IP Storage Area Networks

EqualLogic® PS Series: The Leader in Affordable SANs

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EqualLogic, Inc. pioneered affordable IP SANs as an alternative to DAS and Fibre Channel (FC) SANs.[1] Three years ago we projected that the PS Series would significantly raise the bar in terms of ease of use, thus enabling medium-sized businesses and departments of large enterprises to realize the benefits of consolidating their storage with storage area networks (SANs) using standard Ethernet technology. Our projections have come true – the product does what EqualLogic said it would, the market acceptance of iSCSI SANs is growing, and EqualLogic is recognized as one of the leaders in storage.[2] In response, many new and established companies have introduced less-featured versions of their products to compete with the PS Series, but EqualLogic remains the leader in both functionality and total cost of ownership (TCO).

A recent survey of 105 EqualLogic customers by IDIX, Inc.[3], a market research company specializing in customer satisfaction surveys, supports the early claims that were made regarding the PS Series. In fact, it is even more true today that the PS Series reduces management load and saves customers money. For example, most of the surveyed customers reported they spend little or no time tuning performance of their EqualLogic storage.

In September 2005, *Network Computing* magazine reported on real-world performance tests comparing the EqualLogic PS200E against EMC® CLARiiON® CX300i, LeftHand Networks® LeftHand SAN Network Storage Module 150, and MPC® DataFRAME™. Their conclusion: "EqualLogic dominated the competition… We compared features, performance, management, scalability, and price… It was a relatively easy call to present our Editor's Choice award to EqualLogic."[4]

This paper compares the newest offerings from EqualLogic against its now-expanded competition, updating the comparisons we made in 2003 of the initial PS Series product against its competition.[1] The EqualLogic products continue to represent the best TCO over three years: 70% less than the DAS solution, 56% less than the FC SAN solution and 44% less than the iSCSI file server solution. The PS200E also has the lowest initial purchase cost of any of the alternatives: 20% less than DAS, 58% less than an equivalent FC SAN solution and 56% less than an equivalent iSCSI file server solution. When the cost of upgrading to a disaster tolerant configuration is considered, the PS200E maintains its lead over the iSCSI file server solution and considerably widens its lead over the FC SAN solution. The EqualLogic PS Series continues to be a revolution in the world of consolidated storage.

[1] "Finally, Affordable SANs", Ellen and Richard Lary, EqualLogic Whitepaper, October 2003
[2] "Top Ten Private Companies: Summer 2005", Byte and Switch, September 20, 2005
[3] IDIX Open Research, Product Reviews and Awards. For details, see: http://www.equallogic.com/docs/2005_10_IDIX_ExecSummary_EQLcustomers.pdf
[4] "Review: iSCSI Modular SANs Ready for Liftoff", Steven Hill, Network Computing September 22, 2005

What is Storage Consolidation?

Prior to the late 1990's, storage networking, as we know it today, did not exist. Every server had its own direct attached storage (DAS). Companies purchased a wide variety of applications to meet their business needs; server, operating system, and database choices were driven by the needs of the application. This led to deployment of a large number of heterogeneous computer platforms. Storage was considered part of the server and not a part of any strategic decision.

Application requirements continued to grow placing increased demand on servers and requiring ever increasing amounts of storage. The value of corporate data drove the adoption of high availability solutions – replication and backup were essential components. The need to maintain application availability in an environment of rapid data expansion often resulted in overpurchasing of storage, to avoid the possibility of application outage due to lack of storage capacity. Storage management became a large component of the increasingly complex IT problem – storage could not be shared between systems and was not equally utilized, causing hot spots and corresponding performance issues. While array controllers provided advanced storage functions, the business continuance functions (i.e. disaster tolerance, multipathing, mirroring) were too expensive to deploy and manage on each server.

In today's security-conscious IT environment, another advantage of storage consolidation is that it enables the remote replication of data for disaster tolerance. For all but the most critical financial applications, the technology of choice for implementing real-time disaster tolerance is asynchronous mirroring of data, where data is sent over an IP link to a storage system at a remote site shortly after it is written to the storage system at the primary site. This protects data against all physical threats to its primary home, and, if a remote snapshot facility is combined with the remote mirroring facility, also protects against disasters caused by viruses, malicious system intrusion, and operational mishaps at the primary site.

