Enterprise Strategy Group | Getting to the bigger truth.™

Lab Validation Report

Dell PowerVault MD36X0f Series

Mixed Workload Performance with Application Aware Data Management

By Brian Garrett

June 2011

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Contents

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. Although this report may utilize publicly available material from various vendors, it does not necessarily reflect the positions of such vendors on the issues addressed in this report. This ESG Lab report was funded by Dell.

All trademark names are property of their respective companies. Information contained in this publication has been obtained by sources The Enterprise Strategy Group (ESG) considers to be reliable but is not warranted by ESG. This publication may contain opinions of ESG, which are subject to change from time to time. This publication is copyrighted by The Enterprise Strategy Group, Inc. Any reproduction or redistribution of this publication, in whole or in part, whether in hard-copy format, electronically, or otherwise to persons not authorized to receive it, without the express consent of the Enterprise Strategy Group, Inc., is in violation of U.S. Copyright law and will be subject to an action for civil damages and, if applicable, criminal prosecution. Should you have any questions, please contact ESG Client Relations at (508) 482.0188.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

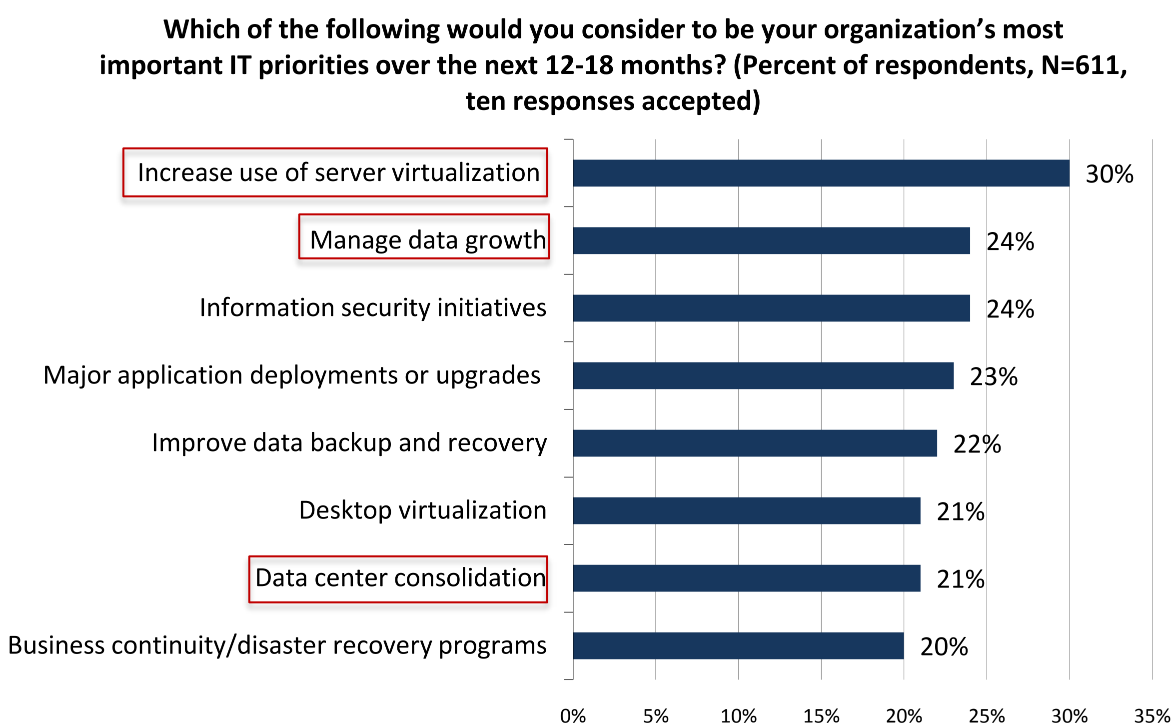
Introduction

This ESG Lab report explores the capabilities of a Dell PowerVault MD36X0f Series storage system deployed in a consolidated virtual server environment with a focus on the value of predictably balanced mixed application performance and application aware storage management plug-ins.

The Challenges

A worldwide wave of server and storage consolidation is reducing the cost and complexity of delivering IT services to the business. Consolidation is clearly a priority as a growing number of organizations embrace server virtualization technology. In a recent survey, ESG asked IT decision makers to list their top priorities over the next 12-18 months.[1] As shown in Figure 1, increased use of server virtualization, data growth management, and data center consolidation were all top priorities.

