

Lab Validation Report

Fujitsu ETERNUS8000

Large Scale Storage Consolidation for the Enterprise

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September 2009

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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 Fujitsu.

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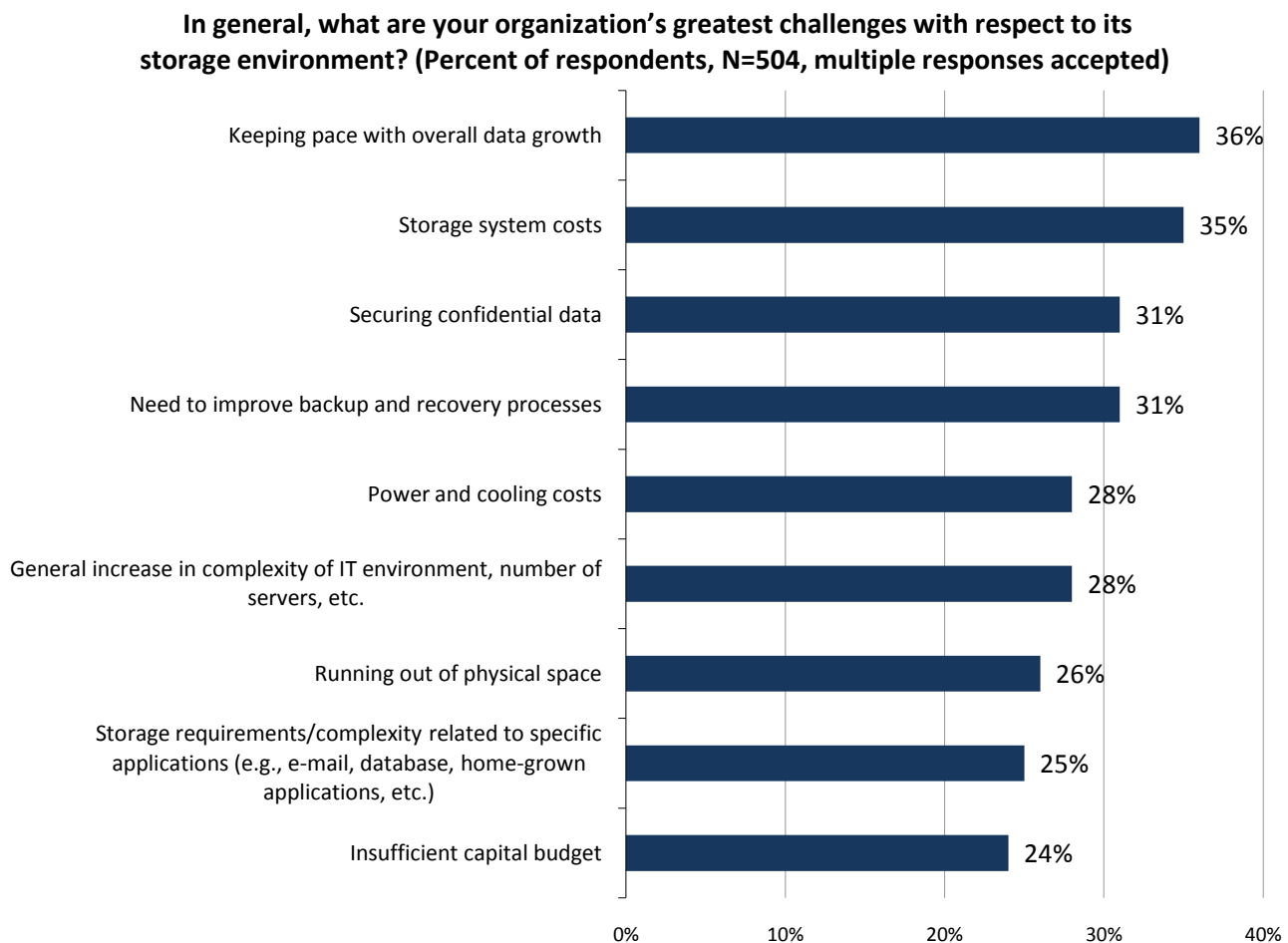
Introduction

The Fujitsu ETERNUS8000 storage system is an extremely scalable enterprise-class storage platform that combines massive scalability (up to 2.7 petabytes) with data availability, security, and operational efficiency. This ESG Lab Report documents the results of hands-on testing of the ETERNUS8000 with a focus on performance and capacity scalability, availability, data mobility, power efficiency, and security.

Background

Organizations of all sizes are struggling to meet the conflicting challenges associated with macroeconomic global financial uncertainty and micro-level information storage growth and complexity. As users continue to struggle to manage increasing volumes of data, they are also tasked to do so with constrained—or even reduced—resources. Consequently, users are more willing than ever—even compelled, in certain cases—to look for new ways to address their needs.

Figure 1. Top Storage Challenges



Source: Enterprise Strategy Group, 2009.

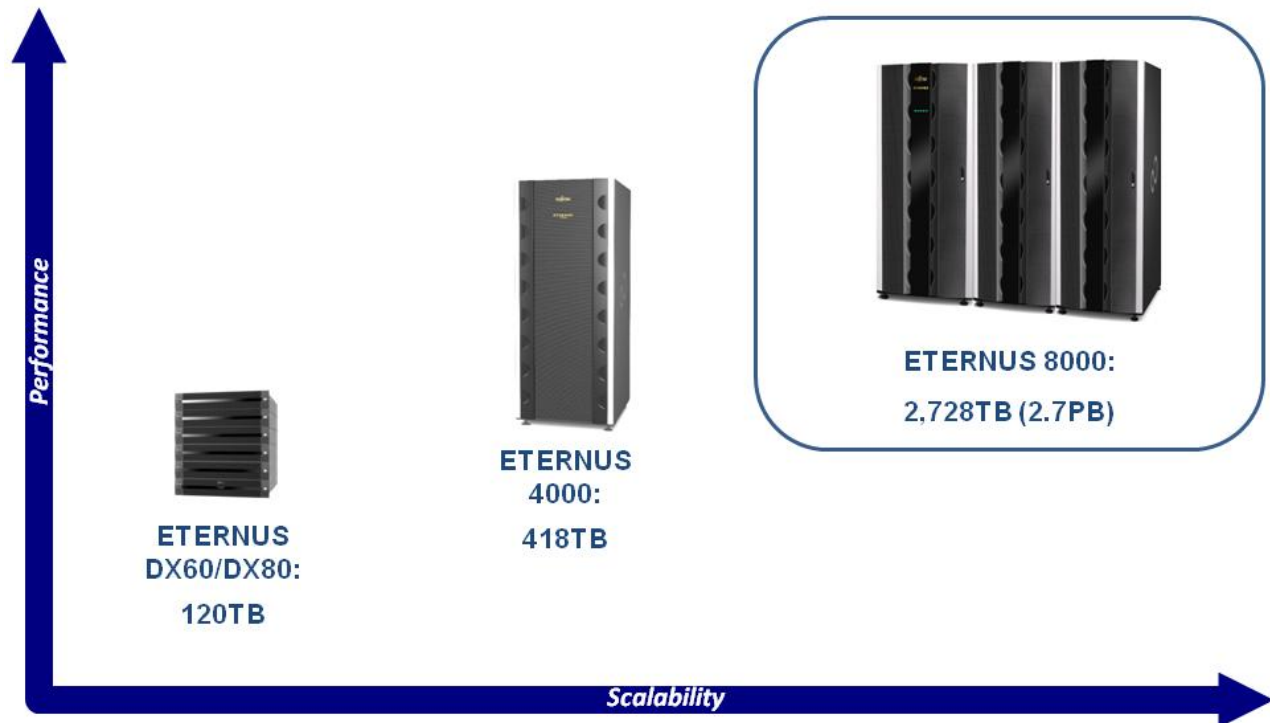
As recent ESG research of the enterprise IT market shows (see Figure 1), users are heavily focused on the joint challenges of physical resource constraints (as evidenced by data growth, capital cost, power and cooling expenses, and floor space issues) and management resource limitations (as evidenced by the need to improve backup and recovery processes as well as addressing complexity in numerous areas).¹

¹ Source: ESG Research Report, 2008 Enterprise Storage Systems Survey, November 2008.

Fujitsu ETERNUS

Fujitsu has focused on these customer trends and priorities with its ETERNUS family of disk storage systems. ETERNUS is designed to address the most crucial challenges faced by storage and IT managers.

Figure 2. The Fujitsu ETERNUS Family



The ETERNUS8000 is a massively scalable enterprise storage consolidation platform supporting both open systems and mainframe connectivity. In addition to massive scalability, the ETERNUS8000 offers advanced storage attributes and functionality that, though derived from Fujitsu's mainframe roots, is attuned to the needs of today's enterprise:

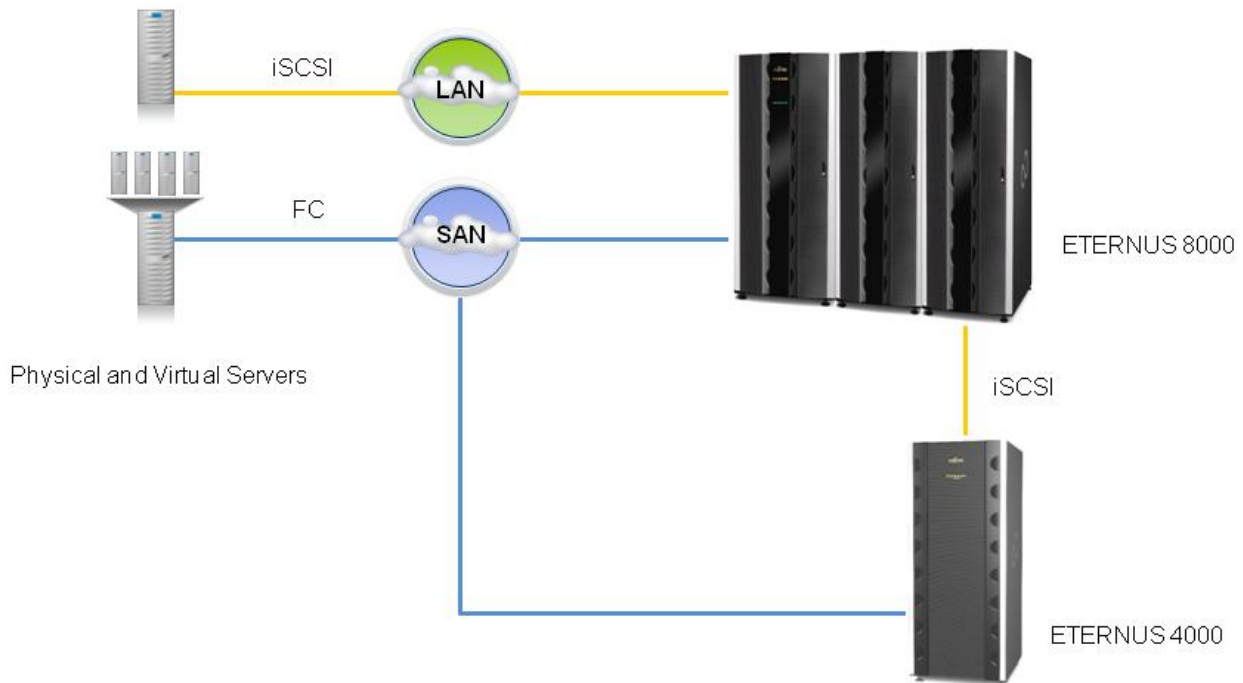
- **Capacity and Performance Scalability** – ETERNUS boasts the industry's largest storage capacity (over 2.7 petabytes) and 2.83GHz quad core processors to significantly increase performance over previous generations.
- **Data Integrity** – ETERNUS offers data block checking and RAID6 (double parity) support.
- **Enhanced Security** - Integrated hardware-based data encryption, both 'on the fly' for remote copy functions and 'at rest' to secure data on drives removed from service, secures users' data.
- **Data Protection and Availability** - A variety of high-speed internal and external volume copy functions provide high availability and business continuance.
- **Flexible Management and TCO Reduction** - Capacity on Demand (CoD), online data migration, and thin provisioning capacity virtualization enable better utilization of resources with no disruption to operations.
- **Green IT** – Power and cooling requirements are reduced with ECO mode using MAID technology and low-power, high performance 73 GB and 146 GB SSD support.