Why is it Beneficial?

During times when infrastructure spending is flat or reduced, storage management is at the center of an increasingly complex IT problem. Migrating from DAS, which is expensive, inefficient and not scalable, to consolidated storage (i.e. a storage area network) does provide a solution. Conventional Fibre Channel SANs, however, continue to be expensive and complex.

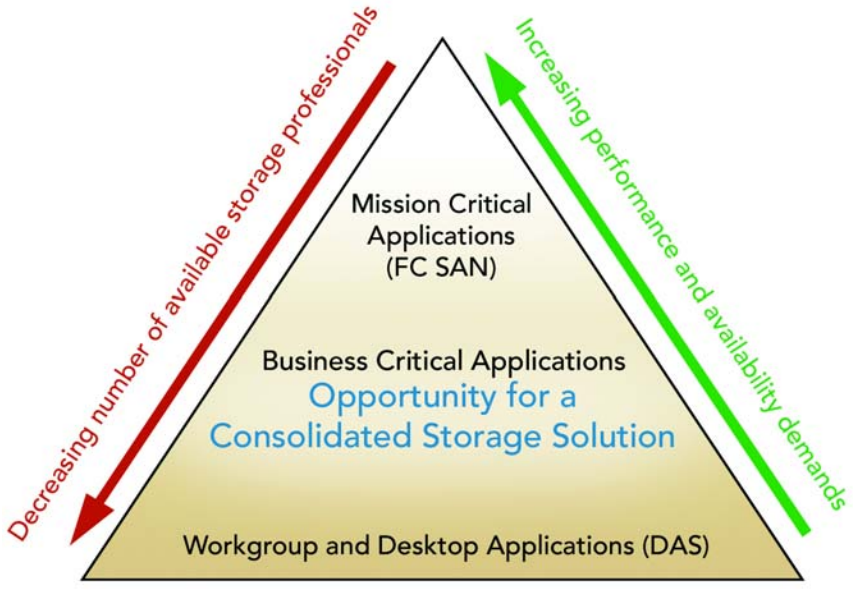
Fortunately, the advent of Ethernet-based SANs and the iSCSI standard has meant that customers can be provided with a centralized storage solution at a significantly lower cost and with less management overhead than a Fibre Channel SAN. This is particularly significant in the midrange market. Like larger enterprises, medium sized companies want to gain the financial advantages of consolidating their storage; however, one of the additional challenges faced by midrange enterprises is that they have limited IT support staff.[5] iSCSI-based storage consolidation requires considerably less staff training than Fibre Channel SAN solutions, as most IT staff already understand the principles of Ethernet networking.

[5] "Business Continuity in SMB", Christine Chudnow, Computer Technology Review, October/November 2005

Breaking the Barriers to Using SANs for Storage Consolidation

EqualLogic recognized that what prevented the widespread use of SANs in the data center was the cost and complexity of SAN deployment and maintenance. Specifically, before integrated solutions such as the PS Series, many individual hardware and software components needed to be installed and managed in a synchronized fashion. The burden of supporting and upgrading many disparate elements is intimidating to organizations without large staffs and budgets. Often the hardware and software do not operate in an integrated manner. System vendors have addressed the problem with customized management solutions, which add to the burgeoning problem of fragmented storage management tools. In addition, the most common network technology, Fibre Channel, is very complex and comparatively expensive. And, despite predictions of dropping prices, it remains expensive and complex compared to Ethernet technology. For the business that has neither trained, exclusive storage support personnel nor an extensive budget for storage, the bar for a Fibre Channel SAN is too high. Many of these smaller enterprises require the high-end features of a Fibre Channel SAN, but at a lower cost with less complexity. (See Figure 1)