Figure 1. Top 2011 IT Priorities



Source: Enterprise Strategy Group, 2011.

However, despite the broad success of server virtualization, nagging issues and challenges exist. As a result, a low percentage of the potential workloads that can be virtualized have been migrated to virtual machines, and the consolidation ratios of virtual machines per physical server remains relatively low. A recent ESG survey explored the storage challenges associated with the next wave of server virtualization.[2] Given the rapid growth in the number of virtual machines being deployed, it's no surprise that scalability, performance, and the overall volume of storage capacity have been identified as key challenges.

Consolidation and server virtualization are changing the way that IT infrastructure is managed. Managing IT infrastructure from a centralized virtual server console is simplifying the process of deploying new applications. Storage system management tools need to be integrated with the virtual server management interface and higher level application management frameworks to increase the value of a centrally managed IT infrastructure.

[1] Source: ESG Research Report, *2011 IT Spending Intentions Survey*, January 2011.
[2] Source: ESG Research, *2010 Server Virtualization Survey*, September 2010.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

The Solution

The MD36X0f is a modular data storage system with balanced mixed workload performance and a rich set of application aware management tools. The MD36X0f uses the latest 6 Gbps Serial Attached SCSI (SAS) interface for the back-end connection to disk drives and a flexible set of front-end server connectivity options. The high performance 8 Gbps Fibre Channel (FC) host attach option provides connectivity for applications with high performance and availability requirements. SAS, which has traditionally been used for an affordable connection to entry level disk arrays (often referred to as "just a bunch of disks," or JBOD), is also supported for high speed, low cost host connectivity.

Figure 2. Introducing the Dell PowerVault MD36X0f Storage System

Supporting up to 4 GB/sec of throughput and 40,000 IOPS, the key capabilities of the MD36X0f include:

- Up to eight additional 8 Gbps FC host interfaces.
- Up to 96 high-speed SAS, cost-effective nearline SAS, self-encrypting, or solid state drives.
- 3.5 and 2.5 inch drive enclosures.
- Up to 4 GB of cache.
- Advanced recovery capabilities, including snapshots and volume copies.
- Advanced availability capabilities, including dual controllers and remote replication.

A growing set of application aware management plug-ins provide tight integration with management tools from Microsoft, VMware, and others. Plug-ins simplify management of MD36X0f storage with built-in provisioning, monitoring, event management, and advanced data recovery. A growing set of management frameworks are supported, including VMware vSphere

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

The Results

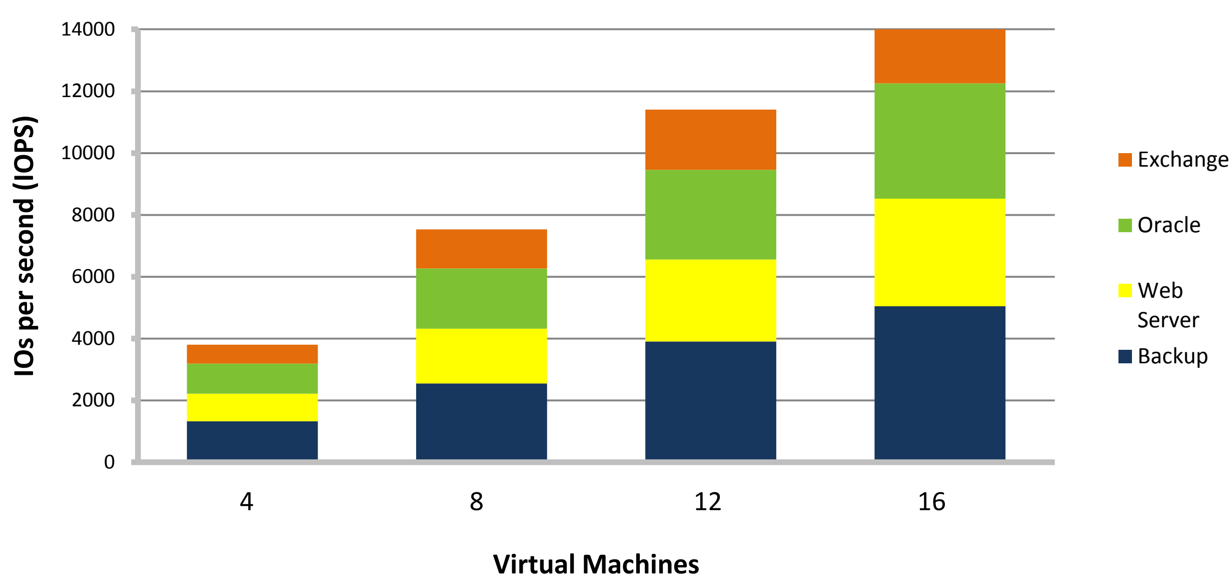
This report documents the performance and application management capabilities of the MD36X0f. Performance testing with a mix of real-world applications in a VMware vSphere-enabled virtual server environment and mix of management framework plug-ins explores how:

- A single MD36X0f with 88 15K RPM SAS drives attached to a pair of powerful multi-core servers running a mix of real-world application workloads in 16 virtual machines supports up to:
  - **20,458 mailboxes** using the Microsoft Exchange 2010 Jetstress utility
  - *and* **3,724 database IOs per second** for small OLTP IOs with the Oracle Orion utility
  - *and* **856 MB/sec of throughput** for large OLAP Oracle Orion operations
  - *and* **3,490 simulated web server IOPs**
  - *and* **1,260 MB/sec of throughput** for simulated backup jobs
  - with predictably fast response times and scalability.

- Management tools were examined with a goal of confirming that provisioning, monitoring, and protecting application data residing on an MD36X0f storage system can be simplified with application aware capabilities including:
  - Storage vCenter vSphere Plug-in.
  - Site Recovery Adapter for VMware Site Recovery Manager (SRM).

The predictably fast, mixed workload performance scalability of the virtualized environment tested by ESG Lab is summarized in Figure 3. The results will be explored in detail later in this report, but for now it should be noted that the performance of the MD36X0f scaled well as a mix of real-world application workloads run in parallel on up to 16 virtual machines.

Figure 3. MD36X0f Mixed Workload Scalability



The balance of this report explores how the tests were accomplished, what the results mean, and why they matter to your business.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

ESG Lab Validation

The real-world performance capabilities of the MD36X0f storage system were assessed by ESG Lab. The methodology presented in this report was designed to assess the mixed workload performance and manageability of an MD36X0f in virtual server and consolidated application environments.