The balance of this report presents the results of hands on testing of the Fujitsu ETERNUS disk storage systems with an eye toward validating the performance, scalability, and reliability of the platform while examining its advanced availability, environmental, and security features.

ESG Lab Validation

ESG Lab performed hands-on evaluation and testing of the Fujitsu ETERNUS8000 at Fujitsu's lab in Sunnyvale, CA. Shown in Figure 3, testing utilized Fujitsu ETERNUS storage systems connected via Fibre Channel and iSCSI to physical and virtual servers. Testing was designed and executed using industry standard tools and methodologies to validate performance, reliability, operational efficiency, security, and availability as well as integration with VMware Site Recovery Manager software.²

Figure 3. The Fujitsu ETERNUS Test Bed



Ease of Deployment and Flexible Management

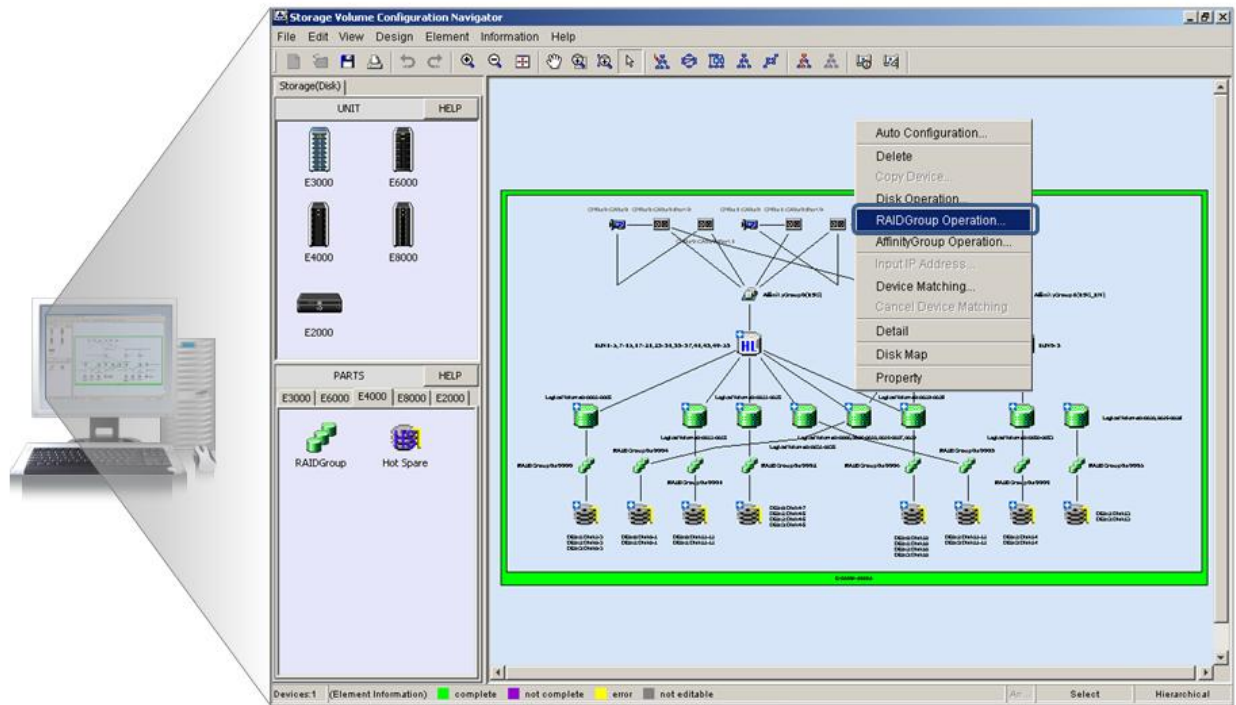
ESG Lab first examined the management interface of the ETERNUS array, evaluating the relative ease with which volumes could be created, managed, and manipulated by a storage administrator. Fujitsu offers Storage Cruiser, a full featured client-server management application, as well as ETERNUSmgr aid, providing basic storage provisioning and performance management functionality.

ESG Lab Testing

The first step was to launch the Storage Cruiser Configuration Navigator, seen in Figure 4. The column on the left shows icons for all arrays under management at the top with disk level detail beneath. The main panel is a visual representation of the selected system. ESG Lab right-clicked in the main panel and selected 'RAIDGroup Operation.'

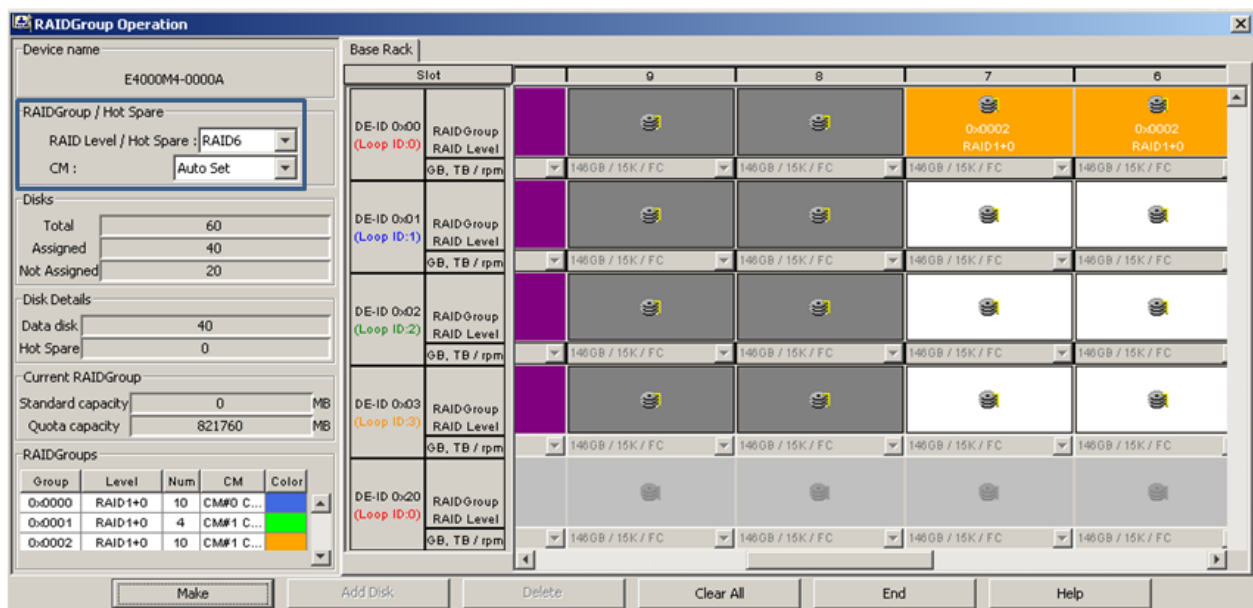
² Configuration details can be found in the Appendix.

Figure 4. Storage Cruiser Configuration Navigator



The RAIDGroup Operation screen, seen in Figure 5, shows all disks in the system and is color-coded for clarity. Drives in RAID groups are identified by color, white designates hot spares, and dark gray indicates drives available for assignment. ESG Lab selected eight available drives and created a RAID6 group.

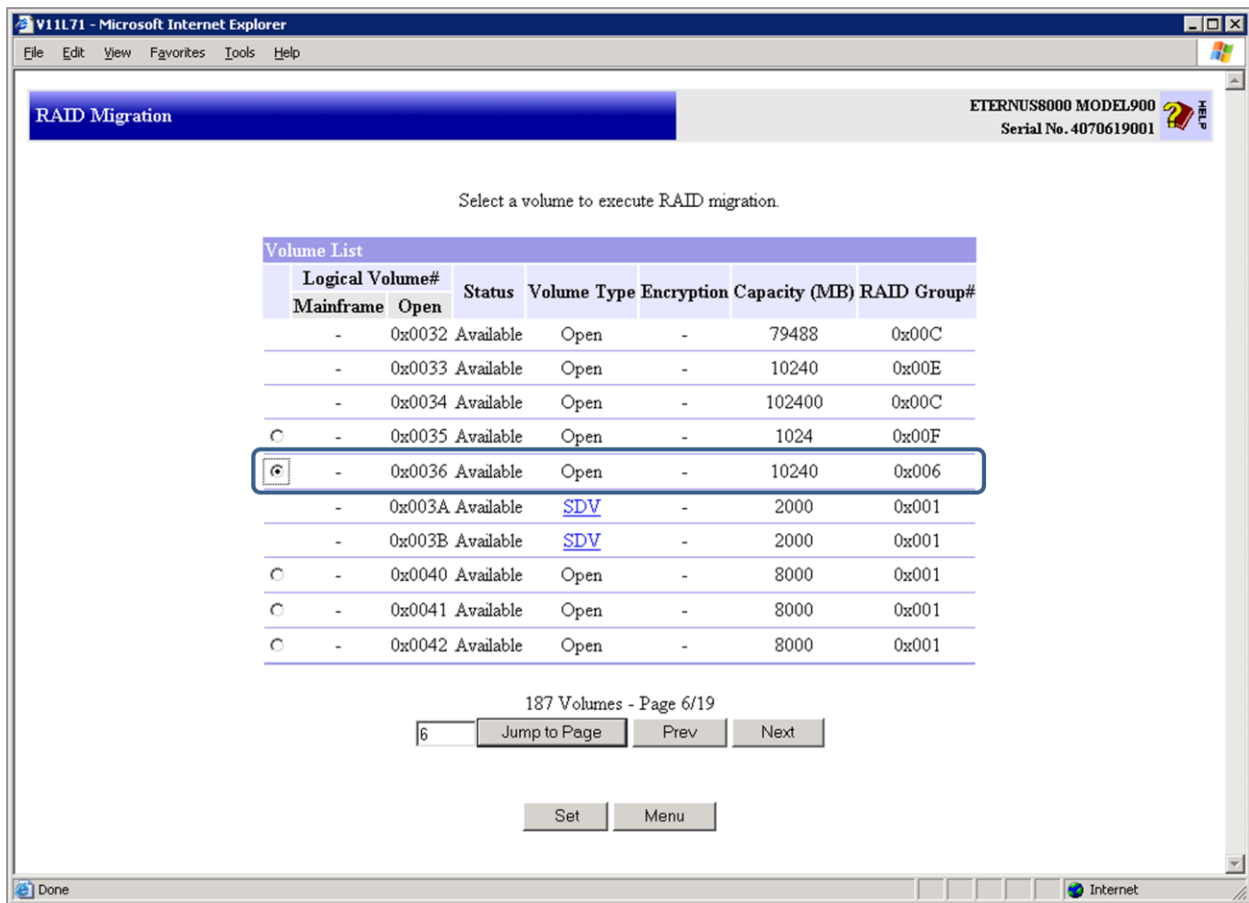
Figure 5. Creating a RAID Group



Next, a 10 GB logical volume was created from the available capacity in the newly created RAID group. ESG Lab then created an ‘affinity group,’ which is a key part of Fujitsu’s volume masking technology and assigned a pair of ETERNUS FA ports to it.³ The 10 GB volume was added to the new affinity group and presented to an attached server by assigning the host WWNs to the affinity group. The last step was to perform a rescan in Windows disk administrator and format the new 10 GB volume. Start to finish, the entire volume creation and assignment process took about 10 minutes. The Resource Coordinator Tool (not tested by ESG) enables access path configuration, which gives the ability to configure end-to-end connectivity from ETERNUS FA to a host HBA in one operation.