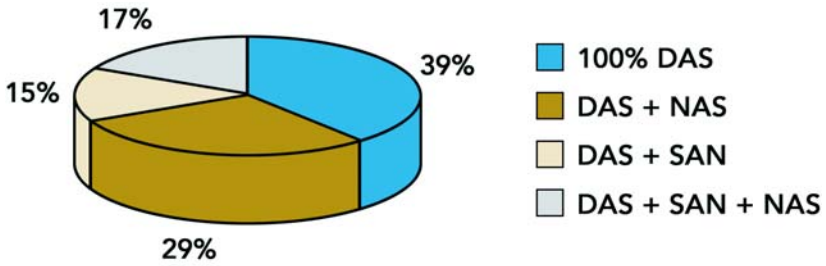
Figure 1
Opportunity for a Consolidated Storage Solution for Mid-Tier Storage



EqualLogic has been delivering a complete, integrated storage solution based on a flexible and expandable virtualizing storage controller connecting to servers using the iSCSI standard, making ease of use a top engineering priority. As *Network Computing* magazine put it, "EqualLogic understands iSCSI. It offers a killer combination of storage-optimized controllers, efficient internal data architecture, and a simplified control interface that makes storage management incredibly simple."[6]

[6] "Review: iSCSI Modular SANs Ready for Liftoff", Steven Hill, Network Computing September 22, 2005

In fact, when surveyed by IDIX, 85% of the respondents indicated that EqualLogic fit into their plans to consolidate servers or upgrade operating systems. These respondents used EqualLogic's PS Series to replace or supplement the following kinds of storage products:



A SAN cannot be used as a consolidated storage solution for midrange storage unless it can deliver high-end features at a significantly lower cost and with less complexity than other consolidated storage solutions. The customer survey regarding the integrated data protection features of the PS Series shows that 81% are using snapshots, 45% are using multipath access, and 28% are using remote replication. Significantly, 98% of customers in a position to compare the PS Series to other similar products rated EqualLogic's data protection features above average.

Our earlier paper also stated "In addition, storage configuration must be simplified and day-to-day management tasks minimized while avoiding the use of specialized networking technology that requires extensive training." 1 Three-fourths of EqualLogic customers surveyed stated that iSCSI (a non-specialized networking technology) was one of the attraction points for their purchase. In addition, they indicated management tasks were greatly simplified. The new and/or consolidated storage enabled them to save time. More than 95% of the surveyed customers reported they spent less than two hours per week managing their storage.[7]

Clearly, EqualLogic understands their customers' needs and created a product that met those needs. Now, other companies like EMC Corporation/Dell Inc., Network Appliance, Inc. and Hewlett-Packard Company have introduced storage systems offering some enterprise functionality targeted at smaller businesses and departments.

EqualLogic's PS Series Sustains its Advantages

The PS200E from EqualLogic, the foundation of the PS Series enterprise SAN solutions, deliver high-end storage management features in an affordable Ethernet-based SAN. Based on patented technology, the PS Series products provide efficient storage utilization, centralized single-system management, and highly available data, keeping your business operating around the clock. Most important, their initial system investment and ongoing management efforts and costs are significantly less than those required for DAS, Fibre Channel SAN, midrange NAS, or competing iSCSI SAN configurations.

[7] IDIX Open Research, Product Reviews and Awards, www.equallogic.com

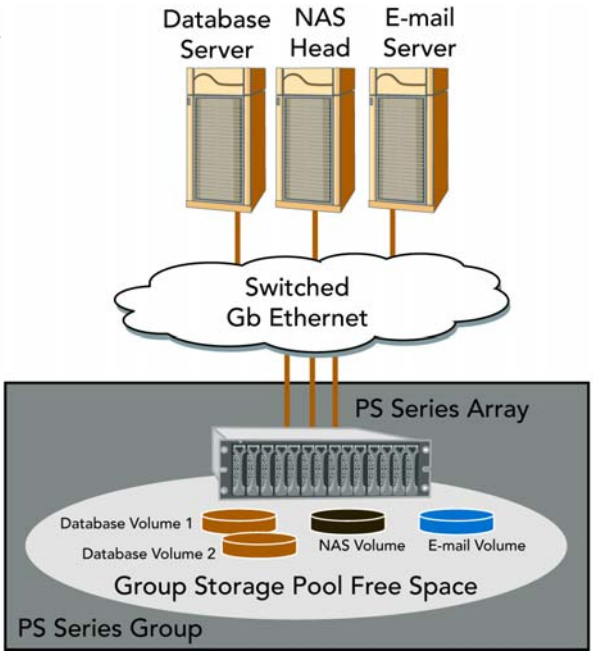
The modular design of the PS Series means you buy only the storage that is essential today–when more space is needed, capacity can be seamlessly expanded while data remains online. With integrated storage management features such as automatic RAID configuration and load balancing, snapshots for centralized online backups, and remote data mirroring for disaster tolerance, the PS Series can significantly decrease the cost of deploying and managing storage.