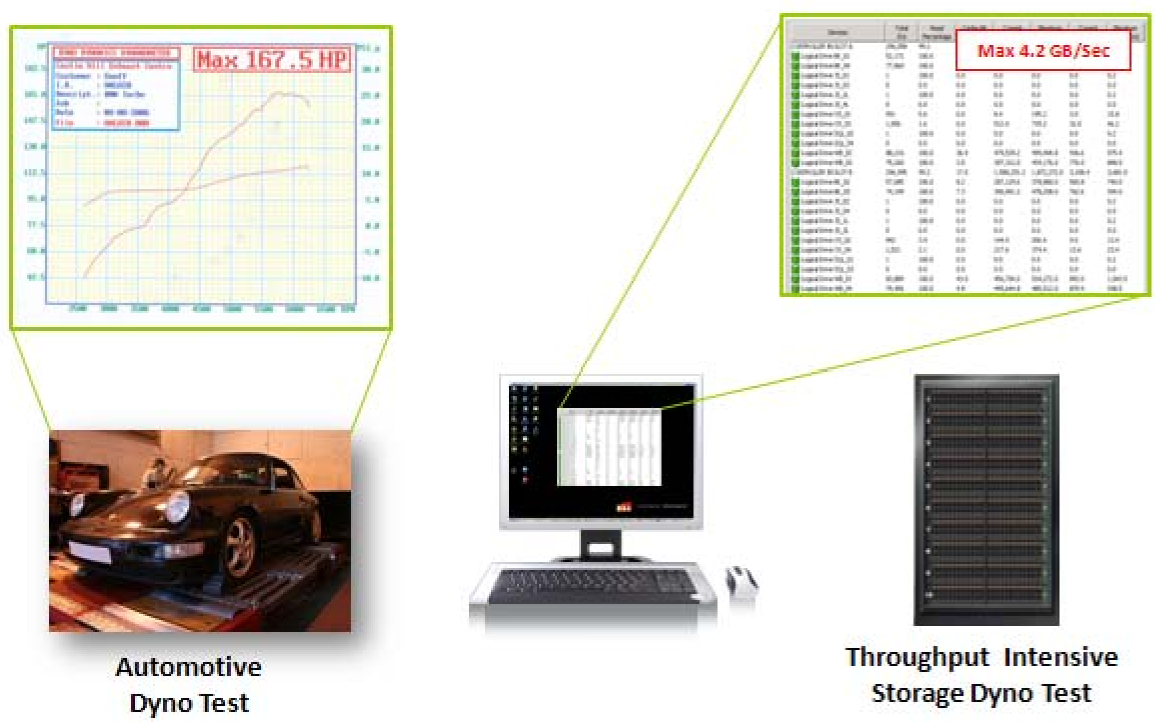
Results

In a way, storage system benchmark testing is like an analysis of the performance of a car. Specifications, including horsepower and acceleration from 0 to 60, are a good first pass indicator of a car's performance. But while specifications provide a good starting point, a variety of other factors should be taken into consideration including the condition of the road, the skill of the driver, and gas mileage ratings. Much like buying a car, a test drive with real-world application traffic is the best way to determine how a storage system will perform.

Characterization

Performance analysis began with an examination of the low level aggregate throughput capabilities of the test bed. This testing was performed using the Iometer utility running within the eight virtual machines that were used later during mixed workload testing. Iometer access definitions, which measured the maximum throughput from disk, were used for this first pass analysis of the underlying capabilities of the MD36X0f.[3] Similar to a dynamometer horsepower rating for a car, maximum throughput was used to quantify the power of a turbo-charged MD36X0f storage engine. As shown in Figure 4, ESG Lab recorded a maximum throughput of 4.2 GB/sec.

Figure 4. Characterizing the Storage Engine



[3] The configuration and methodology that was used during characterization testing is described in the Appendix.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

What the Numbers Mean

- Much like the horsepower rating of a car, the throughput rating of a storage system is a good indicator of the power of a storage system's engine.
- Storage throughput is a measure of the bandwidth available to the system. Throughput can be measured on a stream or aggregate basis. A stream is represented by one application or user communicating through one IO interface to one device. Aggregate throughput is a measure of how much data the storage system can move on a whole for all applications and users.
- ESG Lab recorded a peak aggregate throughput of 4.2 GB/sec in a VMware vSphere environment.
- When comparing the performance capabilities of two servers in a virtual server environment, the server with more cache tends to perform better. ESG Lab is confident that a similar pattern holds true for storage systems. A storage system with more cache—and better caching algorithms—should perform better in a virtual server environment.
- ESG Lab characterization testing indicates that the MD36X0f has more than enough cache and front-end bandwidth to meet the needs of virtualized applications.
- ESG Lab is convinced that the caching algorithms of the MD36X0f provide a significant performance boost during virtualized mixed application testing.

Why This Matters

A storage system needs a strong engine and a well-designed modular architecture to perform predictably in a mixed real-world environment. One measure of the strength of a storage controller engine is its maximum aggregate throughput. ESG Lab testing of the MD36X0f in a VMware vSphere environment achieved 4.2 GB/sec of aggregate large block sequential read throughput.

In ESG Lab's experience, these are excellent results for a dual controller modular storage system. As a matter of fact, these results provide an early indication that the MD36X0f is well suited for virtual server consolidation and mixed real-world business applications.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Mixed Workload Storage Performance Testing

Conventional server benchmarks were designed to measure the performance of a single application running on a single operating system inside a single physical computer. SPEC CPU2000 and CPU2006 are well known examples of this type of server benchmarking tool. Much like traditional server benchmarks, conventional storage system benchmarks were designed to measure the performance of a single storage system running a single application workload. The SPC-1 benchmark, developed and managed by the Storage Performance Council, is a great example. SPC-1 was designed to assess the performance capabilities of a single storage system as it services an online interactive database application.

Traditional benchmarks running a single application workload can't help IT managers understand what happens when a mix of applications are deployed together in a virtual server environment. To overcome these limitations, VMware created a mixed workload benchmark called VMmark. VMmark uses a tile-based scheme for measuring application performance and provides a consistent methodology that captures both the overall scalability and individual application performance of a virtual server solution. VMmark measures performance as a mix of application workloads are run in parallel within virtual machines deployed on the same physical server.

