LAB VALIDATION REPORT

EMC Symmetrix V-Max

24xForever Storage for Virtualized Data Centers

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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.

Introduction

IT managers have relied on the trusted family of EMC Symmetrix storage solutions to meet the availability, scalability, and performance needs of enterprise-class applications for more than a decade. This report documents hands-on testing and validation of the revolutionary new Symmetrix architecture with a focus on enhancements ideally suited for the growing number of organizations that rely on virtualized servers and a consolidated information infrastructure. New management abstraction improvements, including wizard-based virtual storage provisioning and online VLUN migration, are highlighted.

Background

The virtualization of servers has had, and continues to exert, a profound and positive impact on networked storage. Once servers and applications are shared, flexible, and mobile, it is only sensible that the storage underpinning them is made part of a shared, malleable, and powerful data pool. This simultaneous consolidation and sharing allows central and easier management: IT can be far more responsive to the changing needs of the business, and—a crucial point given the current economic situation—it enables better cost efficiency and effectiveness. Quite simply, it is the modern fulfillment of the old IT adage: 'do more with less.'

While the benefits of a highly virtualized and consolidated information infrastructure are clearly obvious, ESG research indicates that IT managers struggle with a number of challenges when deploying server virtualization with networked storage.[1] As shown in Figure 1, IT managers looking to consolidate on a massive scale are concerned about performance, cost, and manageability, as well as best practices, testing, and qualification.

FIGURE 1. STORAGE CHALLENGES DUE TO VIRTUALIZATION

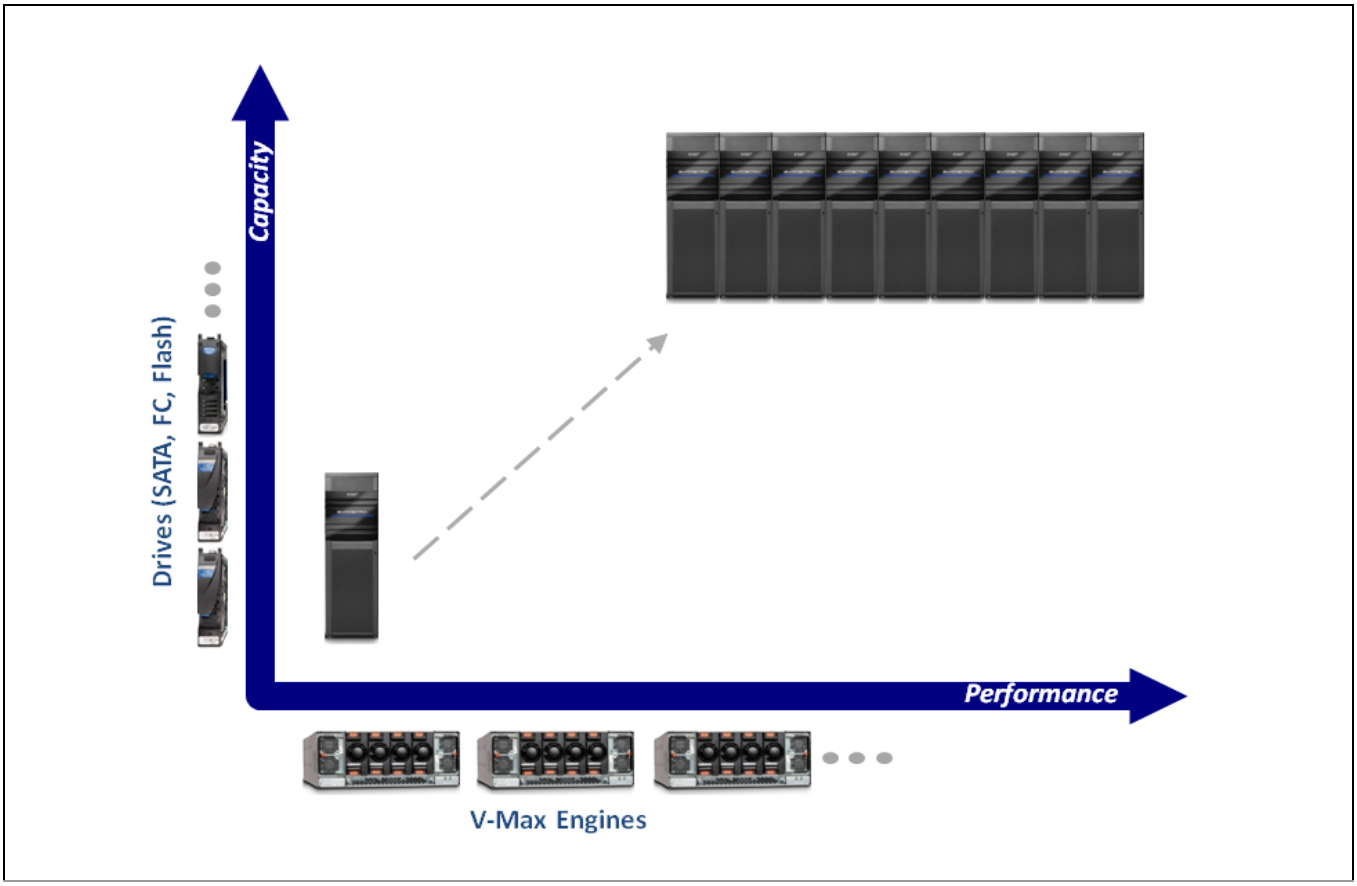
[1] Source: ESG Research Report, *The Impact of Server Virtualization on Storage*, December 2007.

Introducing the EMC Symmetrix V-Max

The new Symmetrix V-Max is ideally suited to meet the needs of a highly consolidated information infrastructure. The V-Max boasts a number of significant hardware advances, including more powerful multi-core processors, additional bandwidth, and continuously improving energy efficiency. These evolutionary advances are packaged within a revolutionary new architecture that breaks the limits of traditional back-plane connected enterprise-class storage arrays using a collection of fault-tolerant director pairs, which individually make up V-Max Engines, interconnected via a virtual matrix. This revolutionary new architecture increases flexibility and lowers the cost of ownership today, with the potential to change the way IT managers solve enterprise-class information challenges in the future. This radical new approach has the potential to extend the bounds of an online storage solution from the confines of a rack to the walls of the data center—and beyond.

A virtual matrix allows the sharing of all major components—CPU, memory, disks, ports—across all V-Max Engines. This approach was designed to address the challenges of a highly consolidated information infrastructure including linear scale-out, fully non-disruptive operation, advanced functionality, and automation. It retains interoperability with existing Symmetrix systems and legacy applications and is ideally suited to meet the needs of highly consolidated data centers. Starting with a rack-mounted enclosure full of drives and a single V-Max Engine, the flexible new architecture of the Symmetrix V-Max can be used to scale performance and capacity to meet needs of a wide range of applications.

FIGURE 2. ENTERPRISE-CLASS SCALABILTY OF THE SYMMETRIX V-MAX TODAY



Although the architecture has changed, the new Symmetrix preserves its proven high-end capabilities—a crucial and positive point for the many satisfied users of the current product line. It supports mainframe, UNIX, and server virtualization environments with ultra-high availability, reliability, and online serviceability. Familiar, valuable, field-proven capabilities, including remote mirroring (SRDF), cloning (TimeFinder), and virtual provisioning (a.k.a. thin provisioning) are all still there.

This intriguing mix of field-proven capabilities running on a revolutionary new hardware platform has been used to extend the evolutionary march of continuously advancing capabilities that customers have come to expect from the Symmetrix product line:

- Petabytes of capacity
- Gigabytes of internal memory and bandwidth
- Enterprise-class performance scalability
- 24xForever availability
- Fully non-disruptive operation
- Mixed server support including zSeries, iSeries, Unix, VMware, Hyper-V and Xen
- Mixed drive support including Flash, FC, and SATA
- Continuously improving ease of use
- Automated online migration

The balance of this report presents the results of ESG Lab hands-on testing with a goal of examining the revolutionary new architecture and evolutionary new capabilities of the Symmetrix V-Max.