The PS Series is a family of self-contained, fault-tolerant iSCSI block-storage arrays designed for Ethernet environments. Each array contains industry-standard disk drives as well as redundant high-performance storage controllers, power supplies, and fans, in a compact rack-mountable chassis. All components are hot swappable. You get enterprise-level functionality, using standard networking technology, all at an affordable price. Connecting an array to a network and running a simple utility are the only requirements for installation. The Idix customer survey reported that 79% of EqualLogic customers installed their storage system in one hour or less. Furthermore, 95% of these surveyed customers stated it was easy to install.[8]

Grouping one or more PS Series arrays allows you to manage multiple arrays as easily as you can manage one. A group of PS Series arrays presents a single, dynamic pool of shared storage. Administrators allocate portions of the storage pool to volumes, which are seen on the network as iSCSI targets. As arrays are added to the group, capacity and network bandwidth expand seamlessly, with no user intervention required and no increase in management overhead. Data placement and load balancing across disks and arrays occur automatically, as needed. The customer survey supports EqualLogic's claims of seamless scalability and easy provisioning. Overall, 80% of the surveyed customers reported they gained from 1-8 hours per month that could be spent on other tasks.[9]

Figure 2 shows a group with one PS Series array.

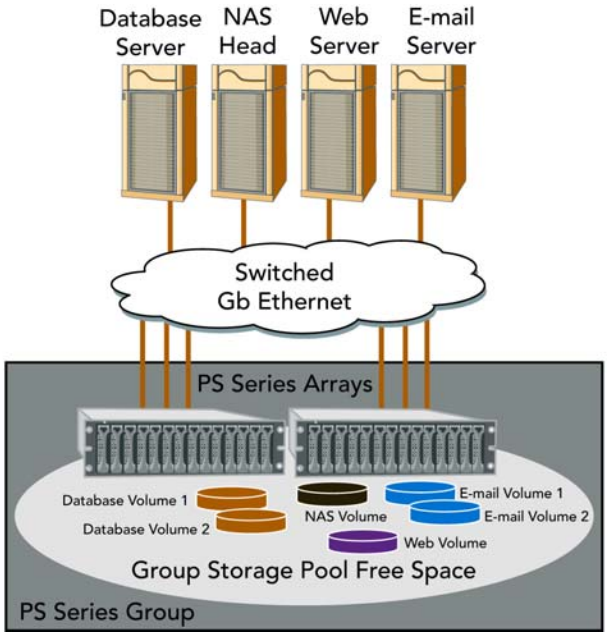
Figure 2
A Group with One PS Series Array



[8] Ibid
[9] Ibid

Figure 3 shows the addition of a second PS Series array to a group to increase capacity. The storage pool expands seamlessly, providing more space for volumes. Network bandwidth also increases, due to the additional network interfaces.