ESG Lab tested the ETERNUS platform’s ability to migrate volumes online, with a system actively reading and writing to the volume. ESG Lab simulated an active application using the industry standard Iometer benchmarking utility.⁴ First, Iometer was started on a server attached to the ETERNUS under test. A continuous OLTP database workload was then run against a 10 GB volume mounted from the ETERNUS. While this simulated application workload was reading and writing to the 10 GB volume, ESG lab used ETERNUS Manager to select the volume for migration, seen in Figure 6.

Figure 6. Online RAID group Migration Setup: Select Source



³ Affinity groups contain unique host identifiers (Fibre Channel WWNs or iSCSI initiator IQN), WWNs of the ETERNUS FAs and the volumes to be assigned to a host or group of hosts.

⁴ Iometer is an open-source I/O measurement and characterization utility, available for download at: <http://www.iometer.org/>

Next, the destination RAID group was selected and available space was allocated, as shown in Figure 7. Finally, ESG Lab clicked 'Set' to execute the migration. ETERNUS Manager requested confirmation, displaying the source and destination RAID groups. Upon clicking 'OK,' the volume migration began. A quick look at the server confirmed that iometer was still running with no disruption as the migration took place.

Figure 7. Online RAID group Migration Setup: Configure Target

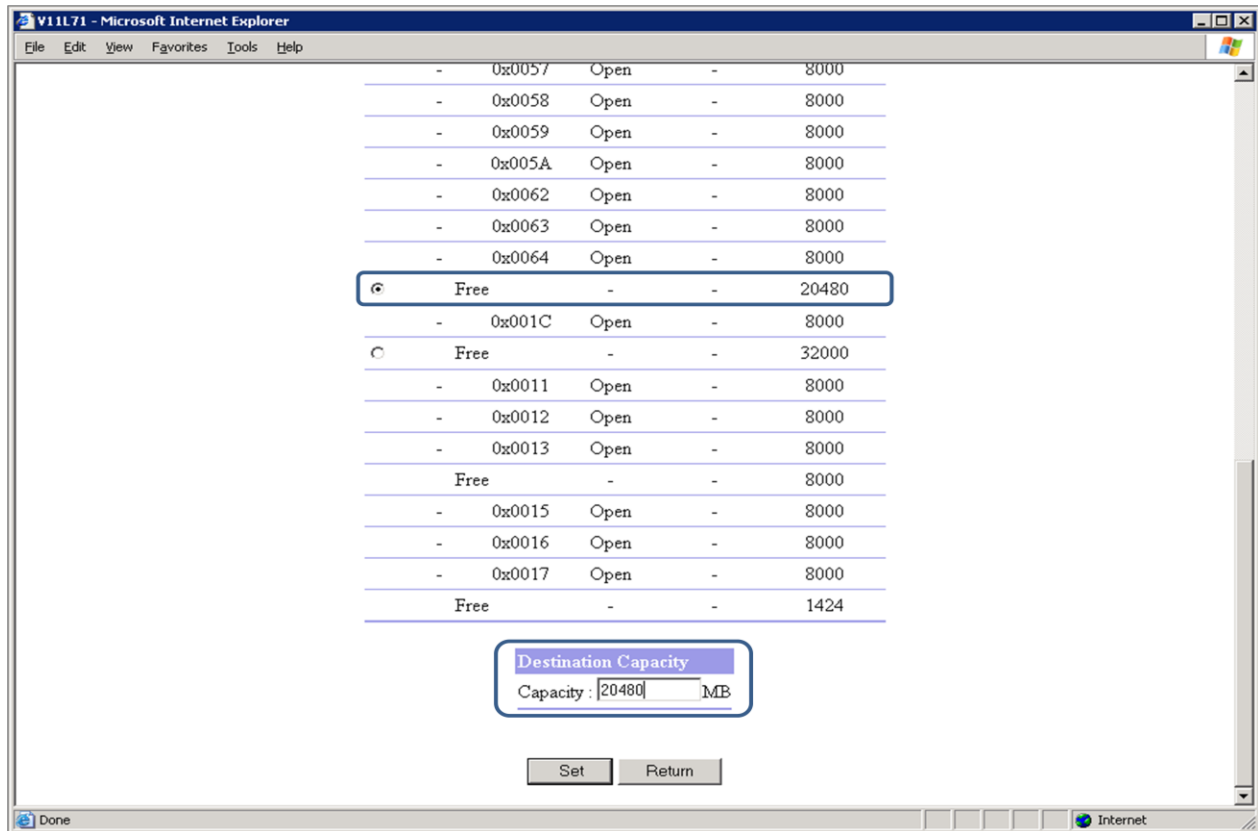
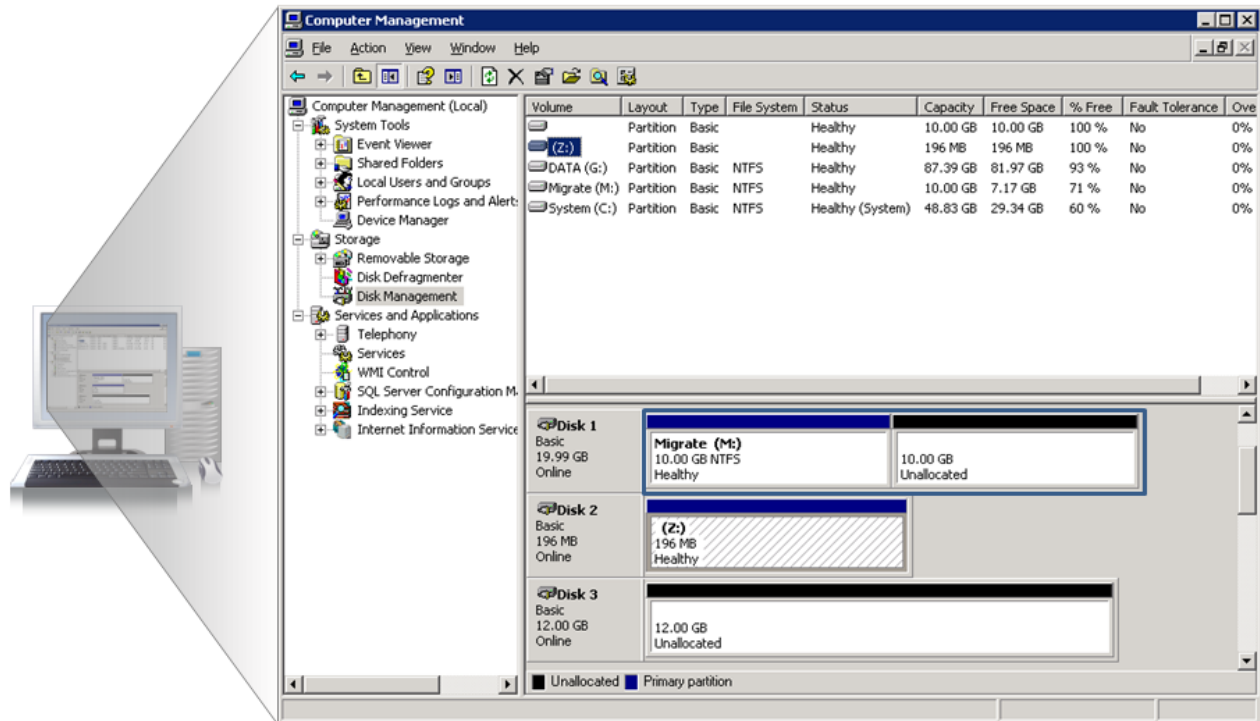


Figure 8. Migration Complete: New Space Available



Within a few minutes, the volume migration completed and ESG Lab then expanded the volume using Microsoft Disk Administrator (see Figure 8). A final examination of Iometer showed that the application was still reading and writing to the drive with no errors.

Why This Matters

Storage deployments are growing in capacity and complexity within organizations of all sizes while IT managers are increasingly being asked to manage this growing storage capacity with stagnant, or shrinking, budgets and staffing. Efficient deployment and management of storage is essential.

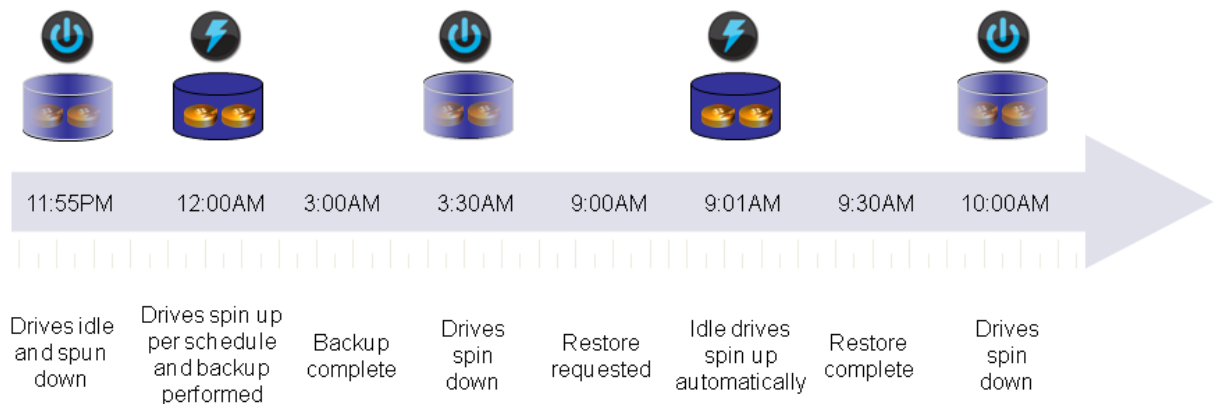
Fujitsu ETERNUS provides a straightforward management interface that offers advanced storage functionality with minimal complexity. ESG Lab was able to provision new storage and present it to a server in less than 10 minutes. Data migrations were just as easy and completely non-disruptive, which enables administrators to provide better service levels to applications and users while making it easier to manage the system over its lifetime, helping further reduce costs and do more with less.

