LAB REPORT

Hitachi Adaptable Modular Storage 2000 Family
Real-world Application Performance Analysis
in Microsoft Exchange Server 2007 Environments

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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 Hitachi.

Introduction

This ESG Lab Report analyzes the operational efficiency (scalability, reliability, availability, and performance) of the Hitachi Adaptable Modular Storage 2000 family in real-world, mission-critical environments. Hitachi's excellent Microsoft Exchange Solution Reviewed Program - Storage (ESRP) and Storage Performance Council SPC-1 benchmark results were audited and analyzed to validate the tangible business value offered by the Adaptable Modular Storage 2000 family systems.

Background

As seen in Figure 1, ESG projects total worldwide e-mail archive capacity to increase more than 900% over the next four years, from just under 1,500 petabytes in 2008 to more than 13,400 petabytes in 2012.[1] These numbers illustrate the huge increases in primary e-mail capacity and are indicative of lengthening e-mail retention periods. In fact, in a survey of US IT organizations, a significant percentage of IT managers identify e-mail as one of the business applications that will be most responsible for primary storage growth during the next 24 months.[2]

Total Worldwide E-mail Archive Capacity, 2008-2012 (Petabytes)
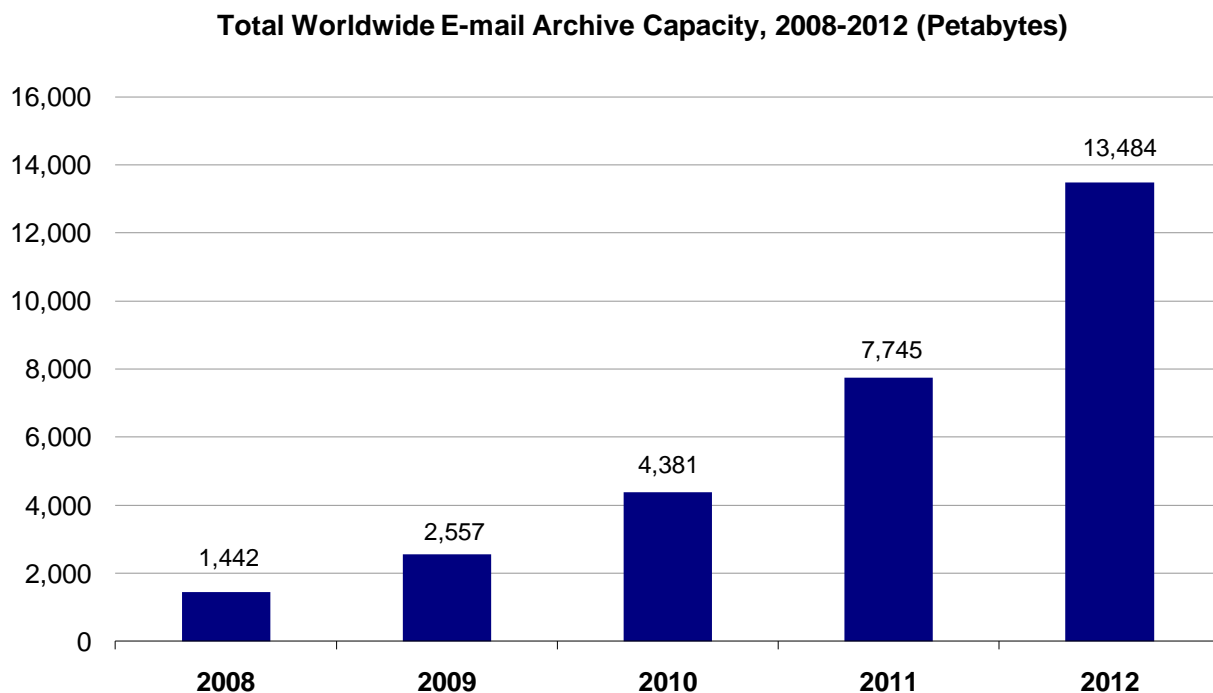
IT managers are being challenged to satisfy this growth in e-mail data while addressing the host of IT concerns that come with it. Mission-critical Exchange environments demand easily manageable systems with predictably scalable performance, enterprise class availability, and rock solid reliability.

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[1] Source: ESG Research Report, *E-Mail Archiving Survey,* November 2007.
[2] Source: ESG Research Report, *Enterprise Storage Systems Survey,* November 2008.

Hitachi Adaptable Modular Storage 2000 Family

Hitachi has focused on these customer priorities with its Adaptable Modular Storage 2000 family of next-generation midrange storage systems. These flexible, modular storage systems are designed to address the most crucial performance, scalability, and availability challenges faced by storage and IT managers supporting mission critical Microsoft Exchange environments. Adaptable Modular Storage 2000 family systems can start small and scale up to 472 TB in a single storage system, as shown in Figure 2. Performance of the new Adaptable Modular Storage 2000 family has increased dramatically over the previous generation and all systems support Fibre Channel or iSCSI host connections.