The novel VMmark tile concept is simple, yet elegant. A tile is defined as a mix of industry standard benchmarks that emulate common business applications (e.g., e-mail, database, web server). The number of tiles running on a single machine is increased until the server runs out of performance. A score is derived so that IT managers can compare servers with a focus on their performance capabilities when running virtualized applications.

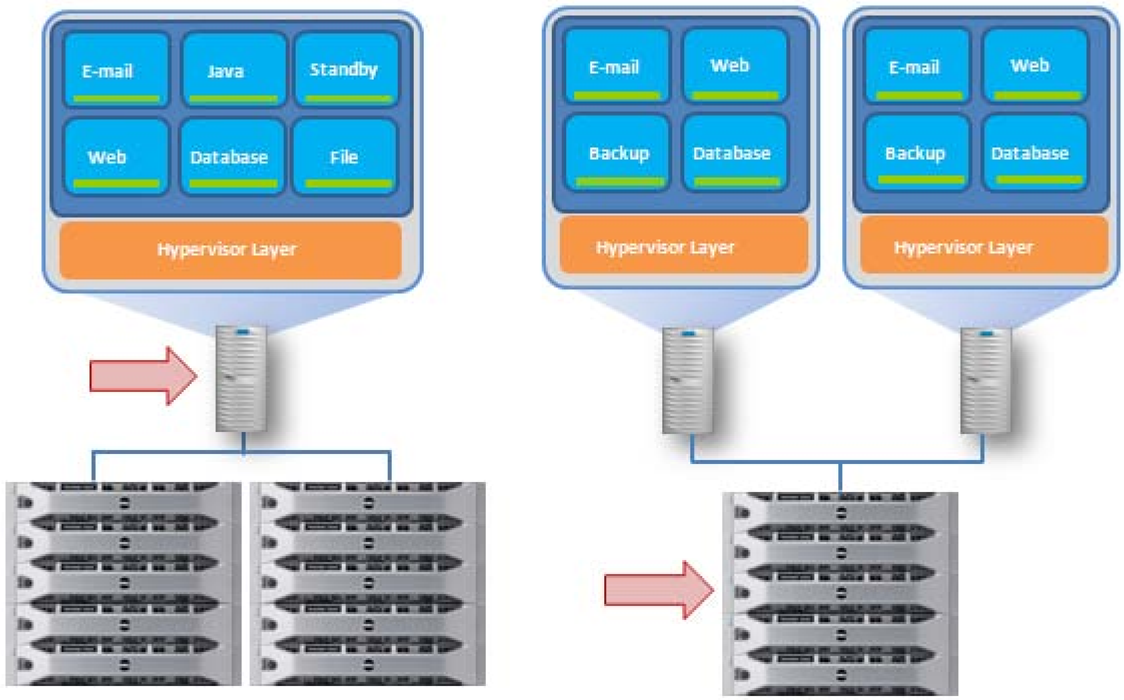
While VMmark is well suited for understanding the performance of a mix of application running on a single server, it was not designed to assess what happens when a mix of applications is run on multiple servers sharing a single storage system. VMmark tends to stress server internals more than it does the storage system. The methodology developed by ESG Lab and presented in this report was designed to stress the storage system more than the servers. Taking a cue from the VMmark methodology, a tile-based concept was used. Each tile is composed of a mixture of four application workloads. Two physical servers, each configured with eight virtual machines, were used to measure performance as the number of active tiles was increased from one to four.

VMmark testing is performed with a single server, often attached to multiple storage systems. When server vendors publish VMmark results, they make sure there is plenty of storage available so they can record the highest VMmark score. This provides IT managers with a fair comparison of the performance capabilities of competitive server technologies.

As shown in Figure 5, ESG Lab storage-focused benchmarking uses a different approach. Instead of testing with a single server and more than enough storage, multiple servers are attached to a single storage system. Rather than running application-level benchmarks which stress the CPU and memory of the server, lower level industry standard benchmarks are used with a goal of measuring the maximum mixed workload capabilities of a single storage system.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