ESG Lab Validation

ESG Lab performed hands-on evaluation and testing of the EMC Symmetrix V-Max at EMC's corporate headquarters in Hopkinton, Massachusetts. The evaluation began with an overview of the new architecture and a physical inspection of a number of V-Max systems running development, integration, and quality assurance tests.

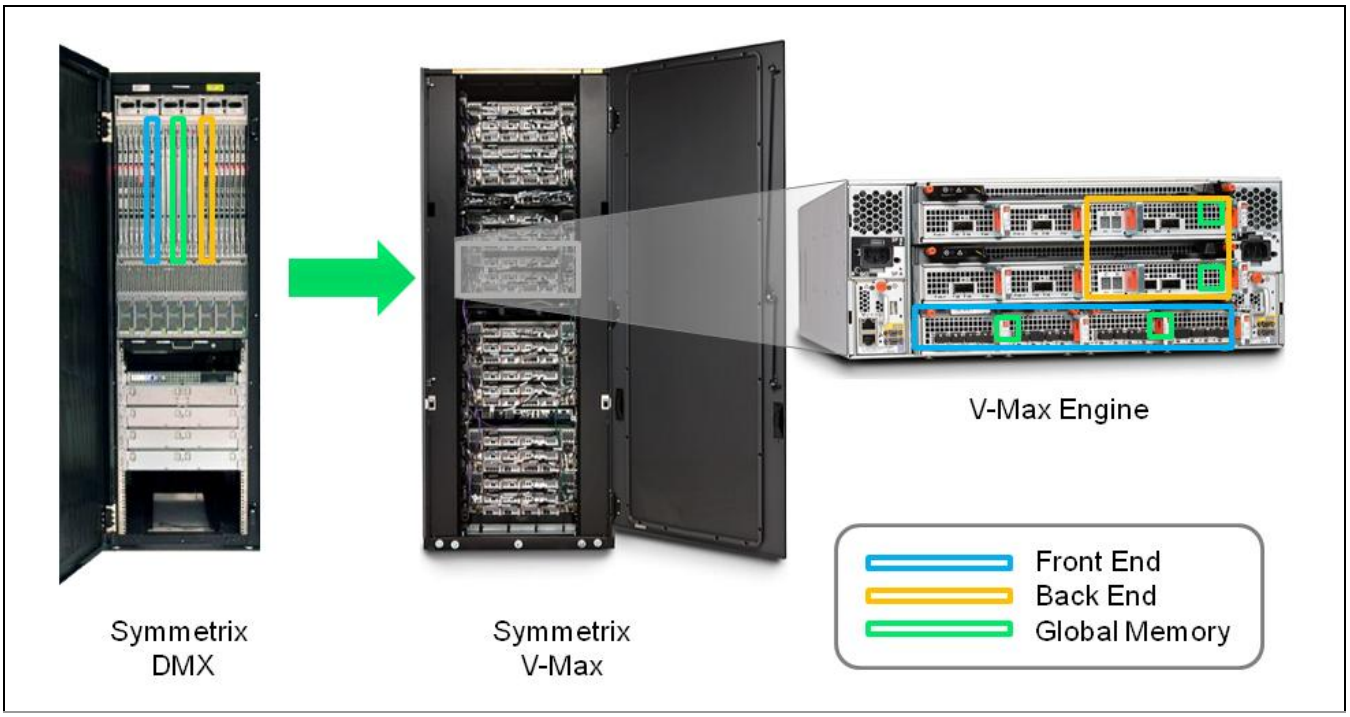
Revolutionary Scalability and Flexibility

The architecture of the Symmetrix has changed, but the basic building blocks are the same as when the first Symmetrix was released more than a decade ago:

- Front-end directors connect to servers
- Back-end directors connect to drives
- Global memory is shared by all directors
- Drive enclosures hold storage capacity

What's new and revolutionary about the architecture of the Symmetrix V-Max is how these building blocks are packaged and connected. As shown in Figure 3, directors and global memory are plugged vertically into a backplane in the Symmetrix DMX. The Symmetrix V-Max uses a modular approach, with V-Max Engines mounted in a frame. A pair of front-end directors, back-end directors and global memory, is consolidated within each V-Max Engine.

FIGURE 3. V-MAX ENGINES: EFFICIENTLY SCALING PERFORMANCE AND CONNECTIVITY

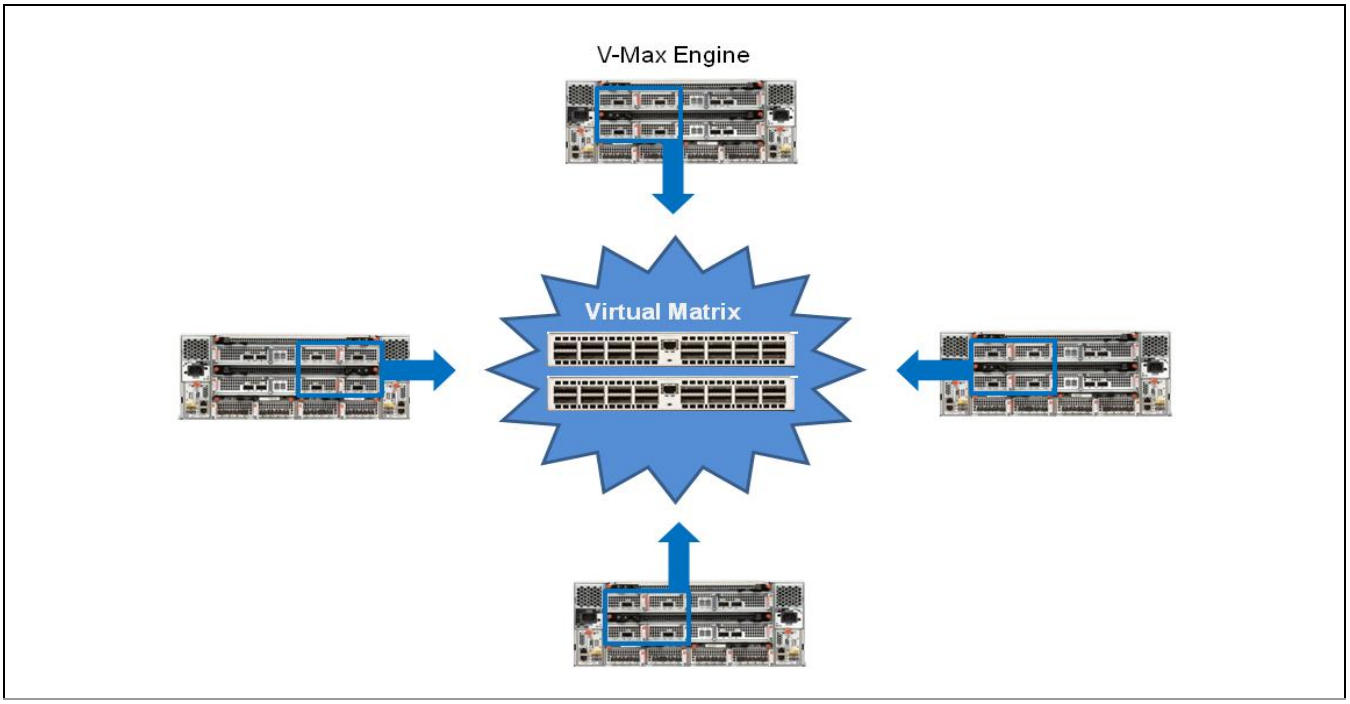


An entry level system can be configured with a single highly available V-Max Engine and one or more drive enclosures. Drive enclosures and V-Max Engines can be added online to meet growing capacity, performance, and availability requirements. Up to eight V-Max Engines can be configured in a single system. Each V-Max Engine is equipped with redundant power, fans, and batteries. This right-sized approach can be used to dramatically reduce power and cooling requirements in the data center compared to the traditional approach of a

large power, battery, and fan complex within each frame. EMC indicated to ESG Lab that they have seen as much as a 22% reduction in power requirements for a V-Max compared to a DMX-4 in similarly configured systems with the same numbers of drives. ESG Lab has not yet verified this claim through Lab Validation testing. One of the additional benefits of this new architectural approach is a move from bottom/top to front/back airflow, which increases energy efficiency as it complements the growing adoption of a hot and cold aisle data center design.

