



LAB VALIDATION REPORT

EMC CLARiION CX4 Modular Storage with Real TCO Impact

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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 EMC.

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Introduction

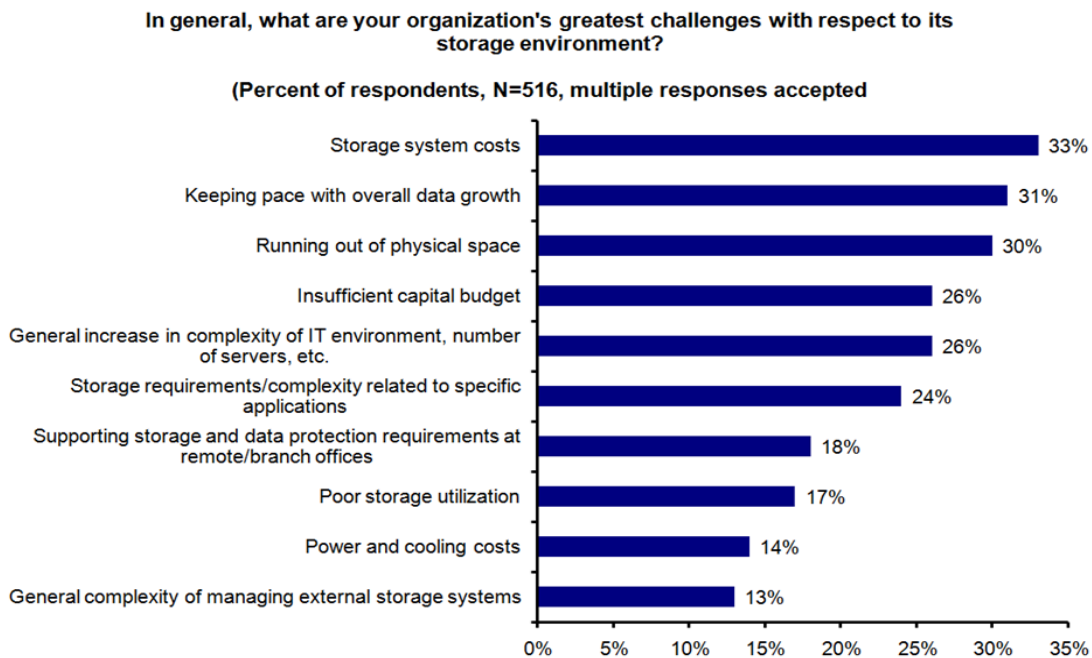
IT managers struggling with explosive data growth and the rapid adoption of server virtualization technology are looking for ways to be more productive and get more out of key applications with the same—or more likely—less budget. The CLARiiON CX4, the fourth generation of EMC’s highly modular CX storage platform, includes a number of new technologies that are designed to improve the total cost of ownership while enhancing the ease of use, performance, and protection of consolidated and virtualized environments.

This ESG Lab report documents hands-on testing of the CX4 with a focus on major usability and manageability upgrades, UltraFlex modular I/O technology, Enterprise Flash Drive support, Virtual Provisioning, and integrated RecoverPoint replication working in concert with VMware Site Recovery Manager. The CX4 family’s ability to optimize virtual server environments using the Navisphere Quality of Service Manager (NQM) and VMware Distributed Resource Scheduler (DRS) is also examined.

Background

ESG research indicates that there are a number of factors driving IT decision makers in medium-sized businesses to make major commitments to server and storage consolidation initiatives. As shown in Figure 1, a large percentage of IT managers cited storage system costs, accelerating data growth, and physical data center space restrictions as their top storage challenges.¹

FIGURE 1. MEDIUM-SIZED BUSINESS STORAGE CHALLENGES



In addition to the storage challenges listed in Figure 1, ESG research indicates that power and cooling reductions and “Green Initiatives” are also top priorities when making purchasing decisions.² As a matter of fact, compared to three years ago, 68% of respondents are significantly more aware of energy consumption and cooling requirements than in the past. Put it all together and it’s clear that IT managers are looking for modular, cost effective storage solutions that are energy efficient and scalable.

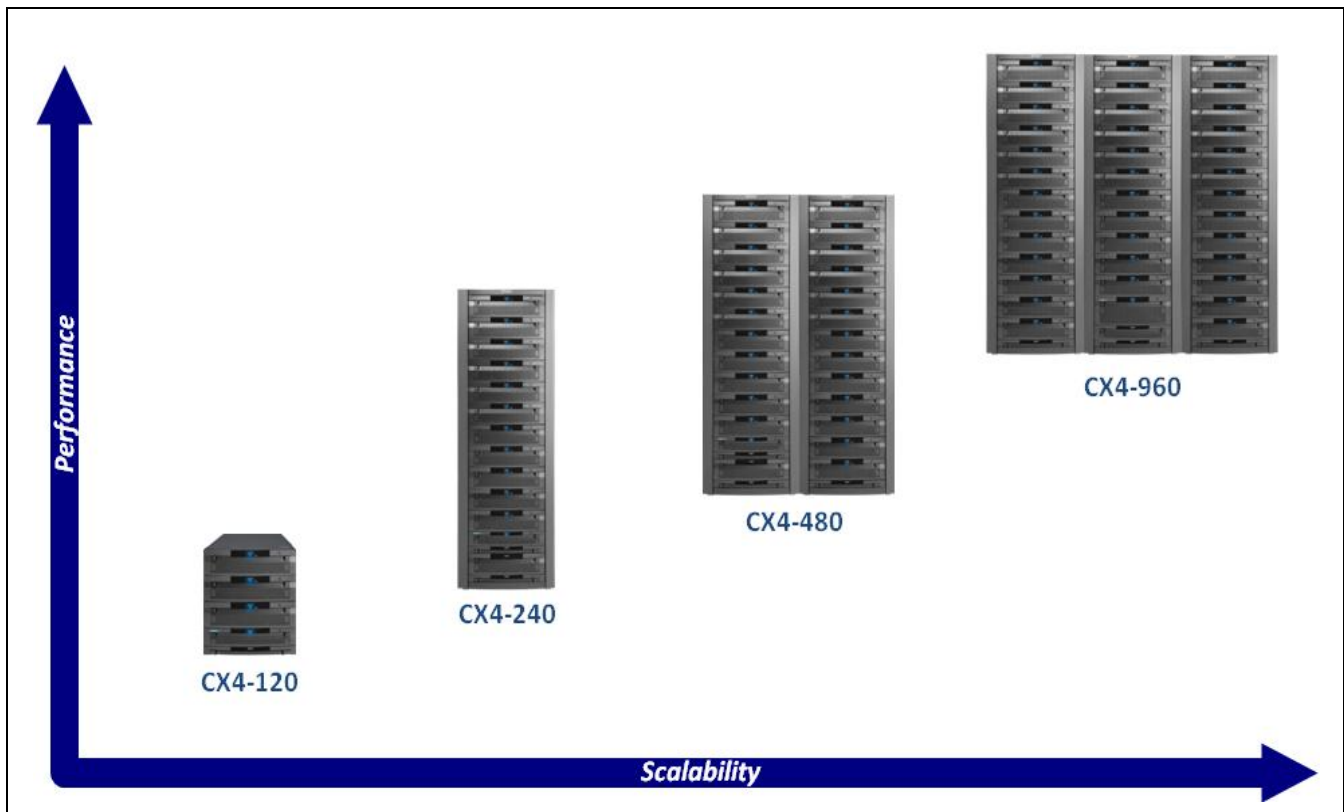
¹ Source: ESG Research Report, *Medium-Size Business Server & Storage Priorities*, June 2008

² Source: ESG Research Report, *Power, Cooling, Space Efficient Storage*, July 2007

Introducing the CLARiiON CX4 Series

The CLARiiON CX4 is a modular, scalable storage system designed to address the most crucial cost and management challenges faced by storage and IT managers. A CX4 storage system can be configured with as few as 5 drives and scale all the way up to 960 drives in a single array as shown in Figure 2. Performance of the new CX4 product lineup has increased dramatically and all systems provide the flexibility to support a mix of Fibre Channel and iSCSI host connections.

FIGURE 2. THE CLARIIION CX4 FAMILY



The fourth generation CX4 storage systems' new features include:

- A hardware platform which leverages 64 bit Operating Environment technology, expanded memory, Dual Core and Quad Core Intel Xeon processors which provide increased performance and scale and a foundation for advanced software functionality.
- A modular, customer-replaceable I/O connectivity architecture for iSCSI and Fibre Channel protocols, increased flexibility, online configuration changes, and long-term investment protection.
- Virtual Provisioning (a.k.a., thin provisioning), which uses just in time capacity allocation and simplified volume management capabilities to reduce the total cost of ownership.
- High-speed, energy-efficient Enterprise Flash Drive technology for most performance demanding applications.
- Low power SATA drive technology and adaptive cooling, dynamically reducing energy use and improving efficiency.
- RecoverPoint write-splitter technology for enhanced disaster recovery and data protection.
- Integration with VMware Site Recovery Manager (SRM) for high availability, data protection, and ease of use.
- Quality of Service (QoS) capabilities optimized for virtual server environments.

This report documents ESG Lab hands-on testing of the EMC CLARiiON CX4 product family with a focus on its ability to increase performance, availability, and investment protection as it reduces cost, complexity, and energy requirements.

ESG Lab Validation

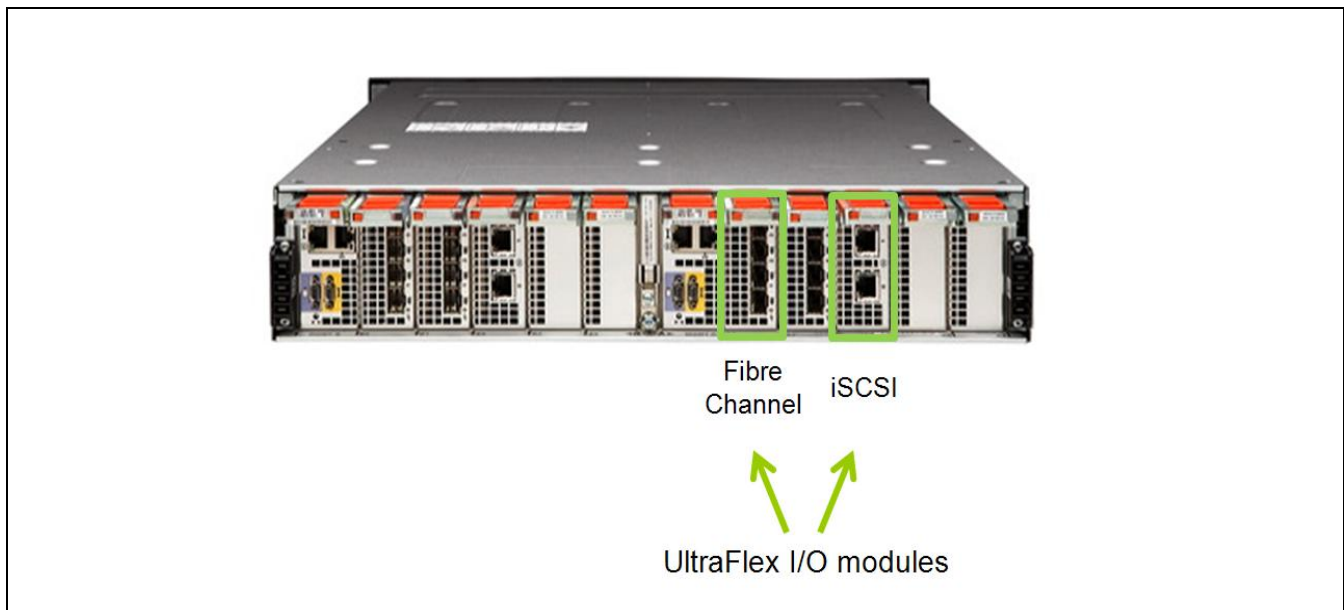
ESG Lab performed hands-on evaluation and testing of EMC's CLARiiON CX4 storage systems at EMC facilities located in Southborough, Massachusetts and Santa Clara, California. Testing began with a look at the new modular I/O architecture of the CLARiiON CX4.