FIGURE 2. THE HITACHI ADAPTABLE MODULAR STORAGE 2000 FAMILY
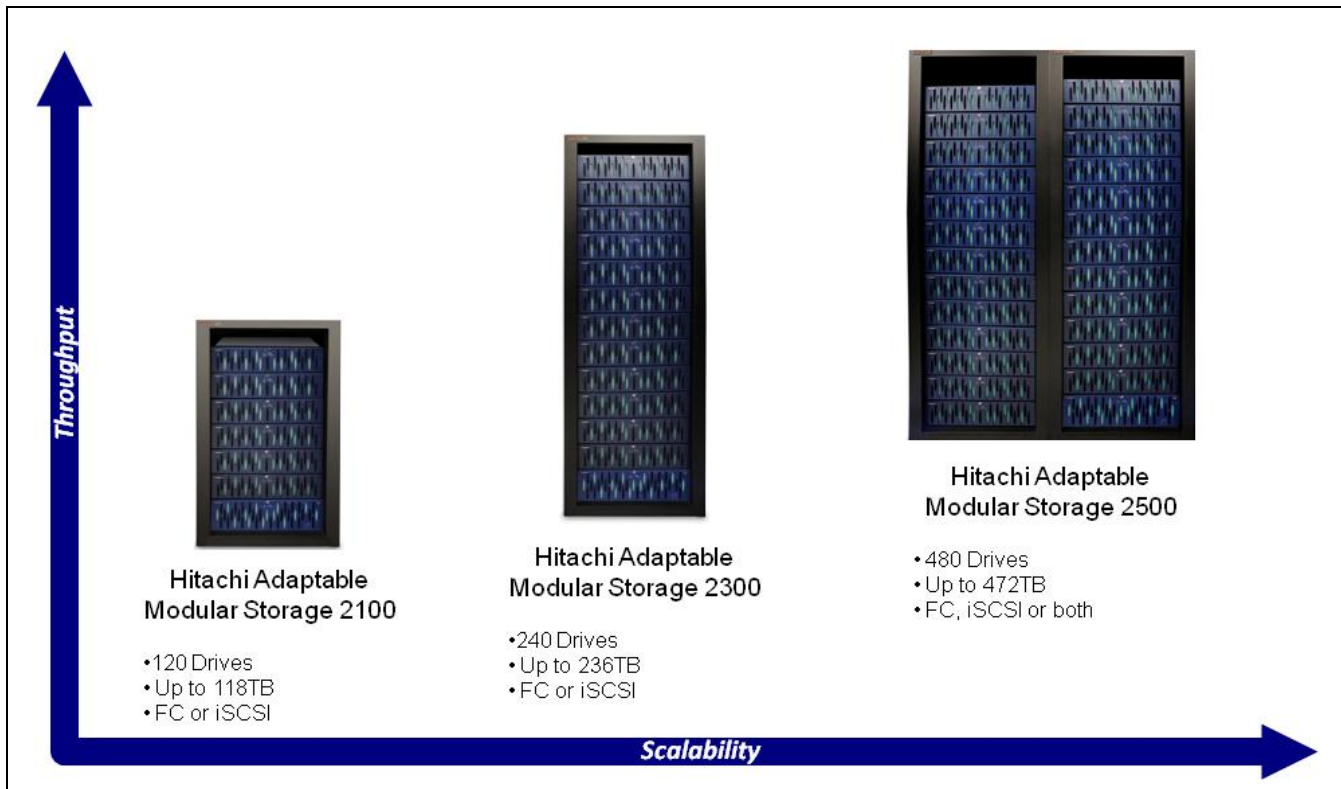
The Adaptable Modular Storage 2000 family is designed to address the dynamic needs of IT in support of mission and business critical applications like Exchange and provide a combination of critical features and functionality not found in other midrange storage systems or direct attached storage.

- **Enterprise-Class Architecture at a Modular Price** - Symmetric, active/active controllers with dynamic load balancing provide predictable response times for a wide range of demands.
- **SAS Inside** – Fully redundant, intermixable SAS & SATA-II back-end provides cost-efficient scalability, performance, and availability.
- **Power Efficiency** - Automatic power savings with SATA-II drives and programmable spin down for all drives optimizes power and cooling requirements.
- **Storage Virtualization -** Modular Volume Migration and Online RAID Group Expansion offer dynamic, online, non-disruptive volume migration and capacity expansion with data re-striping to keep applications on-line and running as capacity requirements increase.

The balance of this report presents the results of ESG Lab testing and analysis of the attributes of the Hitachi Adaptable Modular Storage 2000 family of storage solutions with a focus on real-world application performance in Microsoft Exchange environments.

ESG Lab Analysis

ESG Lab's assessment of the capabilities of the Hitachi Adaptable Modular Storage 2000 family began with hands-on testing of an Adaptable Modular Storage 2300 system at Hitachi's corporate headquarters in Santa Clara, California. Recently published ESRP and SPC performance benchmark results for Adaptable Modular Storage 2100 and Adaptable Modular Storage 2300 storage systems were audited and analyzed.

Hitachi Symmetric Active–Active Controllers

The Adaptable Modular Storage 2000 family systems are modular storage systems with a unique combination of symmetric active-active controllers, dynamic load balancing, and a cost-efficient SAS back end. An Adaptable Modular Storage 2000 system behaves more like an enterprise class array as it provides integrated and automated front-to-back I/O load balancing. Figure 3 compares traditional active-passive controller architecture with the active-active 2000 family architecture. In the traditional architecture, each controller owns a set of LUNs and each server accesses individual LUNs on one path at a time. Load balancing is a manual, administrative task where LUNs are distributed between front-end controllers. If IO is unbalanced, the administrator must manually change ownership of LUNs to the opposite controller until the IO load is balanced between the two, potentially forcing reconfiguration of the server and SAN to maintain access.

