Lab Validation
Report

NetApp V-Series Open Storage Controller

Highly Efficient and Flexible, Heterogeneous Storage Virtualization

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June 2011

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ESG Lab Reports

The goal of ESG Lab reports is to educate IT professionals about established and emerging products, solutions, and technologies in the information technology industry. 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 technologies and solutions. 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 NetApp.
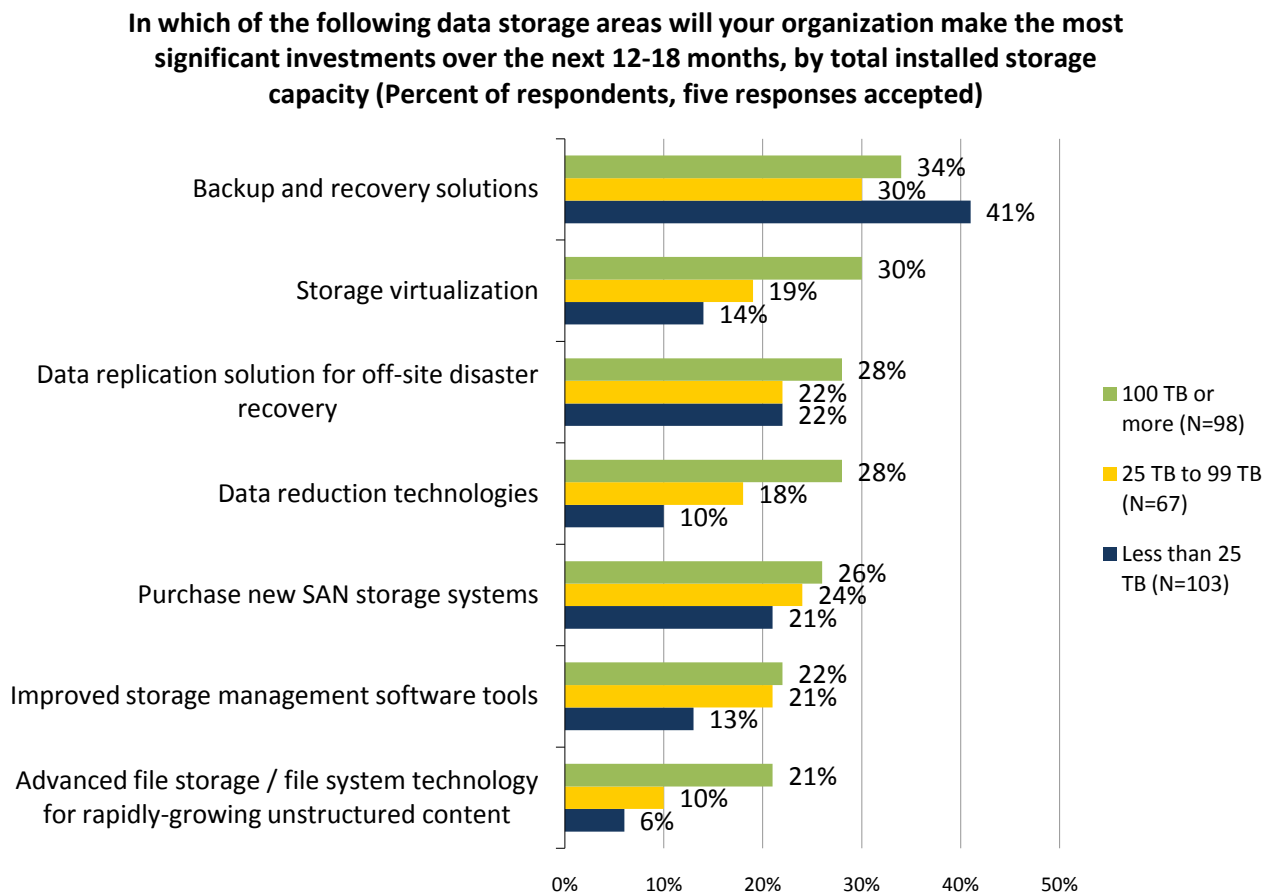
Introduction

One thing is certain in the ever-changing landscape of IT: data volumes continue to grow, regardless of economic cycles. In many organizations, storage solutions that have been deployed to accommodate that growth have been deployed in an ad hoc fashion. Mergers and acquisitions have also contributed to this mix, creating infrastructure built upon multiple storage architectures. This blend of architectures can make managing storage needs a complex and costly process. Just as servers benefitted from virtualization, IT organizations can realize the same cost benefits from storage virtualization; in essence, hiding multiple separate storage controllers behind one centrally managed solution. ESG Lab conducted hands on testing of the NetApp V-Series Open Storage Controller with a focus on examining the storage efficiency, operational value, and performance achieved by the solution.

Background

ESG recently asked customers to list their top spending priorities for storage infrastructure and found that both storage virtualization and data reduction technologies ranked high on the list.[1] Clearly, customers are starting to see the operational savings that can be realized with better tools to manage the growing data needs within their organizations, especially those that can consolidate functions from multiple disparate storage systems into one operation. There is also an understanding that heterogeneous storage environments have an inherent inefficiency that can be resolved by storage virtualization solutions that bring these systems together.

Figure 1. Top 2011 Storage Investments

In which of the following data storage areas will your organization make the most significant investments over the next 12-18 months, by total installed storage capacity (Percent of respondents, five responses accepted)

Source: Enterprise Strategy Group, 2011.

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[1] Source: ESG Research Report, *2011 IT Spending Intentions Survey*, January 2011.

Customers also understand that as their virtual server infrastructure grows and matures, storage becomes the fly in the ointment for providing fast and reliable data services for a much more dynamic environment. In fact, when asked what storage developments need to take place in order to enable more widespread adoption of server virtualization in their organizations, customers mentioned faster storage provisioning and increased use of storage virtualization in their top three responses.[2] It's time for storage to reap the same operational and capital savings that virtualization has brought to the server world.