UltraFlex Modular Technology

UltraFlex technology is a modular redesign of the I/O interface architecture for the CLARiiON CX4 family. UltraFlex I/O Modules are hot-pluggable and customer-installable. Each CX4 model has a base configuration that includes Fibre Channel and iSCSI connectivity in the same system with additional empty I/O slots for future connectivity. This flexible approach, which supports an expandable mix of Fibre Channel and iSCSI modules in the same system, can be used to cost effectively meet the current and future needs of a wide variety of business and application requirements.

Figure 3 displays the rear view of a CX4 controller with 4 Gbps Fibre Channel and Gigabit Ethernet iSCSI UltraFlex I/O modules installed. UltraFlex I/O modules can be deployed and installed while the CX4 remains online and available. The UltraFlex architecture is designed to accommodate emerging I/O interface technologies (e.g., 8 Gbps FC, 10 Gbps iSCSI, FCoE, etc...) for maximum investment protection.

FIGURE 3. CX4 ULTRAFLEX I/O MODULES

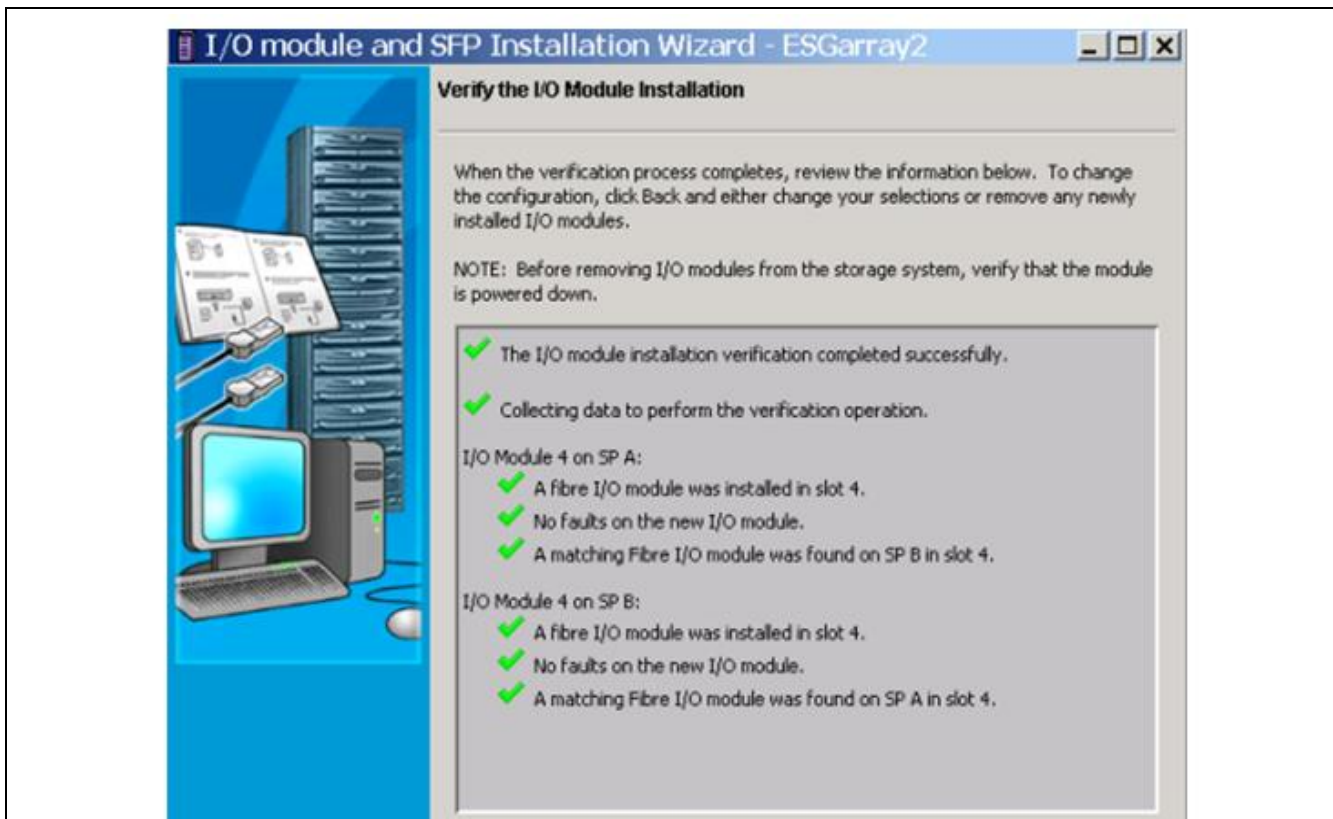


ESG Lab Testing

ESG Lab began with an examination of the new modular UltraFlex Technology and physical inspection of several 4 Gbps FC and Gigabit Ethernet I/O modules. ESG also took a look at an 8 Gbps Fibre Channel I/O module, which is currently under development at EMC. A review of the new UltraFlex architecture and a physical inspection of the I/O modules were followed by an online installation of two Fibre Channel I/O modules.

Using an EMC utility, a write intensive I/O workload was created to verify the ability to install I/O modules while a CX4 is online and active. The Navisphere management console was launched from a web browser. The Navisphere Service Tool (NST) was used to launch the online I/O module and Small Form Factor – Pluggable (SFP) Installation wizard as shown in Figure 4. The wizard checked the CX4 for current hardware and software revisions and verified the health of the system. After selecting the locations for the new I/O modules and slotting them in place, the wizard verified that the I/O modules were properly installed and rebooted each storage processor in turn to bring the I/O modules online.

FIGURE 4. AN ONLINE ULTRAFLEX I/O MODULE UPGRADE



Ten minutes after getting started, ESG Lab confirmed that the Fibre channel I/O modules were configured and ready for use. Proving that production applications remain online and available as UltraFlex I/O modules are added, the background I/O workload ran without incident during this stage of ESG Lab testing.

Why This Matters

Storage hardware I/O interface upgrades are often needed to meet the changing requirements of the business. In most modular storage array architectures, this is typically an offline process that must be scheduled and performed by a customer service representative. In many cases, it even requires a total replacement of the controller chassis. The downtime involved with an offline upgrade can impact productivity and, in the worst case, can impact revenue.

ESG Lab has confirmed that CLARiiON UltraFlex I/O modules can be installed by a customer as applications remain online and available. EMC's tradition of providing excellent levels of investment protection for their CLARiiON customers has yet again been improved with a flexible I/O architecture that supports a mix of current and future I/O modules.

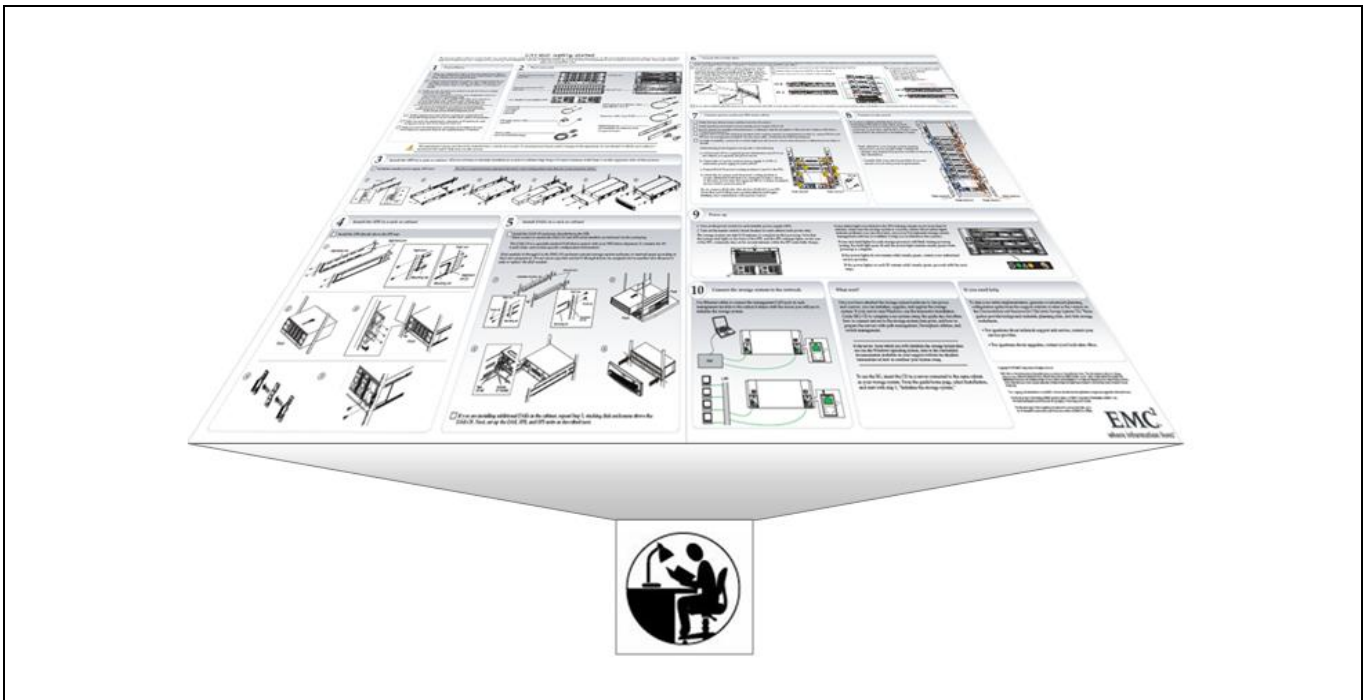
Ease of Deployment

EMC has made vast improvements in the ease of installation and manageability of the CLARiiON product line. A short list of the many usability enhancements includes a new quick install placemat, the IIG (Interactive Installation Guide—CD shipped with the array), an enhanced look and feel for the Navisphere management GUI, and a number of other GUI performance enhancements designed to simplify the management of large configurations.

ESG Lab Testing

ESG Lab looked at the new CX4 Getting Started placemat, shown in Figure 5. The poster-sized placemat is included in the box with every new CX4, much like the poster a user might receive when purchasing a new TiVo. The install guide clearly depicts the ten step process used to unpack, rack, and configure a new CX4 system.

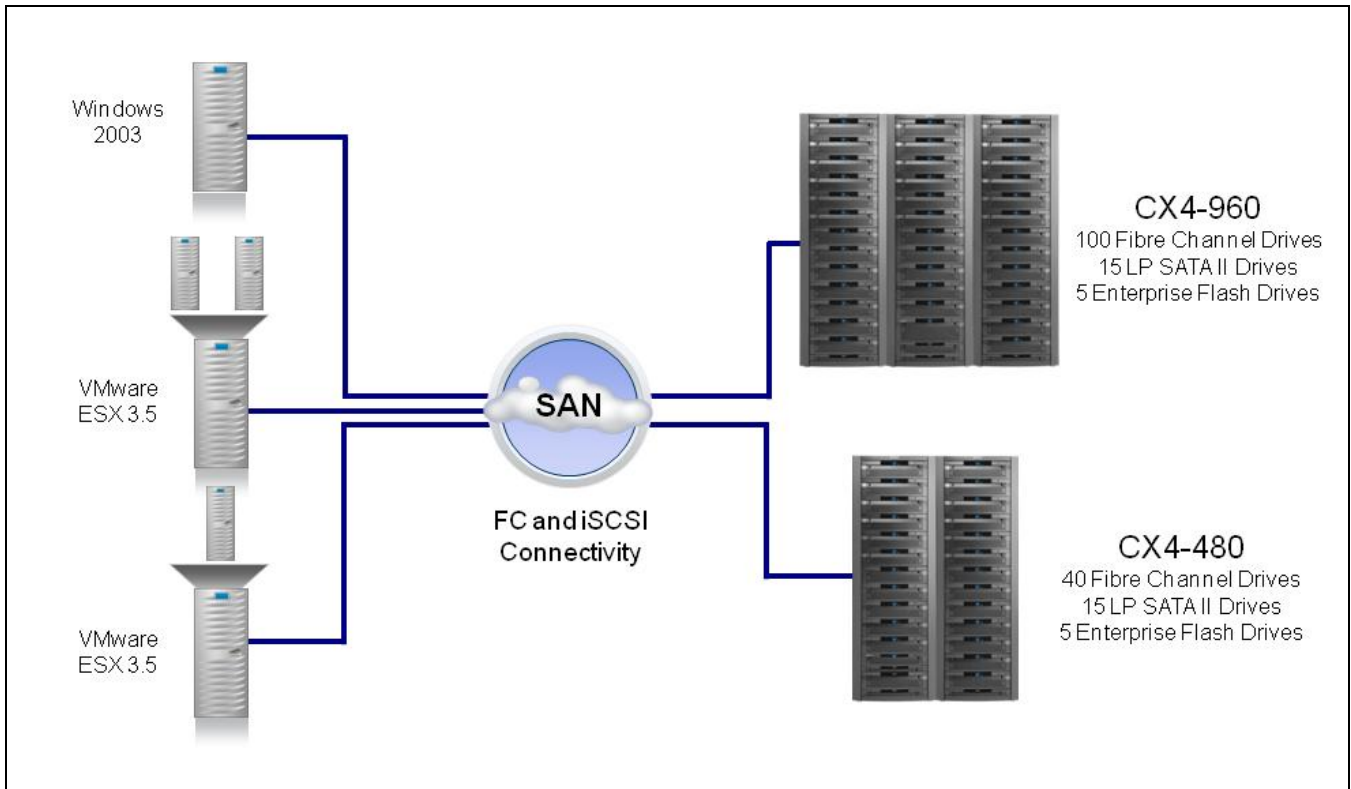
FIGURE 5. THE EMC CLARIIION QUICK INSTALL GUIDE