ECO Mode

ECO mode is Fujitsu's term for power consumption reduction using MAID technology. MAID, an acronym for "Massive Array of Idle Disks," reduces power consumption by spinning down less frequently accessed disk drives when not in use. ECO mode can be set for any type of disk or RAID group in the array. After 30 minutes idle time, drives are spun down, reducing power consumption. Read or write access to any volume on any drive in a spun down RAID group will re-activate the drives. Re-activation can take anywhere from seconds to up to three minutes, depending on the drive type and configuration.

Figure 9 shows the timeline of a use case for ECO mode. In this instance, the customer uses a pool of large capacity SATA disks as backup to disk targets. The drives are scheduled to spin up just before midnight, when nightly backup jobs kick off. Thirty minutes after the last backup job completes, the drives spin down. The drives remain idle until the next scheduled spin up or, in this case, a user requests a restore. At 9:01AM, the backup administrator initiates the restore from the backup application. The drives spin up automatically and the restore runs. Thirty minutes after the restore job completes, the drives spin down again.

Figure 9. Fujitsu ETERNUS ECO Mode



In this scenario, the backup to disk pool remains spun down for about 80% of the time, representing significant power savings.

ESG Lab Testing

First, ESG Lab enabled ECO mode for RAID group 0x005, which contained a volume presented to a Fibre Channel-attached Windows server. ECO mode was enabled by simply setting the ECO mode checkbox and clicking 'Set,' as seen in Figure 10.

Figure 10. Configuring Fujitsu ETERNUS ECO Mode

Microsoft Internet Explorer V111171

File Edit View Favorites Tools Help

ON/OFF only Schedule only Both

Execute

RAID Group#	RAID Level	Status	Controlling CM	Capacity (MB)	DVCF Mode	Usage	ECO Mode Schedule ON/OFF - Schedule	Disk Status	Control Status
0x000	RAID5	Available	CM#0-CPU#0	410880	-	Open	<input type="checkbox"/> None	active	-
0x001	RAID1+0	Available	CM#3-CPU#1	273920	-	Open, SDV	<input type="checkbox"/> None	active	-
0x002	RAID5	Available	CM#1-CPU#0	840192	-	Open	<input type="checkbox"/> None	active	-
0x003	RAID5	Available	CM#2-CPU#1	1407744	-	Open	<input type="checkbox"/> None	active	-
0x004	RAID5	Available	CM#2-CPU#0	840192	-	Open	<input type="checkbox"/> None	active	-
0x005	RAID1	Available	CM#1-CPU#1	704259	-	Open	<input checked="" type="checkbox"/> 0x05 - Demo	active	-
0x006	RAID6	Available	CM#3-CPU#0	2815488	-	Open, SDV	<input type="checkbox"/> None	active	-
0x007	RAID1	Available	CM#0-CPU#1	704259	-	Open	<input checked="" type="checkbox"/> 0x05 - Demo	idle	-
0x008	RAID1	Available	CM#0-CPU#0	136960	-	Open	<input type="checkbox"/> None	active	-
0x009	RAID1	Available	CM#3-CPU#1	136960	-	Open	<input type="checkbox"/> None	active	-

[ECO Mode Schedule List](#)

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Jump to Page Next

Set Menu

Done Internet

There is a drop down menu to select a schedule for disk active times if one is required. As seen in Figure 10, RAID group 0x005 was active at the time ECO mode was enabled. ESG Lab waited 30 minutes after setting ECO mode and checked back in using ETERNUS Manager. Figure 11 shows that the RAID group was reported as idle at this point.

Figure 11. Verifying an Idle RAID Group

RAID Group#	RAID Level	Status	Controlling CM	Capacity (MB)	DVCF Mode	Usage	ECO Mode Schedule ON/OFF - Schedule	Disk Status	Control Status
0x000	RAID5	Available	CM#0-CPU#0	410880	-	Open	<input type="checkbox"/> - None	active	-
0x001	RAID1+0	Available	CM#3-CPU#1	273920	-	Open, SDV	<input type="checkbox"/> - None	active	-
0x002	RAID5	Available	CM#1-CPU#0	840192	-	Open	<input type="checkbox"/> - None	active	-
0x003	RAID5	Available	CM#2-CPU#1	1407744	-	Open	<input type="checkbox"/> - None	active	-
0x004	RAID5	Available	CM#2-CPU#0	840192	-	Open	<input type="checkbox"/> - None	active	-
0x005	RAID1	Available	CM#1-CPU#1	704259	-	Open	<input checked="" type="checkbox"/> - 0x05 - Demo	idle	-
0x006	RAID6	Available	CM#3-CPU#0	2815488	-	Open, SDV	<input type="checkbox"/> - None	active	-
0x007	RAID1	Available	CM#0-CPU#1	704259	-	Open	<input checked="" type="checkbox"/> - 0x05 - Demo	idle	-
0x008	RAID1	Available	CM#0-CPU#0	136960	-	Open	<input type="checkbox"/> - None	active	-
0x009	RAID1	Available	CM#3-CPU#1	136960	-	Open	<input checked="" type="checkbox"/> - 0x03 - rsg	active	-

17 Groups - Page 1/2

Jump to Page Next

Set Menu

Next, ESG Lab issued the 'dd' command on the Windows server. As shown in Figure 12, the response time after the first command was issued was 11,078 ms, or just over 11 seconds. The second command to the volume returned a response in 16ms, exactly as expected as the volume was spun back up. To help put this into context, the Fujitsu design minimizes the power footprint by staging the spin-up of drives. This reduces the maximum power demand that would result from powering up all drives simultaneously. While simultaneous spin-up would result in faster initial response times, it would also require higher peak power demands on the customer's environment.

Figure 12. ECO Mode in Action

```

C:\MaidTest>set CLASSPATH=.\
C:\MaidTest>java timecmd "dd if=\\.\PHYSICALDRIVE3 of=raw.i count=10 bs=1024"
command = dd if=\\.\PHYSICALDRIVE3 of=raw.i count=10 bs=1024
process time = 11078 ms
C:\MaidTest>docmd
C:\MaidTest>set CLASSPATH=.\
C:\MaidTest>java timecmd "dd if=\\.\PHYSICALDRIVE3 of=raw.i count=10 bs=1024"
command = dd if=\\.\PHYSICALDRIVE3 of=raw.i count=10 bs=1024
process time = 16 ms
  
```

Fujitsu is conservative in its estimates and states that drives can take between one and three minutes to re-activate after spinning down. This depends heavily on the drive and RAID configuration; it will certainly take longer for a RAID6 group made up of a large number of SATA drives to re-activate than a RAID-1 Fibre Channel drive pair.

Why This Matters

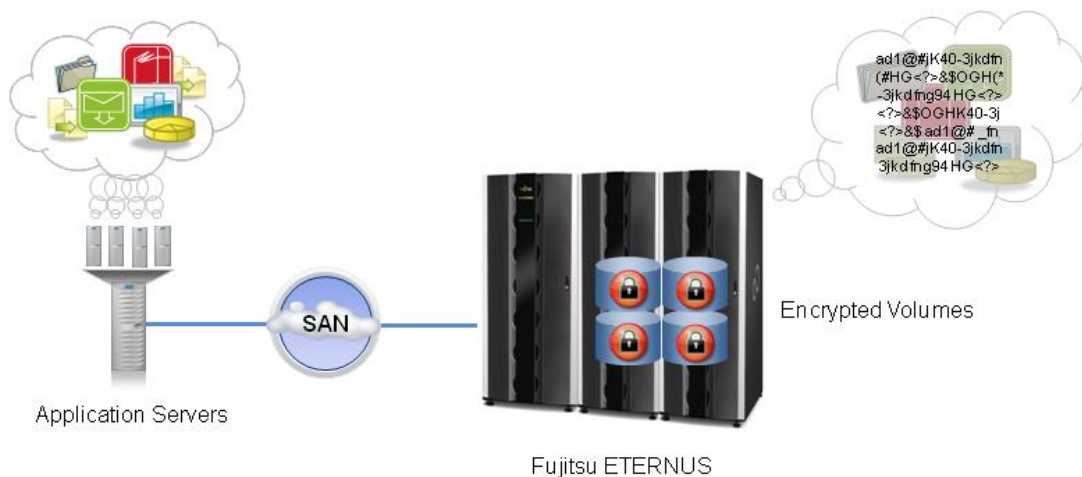
Energy costs are rising steadily and some metropolitan data centers in the United States are already reaching the limits of local utility providers. ESG research indicates that 71% of enterprises surveyed have formal initiatives and programs in place to reduce overall data center power and cooling requirements.⁵ At odds with this is the incredible rate of data growth occurring globally. As more and more data is created and retained, spinning disk drives represent a significant portion of energy consumed and heat generated in the data center.

ESG Lab has confirmed that Fujitsu ETERNUS ECO mode can be used to easily and effectively reduce power and cooling requirements by spinning down idle drives when not in use. In environments making use of large numbers of SATA drives for backup to disk or archiving, this represents a significant savings opportunity.

Fujitsu ETERNUS Disk Encryption

Thanks to information protection legislation—including Sarbanes Oxley in the United States and Japan's Financial Instruments and Exchange Law—information security has gained greater significance in the enterprise. These laws require that access to stored data is restricted to authorized users and unauthorized or accidental access to sensitive information is blocked. ETERNUS Disk storage systems provide on-disk data encryption to address this requirement. Data can be automatically encrypted inside ETERNUS storage systems using either industry standard 128bit AES encryption or a proprietary Fujitsu algorithm. This ensures that data is protected even if the physical drives are removed from the ETERNUS system. The data at rest encryption is performed at the logical volume level and is completely transparent to users with no access control or key management required—the encryption keys are tied to the RAID controllers in each individual ETERNUS system.

Figure 13. Fujitsu ETERNUS Drive Encryption

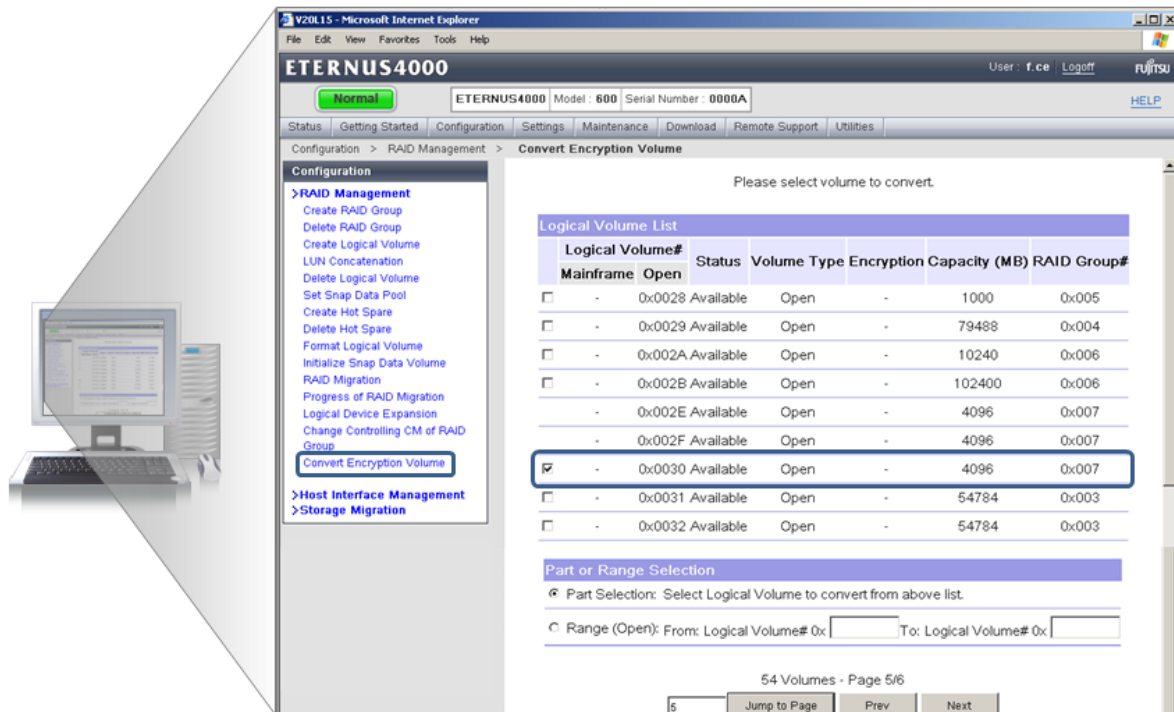


⁵ Source: ESG Research Report, *Global Green IT Priorities: Beyond Data Center Power and Cooling*, November 2008.