NetApp V-Series

The NetApp V-Series is an Open Storage Controller that virtualizes traditional storage arrays, providing SAN and NAS access with integrated data protection with an advanced set of storage efficiency technologies. NetApp V-Series is a mature product offering with thousands of deployments in the field since its release in 2003. V-Series uses the same hardware controller as NetApp FAS systems. Both FAS and V-Series can attach to NetApp storage. V-Series is the controller used when attaching to third-party storage arrays. These capabilities increase the value of existing storage arrays by delivering advanced storage capabilities, which are tightly integrated with a number of mission- and business-critical applications.

Figure 2. NetApp V-Series
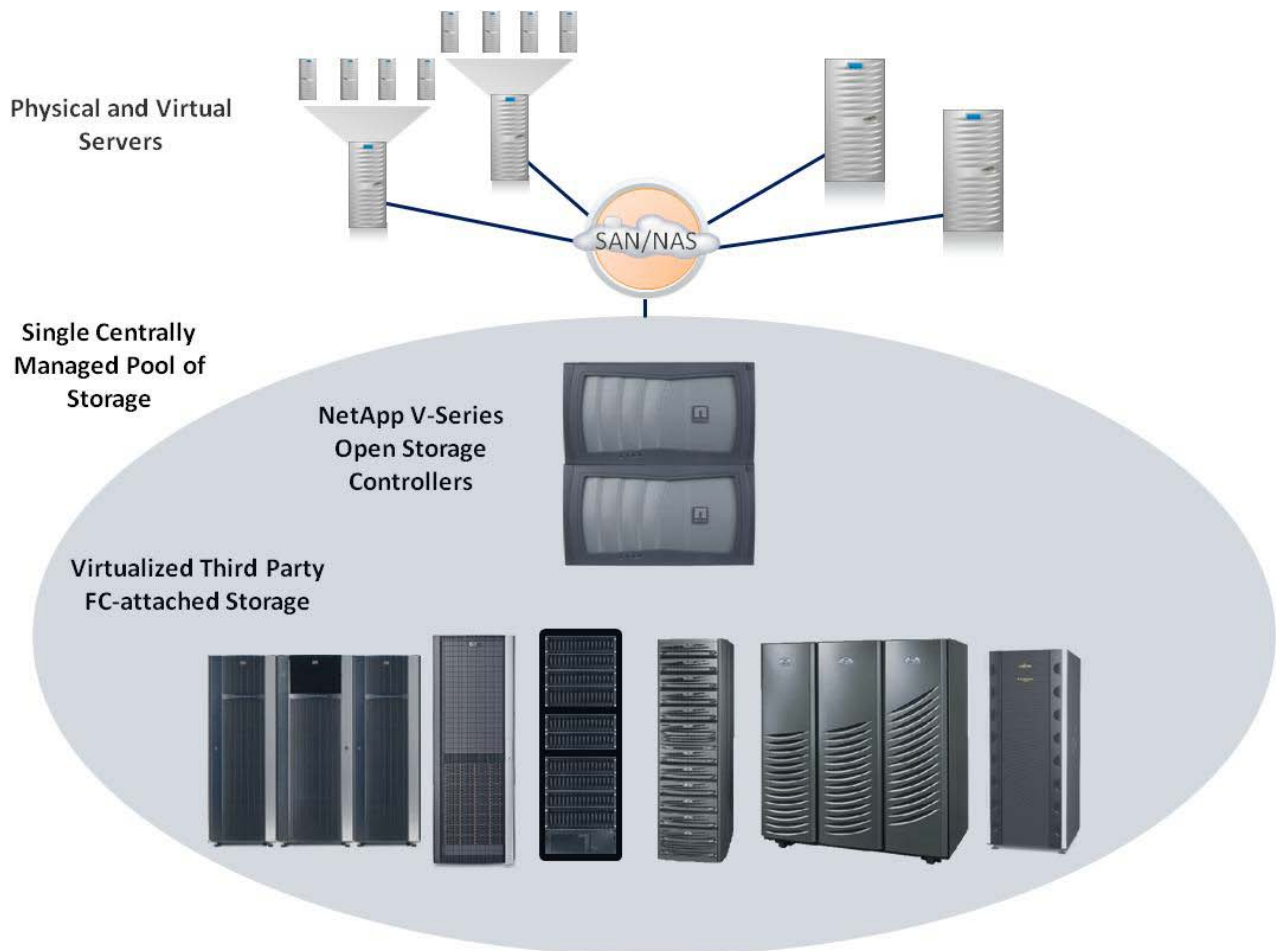
As detailed in Figure 3, V-Series Controllers can scale up to 2.8 PB of raw storage capacity, using both existing third-party storage arrays and NetApp Disk Shelves, in any combination, to support the needs of growing data center storage environments. Capacity can be increased by adding additional storage to third party arrays or by attaching NetApp disk shelves. V-Series controllers are deployed in active-active dual controller configurations for fault

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[2] Source: ESG Research Report, The Evolution of Server Virtualization, November, 2010

tolerance. NetApp supports virtualizing both enterprise class arrays and modular Fibre Channel SAN storage systems from EMC, Fujitsu, HDS, HP, IBM, and 3PAR.[3]