ESG Lab testing continued on two pre-wired and rack mounted CX4 storage arrays. The ESG Lab test bed, as presented in Figure 6, consisted of three Dell PE2850 physical servers (two running VMware ESX server with Windows 2003 Guest OS, one running Windows 2003 natively) SAN attached to a pair of CX4 storage arrays: a CLARiiON CX4-960 configured with 100 high speed FC disk drives and a CX4-480 with 40 FC drives.³ Both CX4 storage systems were also configured with 15 low-power (LP) SATA II disk drives and 5 Enterprise Flash Drives. A mix of Fibre channel and iSCSI UltraFlex I/O modules was used for SAN connectivity.

³ Complete detailed of the test bed is detailed in the Appendix

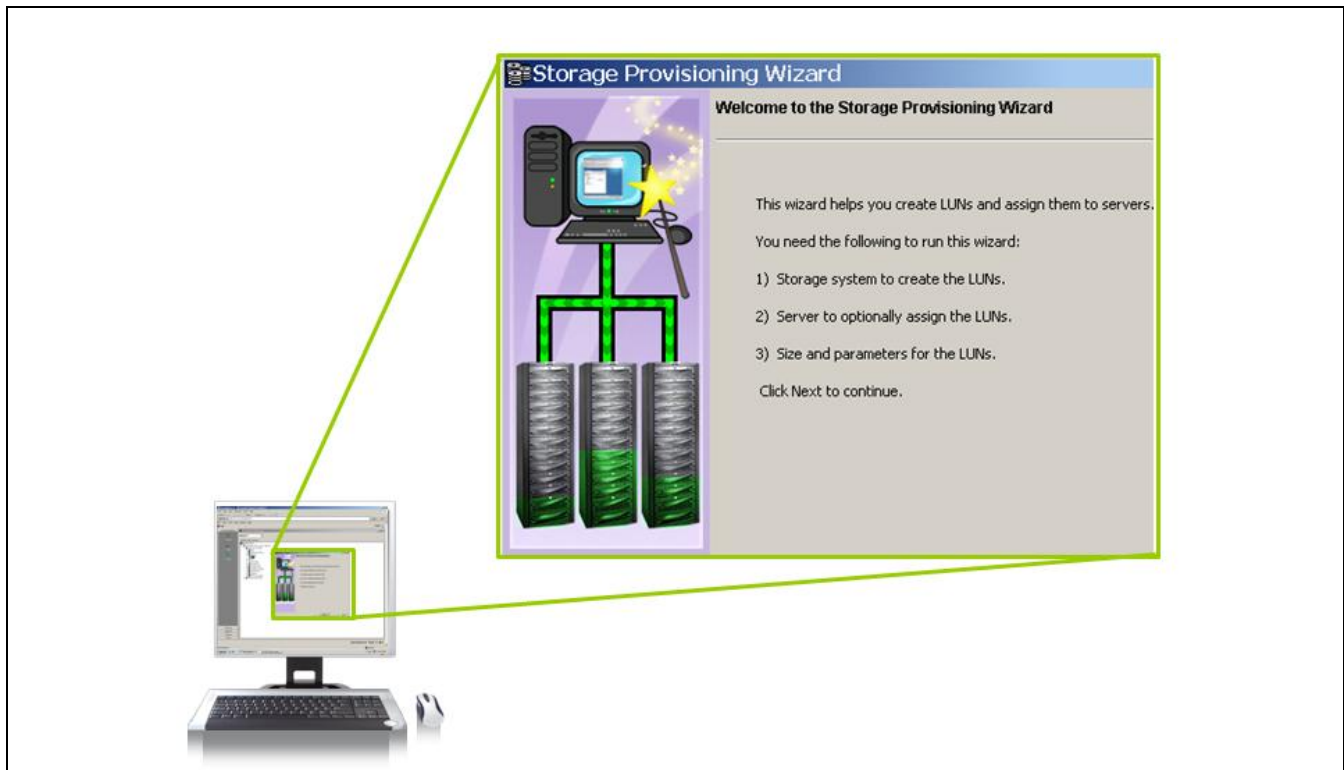
FIGURE 6. THE ESG LAB TEST BED



ESG Lab next examined a number of CX4 usability enhancements. Enhanced LED activity indicators and new search and diagnostic capabilities improve speed and accuracy when trouble-shooting. A new look and feel and a number of performance enhancements designed to simplify the management of large configurations was noted. ESG found the new write cache availability design to be especially powerful as it increases the availability and performance of the system when performing routine controller maintenance tasks.

ESG Lab used the Storage Provisioning Wizard to create and assign 256 1 GB LUNs on the CLARiiON CX4-960 as seen in Figure 7.

FIGURE 7. THE STORAGE PROVISIONING WIZARD



ESG Lab was able to create 256 1 GB LUNs utilizing the storage provisioning wizard through a simple three step process. In less than ten minutes, 256 LUNs had been created and were being scanned and recognized by a Windows Server.

Why This Matters

Modular storage deployments are growing in capacity and complexity within organizations of all sizes. IT managers are increasingly being asked to manage more storage capacity with the same, or less, manpower.

EMC has been continuously improving the ease of deployment and manageability of the CLARiiON product line for a number of years. As a matter of fact, in an ESG Lab review published in 2006, ESG Lab documented that the speed and simplicity of routine management tasks has improved up to 75%.⁴ During this latest round of testing of the fourth generation CLARiiON CX4, ESG Lab has confirmed that EMC is sticking with its game plan of continuous usability improvements, allowing customers to better manage, upgrade, and service the system over its lifetime. These usability improvements help CLARiiON end-users to further reduce costs and do more with less.

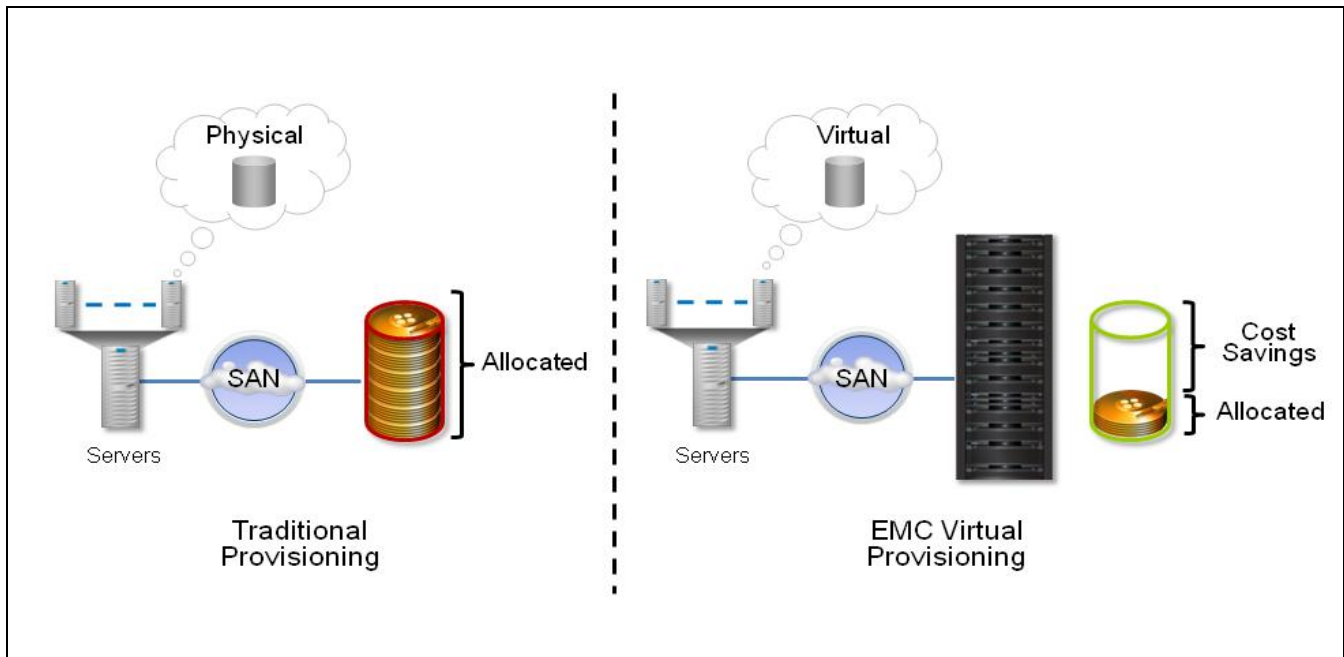
⁴ ESG Lab Review, *EMC Navisphere Ease of Use Improvements Enhance Productivity*, October 2006

Virtual Provisioning

EMC has added thin volume support, known in the industry as thin provisioning, to the latest release of the CLARiiON CX4. Thin volumes are used to define and allocate virtual capacity without having to dedicate physical disk capacity in advance. This feature allows administrators to assign servers all the storage space they might ever need while physically allocating only what is immediately needed by the application or users. Physical capacity is added automatically as needed to meet the changing needs of the business.

Figure 8 illustrates the differences between traditional physical provisioning and EMC's Virtual Provisioning. In this example, a Windows server is accessing a traditionally provisioned 1 TB volume. With traditional provisioning, the full 1 TB of disk space is allocated up front. Dedicating capacity to that particular server/application is required to avoid the risk of downtime when expanding capacity in the future. On the right, with EMC Virtual Provisioning, the server sees the same 1 TB volume, but only a fraction of that physical capacity is actually being consumed. The capacity saved is the difference between what has been physically allocated and what the server sees.