ESG Lab Testing

ESG Lab tested disk data at rest encryption in an ETERNUS4000 system. Using the ETERNUS Manager console, 'Convert Encryption Volume' was selected from the RAID management menu. This brought up a list of logical volumes with a checkbox next to all unencrypted volumes. ETERNUS Manager allows selection of individual volumes or a range, as seen in Figure 14.

Figure 14. Convert Encryption Volume



After selecting volume 0x0030, a volume visible to a test server containing a group of copied files, ESG Lab began the encryption process. Encryption status was visible directly from ETERNUS Manager. Once encryption was complete, ESG Lab confirmed that the files on the drive were still visible from the test server. Next, Fujitsu removed all the drives in the RAID group containing volume 0x0030 from the ETERNUS4000 system and physically installed them in another ETERNUS4000.

Figure 15. Moving Drives to a Different Array

Error detailed information (RAID Group# 0x009)							
No.	Status	Logical Volume#	Logical Volume LBA	RAID Group LBA	Error Stripe No.	Location	Error Disk LBA
		Mainframe Open					
1	CRC Error	- 0x0030	0x0000000000000020	0x0000000002710020	-	DE#02 Disk#0E	0x02710020
2	CRC Error	- 0x0030	0x0000000000000021	0x0000000002710021	-	DE#02 Disk#0E	0x02710021
3	CRC Error	- 0x0030	0x0000000000000022	0x0000000002710022	-	DE#02 Disk#0E	0x02710022
4	CRC Error	- 0x0030	0x0000000000000023	0x0000000002710023	-	DE#02 Disk#0E	0x02710023
5	CRC Error	- 0x0030	0x0000000000000024	0x0000000002710024	-	DE#02 Disk#0E	0x02710024
6	CRC Error	- 0x0030	0x0000000000000025	0x0000000002710025	-	DE#02 Disk#0E	0x02710025
7	CRC Error	- 0x0030	0x0000000000000006	0x0000000002710006	-	DE#02 Disk#0E	0x02710006
	CRC					DF#02	

As seen in Figure 15, the second ETERNUS4000 was unable to read any of the encrypted volumes, returning errors for each encrypted volume on the drives. The implementation of encryption in the ETERNUS4000 and ETERNUS8000 is identical, so testing with the ETERNUS4000 provides a user experience and result exactly the same as would be achieved with an ETERNUS8000.

Why This Matters

Widely publicized data breaches, privacy laws, and boardroom jitters are driving a behavioral shift towards data encryption. ESG research indicates that lost or stolen IT assets are a major source of anxiety for enterprises concerned with confidential data vulnerability. A significant percentage of these organizations believe that encryption technology should be integrated into disk and controller hardware.⁶ Should personal or financial data become compromised, the corporation would potentially be liable for damages and heavy fines. The costs associated with the loss or theft of personal credit card information alone has been staggering: Consider, for example, one of the many public disclosures associated with the loss of tapes containing the personal data of 3.9 million customers. Estimating a cost of \$30 to \$150 per customer for notification and credit services, this single event translates into a total cost of between one and six billion dollars.

These incidents demonstrate that the risk is real and the costs are high. Encrypting data on disk reduces risk, avoids potentially crippling costs, and keeps the CEO out of the headlines. ESG Lab verified that the Fujitsu ETERNUS platform secures data at rest with integrated AES encryption and prevents unauthorized data access after disk drives are removed from the system.

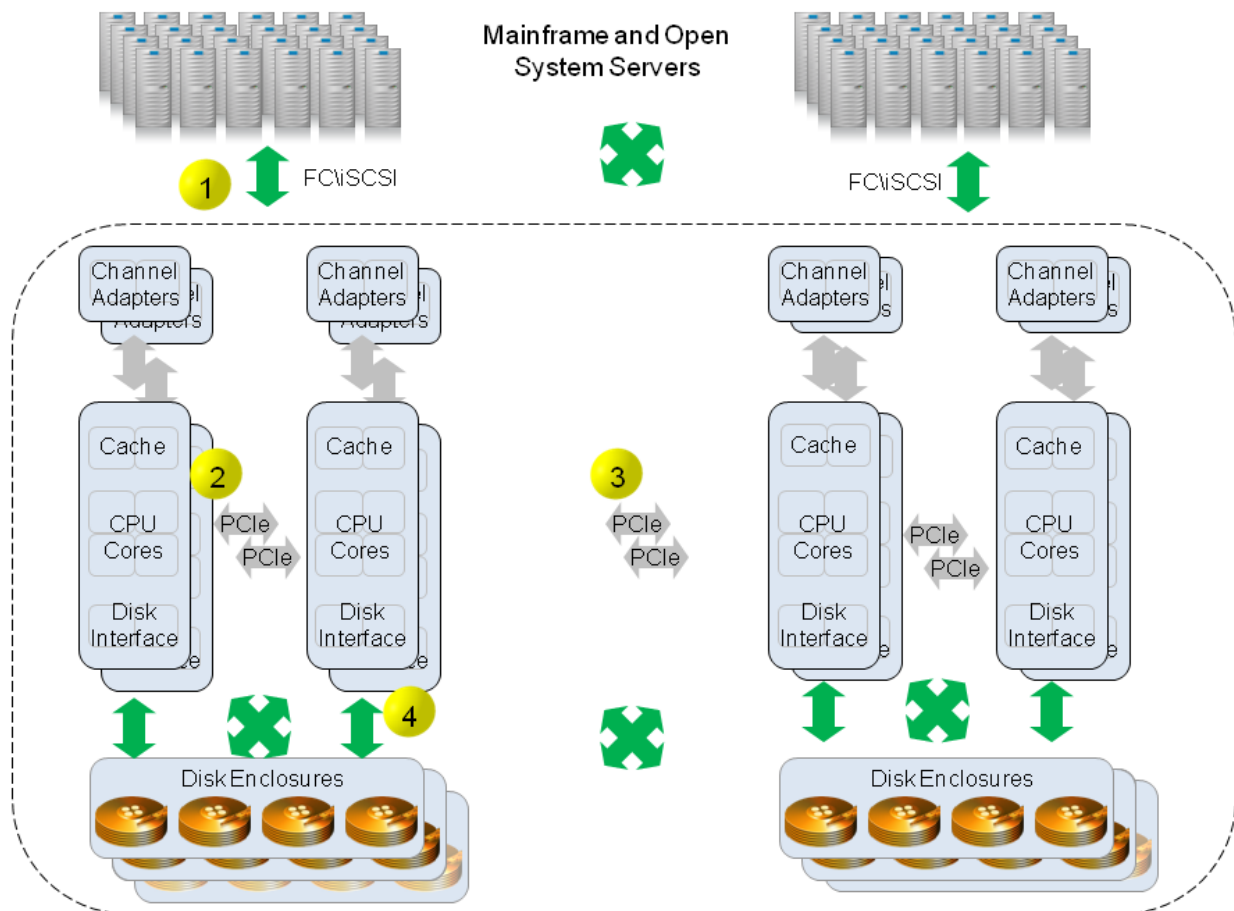
⁶ Source: ESG Research Report, *Protecting Confidential Data*, March 2006.

Performance and Scalability

The Fujitsu ETERNUS8000 is an enterprise-class disk storage system supporting both Fujitsu GlobalServer mainframes and UNIX/industry standard servers in large-scale commercial and scientific environments. The ETERNUS8000 was architected to meet the high-capacity and performance requirements of large organizations while providing a foundation for matching application requirements with appropriate classes of storage. Its platform offers non-stop operation thanks to multiple active controllers, Cyclic CM, a fully redundant back end, and multiple local and remote data replication options. Cyclic CM enables ETERNUS8000 disk storage systems to operate with up to eight controllers, enabling performance and high availability to be maintained during a controller failure or scheduled maintenance. With the Cyclic CM function, write data is duplicated to cache memory on different controllers. If one controller fails or is taken out of service, the remaining controllers automatically reconfigure to close the gap and ensure 100% cache and controller redundancy.

The basic ETERNUS architecture is shown in Figure 16. The architecture of the ETERNUS is designed to eliminate single points of failure and to increase availability as more resources are added to the system. Servers access the ETERNUS through front end channel adapters (1) which support active-active load balanced redundant connectivity. Multiple high speed PCI-Express buses (2 and 3) are used to move control information and data within and between Control Modules. Multiple redundant Fibre Channel loops (4) connect each disk enclosure to multiple controllers.

Figure 16. The Fujitsu ETERNUS8000 Architecture



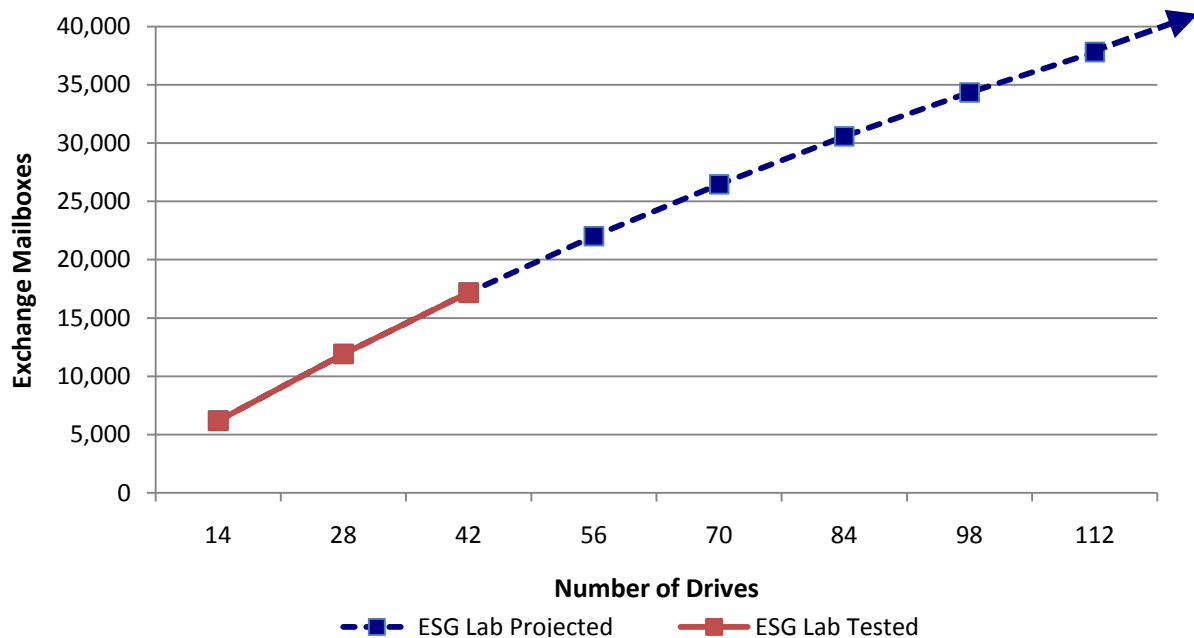
ESG Lab Testing

ESG Lab next analyzed ETERNUS system performance in an Exchange environment via an audit of Microsoft ESRP 2.1 results and hands-on testing using Iometer workloads designed to simulate a Microsoft Exchange 2007 environment. Fujitsu has published a Microsoft Exchange Solution Review Program (ESRP) result for a two controller ETERNUS2000 Model 100.⁷ ESG Lab performed a series of tests against a four controller ETERNUS8000 Model 1100 to simulate Microsoft Exchange 2007 workload scaling using Iometer.