Figure 3. V-Series Scalability

V6200 Series
840-2880TB
48-192GB RAM
3-16TB Flash Cache

V3200 Series
420-1920TB
8-32GB RAM
512GB-2TB Flash Cache
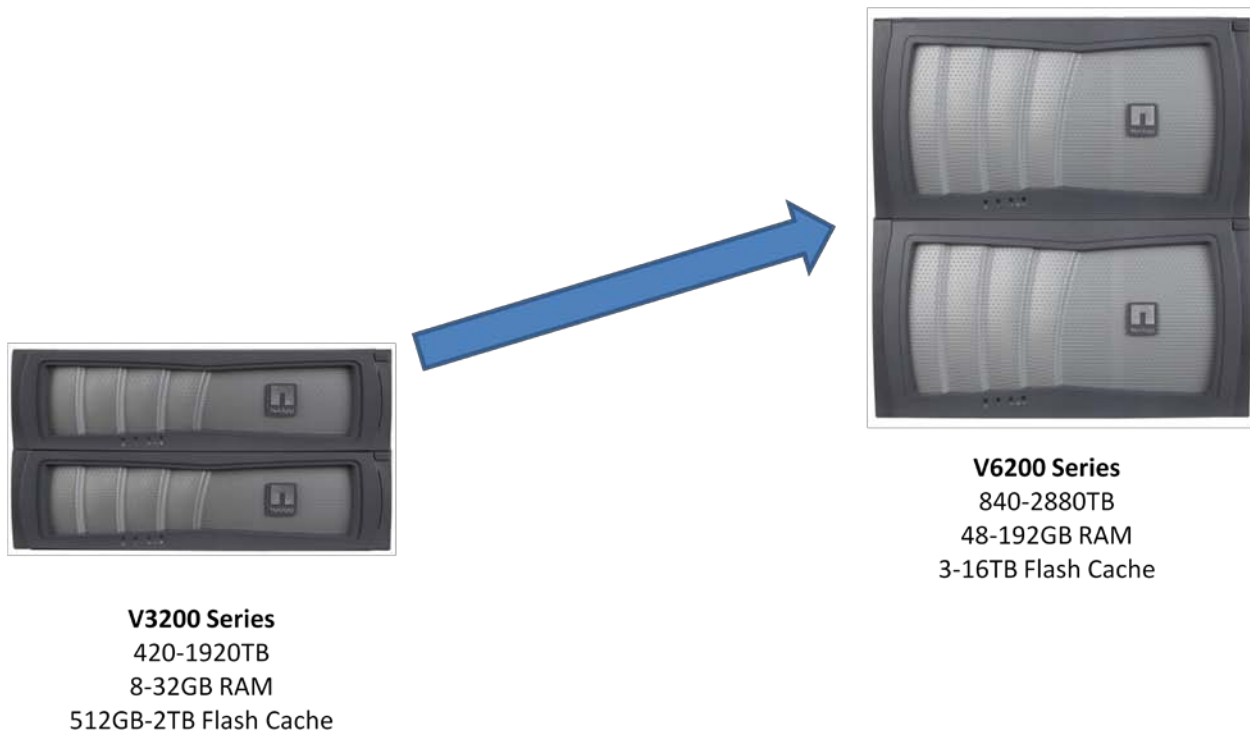
The V-Series open storage controller provides several features that help storage administrators effectively manage a heterogeneous storage environment.

- **Unified Storage efficiency**. NetApp provides storage efficiency technologies for production and backup datasets that include block-level data deduplication, compression, and thin provisioning. These technologies can be deployed individually and in combination for both SAN and NAS, allowing customers to reduce the capital costs associated with storage.

- **Heterogeneous Data protection.** NetApp provides on-disk snapshot backups using capacity and resource-efficient Snapshot technology. Customers can reduce recovery time objectives (RTOs) and improve recovery point objectives (RPOs) across all the storage in their environment. NetApp and its partners—VMware, Citrix, CommVault, and others—integrate their data protection technologies to deliver unified and streamlined business continuance models for consolidated and virtualized environments.

- **FlexClone.** Using NetApp hardware-accelerated provisioning technologies, customers can instantly create clones of production data sets and VMs in order to meet the requests of a dynamic infrastructure without requiring additional storage capacity. Clones can speed test and development, provide instant provisioning for virtual desktop and server environments, and increase storage utilization. This capability is integrated with a number of NetApp partners including Microsoft, VMware, Citrix, and SAP.

- **Heterogeneous Replication and Data Center Mobility.** NetApp SnapMirror and SnapVault are data replication solutions that provide consistent disaster recovery protection for users' business-critical data while enabling business continuance and data center mobility. V-Series extends NetApp replication tools for use with third party storage arrays from different vendors or different array tiers. Replication is deduplication-aware to further improve replication efficiency.

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[3] Access to the V-Series Support Matrix is available to NetApp customers, employees, and partners.

ESG Lab Validation

ESG Lab performed hands-on evaluation and testing of the NetApp V-Series Controller at the NetApp Research Triangle Park facility. Testing was designed to demonstrate the ease of management of the V-Series while providing an efficient, highly available virtualization platform for third-party storage. ESG also validated the performance of V-Series running mixed workloads in a virtual server environment.

Getting Started

Figure 4 illustrates the test bed used by ESG Lab for this Validation report. Two physical servers hosted multiple Windows Server 2008 R2 virtual machines under VMware vSphere. A NetApp V3270 HA system (an HA system is defined as an active-active dual controller configuration) was installed in front of a third-party modular array with 110 146 GB 15K RPM drives.[4] All drives were configured in 5-disk RAID 5 groups, and 44 GB array LUNs were provisioned.

Testing compared the manageability and performance of hosts attached to a V-Series/storage array combination with hosts directly attached to the storage array. The array LUNs from half of the RAID groups were presented directly to two of the VMware servers via Fibre Channel while the array LUNs from the other half of the array raid groups were presented to the V3270, which created aggregates and presented storage to the second set of two VMware servers. An aggregate is a striped storage pool built from either a collection of raid protected array LUNs or a collection of NetApp physical disks that have been protected in RAID-DP RAID groups (RAID-DP is the NetApp implementation of RAID-6). The aggregate is how NetApp logically separates the capacity and performance from a physical disk and serves it via a resource pool to a number of datasets or applications.

All array LUNs were distributed evenly across both controllers in the SAN array. This configuration was in accordance with publically available vendor recommended best practices.