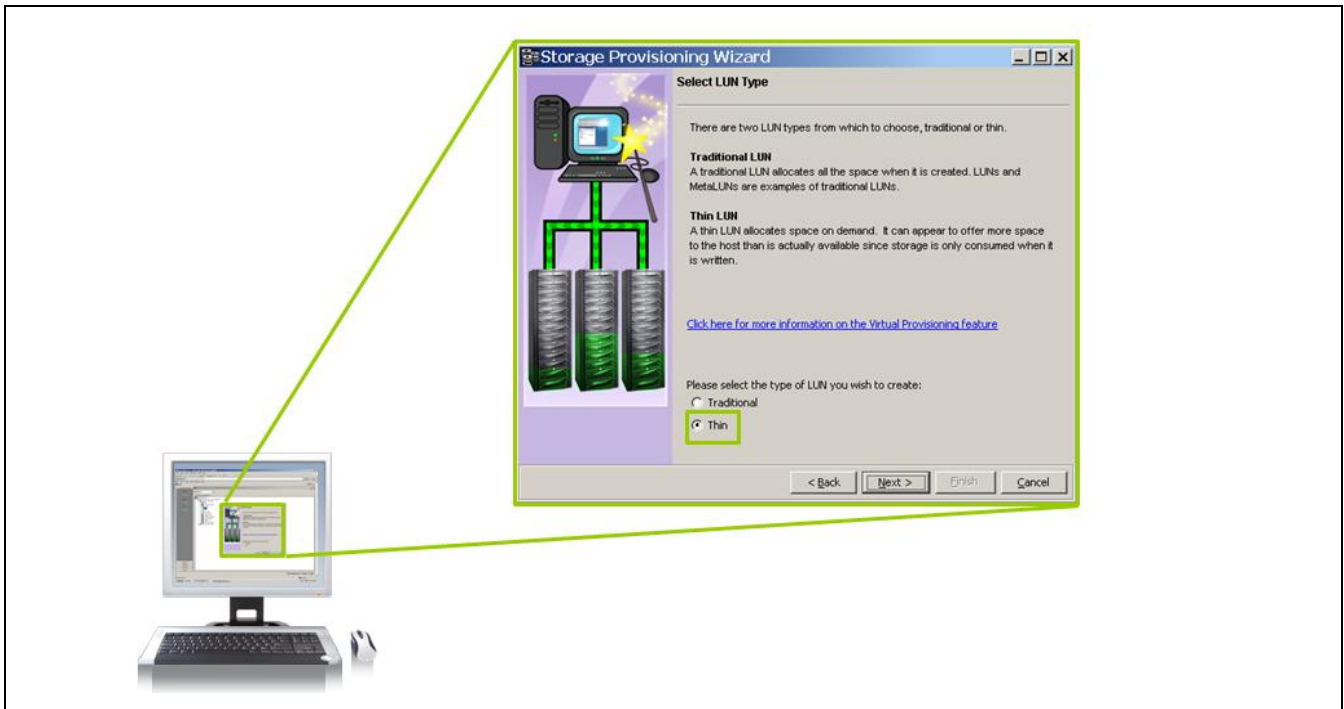
FIGURE 8. TRADITIONAL VS. VIRTUAL PROVISIONING



ESG Lab Testing

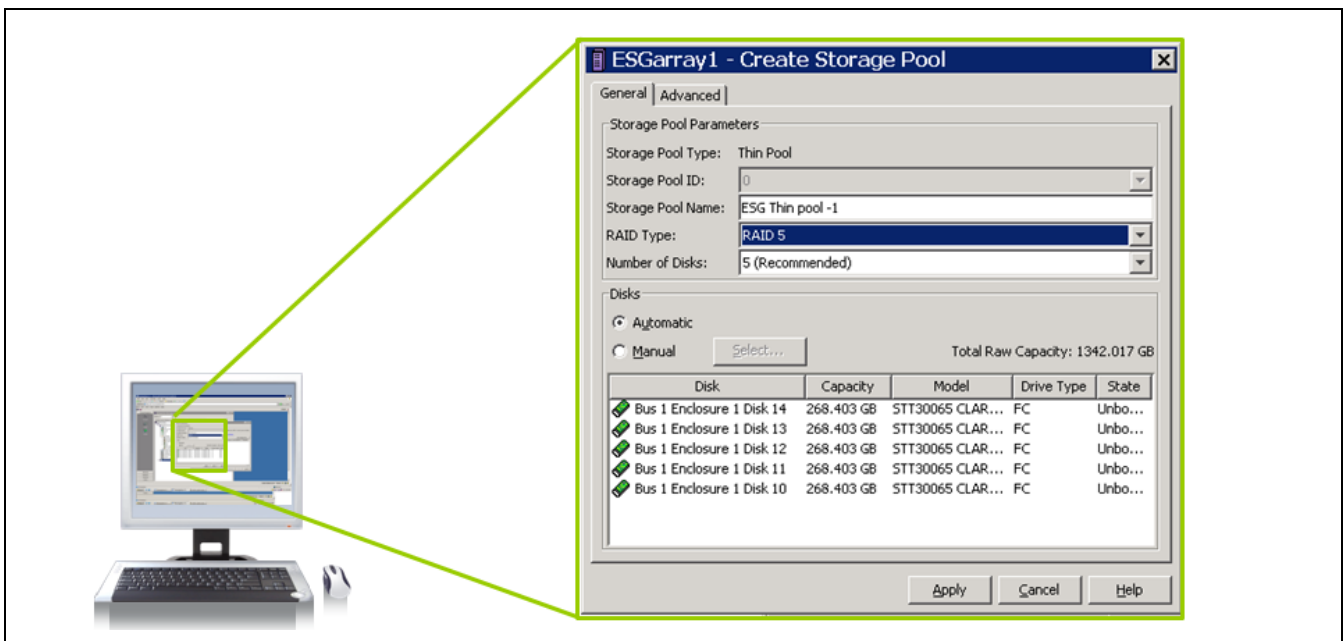
ESG Lab tested Virtual Provisioning with the CLARiiON CX4; the Storage Provisioning Wizard was launched from the Navisphere console. As seen in Figure 9, ESG Lab selected 'Thin' for the LUN type in the first dialog box presented by the wizard.

FIGURE 9. CONFIGURING A THIN VOLUME



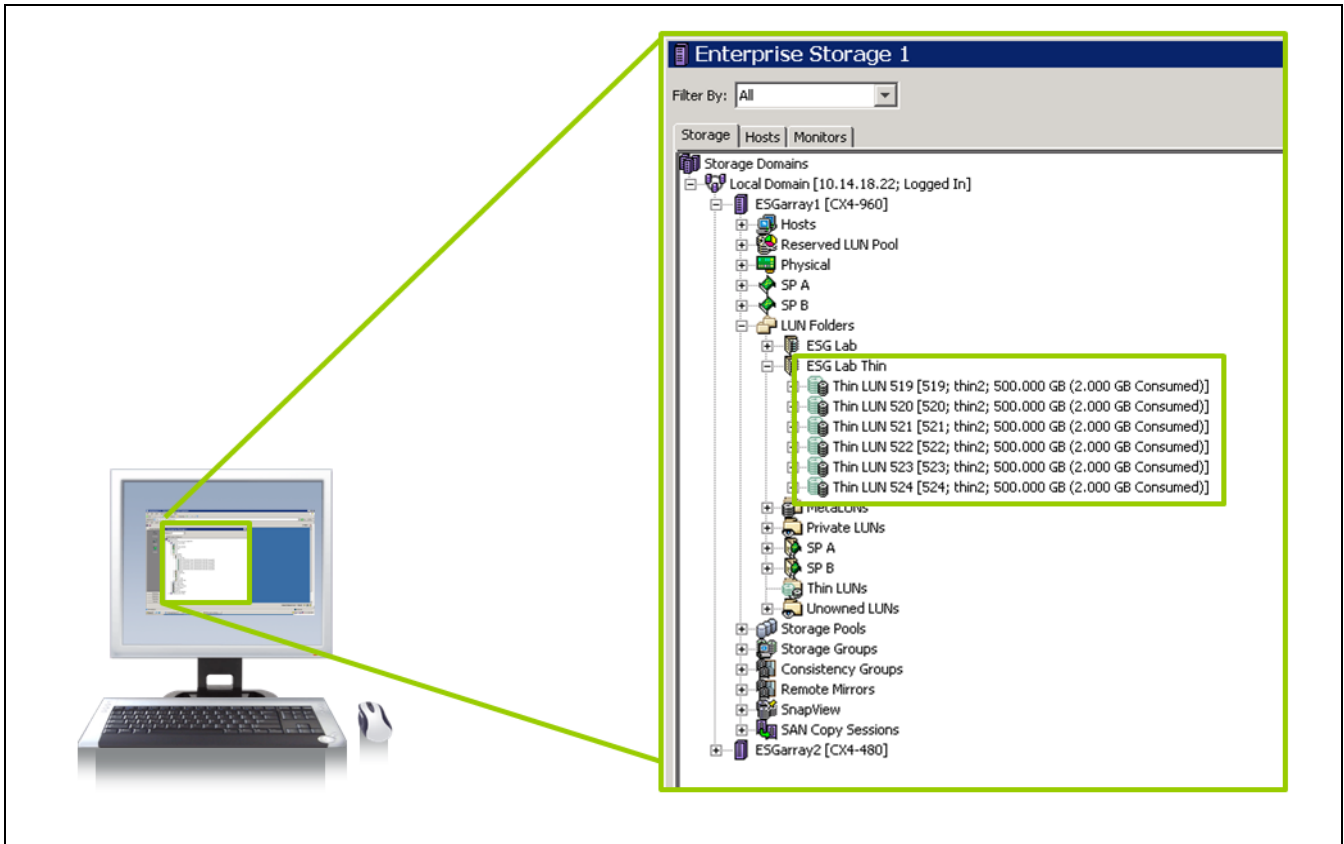
As seen in Figure 10, ESG Lab next created a Storage Pool from which the thin volume would be allocated. ESG Lab named the Pool 'ESG Thin Pool-1,' selected RAID-5 (4+1) protection and 'Automatic' disk selection. Navisphere automatically selected five available 300 GB disks to create a Storage Pool with 1 TB of available space. The 'Advanced' tab was used to set the '% Full Threshold' to 2% to demonstrate the CX4's ability to automatically alert administrators when a Storage Pool requires additional storage capacity.

FIGURE 10. CREATING A STORAGE POOL



The wizard was used to create six 500 GB thin volumes. ESG Lab found that the Navisphere Manager interface and virtual provisioning wizard are extremely intuitive and user friendly. As seen in Figure 11, six 500 GB volumes were created. Note that 3 TB of virtual capacity has been presented, yet only 12 GB of physical disk has been consumed.

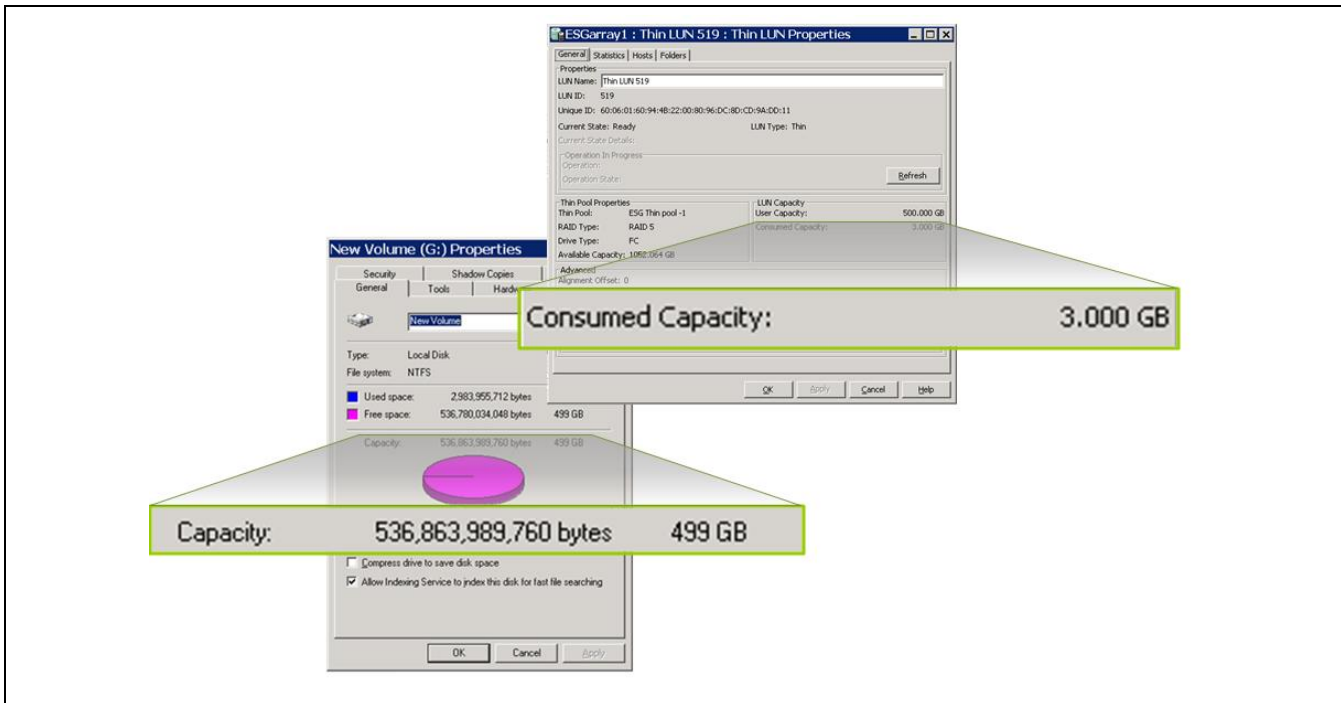
FIGURE 11. VIRTUAL PROVISIONED VOLUMES



At this point, ESG Lab used Navisphere to bind one of the volumes to one of the attached virtual servers running a Windows 2003 guest OS. The volume was mapped as the G:\ drive on the servers. A directory full of files from the local drive of the server was copied to this drive.