V-Max Engines are physically connected to a built-in high speed interconnect. Low latency, high bandwidth interconnects and intelligent software running within each V-Max Engine are used to create a virtual matrix, which connects the engines in a logical any-to-any fashion. A configuration with four V-Max Engines is summarized in Figure 4. The arrows show where redundant cables are used to connect each engine to the virtual matrix.

FIGURE 4. THE VIRTUAL MATRIX



ESG Lab observed a number of Symmetrix V-Max systems running in the lab at EMC. Entry level systems with one or two V-Max Engines and a few drive enclosures were running in a single rack. Multi-rack systems with up to eight V-Max Engines and hundreds of terabytes of configured capacity were observed as well.

Why This Matters

Thousands of organizations rely on the enterprise-class scalability, performance, and reliability of EMC Symmetrix storage systems. From legacy applications running on IBM zSeries (a.k.a., mainframe) and UNIX servers to a growing number of applications running on virtual servers, application and infrastructure consolidation is being used to reduce costs and increase the flexibility and availability of applications relying on EMC Symmetrix storage capacity.

EMC has clearly raised the bar with the Symmetrix V-Max. The revolutionary architectural approach of the Symmetrix V-Max enables new levels of cost-effective scalability and flexibility as the reputation of continuous improvement, backwards compatibility, and rock-solid reliability that has been the hallmark of the Symmetrix product line is maintained.

Ease of Management and Provisioning

The EMC Symmetrix V-Max, with a goal of reducing the time and complexity associated with managing storage in a highly consolidated virtual infrastructure, added wizards and powerful management concepts—including policy-based storage provisioning and role-based access control. Streamlined tasks include assigning storage to a new application, growing the amount of storage allocated to an existing application, automatically assigning LUN addresses to ensure correct operation and failover in a host cluster, adding servers to an existing host cluster, and, last but not least, modifying LUN masking to ensure the isolation and security of information assets. Symmetrix DMX uses lock management to help guarantee the integrity of configuration changes that supported only one configuration change at a time. Lock management in the V-Max has been enhanced to allow execution of multiple change requests in parallel.

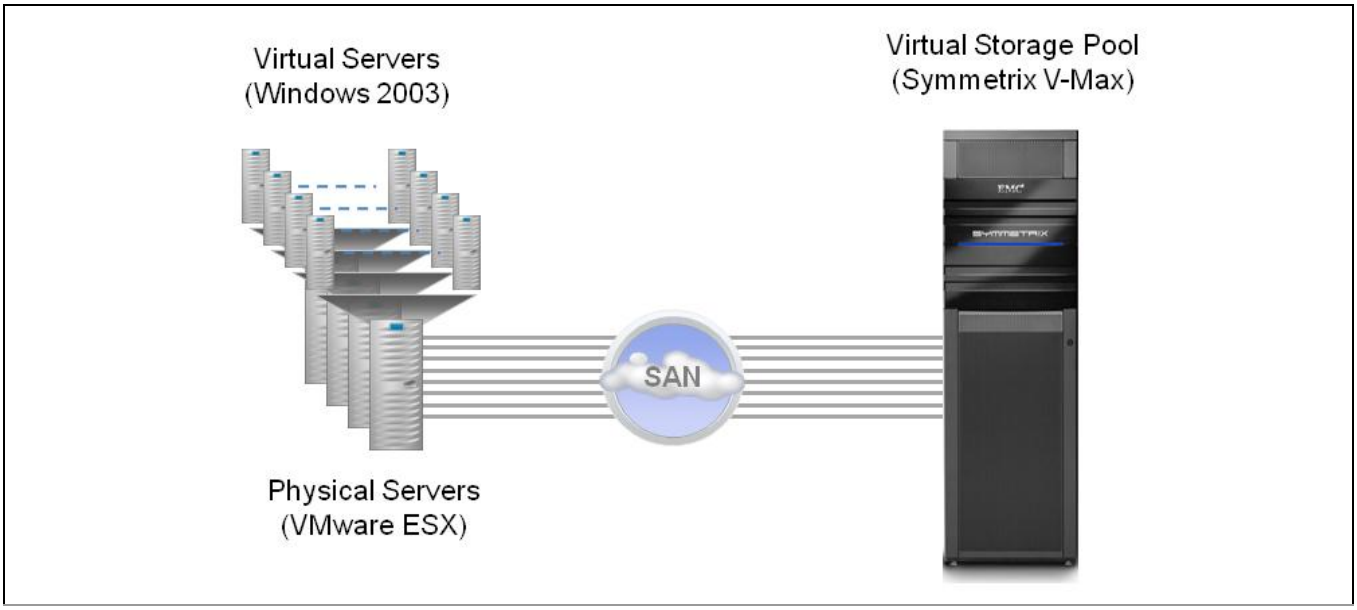
ESG Lab Testing

ESG Lab testing was performed with a goal of mimicking the evolutionary path of a theoretical customer using server virtualization and an EMC Symmetrix V-Max to consolidate and optimize IT infrastructure. The customer begins with a four server ESX farm running a consolidated mix of Windows-based applications (e.g., Microsoft Exchange, SharePoint, and SQL Server) requiring 96 logical units (LUNs) of storage capacity. Over time, one of the applications requires new storage capacity and another server is added to the ESX cluster. In essence, ESG Lab simulated the following customer use case:

- Provision storage for a mix of applications running on a four server VMware ESX cluster
- Increase the amount of storage allocated to a growing application
- Add another server to the ESX cluster to provide more processing power and higher levels of availability

The test bed utilized for ESG Lab testing is shown in Figure 5. The Symmetrix V-Max was configured with two V-Max Engines and 73 TB of raw storage capacity. Each of the servers was connected to the Symmetrix via a pair of 4 Gbps FC connections.[2]

FIGURE 5. THE ESG LAB TEST BED



The number of operations, elapsed time, and complexity of new policy-based wizards were each compared to traditional provisioning methods. The number of decisions requiring a senior level of storage expertise was

[2]Configuration details are provided in the Appendix.

recorded—including the potentially error-prone task of repeatedly looking up addresses during LUN masking changes using traditional provisioning. The three decision points shown early on in the new policy-based provisioning method occurred as groups of storage devices and ports were defined to simplify and automate the management of storage on an application-by-application basis later on. A comparison of the two methods is summarized in Figure 6 and TABLE 1.