Because V-Series can serve both NAS and SAN protocols, additional volumes were presented to the VMware servers using NFS from the V-Series for some additional tests not possible on a block-only based storage array.
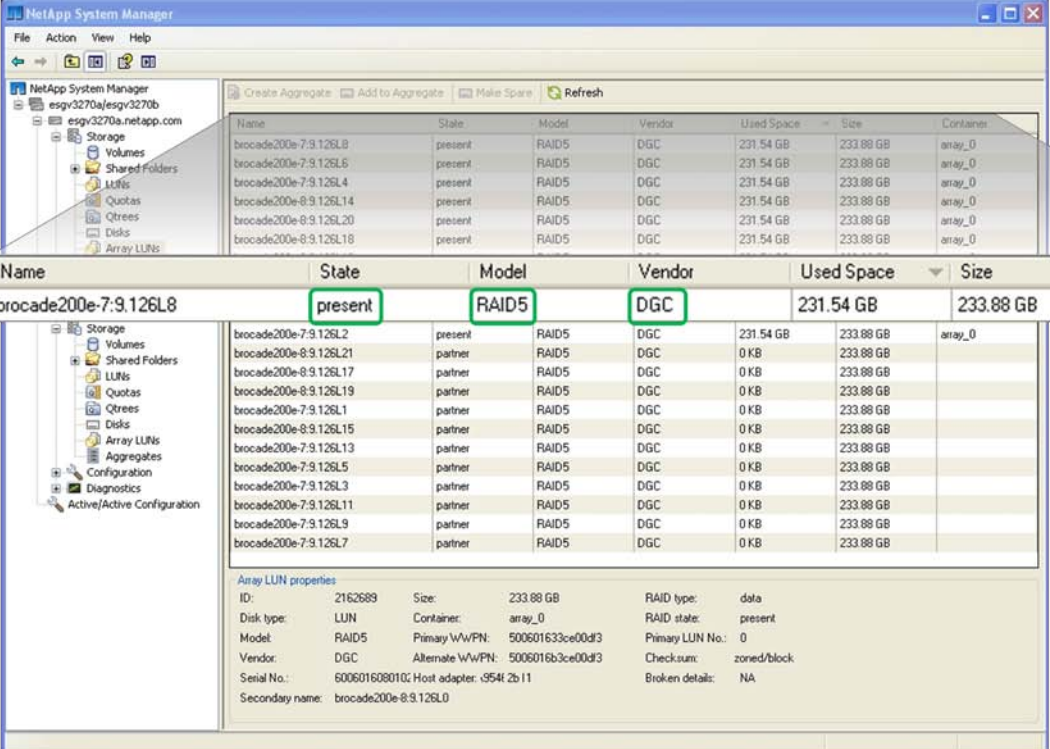
Figure 4. The ESG Lab Test Bed

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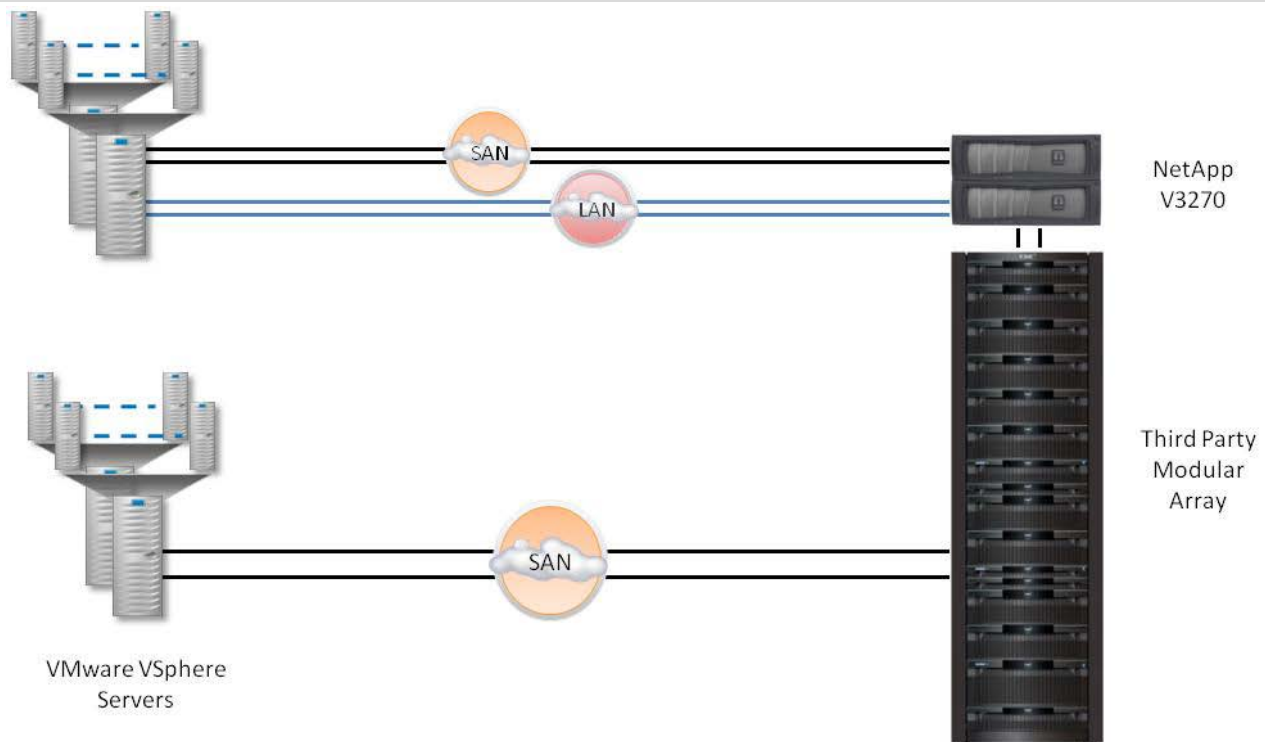
[4] Detailed configuration information can be found in the appendix.

Host Bus Adapters from Emulex and Brocade 200E Fibre Channel switches were used for SAN server connectivity and switching. The native multi-path driver built into VMware ESX was used for a fault tolerant connection between servers and the SAN fabric.