Figure 12 shows the properties of the G:\ drive on the left, and the CX4 perspective on the right. Note that the virtually provisioned 500 GB volume is consuming only 3 GB of physical disk capacity.

FIGURE 12. VIRTUAL PROVISIONING IN ACTION



In the next series of tests, ESG Lab tested the CX4's ability to alert administrators when thin storage pools exceed pre-defined thresholds. Additional file data was copied to the thin G:\ volume. As the consumed capacity in the thin storage pool exceeded a pre-defined threshold of 2% (~24 GB), Navisphere generated an alert and automatically sent an e-mail to the system administrator.

Finally, ESG Lab tested the ability to expand the capacity of a storage pool non-disruptively. ESG Lab right clicked on the 'ESG Thin Pool-1' icon in Navisphere and selected 'Expand Thin Pool.' Six more drives were added to the pool. The Navisphere properties screen confirmed that the physical capacity in the storage pool had expanded from 1 TB to 2.4 TB. The process was simple and seamless—I/O activity continued without interruption during the online capacity upgrade.

Why This Matters

ESG conducted a survey of storage administrators focused on the limitations and challenges of traditional storage provisioning methods. More than half reported that between 31% and 50% of their purchased capacity was stranded and unused.⁵ Eighty percent felt that storage provisioning had a significant negative impact on IT time and resources. In other words, traditional storage provisioning methods are placing a strain on capital and operating budgets.

ESG Lab has validated that CLARiiON Virtual Provisioning can be used to reduce the cost and complexity of storage provisioning while providing end-users with significant capacity savings—especially within dynamically expanding virtual server environments. As stranded storage is reclaimed, the purchase of new storage systems can be delayed or deferred. Higher utilization rates mean fewer storage systems deployed, thereby reducing capital costs as well as operational costs such as power, cooling, and space requirements in the data center.

⁵ Source: ESG Report, *Thin Provisioning*, April 2006

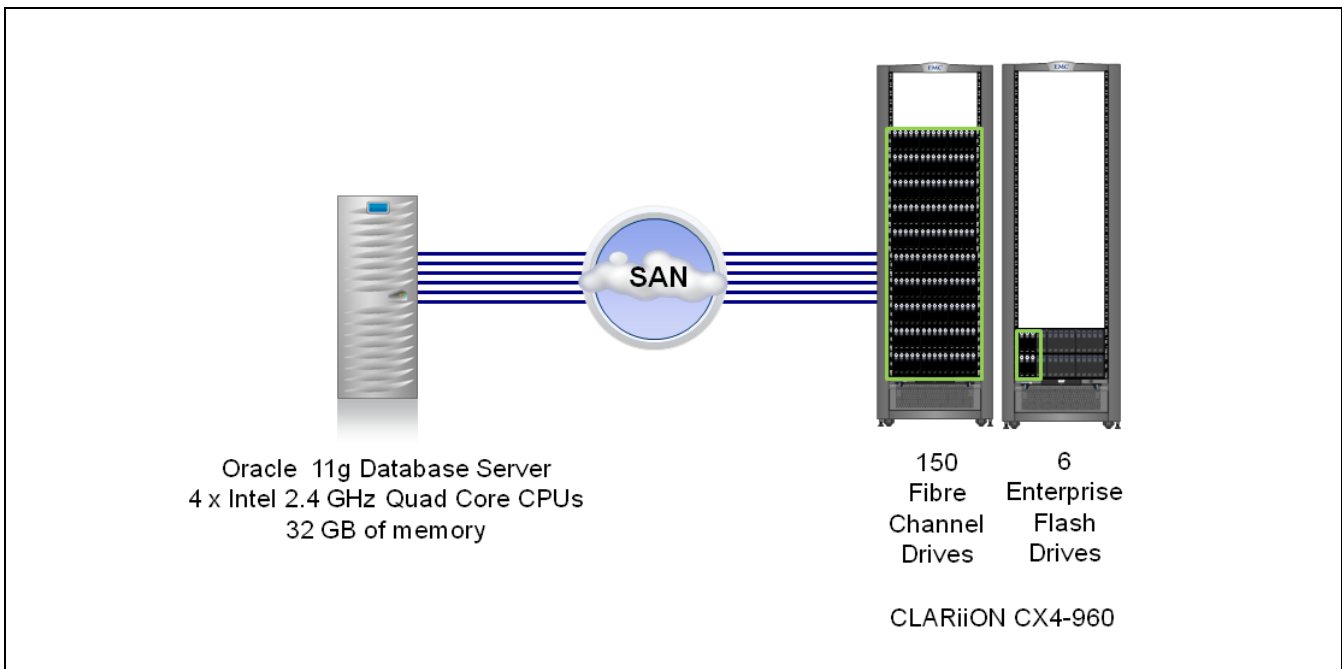
Enterprise Flash Drives

Enterprise Flash Drives is EMC's term for the solid state disk (SSD) technology offered first in its enterprise class DMX product line. Support for Flash drives is now also available on the modular CLARiiON CX4 product line. Flash drives store data using NAND Enterprise Flash memory. They provide throughput (IOPS) and response times that are an order of magnitude faster than the fastest traditional hard disk drive. Because Flash drives have no moving parts, they are more reliable, consume less electricity, and require less cooling than a traditional hard drive.

ESG Lab Testing

ESG Lab performed hands-on testing to compare the real-world performance and power consumption of Flash Drives and Fibre Channel disk drives. As seen in Figure 13, the test bed contained a CLARiiON CX4-960 with 150 15k RPM 300 GB Fibre Channel Drives and just six 73 GB Flash drives. The Fibre Channel and Flash Drives were both configured for RAID-5 protection and presented as a series of LUNS spread evenly across both Storage Processors. The database server was a Dell R900 server running Oracle Enterprise Linux 5.2 and Oracle 11g.⁶

FIGURE 13. THE CLARIIION CX4 EFD VS. FIBRE CHANNEL PERFORMANCE TEST BED



The FC LUNs were placed into one Oracle Automated Storage Management (ASM) disk group and all Flash LUNs were placed into another ASM disk group. All Oracle files, including logs, were placed into each disk group. The total database size was 260 GB.

Two Oracle workloads were tested. Testing began with a multi-user online transaction processing (OLTP) system that emulates a warehouse order entry application. The OLTP workload was modified for a second test to assess the performance of a read-intensive search request application requiring fast table scans. Performance was monitored at the Oracle database application level and at the CLARiiON storage subsystem level.

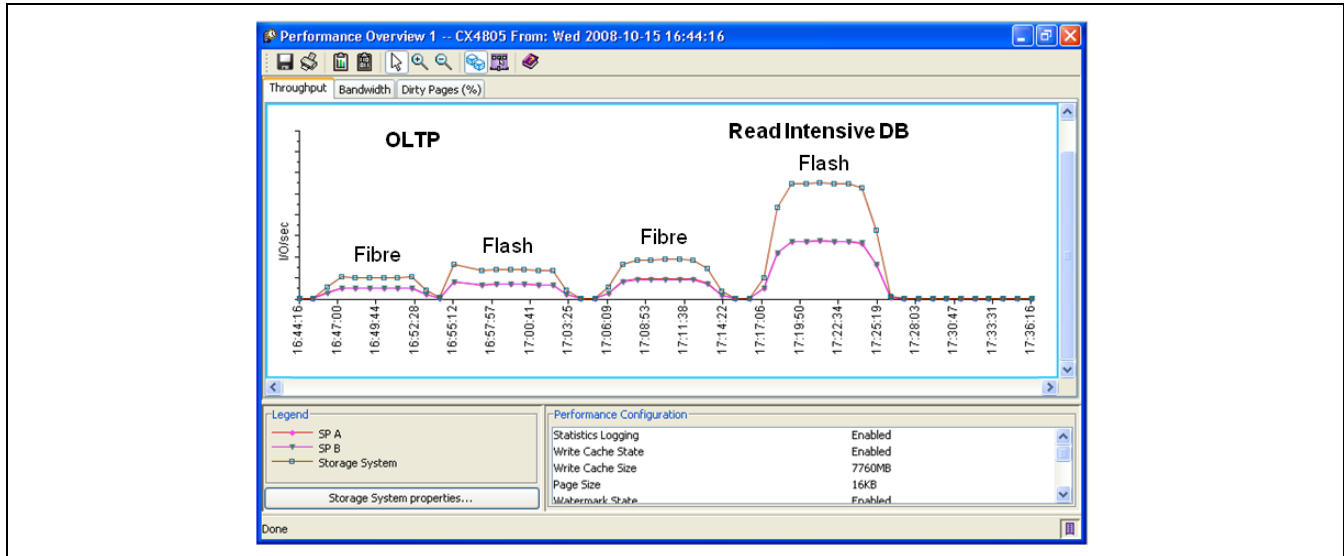
Analysis of results focused not only on the performance improvements that can be achieved with CLARiiON CX4 with Flash drive technology, but also on the total cost of ownership savings that can be achieved as a large

⁶ Configuration details are listed in the Appendix.

number of under-utilized FC drives are replaced with a handful of Flash Drives consuming dramatically less power, cooling, and space in the data center.

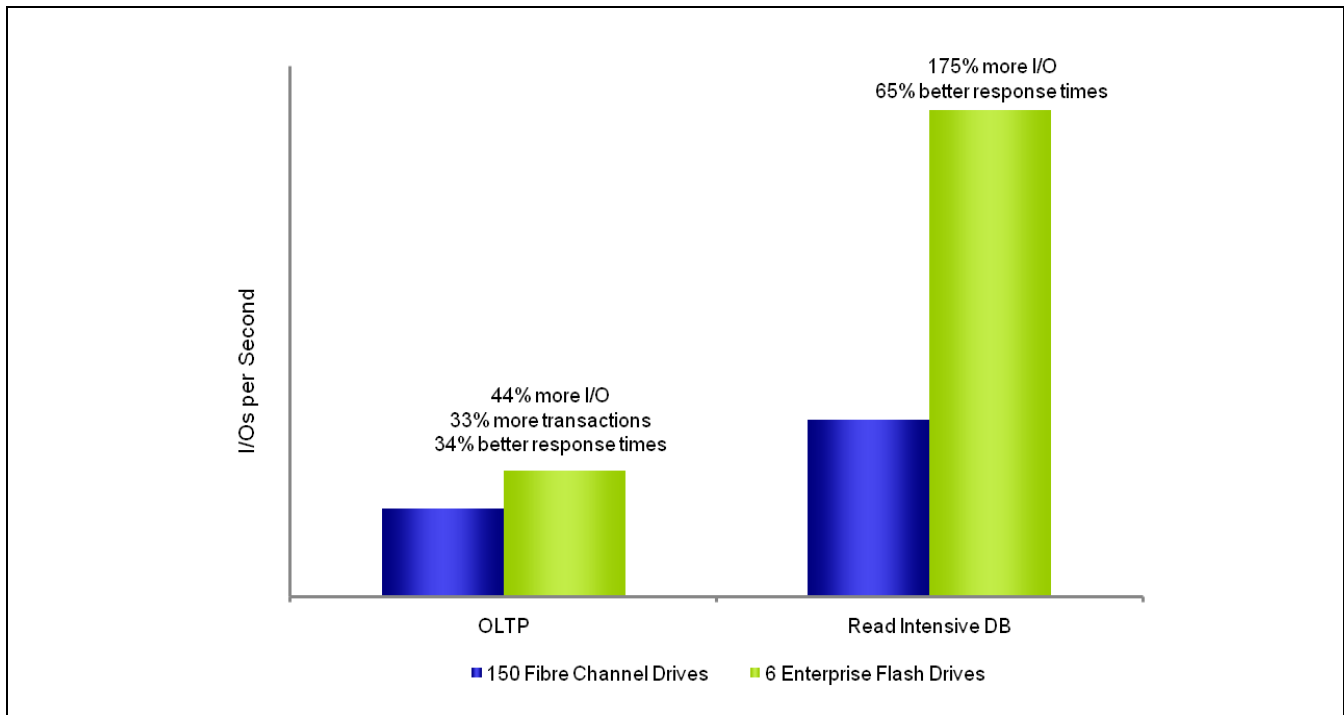
Figure 14 shows a Navisphere Analyzer Performance screen shot after each of the tests had completed. Using only six Flash Drives (versus 150 Fibre Channel drives), the number of I/O's per second improved significantly for each workload.