Figure 3
Scaling a Group to Increase Storage Capacity



Specifically, a group of PS Series arrays provides the following benefits:

- Runs on ubiquitous Ethernet networks with the iSCSI protocol. By using Ethernet, EqualLogic eliminates the need to train administrators in specialized technologies and hardware. Interoperability issues, common in many Fibre Channel SANs, are not a problem.
- Reduces costs due to the high volumes and intense vendor competition in the Ethernet hardware market. One of the major costs when building a Fibre Channel SAN is the cost of connecting each server, which ranges from $1,400 to $2,500. This alone makes Fibre Channel an impractical technology for midrange servers. Using standard Ethernet technology, the cost of connecting a server is always less than $500; in many cases it is free, as most midrange servers have two or three Gigabit Ethernet interfaces built in to their motherboard.
- Uses iSCSI to provide standard, robust, password-based authentication between the providers and the consumers of storage resources. This eliminates the need to understand and manage Fibre Channel's arcane Switch Zoning and LUN Masking security features.
- Delivers enterprise-level functionality as part of the base product. Included are multi-path access, graphical and command line management interfaces, volume snapshots, host access controls, automatic load balancing, and asynchronous remote data mirroring with remote snapshots. There are no software licenses to deal with, and maintenance is greatly simplified. One does not need multiple management consoles to perform a storage management procedure on behalf of an application. Volume creation, resizing, and backup/restore operations using snapshots can all be done in a single Web browser session.

- Eliminates the need for administrators to manually map volumes onto physical disks or individual controllers. To create a volume, you specify only a name and size. To increase the size of a volume, specify only the new size. The group of PS Series arrays handles the details of storage allocation and capacity balancing across the available physical disks and arrays. In addition, dynamic rebalancing occurs automatically as performance metrics change.
- Automatically reallocates physical resources to volumes when the hardware configuration changes. This means that when an array is added to a group, the additional storage space, disk performance, and network bandwidth provided by the new array are immediately available to applications with no manual configuration tasks required.

PS Series Features

The PS Series family consists of the PS100E, PS200E and PS300E, as well as additional models built from these base systems (PS50E, PS100X, PS800E, PS1200E, PS1600E and PS2400E). All configurations are completely interoperable and upgradeable, with capacity scaling from 1 TB to over 100TB, and performance scaling from 60,000 IOPS to over 1,000,000 IOPS - without disruption of application or data availability.

- Industry-standard components.
  All members of the PS Series work with any Ethernet switch and industry host bus adapter that support iSCSI. All major operating systems offer an iSCSI driver as part of the base operating system, and iSCSI hardware acceleration is a readily available option. In addition, there are no learning curves or complex management tasks as with other storage consolidation solutions. Because an array uses standard Ethernet connections to access the storage, administrators need no special knowledge beyond an understanding of basic networking.
- Easy installation.
  A simple hardware configuration and setup utility make a group of PS Series arrays easy to install. Connecting an array to a network and configuring it into a group takes only minutes. RAID configuration and disk sparing are done automatically. With the graphical interface, creating and managing volumes and configuring security, networking, and event notification are point and click operations.
- Hands-off operation.
  A group of PS Series arrays handles the difficult aspects of storage administration, including performance optimization and load balancing. When an array is added to a group, volumes are automatically spread across the new disks. “Hot spots” caused by frequently accessed data are identified and eliminated without user intervention. The fully redundant, fault tolerant array also handles hardware failures without disrupting availability and provides various mechanisms for notifying administrators when events occur.
- Scalability.
  Adding capacity to a group of PS Series arrays is as simple as inserting a new drive into an array or connecting another array to the network and adding it to the group. Volumes remain available and servers are not disrupted. There is no need to open a server cabinet or reconfigure an operating system. The new array’s disk space is automatically added to the group storage pool, and

volumes are load balanced across the arrays. Performance improves because data is spread across more disks and network I/O is spread across more network interfaces. Storage processing power also increases due to the additional controllers and caches. However, as the configuration scales, the management effort is still the same as the effort required for a single-array group. Arrays can be configured in a group of PS Series arrays, allowing the capacity to scale seamlessly to 100 TB of raw capacity.

- Auto-load balancing and auto-optimization.
  A group of PS Series arrays can detect when capacity or performance is out of balance. Rebalancing occurs automatically while the group maintains continuous data availability.
- Volume snapshots, replication and instant restore/cloning.
  A snapshot quickly captures the contents of a volume at a specific point in time for backups, testing, and upgrades. Both instant and scheduled snapshots are supported, and every volume can have hundreds of outstanding snapshots. Snapshots are stored in a very space-efficient manner and the restore of a volume from a snapshot is nearly instantaneous.