Figure 5 shows the NetApp System manager view of 22x third-party array LUNs presented to the V-Series controllers. The headings provide information about the array LUNs, such as RAID protection levels, manufacturer, and the aggregate to which the array LUN has been assigned. In this example, the array LUN called out is RAID 5 protected and is presented by an EMC CLARiiON array (DGC is the vendor code for EMC CLARiiON), and is a member of aggregate array_0.

Figure 5. The NetApp System Manager

The V-Series product supports both NetApp disk shelves and third-party storage arrays. When using NetApp storage, RAID protection is based on NetApp RAID-DP technology. RAID-DP is a double parity RAID 6 implementation that prevents data loss if two drives in the same RAID group fail. With third-party storage, the LUNs are RAID protected based on the third-party array's technology. No additional RAID protection is applied to array LUNs by the V-series controllers. Once incorporated into an aggregate on the V-Series, the array LUNs can be capacity optimized using FlexVol, thin provisioning, and NetApp block-level deduplication.

ESG Lab Testing

ESG Lab used the NetApp Virtual Service Console (VSC) version 2.0 to demonstrate the power and simplicity of the V-Series in a consolidated, virtualized environment. The VSC Plug-in was installed on a server running the VMware vSphere Client. As shown in Figure 6, VSC can be used to perform routine storage management tasks using an intuitive right mouse click from within the vSphere Client. In this example, a right mouse click was used to create ten hardware-accelerated virtual machine clones using the Rapid Clone wizard. Just four mouse clicks and eight minutes after getting started, the Rapid Clone wizard had created 10 copies of a 43 GB virtual machine.

For comparison, ESG created 10 clones using standard tools on the VMware server directly attached to the third-party storage array. The clone operations took an hour and 12 minutes to complete, nine times longer than the Rapid Clone wizard.

Why This Matters

Poor utilization, increasing complexity, rising costs, and the need to improve the availability and recoverability of IT services are driving a growing number of organizations to make major commitments to server and storage consolidation initiatives. ESG Lab has confirmed that the NetApp V-Series Controller can be used to consolidate a mix of commonly deployed third-party storage devices under a single management interface with common tools and techniques across every platform.

Storage capacity requirements and management complexity are also rising as a growing number of applications—and users—rely on server virtualization. ESG Lab has confirmed that a centralized pool of heterogeneous storage supporting a consolidated mix of servers and applications can be easily virtualized and managed using the NetApp V-Series. The NetApp Virtual Storage Console (VSC 2.0) was especially intuitive and powerful.

Performance

Historically, data stored in a SAN array's cache provided performance gains for just the host or server which originally requested the data. NetApp Virtual Storage Tiering enhances the IO model of a traditional storage array with deduplication-aware caching. When a virtual machine requests data held in the V-Series cache, it is available to fulfill any subsequent IO request from any virtual machine which requests its own copy of this data, either in whole or in part. The result is a significant increase in cache hit ratios coupled with a significant reduction in requests for data from disk. This is in part a byproduct of a shared virtual host infrastructure and is observed with any data set or solution which has enough redundancy to benefit from deduplication.

The NetApp V-Series uses multiple technologies to provide exceptional performance in mixed workload, virtualized environments.

- The WAFL file system enables extremely fast random write performance as data can be written anywhere in the file system with no processing overhead.
- The V-Series can stripe virtual volumes of any size across very large pools of protected LUNS, putting more disk spindles to work on disk intensive workloads.
- NetApp Virtual Storage Tiering, enabled via Flash Cache expansion modules, increases data access and takes advantage of NetApp block-level deduplication. Deduplication-aware cache operates with no setup or administration overhead. Cache in the V-Series operates across all disks in all storage pools, enhancing performance across all storage.

ESG Lab Testing

ESG Lab used the Iometer workload generation tool to emulate a mix of real-world applications (Exchange2007, SQL Server, file server, and web server), to simulate an IO mix that's typical of multi-user business and productivity applications.[5] The objective was to determine the impact on performance of NetApp V-Series on an existing hardware environment, as well as the potential additional benefit of adding Flash Cache. ESG Lab ran the mix of four workloads on 11 virtual machines attached to the third-party modular array and then the same workloads were run on 11 virtual machines provisioned from the V3270. Figure 7 shows the relative performance of the SAN array, the V3270, and the V3270 with a 512 GB Flash Cache card installed. The data shown is the summed performance of all 11 VMs for each configuration and workload.

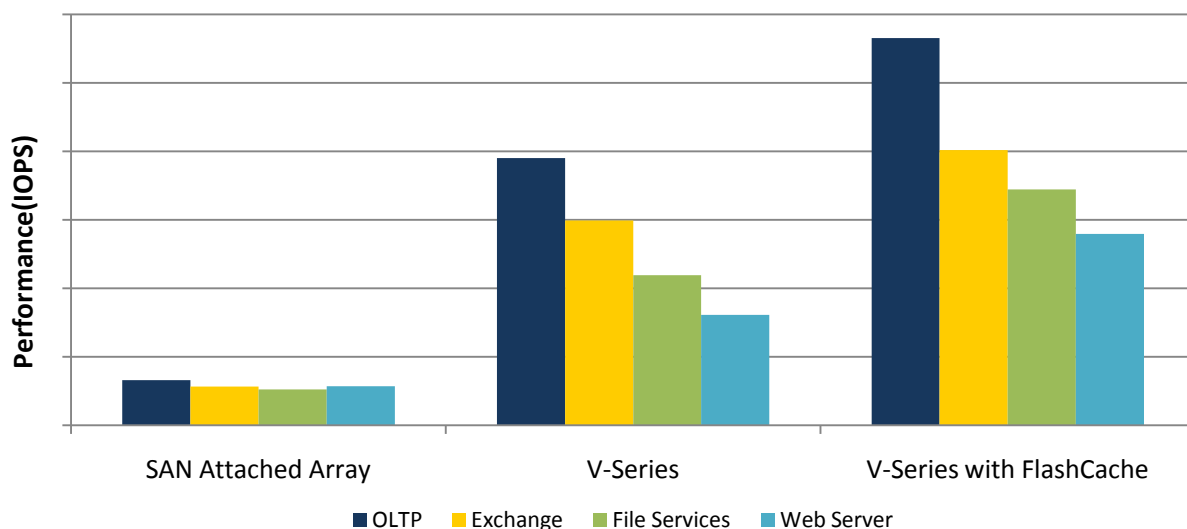Figure 7. Performance : SAN Array, V3270, and Flash Cache

Table 1 and Table 2 show the performance data of the configurations tested.