FIGURE 14. CLARIION CX4: FLASH VS. FIBRE CHANNEL PERFORMANCE COMPARISON



A deeper analysis of the performance benefits of the Flash Drive configuration is shown in Figure 15.

FIGURE 15. ORACLE DATABASE: FLASH VS FC PERFORMANCE COMPARISON (6 FLASH VS 150 FC DRIVES)



What the Numbers Mean

- Six Flash Drives performed better than 150 Fibre Channel Drives for both of the Oracle tests.
- Flash Drives performed 33% more transactions and improved response times by 34% during OLTP testing.
- The performance gap widened significantly to 175% more I/O for the read-intensive DB test.
- Latency, which translates directly into delays experienced by users, improved up to 65% with Flash Drives.
- With no moving parts, each Flash Drive processed between 36 and 70 times the number of I/Os per second compared to a mechanically spinning Fibre Channel Drive.
- The Flash Drives utilized 89% of their usable capacity, while the Fibre Channel Drives utilized less than 1%. This implies that for applications with extreme performance requirements, the CLARiiON CX4 with Flash Drives can dramatically increase the ROI for a storage solution.
- An ESG Lab audit of cost of CX4 infrastructure, media, and maintenance indicates that a configuration with six Flash Drives costs less than a configuration with 150 Fibre Drives.
- Using an average cost of commercial power in the US of 9.71 cents per kilowatt-hour in 2008 and a cost of cooling estimate of 60% the price of power, the Flash Drive configuration reduces power and cooling costs by a factor of 97%.⁷
- Using six Flash Drives instead of 150 Fibre Channel Drives reduces space requirements by 96%.
- A bottom line cost analysis of the total cost of ownership (including the cost of acquisition, maintenance, power and space) indicates that a CLARiiON CX4 configuration with six Flash Drives is 88% more cost effective than one with 150 Fibre Drives for the performance-bound application scenarios tested by ESG Lab.

Why This Matters

Mechanically spinning disk drives are the slowest component in the application compute chain. IT managers with extreme performance requirements have historically tackled this problem by deploying the fastest and most expensive drives and using less than the full capacity on each drive. This can be a tremendous waste of capital costs (drives) and operating costs (space, power, and cooling).

ESG Lab has confirmed that targeted use of Enterprise Flash Drives for critical application data sets (e.g., heavily used database index, temp and swap files) can not only be used to dramatically increase performance, it can also be used to dramatically reduce the total cost of ownership for performance-critical application environments.

⁷ http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html

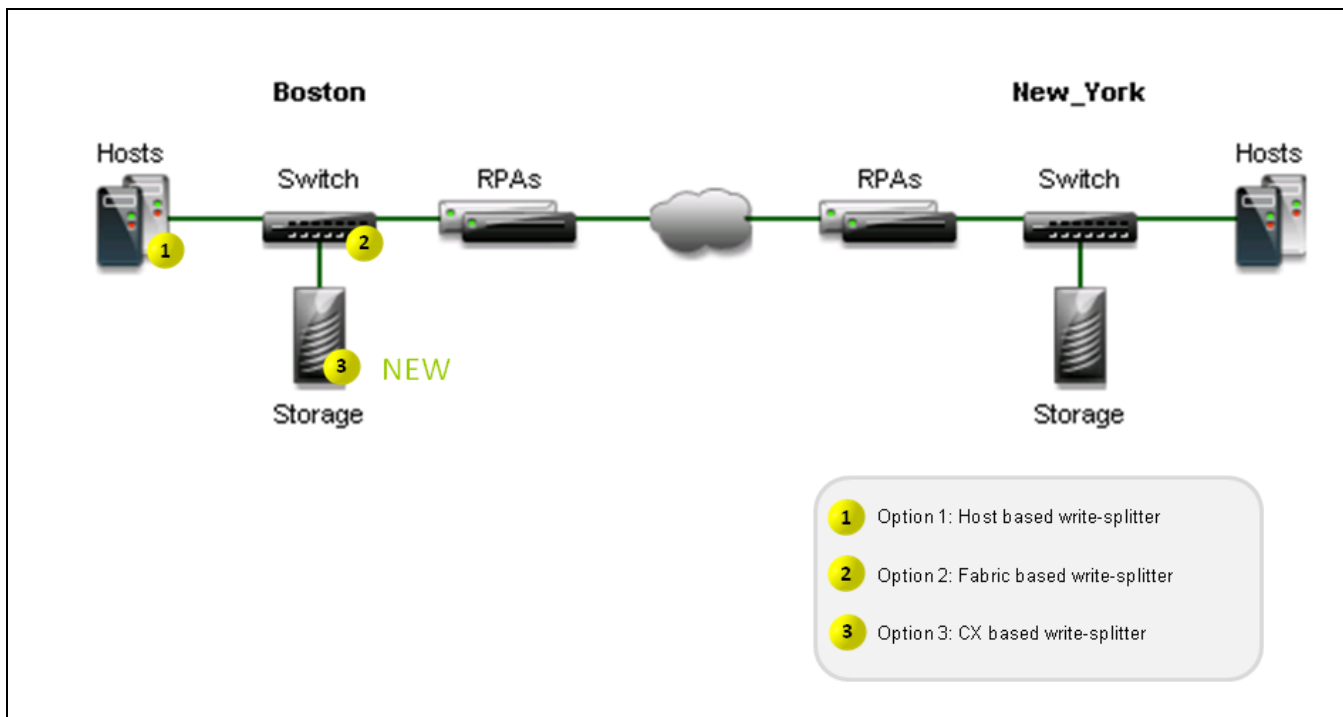
Integrated RecoverPoint Technology

RecoverPoint is EMC's continuous data protection (CDP) and continuous remote replication software for local and remote data protection and recovery to any point in time. RecoverPoint can be integrated into existing application protection processes, including disaster recovery solutions in VMware environments, to hasten the quick recovery of business-critical applications to a selected time or event. With the introduction of the CX4, EMC has built a RecoverPoint write-splitter directly into FLARE (EMC's CLARiiON firmware), which enables both local protection and remote DR copies for precise point-in-time rollback. EMC RecoverPoint replicates data to local SAN-attached storage using Fibre Channel and to remote sites over IP-based WAN connections. Bandwidth reduction technology and data compression enable RecoverPoint to make the most out of available network resources. RecoverPoint also allows systems to fail over to a secondary site and continue operations in the event of an outage or disaster at the primary site.

The three methods for implementing vital RecoverPoint write-splitter functionality are shown in Figure 16. The first method has the write-splitter running as a lightweight agent in host servers. The second method moves it to an intelligent data mover inside a FC switch. And the third method, delivered with every CLARiiON CX4 (and available on the CX3 since February 2008), has the write-splitter running within the CLARiiON itself.

In all of these scenarios, the RecoverPoint write-splitter communicates with RecoverPoint appliances (RPAs) installed at each end of the communication link between sites. In the ESG Lab replication test bed, RecoverPoint appliances were pre-configured in the local and remote locations and connected via a simulated WAN link between Boston and New York.

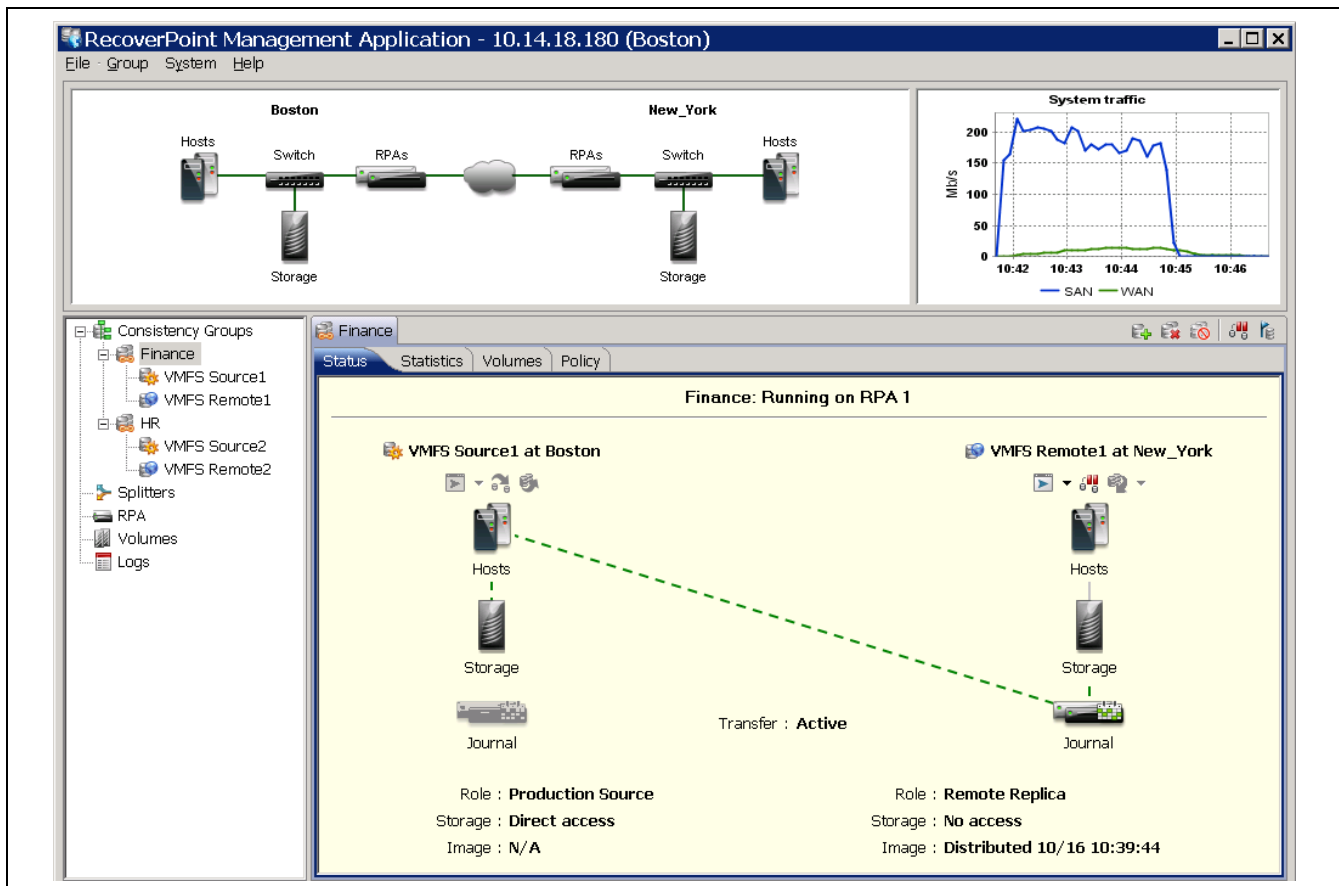
FIGURE 16. THREE OPTIONS FOR DEPLOYING RECOVERPOINT WRITE-SPLITTER TECHNOLOGY



ESG Lab Testing

ESG Lab used the RecoverPoint Management web console to manage and monitor RecoverPoint replication. As seen in Figure 17, replication was being performed between the local Boston data center and the remote location in New York. The RecoverPoint write-splitters were running in the CLARiiON arrays, labeled as Storage in the Boston and New York locations at the upper left. The system traffic pane at the upper right was used to monitor the SAN and WAN traffic through the RecoverPoint appliances (RPAs). The status window at the bottom right was used to monitor the health and progress of replication and recovery operations.