  For disaster tolerance, volumes can be asynchronously replicated across any IP network between two arrays separated by distance to ensure data safety. Multiple "recovery points" for each volume are saved at the remote site to protect against software disasters (e.g. viruses) as well as hardware disasters. These integrated snapshot and replication capabilities represent a turning point for affordable networked storage solutions and can greatly simplify and improve the performance of backup and recovery operations.
- Provisioning and utilization.
  Because it can easily grow or shrink according to application storage needs, a group of PS arrays eliminates the over-provisioning and under-utilization of storage resources. Administrators are able to purchase additional storage only when it is necessary.
- Performance.
  The PS200E left its competitors in the dust during a group performance test by InfoWorld at their test center.[10] For an I/O load similar to that of Microsoft Exchange and many commercial databases, the PS200E outperformed its closest competitor (out of seven storage systems tested) by over 40%.
- Other enterprise-class data services.
  Disk virtualization, RAID 10/RAID 50, multi-path I/O (MPIO) support, and support for the Microsoft System Center Data Protection Manager (DPM), Volume Shadow Copy Service (VSS) and Virtual Disk Service (VDS) are included with no additional cost.
- Investment protection.
  All members of the PS Series fully interoperate with all other family member arrays.

[10] "iSCSI SAN Unleashed", InfoWorld Test Center Special Report, October 1, 2005

PS Series – The Cost-Effective SAN

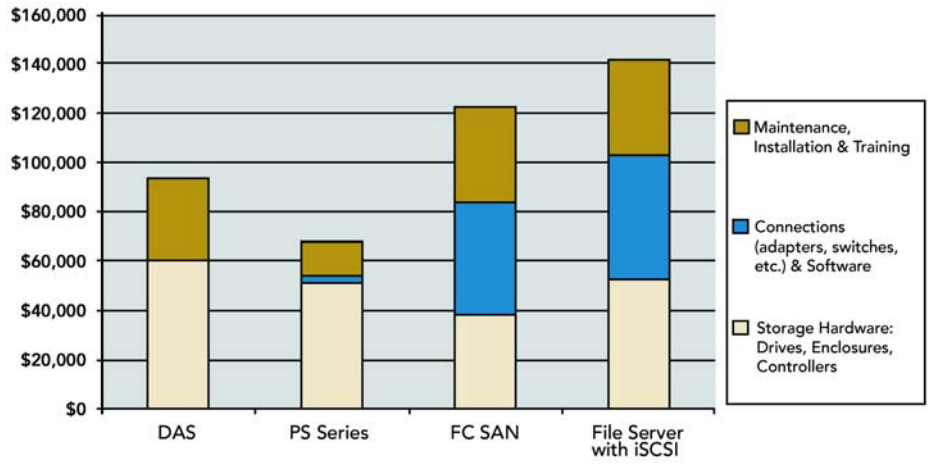
The customer survey data supports the earlier claims that with the introduction of the PS Series from EqualLogic, it is now possible to create a consolidated storage solution that offers the benefits of networked storage at a cost and complexity lower than either DAS or any other networked storage alternative of equal power.

In an earlier study, the initial storage costs for hardware, software, and training, as well as the ongoing management and maintenance costs for hardware and software were compared for DAS, FC SAN, and PS100E configurations. Over three years, the cost of a PS Series solution was 35% of an equivalent DAS configuration and approximately 45% of an equivalent SAN solution. We concluded that the PS Series was well positioned to eliminate the barriers to adopting consolidated storage and that it delivered a simple solution that provided an excellent return on investment.

We have updated and extended this TCO comparison. For cost comparisons, we have included the SmartArray 6402 DAS solution (from Hewlett-Packard Company), the CLARiiON CX300 FC array (from EMC Corporation), the FAS270 file server with iSCSI capability (from Network Appliance, Inc.) and the PS200E (from EqualLogic, Inc.). All systems have been configured to support 5 TB of storage and 8 client computers. Prices were obtained from public sources available on the web and represent the kind of discounts over list price generally present in GSA schedules.