FIGURE 3. HITACHI ADAPTABLE MODULAR STORAGE ACTIVE-ACTIVE LOAD BALANCING CONTROLLERS
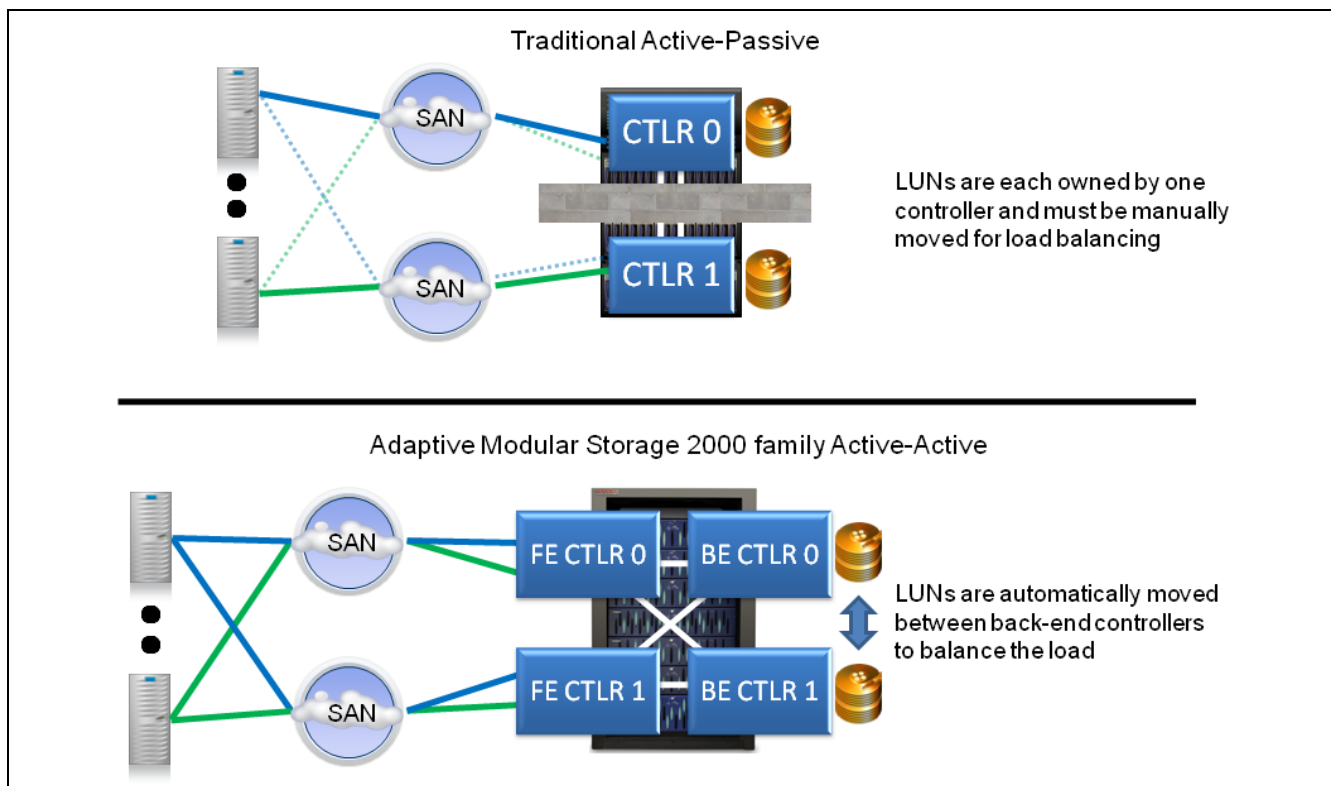
In the Adaptable Modular Storage 2000 architecture, LUNS are not owned by the front-end controllers and servers can access their LUNs through either controller. This has two immediate benefits: administrators no longer have to assign a LUN to a particular controller and the server can be attached to the array through both controllers without having to keep track of the 'active' controller for each LUN. Server side load balancing can then use all available paths to each device while the array automatically performs back-end load balancing—internally without disruption.

ESG Lab Testing

ESG Lab evaluated the active-active, load balanced architecture of the Adaptable Modular Storage 2300 system with a single Windows 2008 server attached to the 2300 using two Fibre Channel HBAs. Iometer was used to generate traffic to a single LUN on the 2300. A bandwidth-intensive 512 KB sequential read workload, similar to a nightly backup job or video streaming application, was run for five minutes. No other IO was running against the array during this test.

Iometer reported an average of 676 IOPS (338MB/sec) overall for the test run. Figure 4 shows the traffic as seen from the SNM2 Performance Monitor. The two charts show IOPS on Controller 0 and Controller 1. Each controller is reporting between 300 and 350 IOPS over the five minutes of the test run, perfectly in sync.

FIGURE 4. MONITORING LOAD BALANCING FROM THE SNM2 CONSOLE
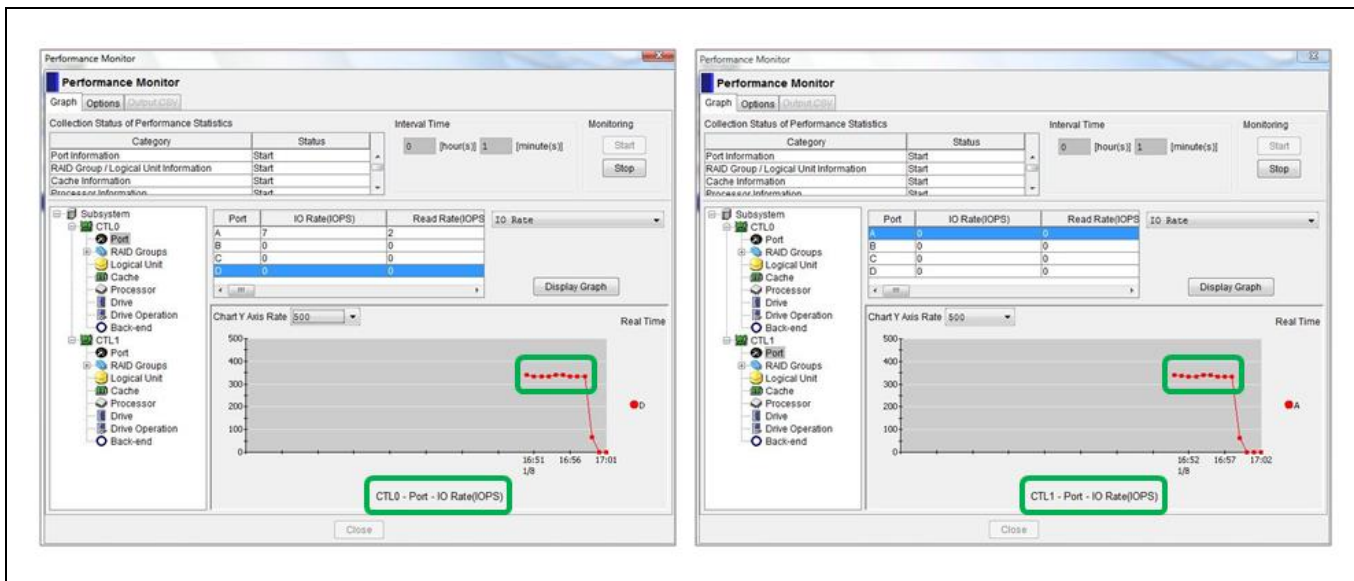
Why This Matters

In a survey of IT professionals, ESG found that performance, scalability, complexity, and cost were consistently among the top storage challenges reported.[3] A major challenge with both direct attached storage and midrange storage systems in Exchange environments has been the administrative effort required to manage scalability and performance. With traditional midrange storage systems, administrators must carefully map servers to resources to avoid bottlenecks and balance the load evenly. With DAS, administrators are limited by the number of drives that can be attached to a single server, which can be a very inefficient use of powerful server resources.

With architectural enhancements and enterprise class load balancing technology, ESG Lab has verified that the Hitachi Adaptable Modular Storage 2000 family can cost-effectively provide easy-to-configure storage for mission-critical applications with excellent performance. ESG Lab validated that the Adaptable Modular Storage 2000 family's active-active controller architecture with automatic load balancing was able to host multiple powerful Exchange servers on a single, high-performance, easy to administer storage array, reducing capital costs for new equipment as well as operational costs associated with storage management.

