance penalty when spreading the load across more physical and virtual servers.

Finally, ESG Lab compared the performance of 3PAR volumes defined over RAID 1 and RAID 5 provisioning groups. Two workloads, chosen to stress the limits of the storage system's performance capabilities, were run at the same time: 512 byte (one block) sequential reads and 512 KB sequential writes. Figure 22 shows the storage performance results as reported by the VMware Infrastructure management console.

FIGURE 22. RAID-1 VS. RAID-5 PERFORMANCE



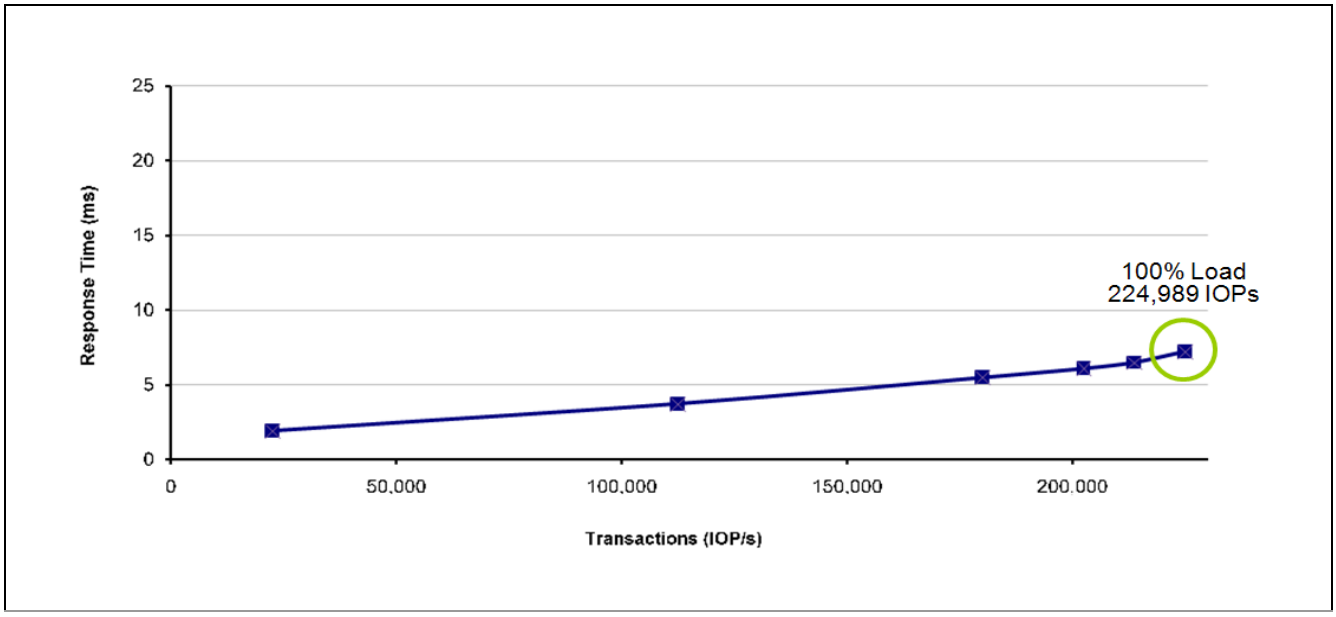
As the diagram shows, RAID 5 and RAID 1 are nearly identical in performance characteristics, confirming 3PAR's claims that users can choose either data protection option without sacrificing performance.

It's interesting to note that when ESG Lab made a physical inspection of the test bed prior to beginning testing, the 3PAR S400 was showing significant drive activity. 3PAR confirmed that this was an active customer demo system and was being used by other groups for other tests and demos. ESG Lab was impressed that we were able to conduct intensive performance tests on this system and achieve excellent and repeatable results while multiple users were using the same system for demos and application testing.

SPC-1 Benchmark

In addition to running physical tests against the 3PAR InServ in a 3cV environment, ESG Lab audited 3PAR's published results of the SPC-1 application-level industry standard benchmark suite maintained by the Storage Performance Council.[11] SPC-1 testing generates a single workload designed to emulate the typical functions of transaction-oriented, real-world database applications. These applications are generally characterized by largely random IO and generate both queries (reads) and updates (writes). Examples of those types of applications include OLTP, database operations, and mail server implementations. SPC results can be roughly mapped by users into easily understood metrics. For a credit card database system, for instance, it might be the number of credit card authorizations that could be executed per second.