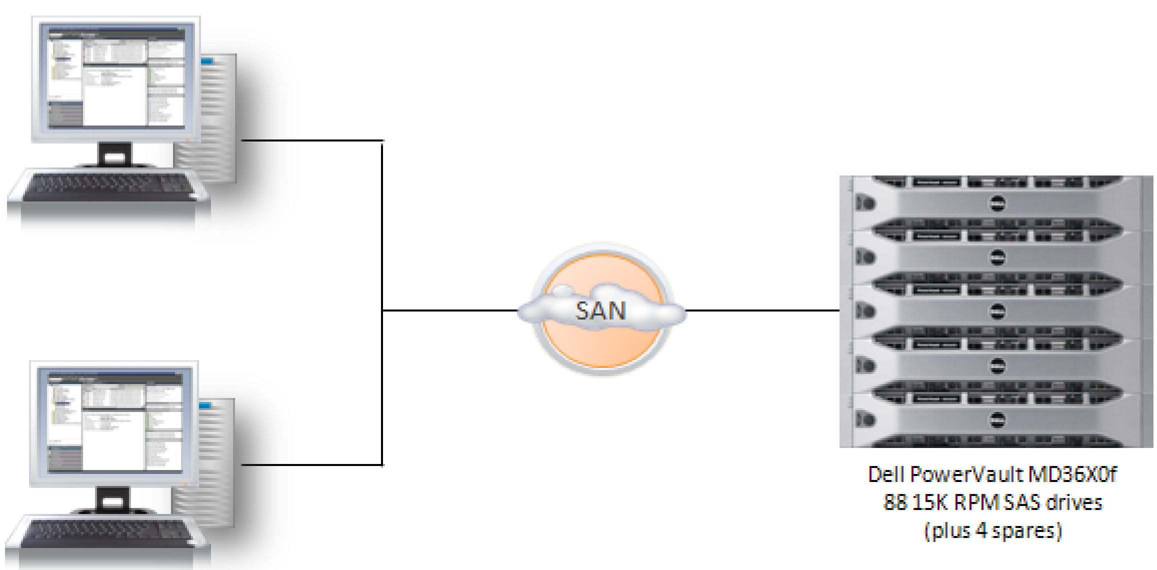
Figure 5. Server-focused VMmark vs. Storage-focused ESG Lab Benchmarking



Test Bed

VMware vSphere version 4.1 was installed on a pair of servers, each with a pair of quad-core processors and a pair of dual-port host adapters. An MD36X0f storage system with 88 10K RPM SAS drives was connected to the servers through a storage area network, as shown in Figure 6.

Figure 6. ESG Lab Test Bed



Workloads

Industry standard benchmarks were used to emulate the IO activity of four common business application workloads:

- **E-mail:** The Microsoft Jetstress 2010 utility was used to generate e-mail traffic. Similar to the Microsoft LoadGen utility used in the VMmark benchmark, Jetstress simulates the activity of typical Microsoft Exchange users as they send and read e-mails, make appointments, and manage to-do lists. The Jetstress utility is, however, a more lightweight utility than LoadGen. Using the underlying Jet Engine database, Jetstress was designed to focus on storage performance.
- **Database:** The Orion utility from Oracle was used to generate database traffic. Much like Jetstress, Orion is a lightweight tool that is ideally suited for measuring storage performance. Orion was designed to help administrators understand the performance capabilities of a storage system, either to uncover performance issues or to size a new database installation without having to create and run an Oracle database. Orion is typically used to measure two types of database activity: response-time sensitive online transaction processing (OLTP) and bandwidth sensitive online analytic processing (OLAP).
- **Web Server:** The industry standard Iometer utility was used to generate web server traffic. The IO definition was composed of random reads of various block sizes. The web server Iometer profile used for this test was originally distributed by Intel, the author of Iometer; Iometer has since become an open source project.[4] Iometer tests were performed on Windows physical drives running over VMware raw mapped devices.
- **Backup:** The Iometer utility was used to generate a single stream of large block sequential read traffic. Operations that tend to generate this type of traffic include backup operations, scan and index operations, long running database queries, bulk data uploads, and copies. One 256 KB sequential read workload was included in each tile to add a throughput intensive component to the predominantly random IO profile of interactive e-mail, database, and web server applications. As most experienced database and storage administrators have learned, a throughput-intensive burst in IO traffic can drag down performance for interactive applications, causing performance problems for end-users. Adding a few streams of throughput-intensive read traffic was used to determine whether interactive performance would remain predictably responsive as the amount of mixed IO utilization increased.

Each of the four workloads ran in parallel, with the Jetstress e-mail test taking the longest to complete (approximately three hours). Configuration details and the settings for each of the workload generators are documented in the appendix.