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[3] Source: ESG Research Report, *Enterprise Storage Systems Survey,* November 2008.

Introducing ESRP

The Microsoft Exchange Solution Reviewed Program (ESRP) is designed to facilitate third party storage testing and solution publishing for Exchange Server. Microsoft Gold Certified or Certified Storage Partners use the ESRP framework to test their storage solutions in the context of a Microsoft Exchange deployment. The programs combine a storage testing harness (Jetstress) with publishing guidelines. Manufacturers use the ESRP framework to test storage solutions and then submit results to Microsoft for review. Approved solution results are posted on the Microsoft Exchange ESRP website.[4] ESRP version 2.1 focuses on Exchange 2007 and Microsoft provides specific recommendations regarding Exchange database size, IO profiles, mailboxes per server, and mailbox size. Hitachi's submissions align and comply with all of Microsoft's recommendations.

The publishing guidelines require vendors to be quite specific as to the server, storage, and Exchange configurations tested. As shown in Figure 5, the level of detail reported includes not only the detailed configuration and layout of the disk array tested, but also the details of the Exchange deployment being simulated.

FIGURE 5. EXCHANGE SIMULATION DETAILS

Number of Exchange mailboxes simulated	10,800
Number of hosts	8
Number of mailboxes/host	1,350
Number of storage groups/host	36
Number of mailbox stores/storage group	1
Number of mailboxes/mailbox store	37.5
Number of mailbox store LUs/storage group	1
Simulated profile: I/Os per second per mailbox (IOPS, include 20% headroom)	0.576
Database LU size	85GB
Log LU size	10GB
Total database size for performance testing	22118.4GB
% storage capacity used by Exchange database**	90%

ESRP is different from standard IO generation benchmarking suites in three important ways. First, ESRP employs the Jetstress utility to create real Exchange traffic that runs against real Exchange databases—with logging and file attachments—exactly as in the real world. Second, the testing is designed to measure both the performance and the 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. Finally, ESRP is focused on producing recommendations from vendors for configuring and deploying their solutions for Exchange 2007.

As will be seen in this analysis, the same storage configuration can support vastly different numbers of mailboxes, depending on user profile and mailbox size. Another factor to examine is the percentage of storage capacity consumed by the Exchange database. Very small percentages (~25%) should be looked at with a more critical eye. As capacity utilization increases, storage performance changes and a system that performed brilliantly at 25% utilization will almost certainly perform less so at 90%.

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[4] http://technet.microsoft.com/en-us/exchange/bb412164.aspx

The goal of ESRP is to verify that a vendor's storage solution can handle an Exchange IO load in a specific configuration sustained over a long period of time with predictable response times. Microsoft makes it quite clear that these tests should not be used for performance comparisons, but in practice, end-users routinely look to these detailed test results to gauge how well a given configuration will perform under specific conditions. This is not a bad use of these results, provided that all relevant factors are taken into consideration.

The ESRP Test Bed

As shown in Figure 6, an Adaptable Modular Storage 2100 and an Adaptable Modular Storage 2300 were utilized for the testing—both configured with a full complement of 15K RPM 300 GB SAS drives. Eight Sun Fire 4600M2 servers were used to run LoadGen and JetStress. Four servers were used in the tests against the 2100 and eight servers were run against the 2300.

FIGURE 6. THE HITACHI ESRP TEST BED
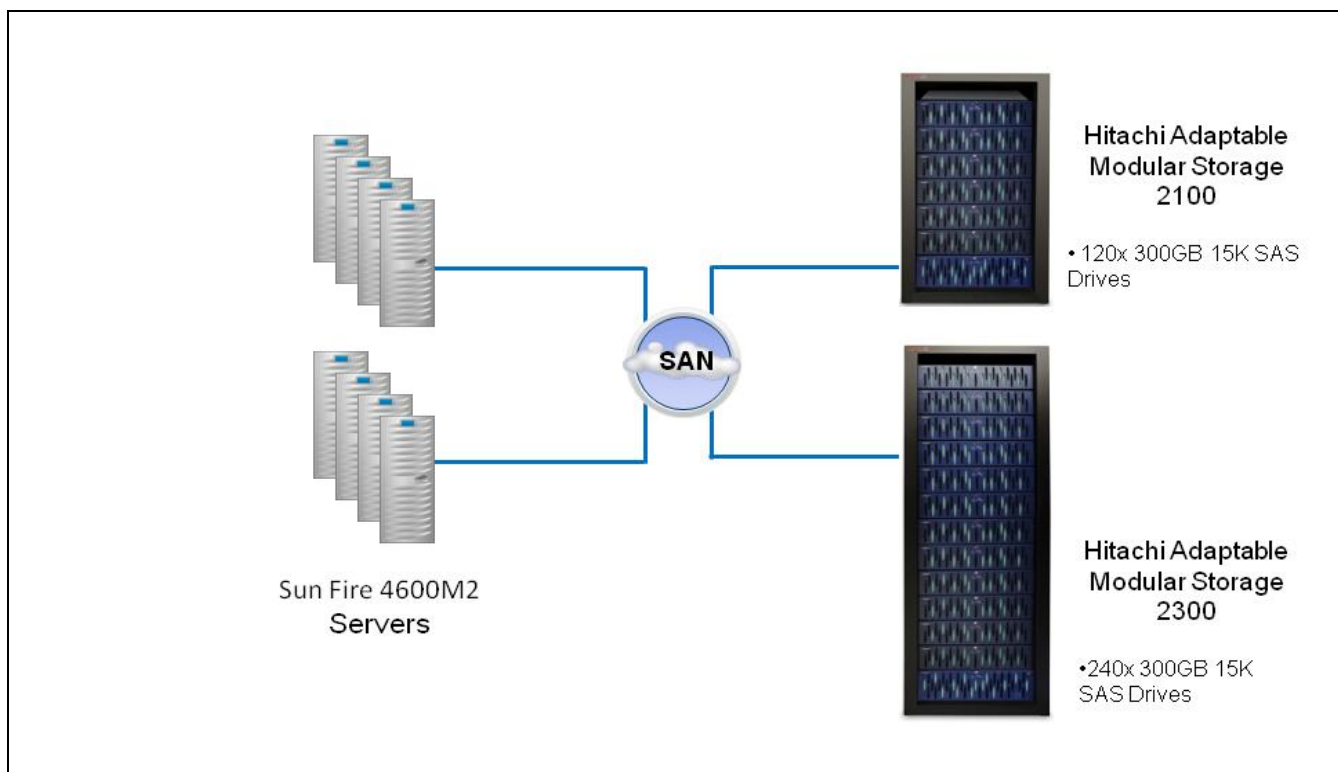
The configuration details for each test run are summarized in Table 1. Hitachi tested six different scenarios to highlight the flexibility and predictable scalability of the Adaptable Modular Storage 2000 family platform.