FIGURE 23. 3PAR'S SUBMITTED SPC-1 RESULTS



3PAR has submitted an outstanding result of 224,989 SPC-1 IO requests per second at 100% load with an average response time of only 7.22 milliseconds. As of this writing, this is the best published result for a disk-based enterprise-class storage system in terms of both raw performance and price/performance.[12]

TABLE 3. TOP THREE SPC-1 PERFORMANCE RESULTS FOR DISK-BASED STORAGE CONTROLLERS

Rank	Product	SPC-1 IOPS	$/IOPS	Capacity (GB)
1	3PAR InServ T800	224,989	$9.30	77,824
2	HP StorageWorks XP24000	200,246	$17.96	26,000
3	Hitachi Data Systems USP V	200,246	$17.61	26,000

[11] SPC methodology and results can be found at http://www.storageperformance.org/
[12] http://www.ideasinternational.com/benchmark/ben020.aspx?b=99084824-4650-44ce-996b-93b06f10bef1

What the Numbers Mean

- The 3PAR InServ T800 has been used to record the best disk-based enterprise-class storage system results in the industry.[13]
- A helpful price/performance metric based on published list prices is included in all SPC results. Note that 3PAR delivered the industry leading disk-based SPC-1 performance result at a cost effective price of $9.30 per database IO operation per second.

Response time is an extremely important component of SPC results, as this is the delay that an application will experience (and pass on to users) when a storage system is stressed to its limits. A generally accepted threshold for online transactional applications is 30 ms, beyond which application delay becomes apparent to users. The SPC will invalidate any results with response times higher than 30 ms.

In this context, the InServ performance is even more impressive. It should be noted that the numbers published in these reports are for disk subsystem IO requests. Since real world applications typically issue multiple IOs per transaction, there is no easy way to say how much real world performance these numbers represent. Suffice it to say that a system that can process 224,989 random, small IO requests per second with an extremely low response time can process huge volumes of transactions per second.

SPC-1 results are audited by the Storage Performance Council and peer reviewed to ensure consistency. Executive Summary and Full Disclosure Reports (FDRs) for each SPC benchmark result are publicly available for download and review.[14] While this can be useful for comparison between vendors, it is important to note that not all vendors participate and publish results.

Why This Matters

ESG research indicates storage performance is a top concern when implementing server virtualization; more than half of IT managers surveyed indicated performance as their biggest challenge when it comes to implementing server virtualization with networked storage.[15]

Predictable performance scalability is a critical concern when a mix of applications shares a storage system. A burst of IO activity in one application (e.g., a database consistency check) can lead to poor response times, lost productivity, and, in the worst case, lost revenue. A server virtualization environment potentially presents the most diverse mix of application types and IO access patterns to a storage array.

ESG Lab found 3PAR's automatically balanced and self-tuning architecture was able to provide predictably scalable throughput-intensive and response-time sensitive performance in the 3cV environment with excellent price-performance that's significantly less than the cost of legacy enterprise-class storage systems.

ESG Lab was particularly impressed with 3PAR's peer-reviewed SPC-1 benchmark results, which demonstrate that the InServ is delivering industry leading performance while providing exceptional storage economics to end-users.

[13] The top SPC-1 result as of the writing of this report is held by Texas Memory systems for a solid state disk array with an ASU capacity of 137 GB compared to tens of thousands of GB for the disk-based results shown in Table 3. The next ranked solution is an IBM SVC storage virtualization built using multiple SAN virtualization appliances managing multiple disk arrays. EMC has chosen not to publish SPC results.
[14] http://www.storageperformance.org/results/benchmark_results_spc1
[15] Source: ESG Research Report, *The Impact of Server Virtualization on Storage,* December 2007

ESG Lab Validation Highlights

- ☑ The 3cV solution was simple. The 3cV components were easy to install, configure, and deploy and the entire solution was up and running in an hour.
- ☑ The 3cV solution was agile. Migrating virtual machines between physical servers and changing the underlying storage service-levels required no unusual administration effort and was transparent to applications.
- ☑ The 3cV solution was efficient. The system's rated power consumption was significantly less than a traditional array with standard rack-mounted servers.
- ☑ 3PAR thin provisioning was dead-simple to use and required no pre-allocation of capacity.
- ☑ Performance was impressive. The 3PAR architecture widely striped all IO across all drives in the system with no tuning required.
- ☑ The system performed well even though multiple users were accessing the system with different applications and workloads unrelated to ESG Lab testing.
- ☑ The 3cV solution demonstrated nearly linear scalability. As the numbers of virtual servers were increased, the combined resources of the 3cV solution also scaled, up to 641 MB/Sec.
- ☑ The 3cV solution demonstrated good performance for a real-world application like Exchange through a simulation of 29,117 e-mail users using a Microsoft Exchange 2007 heavy user workload profile.
- ☑ The 3cV solution demonstrated impressive RAID 5 performance. A capacity-efficient RAID-5 configuration provided virtually equal performance and throughput to RAID-1 in ESG Lab testing with no tuning or special configuration.