FIGURE 6. SIMPLIFYING THE STORAGE MANAGEMENT OF A VMWARE ESX CLUSTER

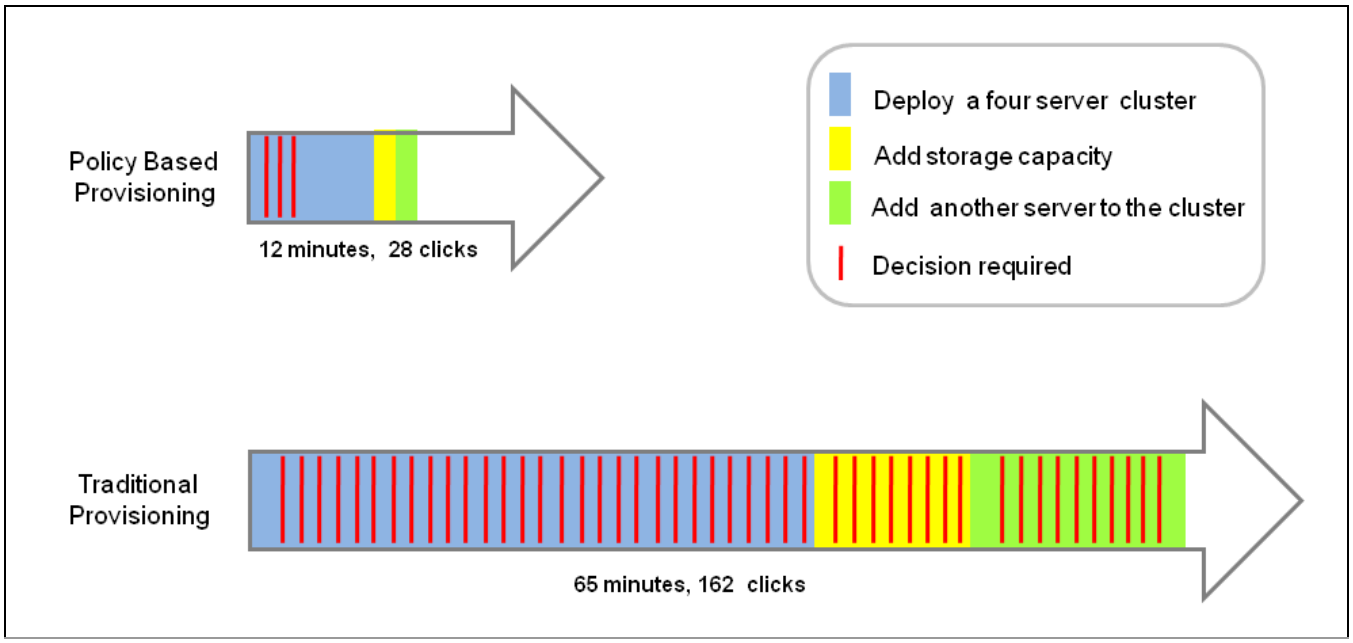


TABLE 1. SIMPLIFYING STORAGE MANAGEMENT OVER A VMWARE ESX CLUSTER

	Traditional Provisioning		Policy-Based Provisioning	
	Minutes	**Operations**	**Minutes**	**Operations**
Deploy	50	108	8	20
Add Capacity	6	22	2	4
Add a Server	9	32	2	4
Total	65	162	12	28

What the Numbers Mean

- For the virtual server example evaluated by ESG Lab, wizard-driven policy-based provisioning was 82% faster (12 minutes vs. 65 minutes) and significantly easier (83% fewer operations, less decisions, and significantly more automated) than traditional provisioning methods.
- Fewer decisions and more automation reduces the risk of mistakes and security vulnerabilities.
- Faster provisioning increases efficiency, enabling the organization to manage more storage per administrator.
- The advantages are magnified as the size and complexity of a virtual server environment increases. In particular, the new LUN masking wizard is a simple four step process, regardless of the size or complexity of the environment. In contrast, the complexity and time required for LUN masking with traditional provisioning methods increases dramatically as the size of the virtualized infrastructure grows.
- Dependent on the level of change activity within a data center, this could translate into savings of hundreds if not thousands of man-hours.

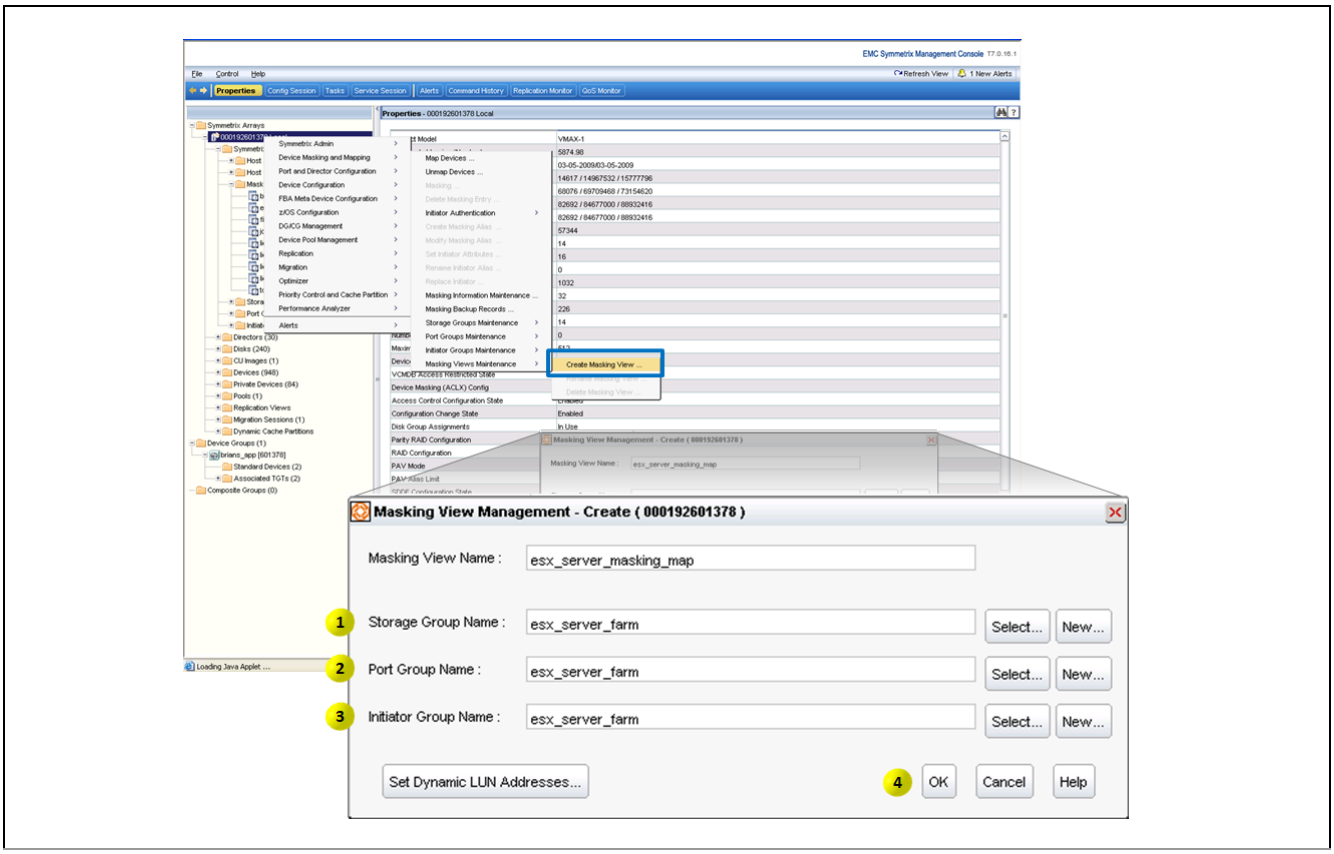
The balance of this section of the report explores the results of the ESG Lab tests summarized in Figure 6. Screen shots taken during ESG Lab testing are presented to give the reader a feel for the improved manageability of the Symmetrix V-Max.

Before we begin, let's take a quick look at some of the challenges associated with configuring an enterprise-class storage system in a highly consolidated virtual server environment. As the number and size of virtual server clusters grow, the management of the shared storage infrastructure gets more complex.

Take, for example, the VMware ESX cluster used for ESG Lab testing. Each of the four servers has two FC interfaces that are logically cabled into the Symmetrix for maximum fault tolerance, yielding eight host interface connections that need to be defined and maintained. With multiple virtual servers and applications sharing the same cluster, a large number of logical devices often need to be defined (96 in our example). Clustering software dictates that the logical address of each of these logical devices is the same, regardless of the server or host interface that is accessing the device. LUN masks need to be defined for each device over each interface to ensure that other servers and applications sharing the same Symmetrix do not have access to storage owned by the VMware cluster. Put simply, as the size of a consolidated virtual server environment grows, so too does the complexity associated with deploying and managing the storage resources assigned to that environment.