TABLE 1. ESG LAB AND ESRP EXCHANGE CONFIGURATIONS

Adaptable Modular Storage Model	Number of Disks	Storage Capacity Utilization	User Profile	Mailbox Size	Number of Servers	Mailboxes Per Server
2100	96	90%	Very Heavy	2 GB	4	1,350
2100	96	94%	Heavy	1 GB	4	2,800
2100	96	47%	Average	250 MB	4	5,750
2300	192	90%	Very Heavy	2 GB	8	1,350
2300	192	94%	Heavy	1 GB	8	2,800
2300	240	37%	Average	250 MB	8	4,500

What the Numbers Mean

- Hitachi has published results for relatively small, medium, and large configurations ranging from an Adaptable Modular Storage 2100 with 96 drives supporting 1,350 mailboxes on each of four servers up to an Adaptable Modular Storage 2300 with 240 drives supporting 36,000 mailboxes (8 servers * 4,500 mailboxes per server).
- Storage capacity utilization averaged 75% and the only tests with utilization below 50% were for the smallest mailboxes/users with the lightest IO. This is a good thing. Often, benchmark results are posted with a system at 25% capacity or less. This technique artificially enhances results as the disk actuators avoid full seeks across the entire surface of the drive (this practice is sometimes referred to as "short-stroking").
- Hitachi has published results for three of the five user profiles defined by Microsoft: 'Average,' 'Heavy,' and 'Very Heavy.' The profiles specify the amount of IO per user as determined by the average amount of e-mail sent and received by a typical Exchange user during a typical workday.[5] The three profiles tested by Hitachi most closely match the vast majority of all real-world Exchange environments.

ESRP Results

FIGURE 7. HITACHI ADAPTABLE MODULAR STORAGE 2000 FAMILY ESRP RESULTS
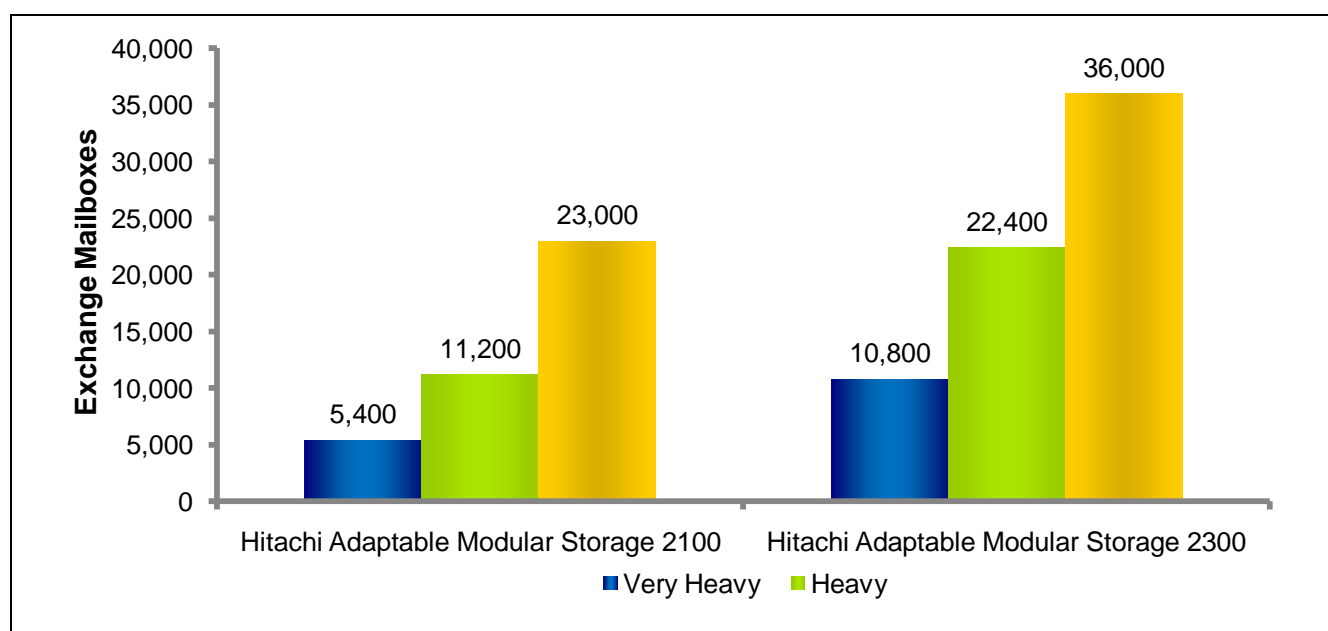
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[5] Microsoft user profile definitions can be found in the appendix.

The columns in the chart represent the number of mailboxes supportable for the different user profiles and mailbox sizes tested by Hitachi. It's important to note a few things here:

- The Hitachi Adaptable Modular Storage 2000 family has demonstrated the performance and reliability required to support mission critical Microsoft Exchange deployments, scaling to 36,000 users in a single system.

- No environment is completely homogeneous and every Exchange implementation will have a mix of different user profiles in unique proportions, so the supportable number of mailboxes will never fall exactly into any one of these scenarios.

- ESRP is designed to assess storage performance and reliability only. Storage is only one factor to be considered when designing an Exchange solution. Users need to consider server CPU and memory, network infrastructure and latency, recovery requirements, and resources consumed by other applications as well as the specific mix of mailbox sizes and usage patterns that will need to be supported. Microsoft provides extensive information on analyzing Exchange Server performance looking at all of these factors, which are outside of the scope of the ESRP-Storage program.[6]

The results of the Hitachi ESRP v2.1 tests are summarized numerically in Table 2.