As can be seen in Figure 4 and Table 2 respectively, the EqualLogic PS200E beat all the other products in both initial acquisition cost and three-year TCO. Even the DAS solution, generally considered to have low cost as its only redeeming attribute, costs more than the PS200E when the cost of external storage enclosures is included. High connection costs still drive the total acquisition cost of FC SAN above that of DAS and the PS200E. The FAS270 suffers from the high cost of high availability (a second, clustered file server). The PS200E, on the other hand, includes all enterprise features at no extra cost and uses commodity Ethernet products for connectivity, so it is the most economical and efficient solution in all dimensions – hardware, software, connectivity, training, maintenance, and ongoing operation and management costs.

Figure 4
Storage Acquisition Cost for 8 Servers Requiring 5 TB of Storage
(three requiring 300 GB, three requiring 700 GB, and two requiring 1000 GB)



Ongoing system management costs are the most difficult data to obtain. Estimates quoted in industry literature cover a wide range. However, there seems to be general consensus that an integrated product that uses iSCSI is much simpler to manage than an integrated product that uses Fibre Channel product due specifically to the more complex nature of FC components used in the solution. A DAS solution takes the most time since it involves so many different servers and storage devices. The dollars per terabyte costs shown in Table 1 reflect the comparative complexity of the DAS, FC SAN, and iSCSI SAN configurations.

Table 1: Management Costs/TB Assuming Burdened Manager Salary of $75K

	TB/Person	$/TB
DAS	3	$25,000.00
FC SAN	8	$9,375.00
Non-virtual iSCSI SAN	8	$9,375.00
iSCSI storage array	16	$4,687.50
PS Series Group	16	$4,687.50

The costs from Table 1 were then used to establish the ongoing yearly costs for each configuration, as shown in Table 2.

Table 2: Comparative Costs for 5TB Solutions

	PS Series Group	DAS	FC SAN	File Server with iSCSI
Hardware and Software Purchased	$50,988	$60,605[11]	$103,892	$126,259
Installation and Training	$1,875	$7,915	$32,323	$16,674
3 Years of Hardware Maintenance	$11,200	$11,483	$15,347	$4,363
Total Initial Cost	**$64,063**	**$80,003**	**$151,562**	**$147,296**
Yearly Software Support Cost	$0	$0	$3,615	$8,149
Yearly Management Cost	$23,438	$125,000	$46,875	$23,438
Total Yearly Cost	**$23,438**	**$125,000**	**$50,490**	**$31,586**
Total 3-Year Cost of Ownership	**$134,376**	**$455,003**	**$303,032**	**$242,055**

[11] Does not include snapshot functionality, which is not available in DAS solutions

As this table shows, not only does a PS Series Group have a lower management cost than a DAS or FC SAN solution, it also has lower initial costs. For a manager of mid-tier storage who is currently using DAS but is looking for a consolidated storage solution, the choice is clear. Instead of an expensive, complex, conventional SAN solution, the Ethernet-based PS Series solutions from EqualLogic provide the most effective use of corporate funds. The total three-year cost of a PS Series Group is 44% of the cost of today's FC SAN solutions, 56% of today's iSCSI file server solutions, and a mere 30% of the cost of DAS solutions.

If a disaster tolerant solution is needed, another storage array must be added at the remote site and a communications path must be enabled between the two sites. There are also additional software licenses that must be purchased to enable the asynchronous mirroring function in the two storage arrays – these licenses are free for the PS Series, but not for its competition. And finally, there are additional installation, training, maintenance, and management costs to handle the two sites. Table 3 depicts those costs for a disaster-tolerant equivalent of the 5TB, eight-server configuration we referenced earlier. It does not include the cost of leasing the needed modems and communications bandwidth between sites, as these are highly dependent on the location of the sites and the amount of data traffic between them.