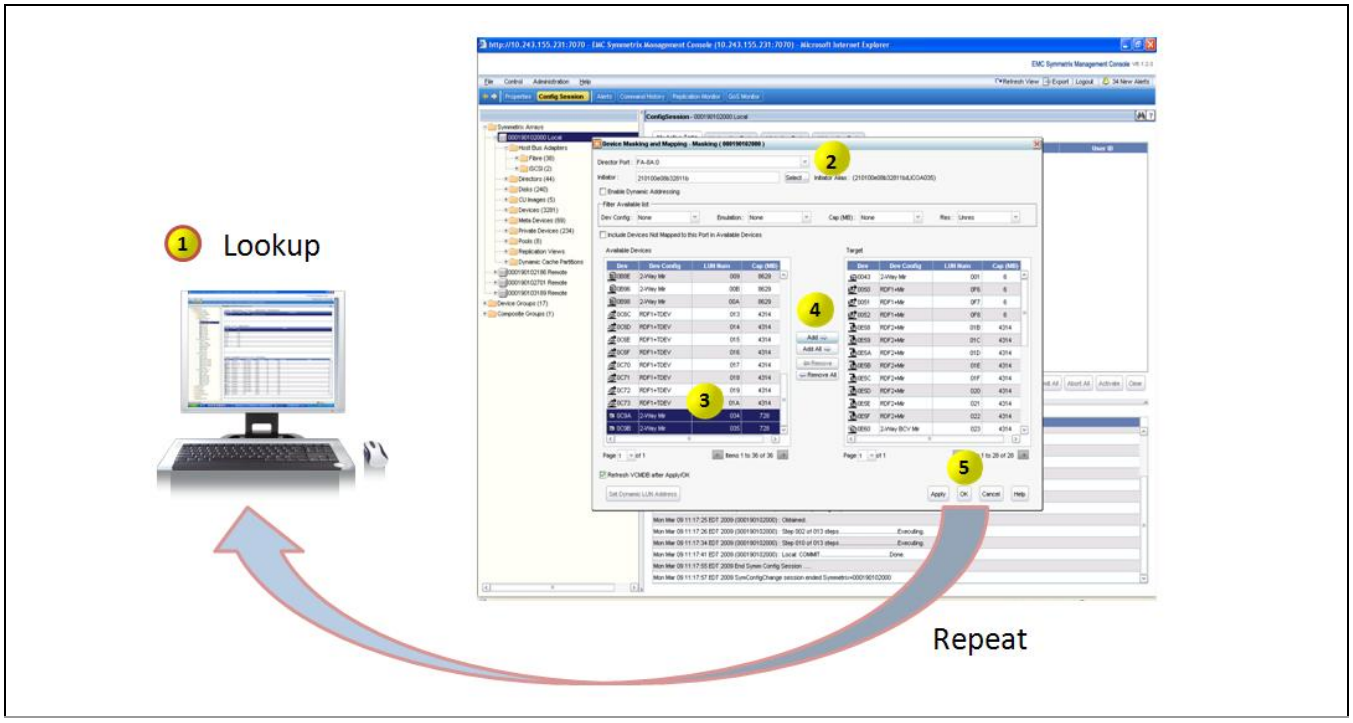
EMC has added a number of new wizards to the Symmetrix Management console, including the masking wizard shown in Figure 7. This intuitive wizard provides a policy-based alternative to traditional LUN masking. The new tabs towards the right were used to define a storage group (to contain the LUNs that the ESX servers will use), a port group (Symmetrix ports), and an initiator group (host ports). Clicking 'OK' kicked off an intelligent and automated process which automatically assigned host addresses and masks for each of the LUNs on each of the eight server host connections. The entire process completed in eight minutes.

FIGURE 7. POLICY-DRIVEN AUTOMATED LUN MASKING



ESG Lab used the traditional LUN masking method to configure the same set of paths and devices. The interface used to define each of the LUN masks is shown in Figure 8. Note that the process begins with a manual lookup of device and port addresses. The five step process was repeated for each LUN mask. The entire process took 58 minutes (vs. eight minutes for the new method).

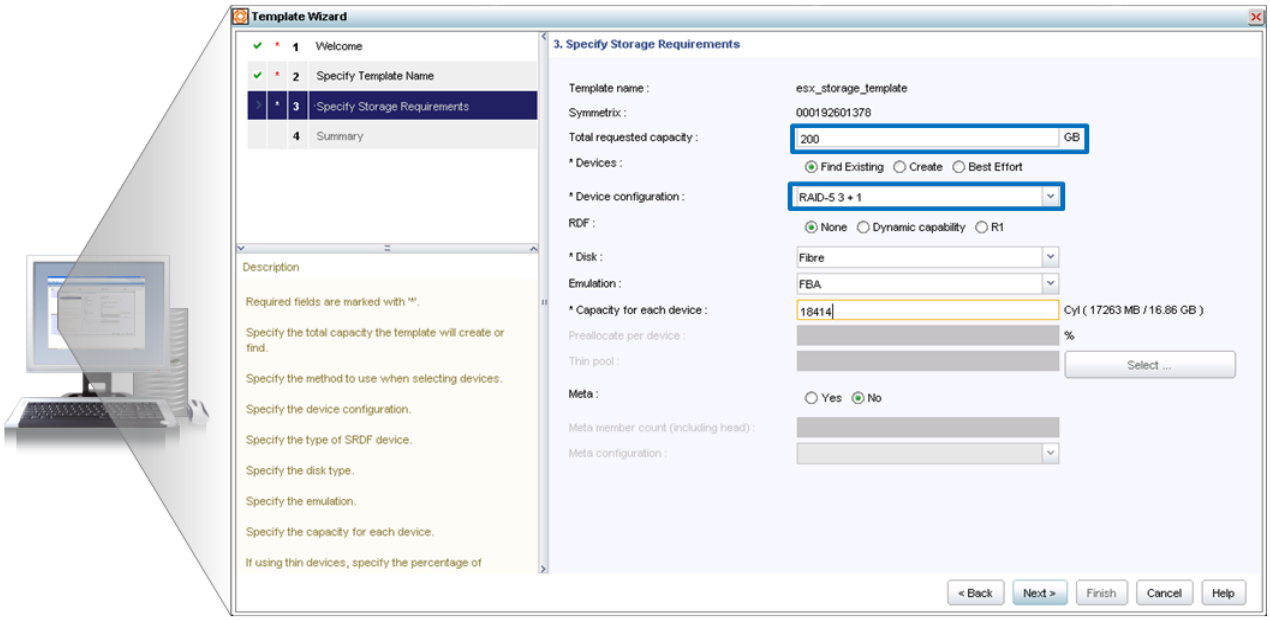
FIGURE 8. TRADITIONAL LUN MASKING



Storage administrators with experience managing a large and consolidated application infrastructure should recognize the challenges associated with traditional LUN masking methods. Typically, the storage administrator has a scratch pad handy to jot down addresses. Mistakes often occur. In the best case, an error could make it impossible for a virtual server to recognize and use a necessary device. In a more insidious case, a device thought to be protected by a LUN mask may be left open for accidental or malicious use by another application.

Next, ESG Lab added capacity to existing devices to accommodate growth of one of the applications deployed within the VMware ESX cluster. The new storage template wizard, shown in Figure 9, was used to find existing devices with 200 GB of RAID-5 3+1 capacity.