TABLE 2. ESG LAB AND ESRP EXCHANGE PERFORMANCE

| User Profile	Adaptable Modular Storage 2100 ESRP Mailboxes	Average response time	Adaptable Modular Storage 2300 ESRP mailboxes	Average Response Time
Very Heavy	5,400	10 ms	10,800	11 ms
Heavy	11,200	10 ms	22,400	10 ms
Average	23,000	10 ms	36,000	10 ms

What the Numbers Mean

- The systems showed remarkable consistency in disk response times, regardless of IO load. The average database disk IO response time was between 10 and 11 MS, while all writes were satisfied in less than 2MS.
- Extremely consistent performance was realized for each test both when looking at individual server results or when all servers were combined. This proves that the 2000 family systems can scale both capacity and performance as needed.
- Microsoft stresses that, to ensure a positive user experience, the Exchange database LUN requires read and write response times of less than 20 milliseconds so that Exchange can service users' client software quickly and efficiently. In this context, the 2000 family's performance is even more impressive. Consider a practical example: An Exchange environment where hundreds or even thousands of users all log in and check e-mail every morning at about the same time. The 2000 family's incredibly stable response times would help ensure that users would see the same responsiveness from their clients during peak load times as during relatively idle periods.
- The twenty-four hour reliability test runs in ESRP proved that the 2000 family's SAS architecture was robust enough to provide consistent performance sustained over long periods with zero errors and 100% data integrity.

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[6] http://www.microsoft.com/downloads/details.aspx?FamilyId=8679F6BD-7FF0-41F5-BDD0-C09019409FC0&displaylang=en

ESG Lab E-mail Testing

ESG lab next analyzed Adaptable Modular Storage 2000 family performance using Iometer workloads designed to simulate a Microsoft Exchange 2007 environment. ESG Lab constructed the Iometer test bed for the Adaptable Modular Storage 2300 with a single server and the same number of disks, raid protection, and layout used to obtain the ESRP results for one of the servers in the test. The Iometer results were compared to the published ESRP IOPS, as seen in Figure 8.

FIGURE 8. ADAPTABLE MODULAR STORAGE 2000 FAMILY EXCHANGE TESTING
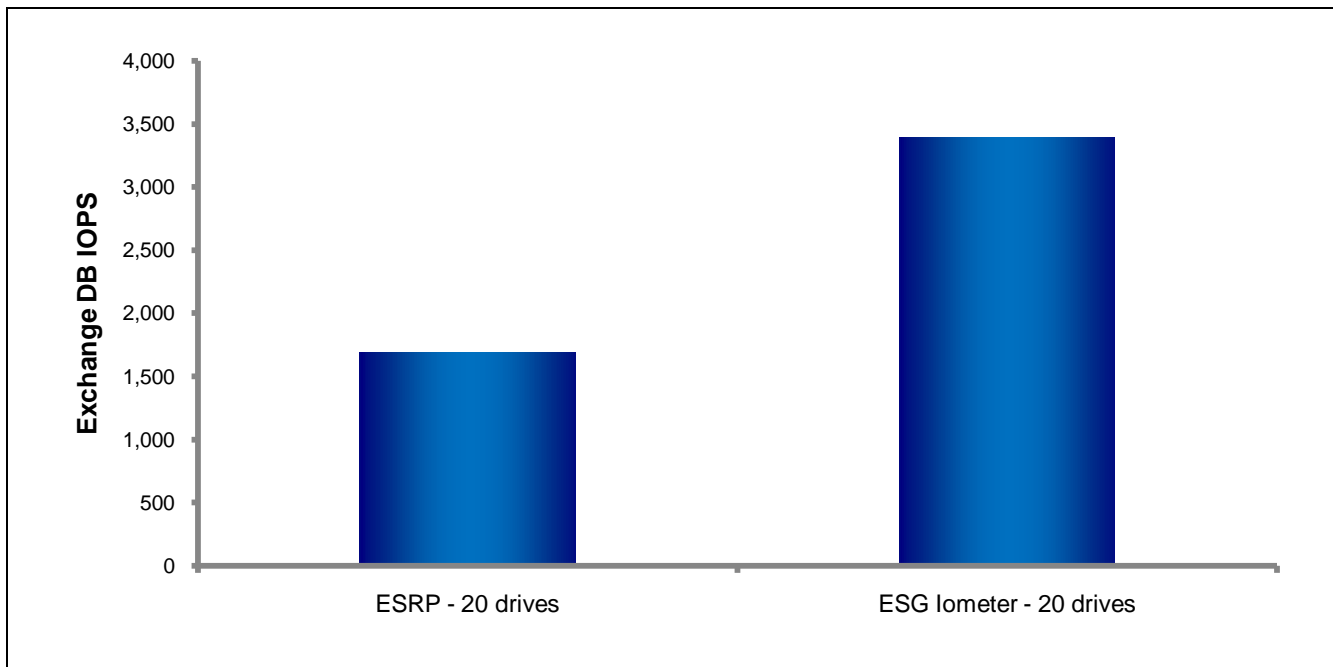
Running Iometer, the 2300 was able to sustain double the number of Exchange DB IOPS as the same system using the same quantity and configuration of disks in the ESRP test. It is important to note that the Iometer utility is optimized for generating IO and can drive a storage system to its maximum performance without placing great demands on server memory or CPU. ESRP is a holistic test that creates a simulation of a complete Exchange environment, using JetStress to generate disk IO and LoadGen to generate Active Directory, DNS, network, and other Exchange server functions. JetStress minimizes the impact and benefits of storage controller cache by limiting the database cache to 256 MB, which forces IO to go to disk. Microsoft documents clearly that ESRP is not a benchmark and will not generate maximum IO for a given solution.