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[5] Workload characterizations are described in detail in the Appendix.

Table 1. Detailed Performance Results–IOPS

	OLTP(4K)	Exchange 2007	File Services	Web Services
SAN Attached third-party Storage	13,141	11,276	10,432	11,400
V3270 with third-party Storage	77,992	59,812	43,831	32,196
V3270 with third-party Storage and Flash Cache	113,054	80,357	68,870	55,898

Table 2. Detailed Performance Results–Average Response Times (ms)

	OLTP(4K)	Exchange 2007	File Services	Web Services
SAN Attached Array	6.70	7.80	8.43	7.72
V3270– third-party Storage	1.13	1.47	2.01	2.73
V3270– third-party Storage and Flash Cache	0.69	0.99	1.16	1.52

What the Numbers Mean

- Performance improved significantly for every random IO workload tested. The 4K OLTP workload posted the most significant improvements, driving nearly 6x the IOPS of the bare array, more than 8x with Flash Cache installed. It's important to note that the data set was deduplicated, and the performance gains were due in large part to the deduplication aware caching on the V-Series.
- The Exchange 2007 workload improved more than 5x moving from the base array to the V-Series, and 7x greater IOPS with Flash Cache. The third-party array was able to support 19,576 "very heavy" users as defined by Microsoft,[6] while the V-Series showed the ability to support more than 100,000 users using the same number of drives based on IOPS alone. The NetApp Exchange sizing tool confirms that a single 3270 can support 100,000 users, but the number of disks needed for simply handling the capacity requirements would far exceed the number used in these tests. Exchange sizing is an involved process with many dependencies. Users are encouraged to work with their NetApp team when sizing for Exchange.
- The third-party storage array was able to sustain 238 IOPS per drive using the 4K OLTP workload, which is a respectable number. The V-Series was able to drive between 1,400 and 2,000 IOPS per drive thanks to the performance enhancing effects of WAFL, the controller cache, and Virtual Storage Tiering with Flash Cache.
- The V-Series also reduced response times drastically, thanks to the large front end cache in each controller; Flash Cache—the module that enables Virtual Storage Tiering—cut response times even further. Response time is the delay that an application will experience (and pass on to users). Lower response times contribute to more responsive applications.

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[6] Microsoft user profile definitions can be found in the appendix.

Why This Matters

ESG research indicates that providing performance resiliency in the face of unexpected workloads is a key goal when designing storage for a highly consolidated or virtualized environment. In fact, 31% of ESG survey respondents reported that performance was their most significant server virtualization challenge, followed closely by capital costs.[7]

Through hands-on testing, ESG Lab has verified that the NetApp V-Series can be deployed to cost-effectively provide high performance, easy-to-manage storage virtualization. IOPS increased by up to 800% while latency decreased by an order of magnitude. As storage environments continue to grow in size and complexity and virtualization becomes more widespread, storage virtualization and consolidation will become a requirement in more user environments in order to achieve these benefits and operational efficiencies.

Efficiency

The NetApp V-Series uses a variety of technologies to increase storage efficiency:

- **FlexVol with thin provisioning** increases storage efficiency by providing just-in-time capacity for applications accessing storage using block-based or file-based protocols (e.g., iSCSI, FC, FCoE, CIFS, NFS). Instead of allocating the maximum amount of storage that an application might use over time, NetApp thin provisioning allocates capacity on demand from a shared pool of storage.
- **FlexClone provisioning** reduces the capacity required to store clones of operating system and application images in a consolidated virtualized environment. A cloned copy created with FlexClone through the Rapid Cloning Utility magnifies capacity savings as it stores just changed data instead of whole copies.
- **Block level deduplication for SAN and NAS** reduces storage capacity by eliminating redundant chunks of data within a storage volume (block or file) via a background operation. Virtual server images are a great candidate for NetApp deduplication because they tend to contain a large percentage of common data between them.

Figure 8. NetApp Capacity Efficiency in Action
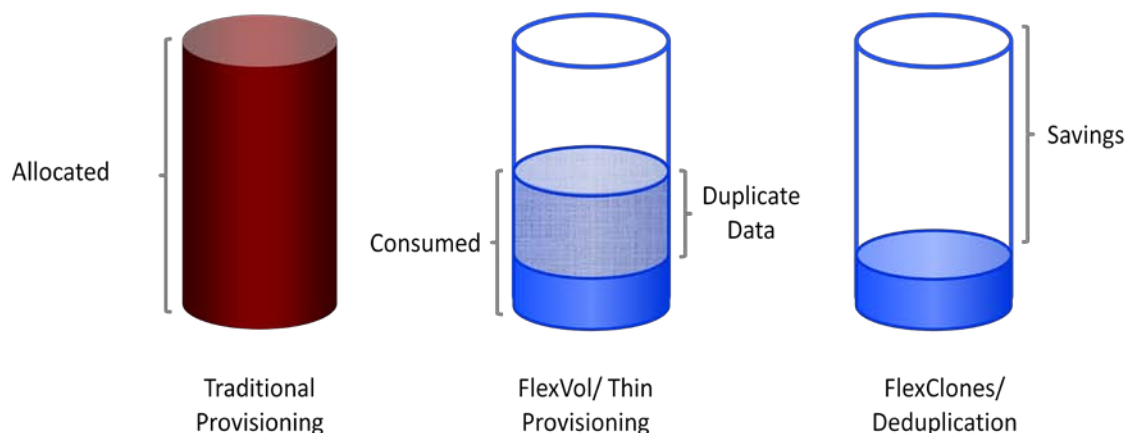
The combined efficiency of NetApp FlexVol, thin provisioning, FlexClone, and deduplication is illustrated in Figure 8. FlexVol with thin provisioning reduces storage capacity as it eliminates the differences between the capacity allocated to an application and what is actually consumed. FlexClone and deduplication eliminate duplicates to magnify the capacity savings.