ESRP is a Microsoft program designed to facilitate third party storage testing and solution publishing for Exchange Server. The program combines a storage testing harness (JetStress) with publishing guidelines for Microsoft Gold Certified and Storage OEM Partners. ESRP employs the Jetstress utility to create real exchange IO traffic that runs against real exchange databases—with logging and file attachments—exactly as in the real world. The testing is designed to measure both the performance and reliability of a given solution. The performance test runs for two hours while the reliability test runs for 24 hours. Both tests must run without exceeding a prescribed disk latency threshold (20 milliseconds) and a reliability test is performed to check for database and log corruption at the end of the run. Manufacturers use the ESRP framework to test storage solutions and then submit results to Microsoft for review. Links to approved solution results are posted on the Microsoft Exchange ESRP website.⁸

The published ESRP results are for a relatively small configuration supporting 2,500 users on just 14 disk drives using Microsoft's Heavy user profile (.384 IOPS per mailbox). ESG Lab testing was performed against an ETERNUS8000 Model 1100 using 14, 28, and 42 drives in a RAID 1+0 configuration. Iometer was used to generate a workload similar to the IO generated by JetStress to provide a quick estimate of the number of Exchange 2007 users that the system could support.

Figure 17. ESG Lab Exchange Simulation Testing



Source: Enterprise Strategy Group, 2009.

ESG lab observed a scaling factor of approximately 92% running the Exchange workloads on successively larger groups of drives. Figure 17 shows the projected scalability of the ETERNUS platform's support for Exchange mailboxes using Microsoft's Very Heavy user profile of .5 IOPs per mailbox. Scaling was nearly linear and response

⁷ <http://www.fujitsu.com/downloads/STRSYS/system/eternus2000-esrp.pdf>

⁸ <http://technet.microsoft.com/en-us/exchange/bb412164.aspx>

times were about 15 ms for all tests. Table 1 shows the results of Iometer testing and estimated supportable Exchange mailboxes using Microsoft's Very Heavy user profile.

Table 1: Iometer Test Results and Projection

Number of Drives	Exchange DB IOPS	Number of Exchange Mailboxes
14	3,094	6,187
28	5,955	11,909
42	8,587	17,174
112 (projected)	18,907 (projected)	37,813 (projected)

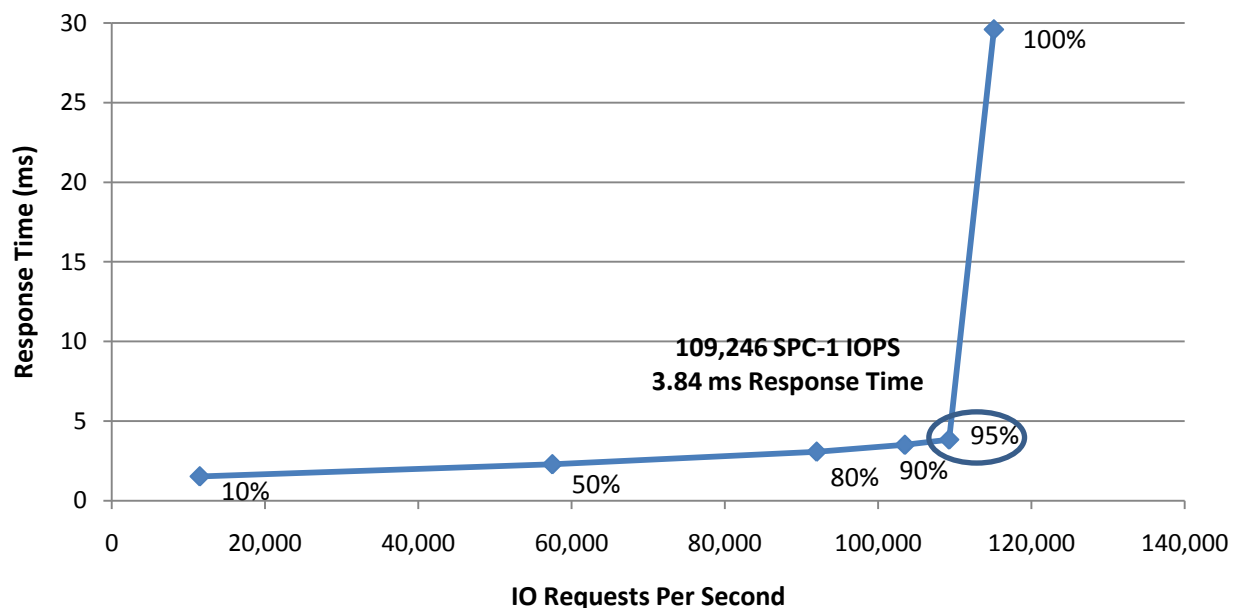
What the Numbers Mean

- The ETERNUS8000 provided sufficient IO to support 17,174 Exchange users with just 42 disk drives.
- IO scaled nearly linearly as drives were added, with minimal differences in response time. This is highly desirable as disk response time has a direct impact on the user experience in an Exchange environment.
- This simulation only projects performance out to 112 drives. The ETERNUS8000 Model 1100 scales to 1072 drives while the model 2200 scales to 2,760 drives. ESG Lab feels strongly, based on hands-on testing and audit of published test results, the ETERNUS8000 can service much higher numbers of Exchange users.

SPC-1 Results

ESG Lab audited Fujitsu's published results of the SPC-1 application-level industry standard benchmark suite maintained by the Storage Performance Council. SPC-1 testing generates a single workload designed to emulate the typical functions of transaction-oriented, real-world database applications. Transaction-oriented applications are generally characterized by random IO and generate both queries (reads) and updates (writes). Examples of those types of applications include OLTP, database operations, and mail server implementations.

Figure 18. Fujitsu ETERNUS8000 Model 1100 SPC-1 Results



Source: Enterprise Strategy Group, 2009.

As seen in Figure 18, Fujitsu has published an excellent result of 109,246 SPC-1 IO requests per second at 95% load with an average response time of less than 3.84 milliseconds. 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 system servicing 109,246 SPC-1 IO requests per second with a response time of 3.84 ms is exceptional.

The SPC-1 benchmark synthesizes a community of users running against storage that is organized logically as would be encountered in a real-world application. SPC is one of the few benchmarks in the industry that helps to deliver value in the area of real world performance characterization. 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 can be executed per second.

It should be noted that the numbers published in these reports are for the previous generation Fujitsu ETERNUS subsystems. As of this writing, Fujitsu is working toward the release of updated benchmarks which should present higher performance numbers than currently published.

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.⁹ While this can be useful for comparison between vendors, it is important to note that not all vendors participate and publish results. ESG Lab applauds Fujitsu's participation in this peer-reviewed program and hopes that it will encourage other vendors of enterprise class storage systems to participate.

Why This Matters

ESG research indicates that performance is a key concern when deploying mission critical applications in a highly consolidated environment. With multiple application servers relying on a shared storage infrastructure, there is a worry that performance requirements can't be met affordably. As a matter of fact, 51% of ESG survey respondents reported that performance was their top concern, followed closely by capital and operational costs.¹⁰

Through careful examination of ESRP and SPC-1 results, combined with hands-on testing, ESG Lab has verified that Fujitsu ETERNUS8000 disk storage systems can be deployed to cost-effectively provide predictably scalable enterprise-class storage for Exchange and OLTP environments of all sizes with excellent price-performance, as evidenced by its excellent \$16.12/SPC-1 IOP, which is the best published result for a mainframe-ready enterprise disk based storage system. As enterprise environments continue to grow in size and complexity, the ETERNUS8000 can clearly provide a platform for affordable performance and capacity scalability.

⁹ http://www.storageperformance.org/results/benchmark_results_spc1

¹⁰ Source: ESG Research Report, *The Impact of Server Virtualization on Storage*, December 2007.

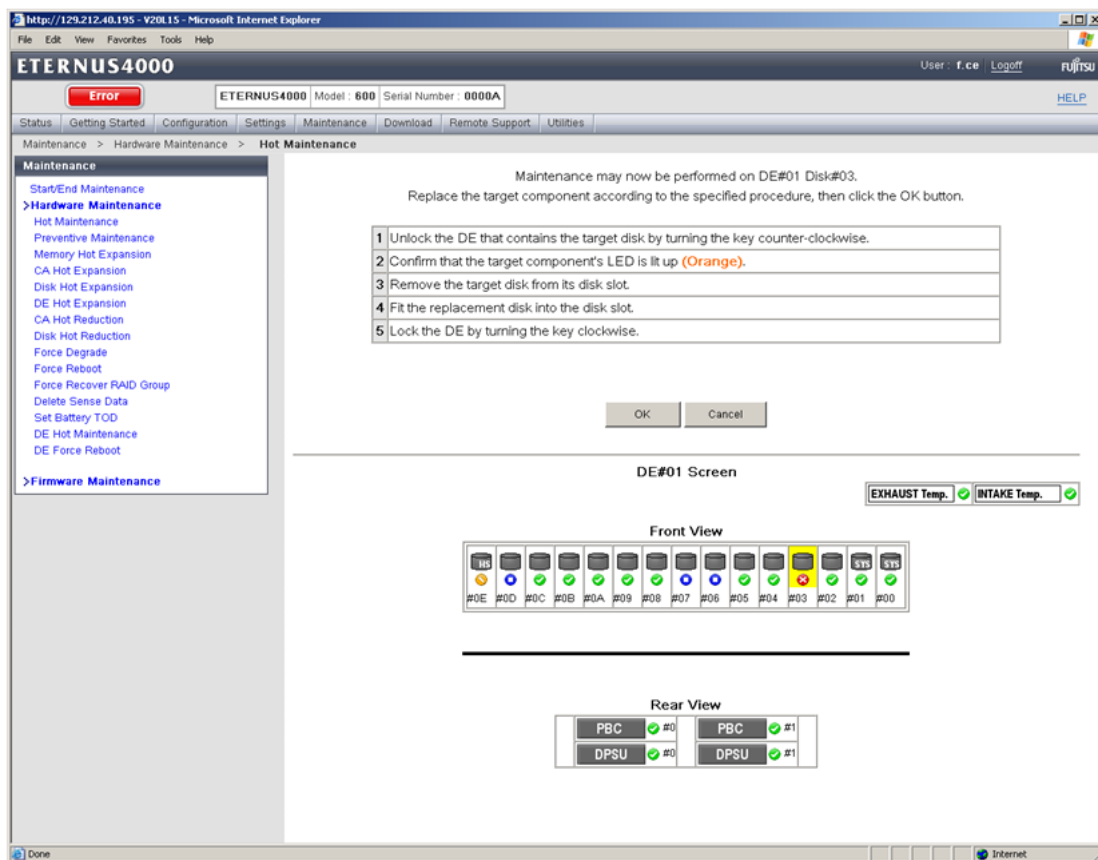
Availability and Business Continuity

Fujitsu ETERNUS disk storage systems offer a broad range of data and volume protection options that enable organizations to provide highly available storage to their users within a single system and across multiple data centers. ETERNUS provides extensive, enterprise class, in-system data integrity and availability assurance. For example, the Block Guard feature adds check codes to data and verifies the data at the Channel Adapter and Device Adapter to ensure operational accuracy and end-to-end storage integrity. Data availability is ensured via component redundancy, hot swap, failure isolation, multi-path access as well as intra- and inter-system volume copy services.