What the Numbers Mean

- Using Iometer, the Adaptable Modular Storage 2300 sustained double the IOPS achieved in the ESRP test, demonstrating excellent headroom held in reserve.
- The Adaptable Modular Storage 2000 family's latency was also extremely consistent, averaging between 9 and 11 milliseconds on all tests. This translates to a positive user experience without storage-induced application delays. As mentioned previously, the Exchange database LUN requires response times of less than 20 milliseconds. As response times climb to 20 ms and beyond, Outlook and Web client performance begin to degrade considerably.
- The Adaptable Modular Storage 2000's active-active architecture made volume configuration and layout for the MS Exchange test easier and faster than with previous generation arrays.
- The combination of substantial IO headroom plus excellent application performance shows that the Adaptable Modular Storage architecture is well suited to the demands of mission critical Exchange deployments.
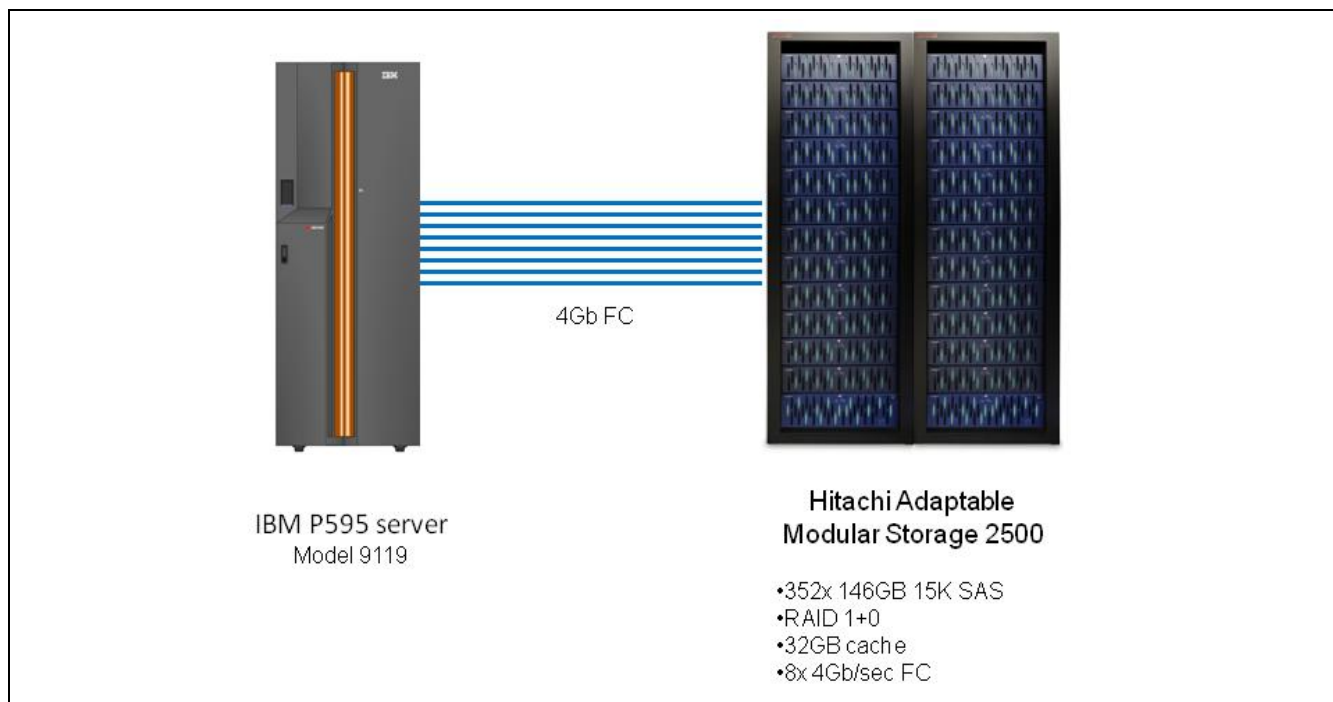
Introducing SPC-1

In addition to running physical tests against the Adaptable Modular Storage 2000 family, ESG Lab audited Hitachi'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 largely random IO and generate both queries (reads) and updates (writes). Examples of these types of applications include OLTP, database operations, and mail server implementations. SPC results can be roughly mapped by users into easily understood metrics. For a credit card database system, for instance, it might be the number of credit card authorizations that can be executed per second.

The SPC-1 Test Bed

Like the ESRP program, the SPC requires full disclosure of very detailed configuration information. The test bed for the Adaptable Modular Storage 2500 SPC-1 test is summarized in Figure 9.

FIGURE 9. THE HITACHI ESRP TEST BED

IBM P595 server
Model 9119

Hitachi Adaptable
Modular Storage 2500

- 352x 146GB 15K SAS
- RAID 1+0
- 32GB cache
- 8x 4Gb/sec FC

4Gb FC

An additional element of SPC disclosure is the list pricing for the solution as tested. This allows for $ per IOP comparisons of the cost-effectiveness of solutions.

SPC-1 Results

Hitachi has published an excellent result of 89,492 SPC-1 IO requests per second at 100% load with an average response time of only 8.98 milliseconds. Figure 10 shows a Response Time/Throughput curve, which visually represents the performance of the system under test as load is increased. A long, flat curve indicates better performance as this denotes that response time stays low as IOPS increase.

FIGURE 10. ADAPTABLE MODULAR STORAGE 2500 SPC-1 RESULTS
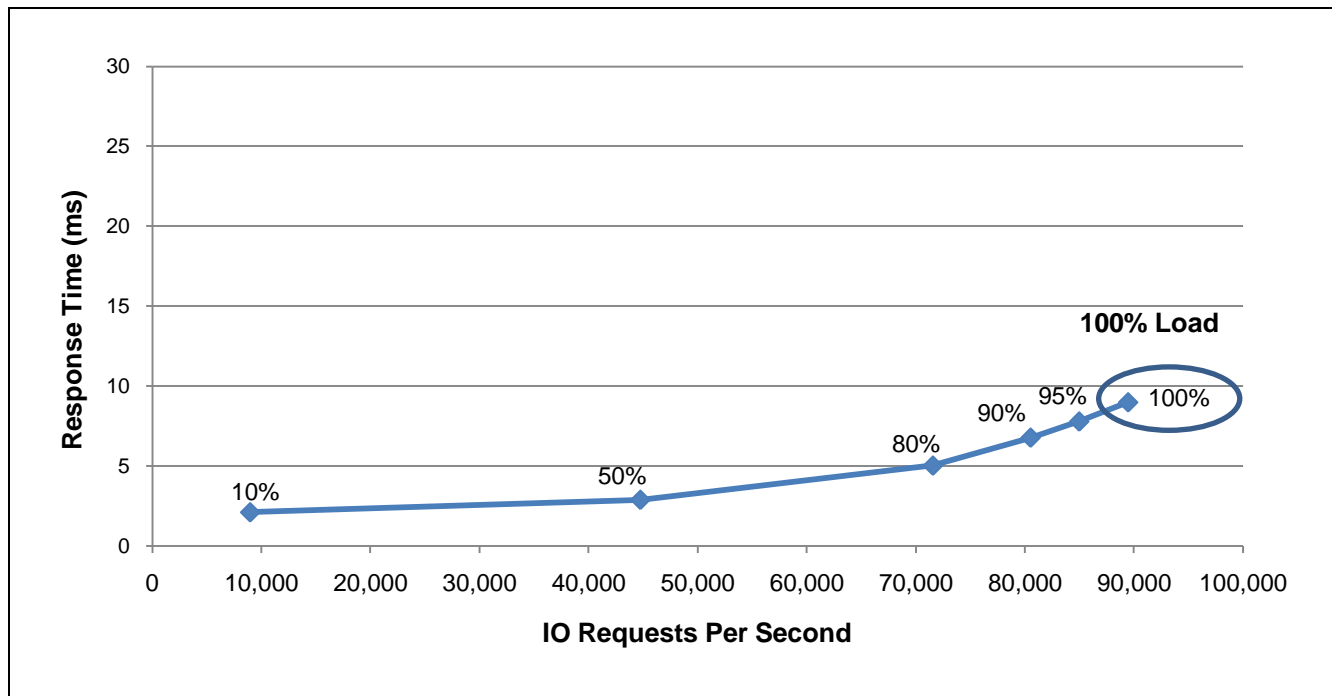
ESG Lab compared these results with submitted results for comparably configured, dual controller midrange storage systems. Table 3 summarizes our findings.