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[7] Source: ESG Research Report, *The Evolution of Server Virtualization*, November 2010.

A Virtualization Guarantee backs the combined effect of NetApp capacity efficient technologies: as part of the program, NetApp is offering a guarantee that its customers will use 35% less capacity compared to traditional storage using NetApp V-Series with deduplication in front of non-NetApp storage in a VMware virtual environment.[8]

ESG Lab Testing

NetApp System Manager was leveraged to monitor the storage efficiency of a consolidated vSphere environment during ESG Lab testing. Volumes presented via Fibre Channel were configured to provide capacity on demand with FlexVol. A NetApp deduplication job was run to eliminate the duplicate data within VMware virtual disk files (.vmdk files). The Rapid Cloning Utility delivered this integration directly in VMware vSphere and was used to realize additional capacity savings with NetApp FlexClone technology.

The source virtual disks for the clones created in these tests were 44 GB in size. Creating 11 clones on traditional Fibre Channel attached storage consumed 480 GB. NetApp deduplication reduced the capacity consumed by the FC attached drives drastically. As shown in Figure 9, capacity requirements were reduced by 94%.

Figure 9. NetApp Unified Efficiency in Action
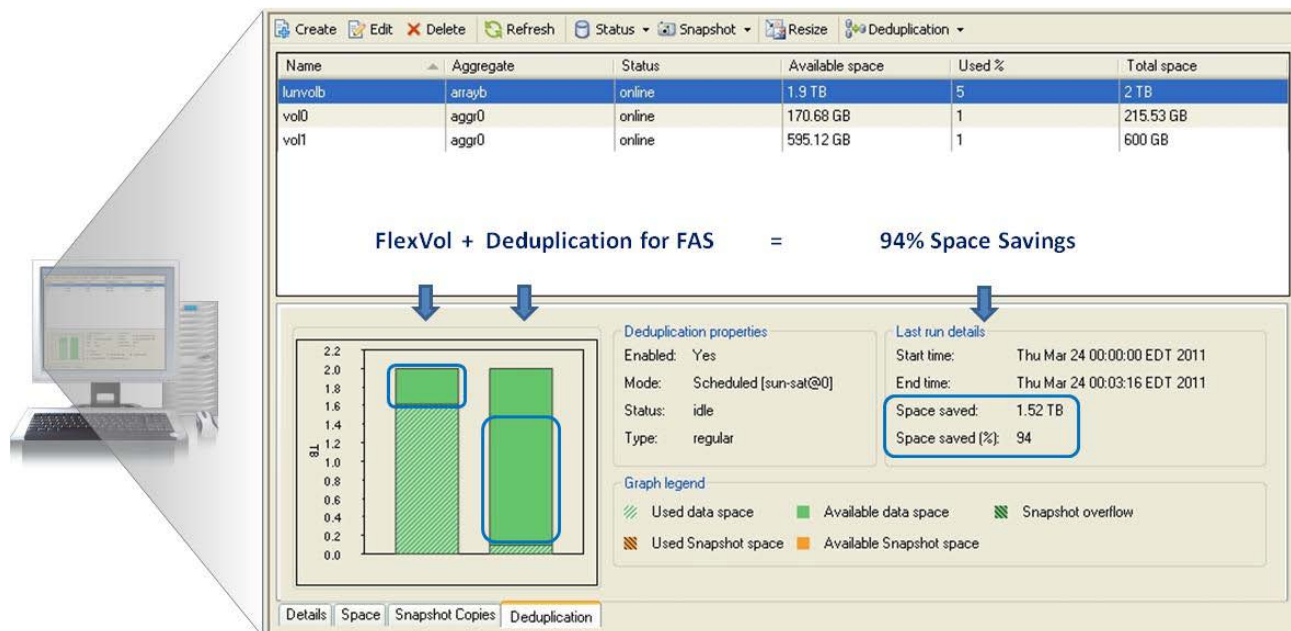
Since V-Series is usually deployed in accounts that already have third-party storage, users could benefit from potential operational cost savings by using their existing arrays with V-Series. While array maintenance such as firmware/microcode updates and parts replacement would still be required, customers could forgo ongoing software maintenance for existing arrays when they deploy V-Series.

Why This Matters

Storage capacity requirements—and costs—are increasing dramatically as a growing number of IT organizations use server virtualization technology to consolidate IT infrastructure.[9] NetApp deduplication and FlexClone, when added to an already-efficient pool of thin provisioned FlexVol storage, can drastically reduce the cost of capacity in growing virtual server environments. ESG Lab observed capacity savings of 94% with a vSphere-enabled pool of common business applications sharing storage consolidated and virtualized by NetApp V-Series.

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[8] For more information, visit www.NetApp.com/guarantee
[9] Source: ESG Research Report, *The Evolution of Server Virtualization*, November, 2010.

ESG Lab Validation Highlights

- ☑ ESG Lab quickly and easily configured and virtualized a centralized pool of third-party storage supporting a consolidated mix of servers and applications using the NetApp V-Series.
- ☑ The NetApp Virtual Storage Console (VSC 2.0) was especially intuitive and powerful, enabling one-click access to powerful storage functionality from within vSphere.
- ☑ ESG Lab used the NetApp V-Series to cost-effectively provide high performance, easy-to-manage storage virtualization using existing, third-party storage arrays. IOPS increased by up to 800% while latency decreased by an order of magnitude.
- ☑ Capacity savings of 94% were achieved in a vSphere environment by NetApp V-Series.