Why This Matters

ESG research indicates that storage scalability and performance are significant challenges for the growing number of organizations embracing server virtualization technology. Storage benchmarks have historically focused on one type of workload (e.g., database or e-mail) and one key performance metric (e.g., response time or throughput). Server benchmarks have typically tested only one server running a CPU-intensive workload that doesn't stress storage. To help IT managers understand how an MD36X0f performs in a virtual server environment, this benchmark was designed to assess how real-world applications behave when running on multiple virtualized servers sharing a single storage system.

[4] http://www.sourceforge.net/projects/iometer

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Virtual Machine Utilization

Mixed application testing began with a quick analysis of server CPU and RAM utilization to make sure that there were no bottlenecks between virtualized application workloads and the MD36X0f. As expected, utilization was manageably low on the physical servers during the busiest mixed workload test (3.2% CPU utilization and 32% memory utilization were observed at the vSphere client).

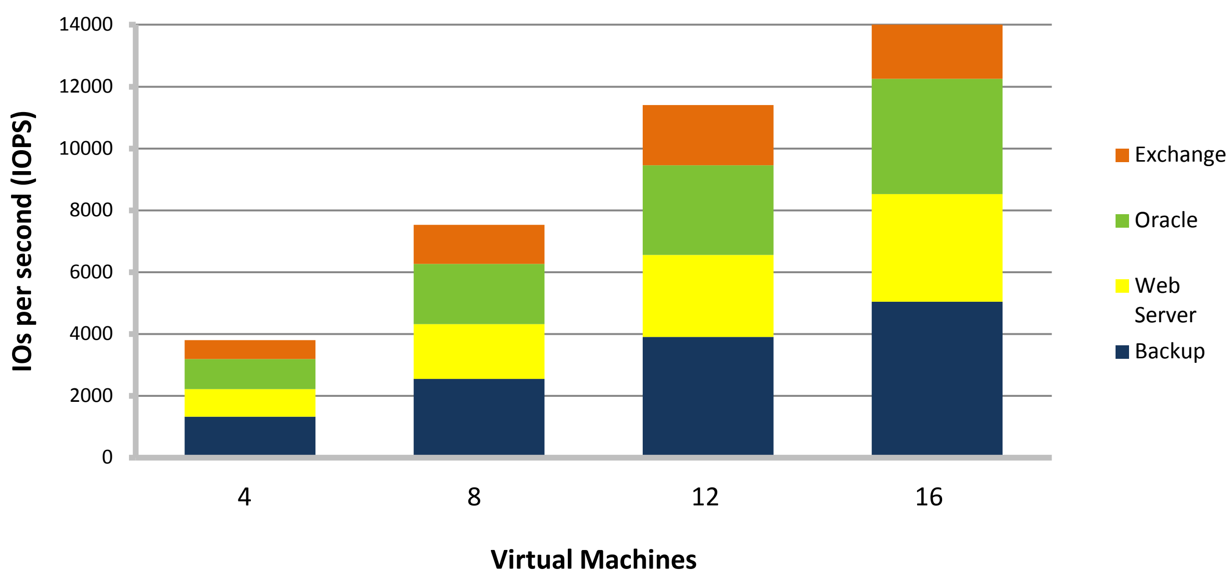
Mixed Real-world IOPS Scalability

IOs per second, or IOPS, is a measure of the number of operations a storage system can perform in parallel. When a system is able to move a lot of IOPS—from disk and from cache— it will tend to be able to service more applications and users in parallel. Much like the horsepower rating for a car engine, the IOPS rating for a storage controller can be used as an indicator of the power of a storage system engine.

While IOPS out of a cache is typically a big number and can provide an indication of the speed of the front end of a storage controller, IOPS from disk is a more useful metric when determining the real-world performance of a storage system servicing a mix of business applications. For example, e-mail and interactive database applications tend to be random in nature and therefore benefit from good IOPS from disk. With that said, a mix of real-world applications tends to generate random and sequential IO traffic patterns that may be serviced from disk or from cache.

ESG Lab measured IOPS performance as reported by the MD36X0f as the number of virtual machines running mixed real-world application workloads increased from four through sixteen. With a mix of random and sequential IOs over 88 disk drives, the goal was not to record a big IOPS number; the goal with this exercise was an assessment of the scalability of the MD36X0f as an increasing number of applications are consolidated onto a single virtualized platform. The IOPS scalability during the peak period of mixed workload activity is shown in Figure 7.