FIGURE 9. USING A TEMPLATE TO AUTOMATE THE ADDITION OF STORAGE CAPACITY

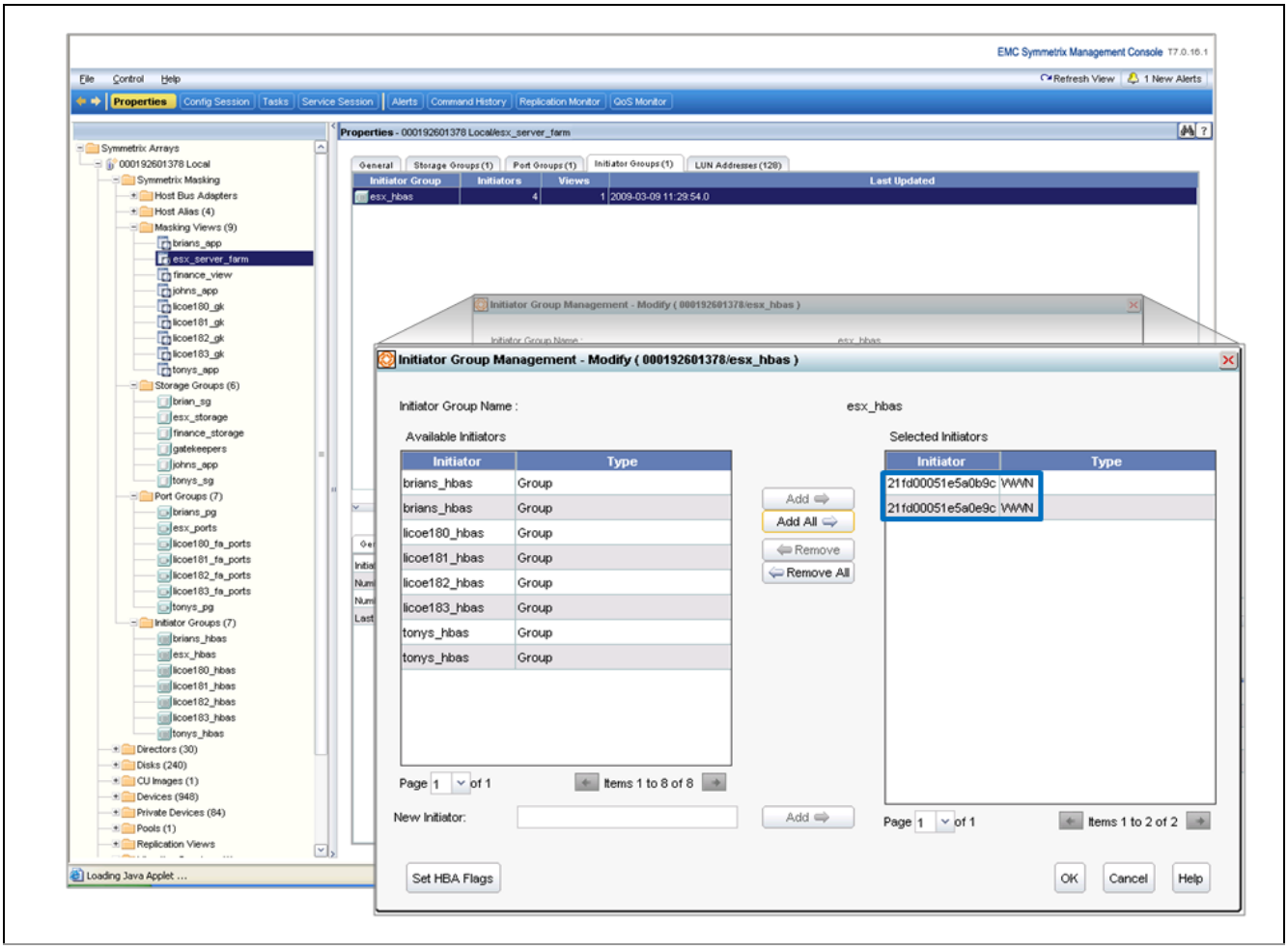


The storage template wizard automates yet another routine, and potentially error prone, storage management task. Finding already defined devices with a specific performance and protection level is traditionally a manual task vulnerable to human error using traditional methods. ESG Lab believes that the ability to find already configured devices, or to create new devices on the fly, will be appreciated by existing Symmetrix customers—especially those that tend to pre-configure all of the capacity within a Symmetrix when it is first deployed (assigning it later to new or growing applications). Extending the capacity of an existing device took two minutes with the new wizard-driven template method, compared to six minutes for the traditional method.

It should be noted that EMC has supported the policy-based definition of classes of storage capacity, and the automated end-to-end provisioning of that storage capacity, in EMC Control Center for some time. EMC Control Center is a storage resource management (SRM) software package that can be used to centrally manage a number of storage systems. ESG Lab believes that EMC customers will appreciate that this level of policy-based control and automation has been built into the Symmetrix Management console.

Continuing the evolution of a theoretical customer in a highly consolidated virtual server environment, the initiator group was modified to support the addition of a fifth ESX server to the cluster. The traditional method required the careful definition of LUN masks for each of the devices in the existing four node cluster. The new method, as shown in Figure 10, was much simpler. The addresses of the two FC host interfaces in the new server were added to the already defined initiator group. The masking wizard did the rest of the work automatically, including assigning addresses and creating masks for all of the logical devices in the existing storage group.

FIGURE 10. ADDING A SERVER TO A CLUSTER



Configuring storage to support a fifth server being added to an existing VMware ESX cluster was completed in 80% less time with the new policy-based method as compared to the traditional method.

Why This Matters

Sixty-two percent of IT professionals surveyed by ESG reported the need to simplify the ongoing management and maintenance as a main driver in moving to server virtualization. Deploying, expanding, and managing are routine tasks with potentially mind-boggling levels of scale and complexity in a highly consolidated virtual data center.

ESG Lab has confirmed that Symmetrix Management Console wizards and policy-based provisioning enhancements can be used to dramatically reduce the time, effort, and potential for error inherent in managing a highly consolidated virtual data center. Hours of focus per week can literally turn into minutes, potentially saving hundreds or thousands of man-hours per year and allowing storage experts to turn their attention back to projects that focus on the core business.

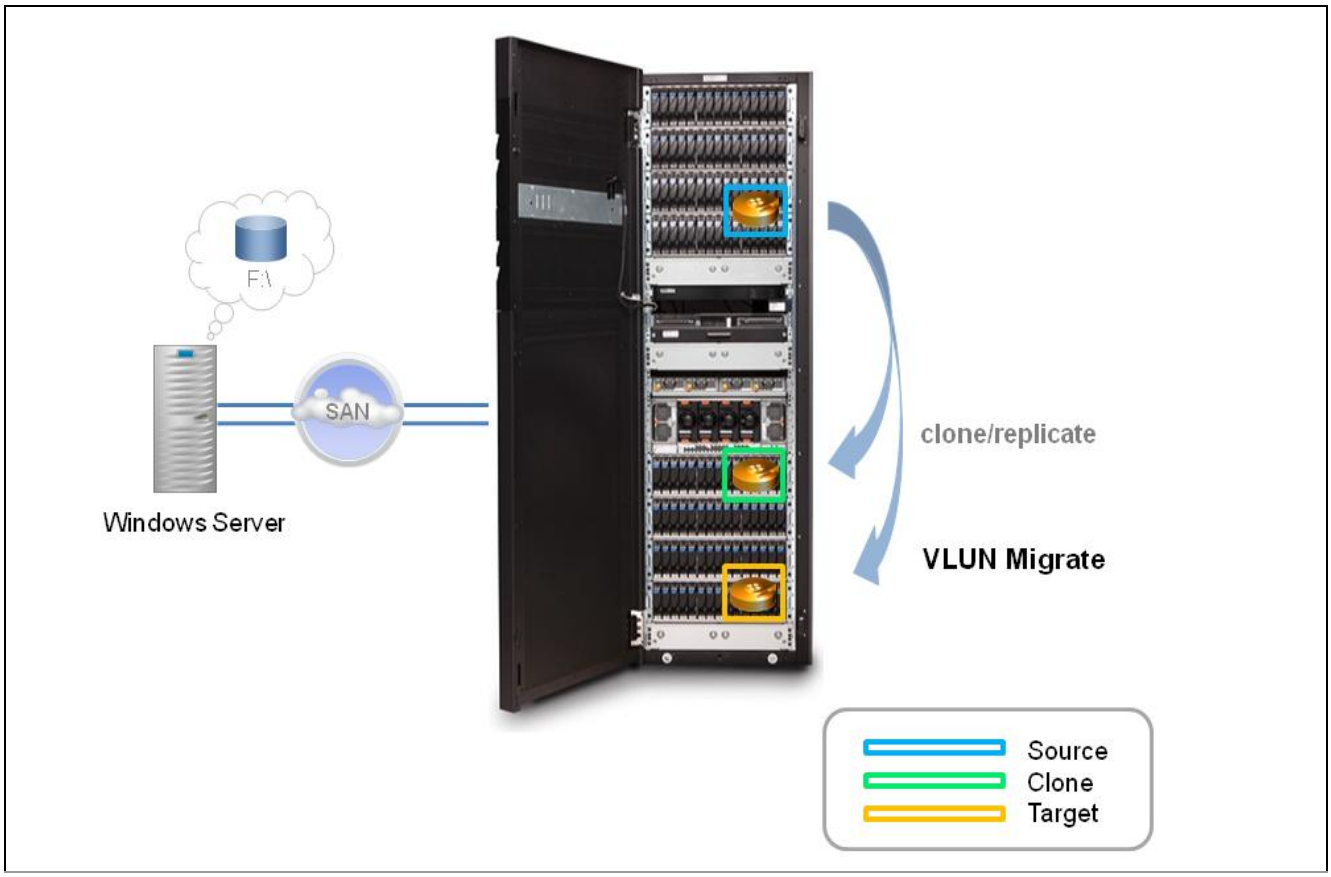
Automated Online VLUN Migration

VLUN Migration enables online migration of data from any storage device to any other storage device inside the Symmetrix, regardless of device type or RAID protection. Migrating data for running applications like e-mail and databases is often problematic for IT administrators. Using traditional methods, an administrator must shut down the application, stop all snapshot and replication processes, move the data, configure the server to see the new volumes, and only then restart the application and replication. Symmetrix VLUN Migration greatly simplifies this process while keeping applications and volume replication online. An administrator simply selects LUNs to migrate, then selects the target disk group and desired protection. Symmetrix VLUN migration can act on individual devices as well as device groups or entire storage groups to change the underlying storage for an entire application or dataset.