Table 3: Comparative Costs for Disaster Tolerant 5 TB Solutions

	PS Series Group	DAS	FC SAN	File Server with iSCSI
Hardware and Software Purchased	$101,967		$326,848	$234,835
Installation and Training	$3,125		$60,771	$26,981
3 Years of Hardware Maintenance	$22,400		$37,031	$8,726
Total Initial Cost	**$127,501**	**Not Applicable**	**$424,629**	**$270,541**
Yearly Software Support Cost	$0		$20,748	$14,705
Yearly Management Cost	$35,156		$70,313	$35,156
Total Yearly Cost	**$35,156**		**$91,061**	**$49,862**
Total 3-Year Cost of Ownership	**$232,970**	**Not Applicable**	**$697,831**	**$420,125**

As can be seen from this table, the FC SAN costs increased disproportionately to the costs of either the PS Series solution or the file server with iSCSI. This is partly due to the need to add extra hardware to bridge FC to Ethernet, but it is mostly due to the need to upgrade the EMC CLARiiON CX300 array to a CX500 array in order to be able to run asynchronous mirroring, which is not available on the CX300. The three-year cost of a disaster tolerant PS Series Group drops to only 33% of the cost of an equivalent FC SAN solutions and remains at 56% of an equivalent file server with iSCSI.

Conclusion

In summary, EqualLogic's PS Series delivers a self-managing storage array that provides enterprise-class features using industry-standard Ethernet SAN connectivity and the iSCSI standard protocol. The result is an ideal consolidated storage solution for mid-tier storage in the data center.

The PS Series provides:

- Mission critical data availability at a cost appropriate for business critical applications.
- Fully automated, self-managing storage that can grow as needed, without downtime and using fewer management personnel than conventional SANs.
- Familiar Ethernet storage infrastructure, which means no added costs for specialized hardware, software, personnel, or training.
- Industry-standard iSCSI protocol, eliminating interoperability issues.

Finally, an affordable consolidated storage solution is available! Over three years, the cost of an EqualLogic PS Series is 30% of an equivalent DAS configuration, 44% of an equivalent FC SAN solution and 56% of an equivalent iSCSI file server solution. The story is even better when a disaster tolerant solution is required. Over three years, the cost of the EqualLogic PS Series is 33% of an equivalent FC SAN and 56% of an equivalent iSCSI file server solution. Note, the DAS solution cannot be configured to provide disaster tolerance.

The EqualLogic PS Series eliminates the barriers to adopting consolidated storage, in either a single site solution or a dual site disaster tolerant configuration, and delivers a simple solution that provides an excellent return on investment.

About the Authors

Ellen Lary has a Ph.D in Operations Research with a specialization in database technology. She was a database researcher and database research manager for Bell Laboratories, Digital Equipment, and Cincom, where she focused on turning leading edge technology into shippable products. In 1994, she rejoined Digital Equipment as the Array Controller Engineering Manager. Under her leadership, Digital's StorageWorks RAID controller product line grew from a proprietary point product to a complete subsystem family with multiplatform support. She was appointed Vice President and General Manager of the Storage Product Division in 1996, and subsequently grew the business from $1.2B to $1.9B over a 20-month period. After the Compaq acquisition of Digital, she was appointed Vice President of Business Critical Storage for Compaq. She left Compaq in June 1999 and formed Tutelary, LLC, a storage consulting company, in February 2000.

Richard Lary has been in the computer industry for 36 years. He started out as a software engineer at Digital Equipment Corporation, building operating systems and compilers for the PDP-8 and PDP-11 computers. In 1975, he served as a member of the core team that defined the VAX computer architecture and then the implementation team for the first VAX computer. After joining Digital's Storage Business Unit in 1978, Richie was a key architect and implementor for the Digital Storage Architecture and a key implementor of several of the hardware and firmware components of the associated product family. He became Digital's Storage Architect in 1990, Digital's Storage Technical Director in 1994, and Compaq Computer Corporation's Storage Technical Director in 1998. As Technical Director, he was responsible for technical oversight of the entire corporate storage architecture and product line. Richie holds 29 patents for his work in processor and storage system architecture and design, and was awarded a Lifetime Achievement Award at the Server I/O Conference in January 2000, in recognition of his contributions. He is now a member of Tutelary, LLC.

For more information regarding the EqualLogic and the PS Series, please visit www.equallogic.com or contact us at 888-579-9762 ext. 7792

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