Issues to Consider

- ☑ ESG Lab has confirmed that the combination of FlexVol, FlexClone, and deduplication can be used to increase storage efficiency in a consolidated, virtualized environment by 94% or more, but storage administrators familiar with legacy storage systems need to change the way they've been managing storage capacity to take advantage of these capabilities. Instead of waiting for an application or an operating system to signal that it is out of storage capacity, a FlexVol just-in-time storage pool must be monitored to make sure it never runs out of storage. The good news is that the NetApp unified management approach can be used to simplify and automate these tasks using familiar management interfaces.
- ☑ The NetApp unified approach supports a broad variety of host interfaces, drive types, and management software packages. NetApp node-based licensing includes in the base configuration a number of software licenses and one protocol. Additional protocols as well as 5 distinct software modules can be added to each controller. Many vendors have capacity-based licenses, feature-based licenses, or licensing based on number of attached hosts. This matters most when comparing the price of a NetApp unified solution to a disk array from vendors that bundle differently. Users need to ensure they are comparing a complete list of interface and software options in the acquisition price from each vendor they are considering.

The Bigger Truth

In a perfect world, data centers would look quite different. They would be centrally managed, with applications, servers, and storage working in concert to provide reliable, cost effective computing services to the business. Changes would be dynamic and fluid, with automation driving workflow. Most organizations, however, have to deal with the reality of an IT infrastructure far from this nirvana.

Even so, organizations are starting to recognize significant cost benefits from adopting a server virtualization strategy that allows IT to dynamically provision workloads for a variety of tasks—for production as well as test and development environments. It stands to reason that these same virtualization gains can be achieved in storage. Significant investments are already sunk into storage infrastructure that is costly to manage and grossly inefficient in handling capacity. Replacing aging infrastructure is often not financially viable due to significant investments organizations have in existing storage.

The server world began to attain true reductions not only in capital expenditures but in operational costs by virtualizing disparate servers' operating systems that in the physical world could only run on separate hardware. Provisioning services for workloads became quick and economical. But as virtualization began to proliferate, the demands on the storage infrastructure became more severe. Storage became the bottleneck to truly automating provisioning of compute services to meet demand. Server administrators don't want to think about the datastore and how it's managed; they just want the storage when they need it. And storage administrators want to make datastores easily available to clients and applications without the overhead of managing cumbersome storage infrastructure.

Using NetApp Unified Storage, users can manage all the heterogeneous storage in their environment as a single pool using a single interface with common tools. Every NetApp V-Series or FAS system—whether primary or deep archive—runs Data ONTAP. Data ONTAP provides a consistent user interface and powerful storage efficiency technology. All storage can be available to applications and users over either SAN or NAS protocols.

ESG Lab quickly and easily virtualized a centralized pool of third-party storage supporting a consolidated mix of servers and applications using the NetApp V-Series. One-click access to powerful storage functionality from within vSphere was provided by the NetApp Virtual Storage Console (VSC 2.0). Using existing third-party storage arrays, ESG Lab provided high performance, easy-to-manage storage virtualization through a pair of NetApp V-Series controllers. IOPS increased by up to 800% while latency decreased by an order of magnitude and capacity savings of up to 94% were measured in a vSphere environment. Similar storage efficiency benefits were observed using NAS protocols as well.

The efficiencies observed in this testing came from the Data ONTAP operating system. Based on ESG's understanding of how the V-Series and Data ONTAP work together, ESG Lab believes these results would be similar for any supported third-party array. While the testing for this report was conducted on VMware servers, similar benefits should apply to other virtualization environments like Microsoft Hyper-V and Citrix XenServer.

If your organization is struggling to keep up with data growth, keep costs in check, and increase the availability of consolidated, virtualized business applications running on traditional modular storage arrays, ESG Lab recommends that you take a serious look at the benefits that can be realized from virtualizing traditional storage with NetApp V-Series. With an integrated family of management capabilities, a common code base that supports block and file-based storage interfaces, capacity efficiency that's ideally suited for virtual server environments, and application-aware snapshots and clones that are fast and efficient, ESG Lab has confirmed that the V-Series from NetApp can bring advanced storage virtualization to heterogeneous storage environments while reducing complexity.

Appendix

Table 3. ESG Lab Test Bed

NetApp V-Series	
NetApp V3270 (two controllers)	Data ONTAP 8.0.1 16 GB Cache per controller 512 GB Flash Cache Module
Storage Software	NetApp System Manager, v 1.1 NetApp Virtual Storage Console, v2.0 NetApp SnapManager for Exchange, v6.0 NetApp SnapManager for SQL Server, v5.0 NetApp SnapManager for MOSS, v5.0 NetApp SnapDrive for Windows, v6.2
Third-party Storage	
EMC CX4-480	110 146 GB 15K RPM FC Drives RAID 5, 4+1 22 Luns@22 GB 11 LUNS@44 GB
	Flare version: 30 (4.30.000.5.005)
Clients	
Servers	Four SGI Rackable S3012 servers, each with 8 CPU cores at 2.5 GHz Xeon and 16 GB RAM
Hypervisor	vSphere version 4.0
Guest Operating Systems	Microsoft Windows Server 2008 R2
SAN Connectivity	
Fibre Channel Switch	Brocade 200E, 4Gb x 16 ports
Iometer Workload Characterizations	
Iometer	Version 2006.07.27
OLTP	4KB IO 100% random, 67% read
Exchange 2007	8KB IO 100% random, 73% read
File Server	Mixed IO size, 100% random, 80% read
Web Server	Mixed IO size, 100% random, 100% read
Microsoft Exchange 2007 User profiles	
User Type	**Estimated IOPS per user Used for Mailbox Calculation (+20%)**
Light	.132
Average	.216
Heavy	.384
Very Heavy (Used for Mailbox Calculations)	.576
Extra Heavy	.768