ESG Lab Testing

Due to the similarity in design and implementation of availability features across the ETERNUS line, ESG Lab was able to test system hardware availability features against an ETERNUS4000 Model 600 and achieve the same results as would be obtained testing against an ETERNUS8000. While running a continuous Iometer workload against a volume presented to a virtual Windows 2003 server in an attached VMware ESX host, multiple errors were injected. A disk drive, power connection, Fibre Channel cable, and CM (Controller Module) were all removed from the system, one at a time, to simulate multiple failures on a running system. First, a drive was removed from the RAID group housing the volume under test. Figure 19 shows the ETERNUS Manager hot maintenance screen displaying the RAID group after the drive was removed from service. The hot spare drive activated automatically and the RAID group began to rebuild.

Figure 19. The ETERNUS Manager Hot Maintenance Screen



It's important to note that the procedure for replacing the drive is clearly presented by ETERNUS Manager, giving customer service personnel unambiguous indication of the drive to be replaced and the methodology for non-disruptively doing so.

Next, ESG Lab pulled a power cable, removed two of the four Fibre Channel connections to the ESX server, and disabled one of the two main controller modules in the system, pausing to examine ETERNUS Manager between each event. After each event, the administrator received an e-mail detailing the fault and a call was placed to Fujitsu support. Iometer continued to run through every event, with no errors and only a momentary pause in IO when the controller module was forced down.

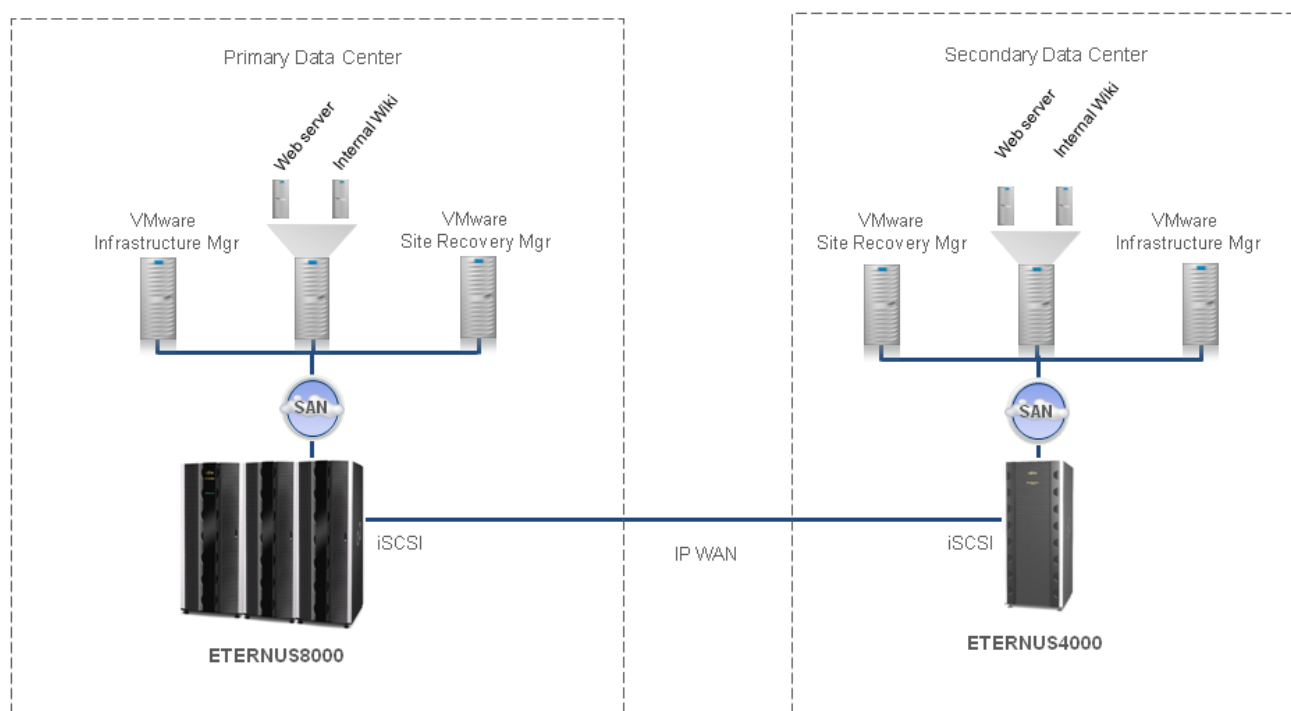
VMware Site Recovery Manager

The test bed used for VMware SRM is summarized in Figure 20. Disaster recovery plans were created to manage the failover, and failback, of web and wiki servers running in the primary data center. Documents were uploaded to the web server and edited while the site failover was performed.

Multiple servers were deployed in the simulated primary and secondary data centers running our test applications as well VMware Infrastructure Manager and VMware vCenter Site Recovery Manager.

An ETERNUS8000 Model 1100 system was deployed as the primary system and an ETERNUS4000 Model 600 was deployed as the secondary. Gigabit Ethernet iSCSI ports on the two storage systems were used to connect the two data centers to a simulated wide area network directly with hardware-based encryption and WAN optimization.¹¹

Figure 20. The VMware SRM Test Bed



VMware ESXi version 3.5, update 4, was used to deploy virtual machines in each of the data centers. All of the virtual machines ran the Windows 2003 Enterprise x64, SP1 operating system. The ETERNUS8000 system ran firmware version V11L71 and the ETERNUS4000 ran firmware version V20L15. ETERNUS SF Advanced Copy Manager was used to replicate data volumes between systems.

¹¹ See the Appendix for more configuration details.

ESG Lab Testing

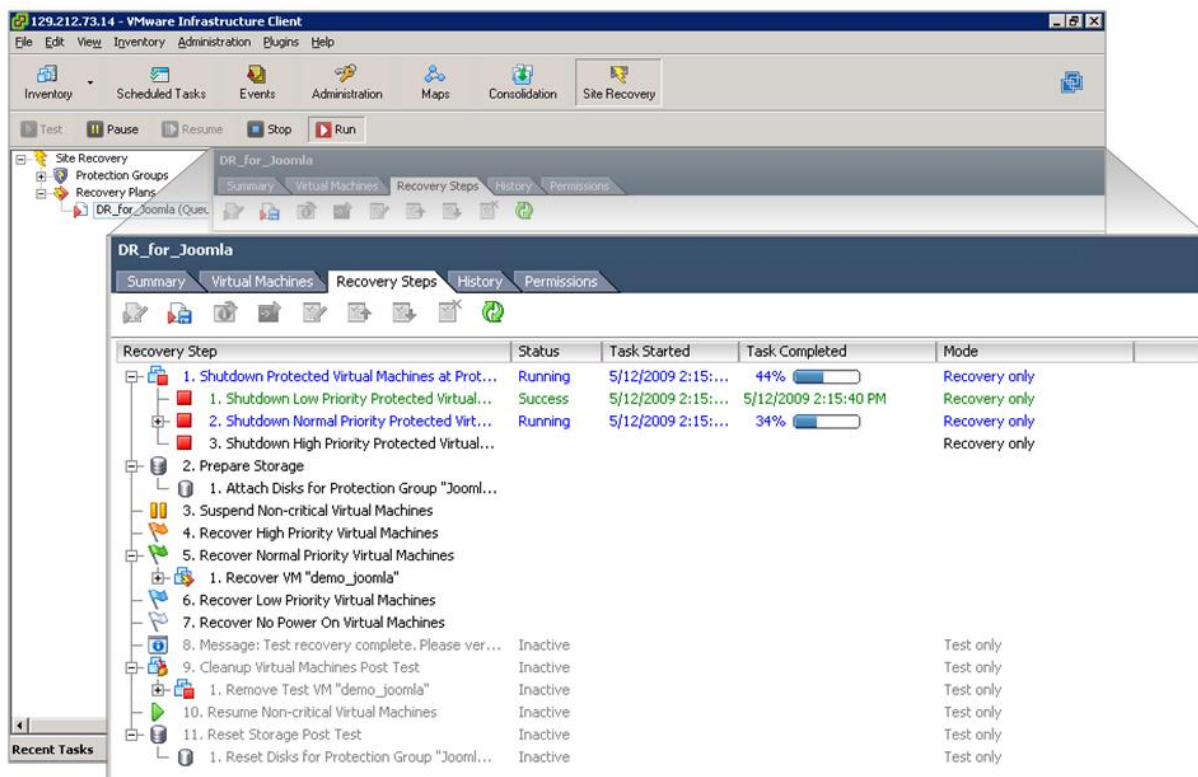
ESG Lab testing began with a review of a pre-configured VMware vCenter SRM disaster recovery plan. The steps required to configure a VMware vCenter SRM disaster recovery plan are:

1. Install VMware vCenter SRM software on a server in each data center
2. Install the ETERNUS SF Site Replication Adaptor on the VMware vCenter SRM server in each data center
3. Launch the VMware vCenter SRM GUI to create a disaster recovery plan
4. Provide the IP address of the key components in the primary data center, including the ETERNUS system
5. Provide a list of virtual machines to fail over

VMware vCenter SRM does the rest; including discovering the virtual machine resources (memory, CPU, network, and drive resources) needed to automatically recreate a working application environment after a disaster.

VMware recovery plans were run during ESG Lab testing to fail over a web server application from a primary data center to a secondary data center. A failover with both data centers up and operational was performed to confirm that the virtual machines protected by a VMware recovery plan (and the applications running in those machines) could be successfully restarted at the secondary data center with no data loss. ESG Lab ran the site failover immediately after an administrator added a document to a page on the web server and viewed the page to confirm the new document was up on the site. Figure 21 shows the progress of the recovery moments after the *Run* button was clicked. ESG Lab noted that progress was very easy to follow. Successfully completed recoveries are depicted in green, the currently executing steps are blue, and any failed steps are shown in red.

Figure 21. Running a Disaster Recovery Plan



The fully automated recovery completed in less than five minutes. Three minutes after the failover had completed, the virtual machine was booted and running, as seen in Figure 22.