Issues to Consider

- ☑ According to ESG research, the second biggest concern—after performance—for networked storage in a virtual server environment is the general lack of best practices documentation. While ESG Lab found the installation and configuration process for the combined 3cV solution easy and straightforward, users will want to consult implementation and best practices documentation from 3PAR, HP, and VMware to complete an installation.
- ☑ Configuring and managing the HP c-Class Virtual Connect interfaces is a bit different than configuring Fibre Channel host bus adapters in a traditional rack mounted server. HP provides extensive documentation describing how to configure Virtual Connect interfaces and the configuration wasn't difficult—just different, requiring a bit of planning and thought when first attempted.
- ☑ The 3cV solutions presented in this report were not invented in the lab. Mutual customers of 3PAR, HP and VMware discovered the benefits of combining these technologies over the past couple years. In other words, while the branding and documentation of this solution is relatively new, the solution itself is running in a number of large-scale production environments.

ESG Lab's View

Server virtualization is being deployed by a large and growing number of organizations with the ambitious, parallel goals of lowered costs, improved resource utilization, non-disruptive upgrades, and increased availability. Each of these benefits is fundamentally enabled by decoupling servers, applications, and data from specific physical assets. Storage virtualization takes those very same benefits and extends them from servers to the underlying storage domain—bringing IT organizations one step closer to the ideal of a completely virtualized IT infrastructure.

IT teams are feeling significant pressure to more effectively support the business, increase asset utilization, and improve information management and security—all while holding down costs across the board. Recent ESG research indicates that a majority of organizations are making significant commitments to server and storage virtualization—as well as blades—in the hopes of improving the performance, cost-effectiveness, and utilization of server resources.[16]

Multiple vendors currently offer server and storage virtualization solutions and the field continues to expand. However, with choice comes complexity. Choosing a solution set to best fit a specific environment, business need, and budget can be a significant challenge. The combination of 3PAR, HP, and VMware answers this challenge with the 3cV solution.

3PAR has been providing highly virtualized utility storage since 2002 to serve as the foundation of a utility computing ecosystem. 3PAR architected its platform to work in unison with server virtualization technologies to create a complete utility computing environment. ESG Lab found 3PAR's utility-based approach to storage extremely easy to set up and manage while offering powerful functionality and impressive performance. The 3PAR InServ is a serious alternative to traditional monolithic arrays.

HP BladeSystem c-Class servers are modular, rack dense industry-standard servers designed to maximize performance and efficiency with the goal of fast, easy deployments that can customize and grow computing power in the data center on demand. ESG Lab was able to configure a blade for SAN boot and install VMware ESX as easily as with a discrete physical server.

VMware Infrastructure virtualizes servers with the ambitious goal of transforming traditional IT infrastructure into an automated, always-on utility computing environment. Customers of all sizes have reduced IT infrastructure costs while streamlining the management of IT environments and delivering improved service levels to the business.

The total time elapsed from the first power up of the HP Blade server to a live ESX Server hosting live virtual machines was just over one hour. This elapsed time included server configuration, SAN zoning, storage provisioning, installation of ESX and a guest operating system. ESG Lab was quite impressed with the smooth installation and straightforward integration of the solution.

Through hands-on testing, ESG Lab found that 3cV provides a robust blueprint for highly virtualized utility computing. With a simple configuration that took just over an hour to set up, powerful server mobility, and excellent performance, ESG Lab confirmed that 3cV delivers the magical combination of a simple, agile, and efficient IT infrastructure.

[16] Source: ESG Research Report, *Medium-Size Business Server & Storage Priorities*, June 2008

Appendix

TABLE 4. TEST CONFIGURATION

Hardware	Software
3PAR InServ S400 – Two controllers • OS Version: 2.2.4 • 240x 147 GB 10K FC disk drives • 2x 4Gb/sec FC host ports used for ESG Lab testing	Iometer Workload Generator Version: 2006.07.27 Workloads: Exchange 2007 EDB 8KB Random 73% read LOG 64KB Sequential 100% write Media Server 32KB Sequential 100% read 1 block sequential read 512 KB sequential write
HP BladeSystem c3000 Enclosure Firmware: 2.20 2x 4 GB FC HBA 4x ProLiant BL460c G1 Blades Firmware: 1.50 2x 4 GB FC HBA ports to the Blade Server enclosure	VMware ESX Server 3.5 Guest OS: Windows 2003 SP2
2x QLogic SANbox 5600 FC SAN Switch Firmware: 6.8.0.3.0	

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