FIGURE 17. THE CX4 INTEGRATED RECOVERPOINT WRITE-SPLITTER IN ACTION



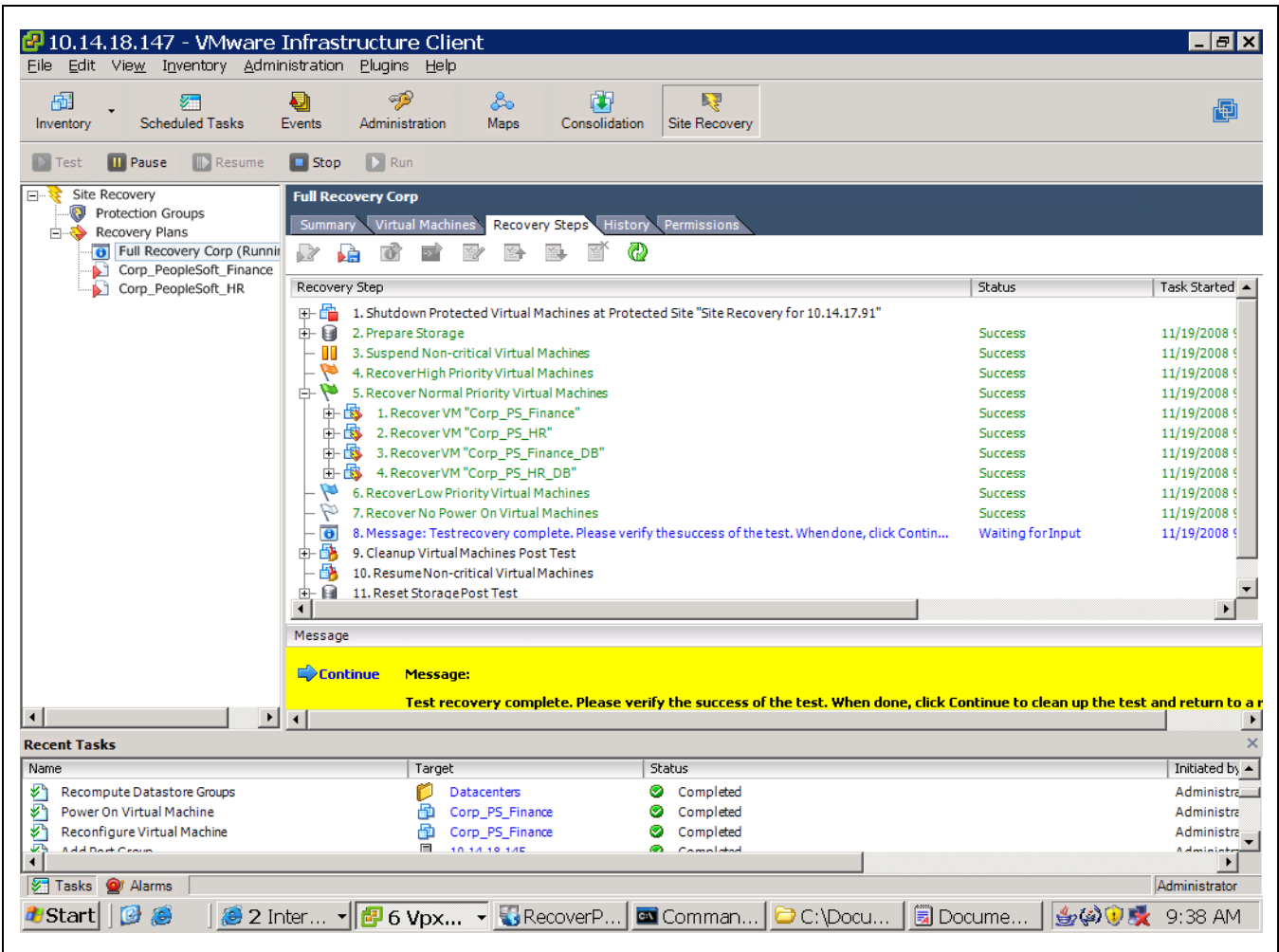
Note that the direction of RecoverPoint replication is shown by a dotted green line. ESG Lab found that the use of animation to show the direction of replication (in this case, from the production Finance application in Boston to the remote site in NY) is extremely intuitive and helpful.

To test the replica and verify that it was reliable and consistent with the production image, ESG granted access to the image of the replica at the remote site and then mounted the volume. Following a rescan of the server, ESG Lab confirmed that the image mounted from the remote site was an exact duplicate of the local image.

Next, ESG Lab validated the automated disaster recovery capabilities of VMware Site Recovery Manager (SRM) integrated with EMC RecoverPoint. A predefined SRM disaster recovery plan was used to test the automated recoverability of two 8 GB virtual machines. A screen shot taken during that test is shown in Figure 18. ESG Lab noted that replication continued and applications remained available throughout the automated execution of the plan. A full recovery was run using the same plan. ESG Lab noted that the direction of RecoverPoint replication changed automatically. The virtual machines were available four minutes and forty-three seconds after the automated disaster recovery process had started. ESG Lab noted that the time that it takes to recover virtual

machines has nothing to do with the size of a virtual machine. Instead, the time to recovery depends on the amount of “data lag.” Data lag is a measure of time needed to finish replicating writes that were in transit between a local and remote site at the time of a failover.

FIGURE 18. AUTOMATED RECOVERY WITH VMWARE SITE RECOVERY MANAGER AND RECOVERPOINT



Why This Matters

IT organizations running mission-critical applications need to guard against service interruptions. An interruption could be something common, such as a server failure, disk drive failure, software error, data corruption, a computer virus, or “pilot” error. It could also be something more disastrous, such as a fire, flood, natural disaster, pandemic, terrorism, or blackout. As a growing number of organizations standardize on the use of virtualized environments for mission-critical applications, rapid, manageable, reliable, and affordable disaster recovery solutions are needed now more than ever.

The CLARiiON CX4 with the RecoverPoint write-splitter simplifies Disaster Recovery deployments since the RecoverPoint write-splitter comes standard with every CX4. ESG Lab has verified that EMC RecoverPoint integrated with VMware Site Recovery Manager automates and simplifies failover and recovery testing in virtualized environments.

Optimizing Quality of Service in Virtualized Environments

IT managers are deploying multiple applications in a single consolidated virtual environment to reduce cost and complexity, but this often makes it difficult to manage performance service levels. Oftentimes, applications and end-users are left waiting for system resources to free up. The manual task of monitoring and diagnosing potential performance problems can be a time-consuming process which often leads to over-provisioning of server and storage resources which increases costs.

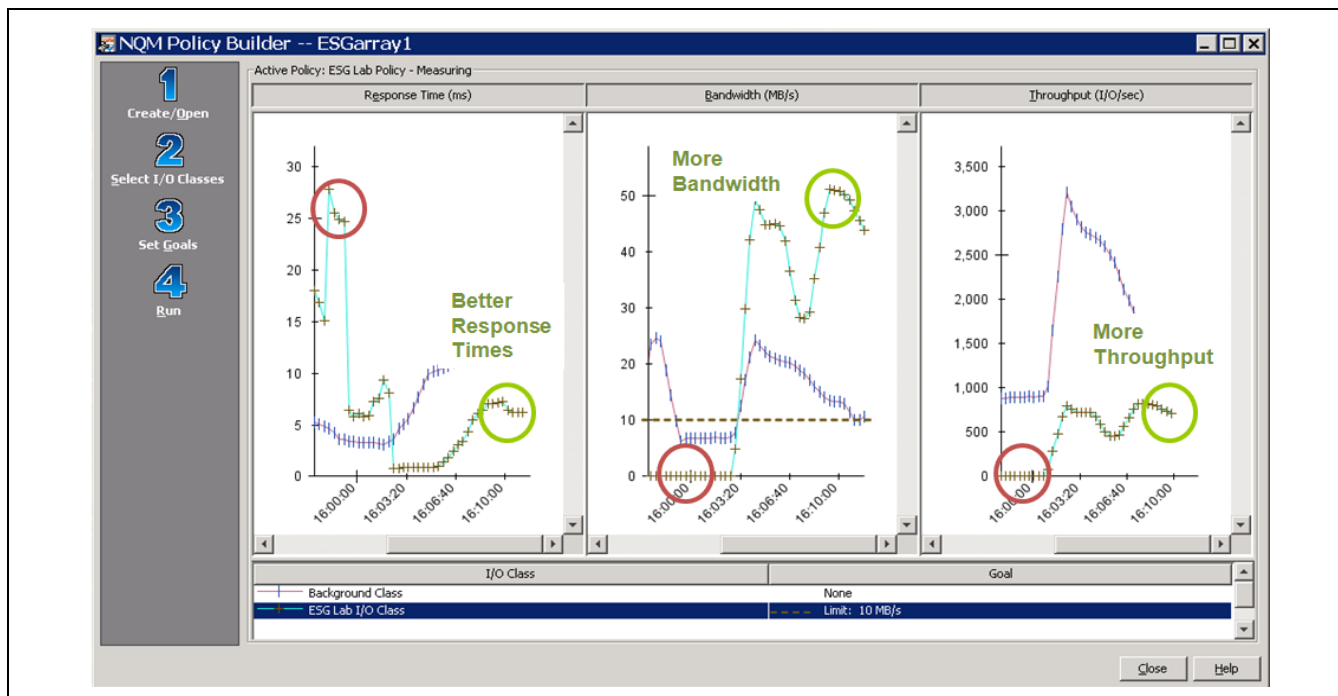
EMC's Navisphere Quality of Service Manager (NQM) enables allocation of CLARiiON CX4's storage system performance resources on an application-by-application basis. NQM can help resolve performance conflicts in virtual server environments where multiple applications share the same storage system. It also enables administrators to create performance thresholds to prevent applications from monopolizing storage-system resources.

VMware Distributed Resource Scheduler (DRS) continuously monitors utilization and allocates server resources among virtual machines according to business needs. DRS can be configured to make recommendations or automatically perform load balancing based on the CPU and memory requirements of applications running in virtual machines. It can also be used to decrease planned or unplanned downtime for improved business continuity.