TABLE 3. ESG LAB AND ESRP EXCHANGE CONFIGURATIONS

System Under Test	SPC IOPS @ 100% Load	Response Time	Number of Drives	IOPS per drive	$/SPC-1 IOPS
Adaptable Modular Storage 2500	**89,492**	**8.98 ms**	**352**	**254**	**$6.71**
Adaptable Modular Storage 2300	**42,503**	**6.33 ms**	**176**	**241**	**$6.96**
Adaptable Modular Storage 2100	**31,499**	**8.15 ms**	**112**	**281**	**$5.85**
System 4	62,243	14.37 ms	256	243	$11.70
System 5	60,515	20.80 ms	224	270	$10.01
System 6	64,993	20.92 ms	288	226	$8.79
System 7	24,997	24.12 ms	150	167	$20.72

The Hitachi Adaptable Modular Storage 2000 family not only posted the best SPC-1 IOPS results for a dual-controller midrange storage system, but also delivered the fastest response time and best cost in dollars per SPC-1 IOPS by a wide margin. Response time is an extremely important component of SPC results. This is the delay an application will experience (and pass on to users) when a storage system is stressed to its limits. The generally accepted threshold for good performance in online transactional applications is 10 milliseconds, beyond which application delay begins to become apparent to users. The SPC will not certify any results higher than 30 milliseconds. The SPC-1 results published by Hitachi reinforce the results seen in ESRP testing and offer further proof of the 2000 family's suitability for mission critical, response time sensitive applications.

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.[7]

Through careful examination of ESRP and SPC-1 results combined with hands-on testing, ESG Lab has verified that the Adaptable Modular Storage 2000 family can be deployed to cost-effectively provide easy-to-configure storage for Exchange environments of all sizes with excellent operational efficiency, offering affordable scalability, reliability, availability, and performance. As Exchange environments continue to grow in size and complexity and server virtualization becomes more widespread, SAN consolidation will become a requirement in more user environments, in order to achieve these benefits and operational efficiencies

ESG Lab's View

IT is increasingly being asked to do more with less. Storage profiling and benchmarking frameworks like ESRP and SPC-1 help IT to design storage solutions that will perform predictably and cost effectively in support of mission critical Exchange deployments in consolidated environments with high availability. Consolidating their Exchange environment allows users to fully realize the benefits and operational efficiencies that a platform like the Adaptable Modular Storage 2000 family has to offer.

ESG Lab found that the Hitachi Adaptable Modular Storage 2000 family provided impressive operational efficiency in support of critical applications like Microsoft Exchange. Enterprise class SAS drives, as offered in the Adaptable Modular Storage 2000 family, provided the same reliability and performance as Fibre Channel drives—proven by ESRP reliability testing. The SAS backplane in the Adaptable Modular Storage 2300 system tested by ESG Lab intermixed SAS and SATA drives in the same drive enclosures for cost-effective scalability. The Adaptable Modular Storage 2000 family also demonstrated enterprise class functionality automatically and transparently; active-active controllers with automatic load balancing allowed for greatly simplified host SAN and LUN provisioning, simplifying management and reducing operational costs.

The Hitachi Adaptable Modular Storage 2000 family performed exceptionally well in both ESRP MS Exchange simulation and SPC-1 OLTP testing, demonstrating not only predictably scalable performance but excellent cost benefit. The Adaptable Modular Storage 2000 family's combination of enterprise class features with easy to manage usability and reduced operational costs is powerful and worthy of serious consideration by any IT organization in search of a cost-effective solution for hosting mission critical applications like Microsoft Exchange.

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

Appendix

TABLE 4. TEST ENVIRONMENT AND CONFIGURATION

Hitachi Adaptable Modular Storage 2300 – 105x 146 GB SAS drives 60x 1 TB SATA drives 8x 4 GB FC connections	Firmware 0852/A-M
2x Brocade 5000 32 port 4 Gb FC switches	Firmware 5.2.1
VMware ESXi v. 3.5 Servers – 1x Dell PowerEdge R905 4x Quad core Opteron CPU 64 GB RAM 2x Qlogic 2462 4 Gb/sec FC HBA	Guest Operating System: MS Windows Server 2008

IOMETER			
Version	2006.07.27		
Access Specification	**IO Size**	**Random/Sequential Distribution**	**Read/Write Distribution**
Exchange 2007 EDB	8KB	90% Random	80% Read
Exchange LOG	64KB	100% Sequential	100% Write
Test	**Number of Servers**	**Physical Drives**	**RAID Protection**
ESRP	1	20	RAID 1+0, 5x 2+2 groups
Iometer	1	20	RAID 1+0, 5x 2+2 groups
Microsoft Exchange User profiles			
User Type	**50KB messages Sent/Received Daily**	**Estimated IOPS per user**	**Estimated IOPS per user Used for Mailbox Calculation (+20%)**
Light	5 sent/20 received	.11	.132
Average	10 sent/40 received	.18	.216
Heavy	20 sent/80 received	.32	.384
Very Heavy	30 sent/120 received	.48	.576
Extra Heavy	40 sent/160 received	.64	.768

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