ESG Lab Testing

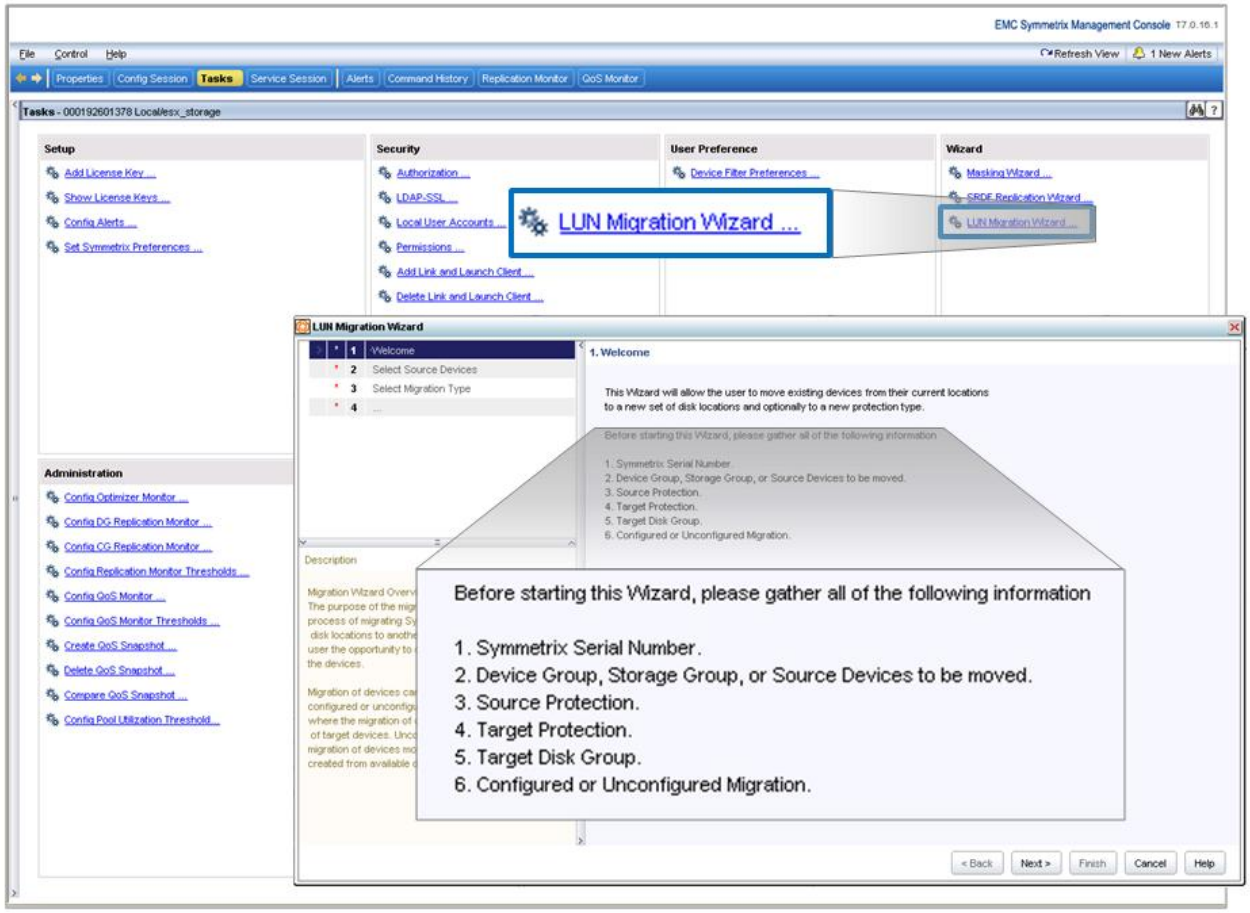
ESG Lab's goal in this phase of testing was to perform a data migration of a volume in use by a server between heterogeneous storage types with local replication (TimeFinder Clone) and configuration changes running while the migration takes place. Figure 11 shows the migration test bed with the online VLUN Migrate and TimeFinder Clone operations running in parallel from the same source volume.

FIGURE 11. VLUN MIGRATION



A machine running Windows 2003 was assigned a LUN allocated from RAID-5 protected FC capacity in the Symmetrix. The LUN was mounted on the server using the Windows disk management tool, formatted with the NTFS file system, and several gigabytes of files were copied into the volume. ESG Lab clicked on 'Tasks' in the Symmetrix Management Console, then clicked on 'LUN Migration Wizard' as seen in Figure 12. The LUN Migration wizard opened with a summary of the steps and information required to migrate a VLUN.

FIGURE 12. LAUNCHING THE LUN MIGRATION WIZARD

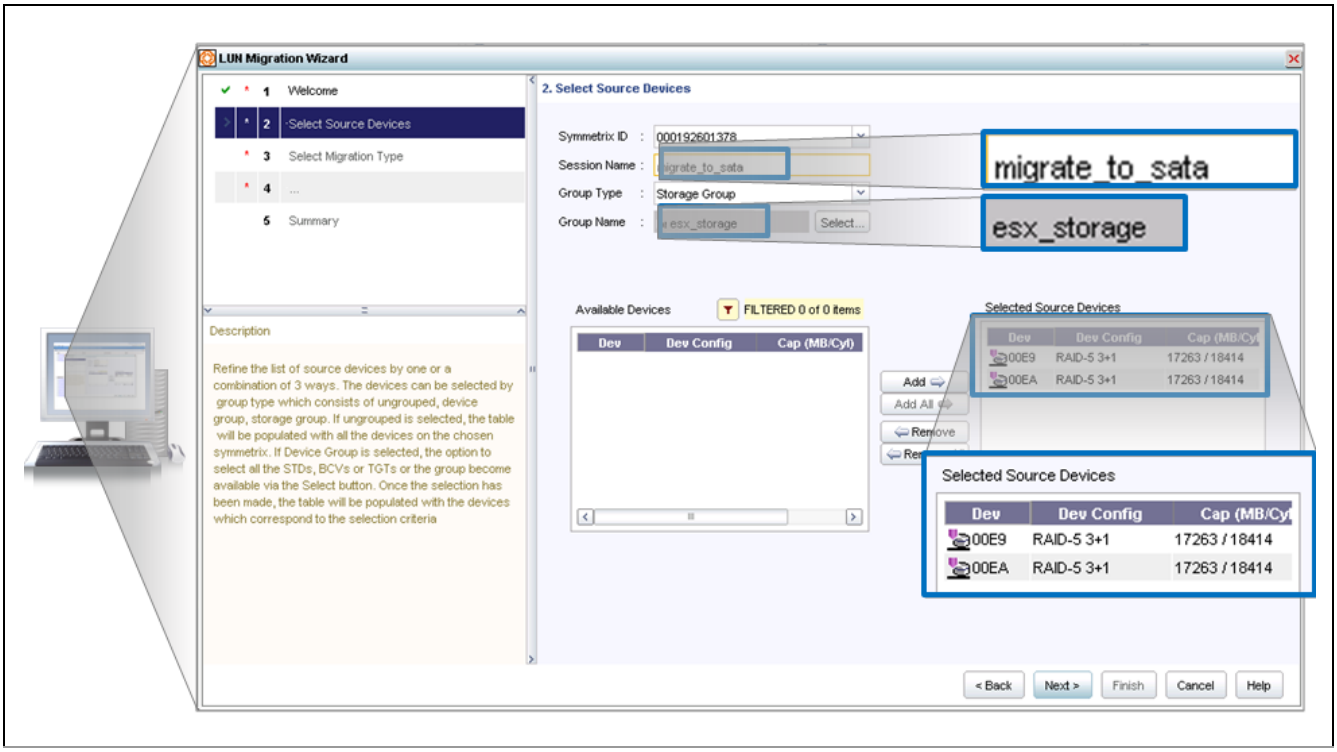


As seen in Figure 13, ESG Lab selected the Symmetrix serial number from the drop down list and created a name for the migration session: "migrate_to_sata." Next, ESG Lab selected 'esx_storage' from the list of storage groups presented by the wizard. The final step was to select the devices in the pool and click 'add' to migrate all volumes in the pool simultaneously.