ESG Lab Testing

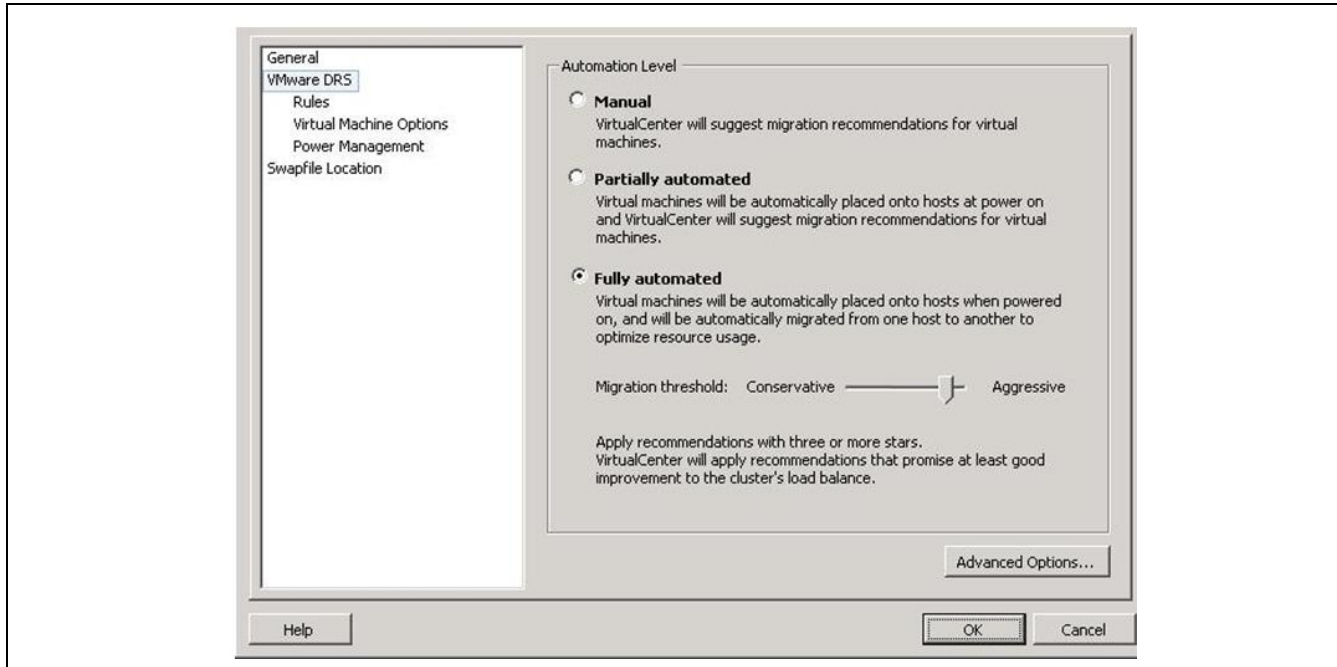
Two physical servers running VMware ESX were connected to the same CLARiiON CX4 storage array. Three virtual machines were configured. The first virtual machine was used to deploy a response time sensitive OLTP database application. The second and third virtual machines ran a throughput intensive application meant to simulate I/O intensive test and development activity. CLARiiON NQM policy wizards were used to monitor and tune performance with a goal of improving the response time and I/O performance of the production OLTP application. Using an intuitive four step wizard, a bandwidth limit of 10 MB/sec was defined for the test and development workload. As shown in Figure 19, the performance benefits for the production OLTP application were dramatic. Response times improved significantly as bandwidth and throughput increased.

FIGURE 19. OPTIMIZING PERFORMANCE WITH NAVISPHERE QUALITY OF SERVICE MANAGER



With resource allocation optimized at the storage system level using CLARiiON NQM, ESG Lab used DRS to tune performance at the server level. The two physical servers were configured within a VMotion network as a DRS-enabled cluster. CPU and memory reservations were defined for the performance-critical OLTP application running in the first virtual machine. The VMware DRS wizard shown in Figure 20 was used to enable automatic migration of virtual machines within the cluster.

FIGURE 20. CONFIGURING VMWARE DISTRIBUTED RESOURCE SCHEDULER (DRS)



ESG Lab watched as DRS automatically moved a low priority test and development virtual machine to the second physical server. This gave more CPU and memory resources to the high priority OLTP application. ESG Lab noted that the combination of CLARiiON NQM and VMware DRS can not only be used to minimize the performance impact of test and development applications, but can also be used to minimize the potential performance impact of backup and recovery operations.

Why This Matters

ESG research indicates that performance is a key concern when deploying applications in a highly consolidated virtual environment. With multiple applications relying on a shared infrastructure, there is a concern that performance requirements can't be met affordably. As a matter of fact, 51% of ESG survey respondents that have already deployed virtual servers connected to networked storage report that performance is their top concern.⁸

With CLARiiON NQM providing quality of service at the storage system level and VMware DRS providing load balancing at the server level, ESG Lab has verified that NQM and DRS can be deployed together to cost-effectively guarantee a defined level of performance for mission-critical applications running in virtualized storage and server environments. As customers continue to search for ways to drive down costs CLARiiON NQM and VMware DRS offer an excellent alternative to the traditional "throw more hardware at it" solution.

⁸ Source: ESG Research Report, *The Impact of Server Virtualization on Storage*, December 2007

ESG Lab Validation Highlights

- ☑ An intuitive wizard was used to install FC UltraFlex I/O modules with no impact to running applications.
- ☑ ESG Lab reviewed a number of usability improvements, including a number of Navisphere Manager enhancements which streamline the management of large configurations.
- ☑ Virtual Provisioning was used to efficiently provision storage while providing significant capacity savings.
- ☑ Database application workloads were used to compare the performance and total cost of ownership of 6 Flash Drives and 150 Fibre Channel drives. Flash Drives performed 33% more transactions and improved response times up to 65%. A bottom line cost analysis—including the cost of acquisition, maintenance, power and space—indicates that the six Flash Drive configuration was 88% more cost effective than the 150 Fibre Channel drive configuration.
- ☑ EMC RecoverPoint integrated with VMware Site Recovery Manager was used to automate and simplify failover and recovery testing.
- ☑ CLARiiON NQM and VMware DRS were used to optimize the performance of a response-time sensitive database application that was being impacted by a pair of throughput intensive test and development applications.

Issues to Consider

- ☑ While ESG Lab has proven that Enterprise Flash Drive technology can provide significantly higher performance and can be cost justified for some performance sensitive applications, ESG Lab recommends careful consideration when deciding when and where to apply this new technology due to its initially high price compared to traditional hard drive technology. In other words, when deciding when and where to use Flash Drives in your organization, look for applications where the value of a transaction may be considered priceless to your business. When the total cost of ownership for performance critical applications is taken into account, ESG Lab is confident that a few Flash drives can provide significant improvements compared to many “short stroked” FC Drives.
- ☑ While the energy efficiency of the CLARiiON product line has been dramatically improved, policy-based drive spin-down could be used to magnify the savings—particularly for large near-line archives that are infrequently accessed. While this technology is currently available in the EMC Disk Library product, it is not yet supported within the CX4 family. EMC has advised ESG Lab that policy-based drive spin down is planned for a future code release of the CX4.
- ☑ UltraFlex I/O modules supporting 8 Gbps Fibre Channel and 10 Gbps Ethernet host interfaces would be a welcome enhancement to the CX4 family to meet the performance needs of extremely bandwidth intensive applications (e.g., high definition video editing). EMC indicates that support for each of these interfaces is planned for a future code release of the CX4.

ESG Lab's View

Imagine the plight of an IT professional trying to justify next year's storage strategy as his senior level manager struggles with the impact of the current global financial crisis. How am I going to keep up with capacity growth of 50% or more annually without blowing the budget? How can I protect my storage investments—now and in the future? Can I manage more capacity with better performance and service levels with the staff I have today? Will my storage investments complement—or complicate—my virtual server consolidation initiative? How am I going to create a winning strategy that works for my organization *and* my team?

ESG has been tracking the success of EMC CLARiiON for more than a decade. With a broad and well-balanced array of features, "five-nines" levels of field-proven reliability (99.999%), and a world-class management and support team, the EMC CLARiiON is being used by more than 300,000 customers around the world as part of a winning storage strategy.

ESG is not only impressed with EMC's ability to continually increase the capacity, performance, and capabilities of the CLARiiON product line, but also by its focus on continuously improving manageability. In 2006, ESG Lab confirmed that the enhanced usability of the Navisphere management GUI reduced the time and mouse clicks needed to perform routine tasks by up to 75%. ESG Lab testing of the fourth generation CX4 family in 2008 has confirmed that EMC is sticking with its game plan of continuously simplifying routine management tasks. ESG Lab was particularly impressed with the new quick start placemat for quick and easy out-of-the-box installation, the new look and feel of the Navisphere GUI, a growing number of intuitive wizards, and GUI performance improvements that streamline the management of large configurations. Each of these enhancements reduces the cost and complexity of managing and upgrading a CLARiiON system over its lifetime.

The CX4 includes a number of innovative technologies which lower the cost of ownership for CLARiiON customers. UltraFlex modules and a flexible mix of I/O interface options enables investment protection for years to come. Virtual provisioning delivers capacity on demand as it avoids the wasted expense of allocated, yet unused, capacity. Use of Enterprise Flash Drives avoids the wasted cost of over-provisioned disk capacity for applications with extreme performance requirements. As a matter of fact, ESG Lab hands-on testing of Oracle database applications has confirmed that CLARiiON CX4 with a six Flash Drive configuration, which costs less than a 150 drive FC configuration, can perform more transactions with significantly faster response times and drastically lower power and cooling requirements. An analysis of the total cost of ownership indicates that a CLARiiON CX4 configuration with six Flash Drives is 88% more cost effective than one with 150 Fibre Channel Drives for the performance-bound application scenarios tested by ESG Lab.

The CX4 continues the CLARiiON heritage of providing a rich set of advanced availability and protection options. RecoverPoint software, which provides continuous local and remote protection, was tested with vital write-splitter functionality running inside the CLARiiON. ESG Lab was extremely impressed with the advanced protection capabilities and drop-dead simplicity of RecoverPoint when tested in 2007. With vital write splitter functionality running within CLARiiON instead of on a host or an intelligent switch, EMC has reduced the cost and complexity of deploying this valuable technology. Making it even more valuable in virtual server environments, ESG Lab has confirmed that RecoverPoint has been integrated with VMware Site Recovery Manager. And last but not least, ESG Lab has confirmed that Navisphere Quality of Service Manager (NQM) and VMware Distributed Resource Scheduler (DRS) can be used to improve the flexibility, efficiency, and predictability of consolidated virtual server environments.

Leveraging the latest in multi-core 64-bit processor technology and supporting up to 960 drives, EMC has dramatically enhanced the capacity and performance scalability of the CLARiiON CX4 product family. While the speeds and feeds are impressive, ESG Lab is most impressed by the continuous improvements in manageability and the long list of valuable new capabilities that have been built into the CX4 platform. From the speed and power efficiency of Flash Drives to the dramatic TCO improvements of UltraFlex and Virtual Provisioning technology, the breadth and depth of the new features built into the CX4 platform can be used to meet the precise needs of any organization. If your organization is struggling to keep up with data growth while providing ever higher levels of performance and availability – with stagnant or shrinking budgets, ESG Lab recommends that you consider the CLARiiON CX4 as the foundation for your own winning storage strategy.

Appendix

TABLE 3. ESG LAB TEST BED

Primary Test Bed	
EMC CLARiiON Arrays	
CX4-960 Rev. 04.28.000.4.505 4 x 4 Gbps FC HBAs	100 x Fibre Channel Drives 15 x Low Power SATA II drives 5 x Flash Drives
CX4-480 Rev. 04.28.000.4.505 2 x 4 Gbps FC HBAs	40 x Fibre Channel Drives 15 x Low Power SATA II Drives 5 x Flash Drives
Host Servers	
Dell PE2850 2.8 GHz CPU; 8 GB RAM	Windows 2003 SP2 2 x 4 Gbps Fibre Channel HBAs
Dell PE2850 2.8 GHz CPU; 8 GB RAM	VMware ESX Server 3.x 2 x Windows 2003 Guest OS virtual servers 2 x 4 Gbps Fibre Channel HBAs
Dell PE2850 2.8 GHz CPU; 8 GB RAM	VMware ESX Server 3.x 1 Windows 2003 Guest OS virtual servers 2 x 4 Gbps Fibre Channel HBAs
FC SAN Switches	
2 x EMC Connectrix DS5000B - 4 Gbps	
Enterprise Flash Drive Test Bed	
EMC CLARiiON Arrays	
CX4-960 Rev. 04.28.0.3.593 4 x 4 Gbps FC HBAs	150 x 15k 300GB Fibre Channel Drives 6 x 73GB Flash Drives
Host Servers	
Dell PowerEdge R900 4 x Intel Quad-Core 2.4 GHz CPU; 32 GB RAM 6 x 4 Gbps FC HBAs	Windows 2003 SP2 Oracle
FC SAN Switches	
2 x EMC Connectrix DS5000B - 4 Gbps	



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