Figure 22. VM Ready to Run at Secondary Site

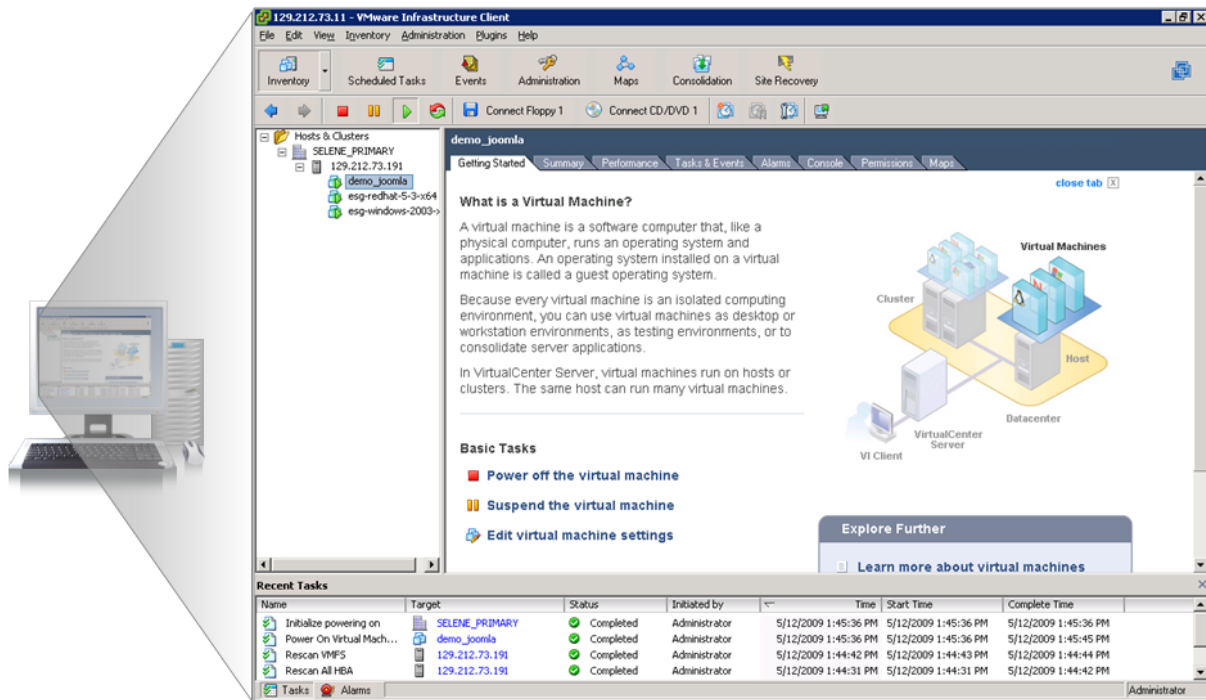
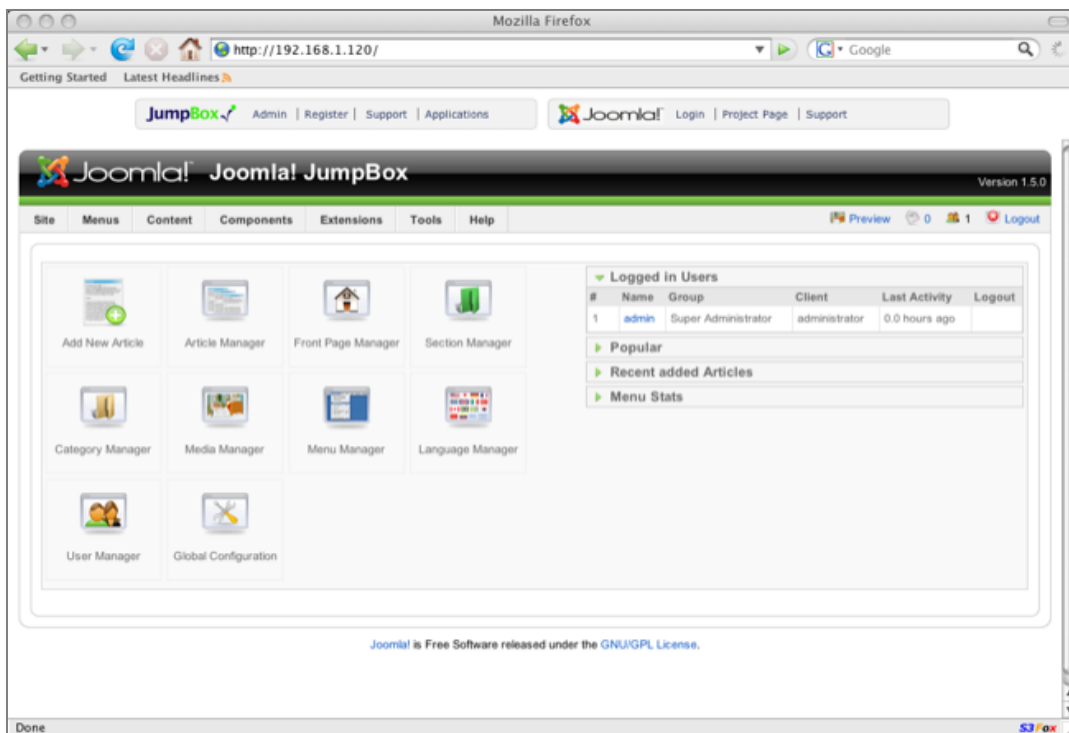


Figure 23 shows the website up and running on a virtual machine in the secondary system.

Figure 23. Applications Recovered and Running at Secondary Site



Once ESG Lab confirmed that the web server was up and that all documents and pages from the primary system were online and complete, the systems and applications were failed back to the primary data center. The VMware infrastructure manager console at the primary site was used to define a new recovery plan using the wizard-driven process described earlier in this report (see page 22). Except for the swapping of IP addresses for the VMware and storage resources at the secondary data center, the process was exactly the same.

Less than thirty minutes after getting started with the definition of a failback plan, the website was back up and running at the primary data center.

Why This Matters

Recovering from a disaster using traditional backup software methods can take days. Disk-based remote mirroring can be used to cut the recovery time to minutes, but traditional solutions which rely on scripts and manual operations can be complex and error prone. When sprinklers are running and cell phones are ringing, complex manual operations are the last thing an IT staffer needs to deal with.

ESG Lab has verified that Fujitsu ETERNUS disk storage systems running ETERNUS SF Advanced Copy Manager, in conjunction with VMware SRM, can be used to automate the recovery of critical applications after a disaster. Less than ten minutes after a simulated failure in a primary data center, applications were up and running at a remote recovery site with zero data loss.

Restoring operations in a rebuilt or new data center is typically the very last step in a disaster recovery process. ESG Lab confirmed that the same wizard-driven process used for failover can also be used for failback.

ESG Lab Validation Highlights

- ☑ ESG Lab was able to provision new storage and present it to an application server in less than 10 minutes.
- ☑ Fujitsu ETERNUS ECO mode was used to easily and effectively reduce power and cooling requirements by spinning down idle drives when not in use.
- ☑ ESG Lab verified that the Fujitsu ETERNUS platform secures data at rest with integrated AES encryption and prevents unauthorized data access after disk drives are removed from the system.
- ☑ Fujitsu ETERNUS disk storage systems can be deployed to cost-effectively provide predictably scalable enterprise-class storage for Exchange and OLTP environments with excellent price-performance.
- ☑ Less than ten minutes after a simulated failure in a primary data center, applications were up and running at a remote recovery site with zero data loss using ETERNUS SF Advanced Copy Manager in conjunction with VMware SRM.

Issues to Consider

- ☑ While ESG Lab found management of the ETERNUS platform to be robust and stable, there are multiple management interfaces: a client server application and a web interface to manage each system. There is some overlap, but in some areas, these apps provide a unique subset of functionality. Ideally, ESG would like to see these management apps consolidated or at least merged, such that all functionality is available on whichever app an administrator chooses to utilize.

The Bigger Truth

Enterprise IT departments are being challenged to address accelerating information storage growth and complexity without compromising performance or availability. As users continue to struggle to manage increasing volumes of data, they are also tasked to do so with constrained—or even reduced—resources. Fujitsu is delivering a level of capability and scalability in the ETERNUS that is compelling and extremely valuable to end-users.

The ETERNUS8000 is a highly available, flexible, and massively scalable disk storage system designed to enable enterprises to quickly and efficiently deliver storage services to their users and customers. The ETERNUS platform provides many capabilities that individually provide great value; but when these capabilities are combined, the result is true enterprise class storage.

ESG Lab found the ETERNUS8000 to be easy to manage while providing impressive performance for critical applications like Microsoft Exchange and OLTP databases. The ETERNUS8000 proved capable of scaling to support more than 37,000 Exchange mailboxes with consistently crisp response times. SPC-1 results were similarly impressive, with the ETERNUS8000 providing 109,246 SPC-1 IOPS with a 3.84 ms average response time. Enterprise class attributes, as implemented in the ETERNUS platform, provide data integrity, hardware reliability, and high availability options required by enterprises as well as functions not found in all enterprise class arrays, such as ECO mode power reduction technology as well as hardware-based encryption for remote replication and disk volumes.

ETERNUS also demonstrated robust integration with VMware SRM for easy to use, automated site failover and recovery. ESG Lab used ETERNUS SF Advanced Copy Manager remote replication technology to support a VMware SRM deployment and failed over from one site to another in minutes.

ETERNUS uses the same architecture and software across its entire storage range to provide demonstrable performance, scalability, and reliability benefits. The ETERNUS8000 provides large-scale storage consolidation, and a range of capabilities that are everything users have come to expect from an enterprise class array in a robust, mature package. Fujitsu has both breadth and depth in the storage business. Decades of R&D and market success have translated into an offering capable of supporting the most critical systems for the largest enterprises.

Appendix

Table 2. Test Configuration

Fujitsu ETERNUS4000 Model 600 – 60x 146 GB FC drives 8x 4 GB FC connections 4x GbE iSCSI host connections		Firmware V20L15	
Fujitsu ETERNUS8000 Model 1100 – 52x 146 GB FC drives 16x 4 GB FC connections 4x GbE iSCSI host connections		Firmware V11L71	
2x Brocade 4100 32 port 4 Gb/sec FC switches		Firmware Fabric OS v6.1.1	
VMware ESXi v. 3.5 U4 Server – 1x PRIMERGY RX600 S4 4x Xeon 2.4GHz Quad core CPU 64 GB RAM 4x QLogic QLA2342 4 Gb/sec FC HBA		Guest Operating System: MS Windows Server 2003 SP1 x64	
Physical Windows Server 1x PRIMERGY RX300-S3 1x 2.33GHz Quad core CPU Xeon 4 GB RAM 2x iSCSI 1 Gb/sec VLANs		Operating System: MS Windows Server 2003 SP1 x64	
IOMETER			
Version		2006.07.27	
Access Specification	IO Size	Random/Sequential Distribution	Read/Write Distribution
Exchange 2007 EDB	8 KB	90% Random	80% Read
Exchange LOG	64 KB	100% Sequential	100% Write
Exchange Simulation	Number of Servers	Physical Drives	RAID Protection
Iometer	1	14-42	RAID 1+0



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