Finally, ESG Lab selected the target disk group. RAID-6 protected SATA disk was selected as the target for this migration. Symmetrix VLUN migration automatically found and selected available target LUNs from the SATA pool. When ESG Lab clicked 'Finish,' Symmetrix VLUN migration automatically started the migration job and began moving data transparently to the SATA LUNs with no impact to the server.

To validate the ability of the Symmetrix to perform multiple configuration changes simultaneously, ESG Lab expanded existing storage while the migration was in progress. This was not possible on the Symmetrix DMX, as the migration would have placed a configuration lock on the array for the duration of the migration.

FIGURE 13. CONFIGURING A LUN MIGRATION



While the migration was still running, ESG Lab started a TimeFinder Clone operation on the two volumes and confirmed that the clone occurred simultaneously with the migration. ESG Lab then began copying new files into the migrating volume. The host continued to write data to the volume throughout the entire process, with no interruption. Once the migration was complete, ESG presented the cloned volume to a second server and verified that the files in the volume matched the files in the migrated volume.

Why This Matters

Managing tiered storage using traditional data migration methods may cause application downtime or interruptions of replications or other critical activities, and can have significant business impact. Recent ESG research indicates that a majority of IT organizations can't tolerate more than four hours of downtime for their most mission critical applications before experiencing a significant impact to their businesses.[3] Five percent indicate that zero downtime has been mandated and mission critical applications must be replicated offsite for business continuance. Given the volumes of data associated with most mission-critical applications, traditional migration methods fall short of meeting both of these strict service level agreements.

ESG Lab was able to configure and execute a Symmetrix VLUN migration quickly and easily between heterogeneous storage and RAID types with no interruption to IO or replication, which translates to no application downtime and no exposure to data loss. Symmetrix VLUN migration provided on-demand storage mobility with zero overhead to the attached server—since the migration completed in the array, no CPU or IO cycles were consumed.

[3] Source: ESG Research Report, *Data Protection Market Trends*, February 2008.

ESG Lab Validation Highlights

- ☑ ESG Lab was impressed with the new Symmetrix architecture. The concept of V-Max Engines and a 'virtual matrix' enables the Symmetrix V-Max to be deployed and provisioned very efficiently. Each system can start small and scale out in a modular fashion with power and cooling more closely aligned with actual hardware deployed, while maintaining the 24xForever attributes users expect of the Symmetrix.
- ☑ The Symmetrix Management Console Masking View made the often complex and error prone task of provisioning storage for large numbers of virtual servers both fast and error free.
- ☑ ESG Lab created groups of ports, storage devices, and host bus adapters and provisioned storage for sixteen virtual machines on four ESX servers in just eight minutes, compared to more than an hour of complex, repetitive tasks to achieve the same results on a traditional system.
- ☑ Provisioning templates enabled ESG Lab to set storage provisioning policies for extremely quick and easy storage expansion to meet the needs of growing applications.
- ☑ Concurrent change management enabled ESG Lab to make multiple configuration changes to the Symmetrix in parallel rather than serially, reducing the time required to schedule and perform complex tasks.
- ☑ ESG Lab was able to configure and execute a Symmetrix VLUN migration quickly and easily between heterogeneous storage and RAID types while data was being written to the volume, with no interruption to replication.

Issues to Consider

- ☑ When using the new policy-based provisioning wizards, a host initiator can be in only one initiator group. If you never plan on running more than one application per host connection, this is not an issue. But if you are in a highly consolidated virtual server environment and may end up with more than one application sharing a single physical host connection, you should familiarize yourself with the best practice EMC refers to as 'cascading initiator groups.'
- ☑ While the Symmetrix has a long history as a massively scalable high performance storage system and the new architecture suggests extreme performance scalability, this ESG Lab validation did not include any performance testing. Performance testing, in your data center with your applications, is strongly recommended before moving into production.
- ☑ While EMC's product qualification, interoperability testing and support are the benchmarks for the industry, the Symmetrix V-Max was in the very early stages of customer deployment when this report was written. As a result, evidence of production-level readiness and reliability was limited. Therefore, ESG Lab believes that IT managers considering a Symmetrix V-Max purchase in 2009 should allocate appropriate time for evaluation and burn-in testing.

ESG Lab's View

As we've come to expect from EMC, this new Symmetrix has hardware that extends the evolutionary path of continuous improvements: for instance, 2X more host ports, 2X more back-end ports, Intel multi-core processors, more scale in general. However, the real news with the updated hardware platform is the revolutionary new architecture. The platform has changed dramatically from a frame-based hard-wired backplane to a flexibly-scalable modular architecture. Yes, this holds the promise of great future potential, but at first release, the real and exciting news is that everything that was supported on the DMX is supported on this new platform—including zSeries, SRDF, and so on.

EMC could have chosen the easy path and done a whole lot less thinking and engineering with similar marketing claims and product benefits in terms of scalability, efficiency, and ease of use. EMC instead chose to port everything to a new architecture while retaining compatibility with its existing product. Although the immediate operational benefits are certainly worthy and to be applauded, there is a great deal of value remaining under the covers at this stage—these key foundational aspects of the new Symmetrix are what ESG believes deserve a standing ovation.

Beyond the revolutionary new Symmetrix architecture, ESG Lab was impressed with evolutionary improvements in ease of use that are tailored to meet the needs of massively virtualized and consolidated data centers. For example, ESG Lab testing found that the new LUN masking wizard can be used to reduce routine storage provisioning and management tasks in a VMware cluster from more than an hour to just twelve minutes. Compared to the traditional method, the new wizard was quick, intuitive, and virtually foolproof. ESG Lab was also impressed with the new VLUN migration wizard that makes within-the-box tiering a snap.

EMC's customers have been relying on the Symmetrix for years—its core attributes of scale, trusted reliability, and performance are no less crucial in the new product. Of course, all these areas have been improved and upgraded with the new release. But the latest incarnation of the Symmetrix is also designed for the new world where virtualization and modular scale-out is the order of the day. The product, viewed in isolation, might look as if it is about EMC, a storage company—and it would indeed stand that scrutiny well. But under the covers, it's evidence of a grander vision for EMC: enabling information infrastructure efficiency and effectiveness.

Appendix

TABLE 2. TEST CONFIGURATION

EMC Symmetrix Array	
Enginuity: 5874 2 V-Max Engines (Director Pairs) 32 4 Gb/sec Fibre Channel ports	194 146 GB 15K Fibre Channel Drives 46 1 TB SATA II drives RAID-1, 5, and 6
SMC Console Dell Workstation	Windows XP SP2 Internet Explorer 7
Host Servers	**Host Servers**
Dell PE2850 Intel Quad core 2.8 GHz CPU; 8 GB RAM	Windows 2003 SP2 2 x 4 Gbps Emulex/LPe11000-E Fibre Channel HBAs
Dell PE2850 Intel Quad core 2.8 GHz CPU; 8 GB RAM	Windows 2003 SP2 2 x 4 Gbps Emulex/LPe11000-E Fibre Channel HBAs
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Dell PE2850 Intel Quad core 2.8 GHz CPU; 8 GB RAM	Windows 2003 SP2 2 x 4 Gbps Emulex/LPe11000-E Fibre Channel HBAs
FC SAN Switches	
2 x EMC Connectrix DS5000B - 4 Gbps	32 ports

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