Figure 7. Mixed Workload Scalability



What the Numbers Mean

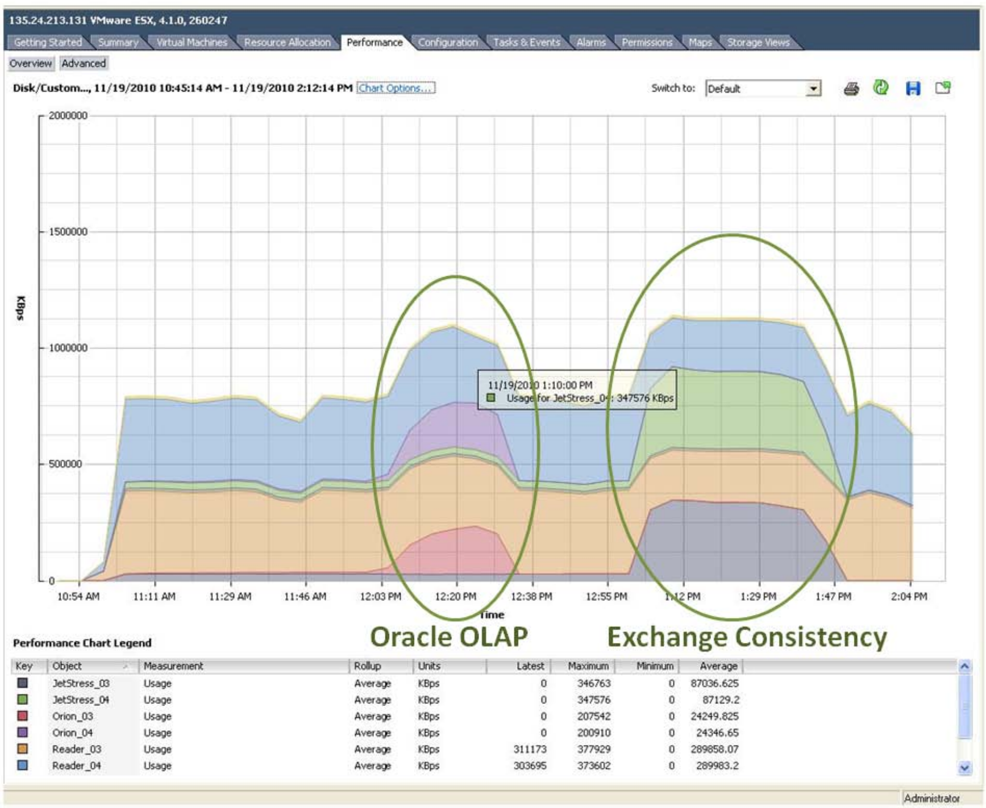
- IOPS varied throughout the mixed workload test with peaks occurring during the Orion small IOPs phase and toward the end as the Jetstress utility performed a database consistency check.
- A peak of 14,709 IOPS was recorded during the four tile run.
- IOPS scaled well as mixed real-world application traffic increased from four through sixteen virtual servers.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Handling Throughput Spikes with Ease

As noticed during IOPS monitoring, peaks of throughput activity could be correlated to the periodic behavior of real-world applications. A burst of aggregate throughput was observed during the Oracle large MBPS test which simulates a throughput-intensive OLAP application. A VMware vSphere view of mixed workload performance on one of the servers is shown in Figure 8.

Figure 8. Peak Throughput (One Server, Four Active Tiles, Stacked VM View)



What the Numbers Mean

- An aggregate throughput level of 2.1 GB/sec was recorded as mixed, real-world applications were run on 16 virtual machines sharing a single MD36X0f storage system (1.1 GB/sec for one of the two physical servers is shown in Figure 8).
- As throughput intensified during the Oracle Orion OLAP test phase, bandwidth utilization for other mixed workloads operating in parallel remained steady.

Why This Matters

Predictable performance scalability is a critical concern when a mix of applications shares a storage system. A burst of IO activity in one application (e.g., a database consistency check) can lead to poor response times, lost productivity, and, in the worst case, lost revenue.

ESG Lab confirmed that the balanced performance of the MD36X0f scales predictably as a growing number of applications are consolidated in a virtual server environment.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Mixed Application Performance Scalability

Having looked at the IOPS and throughput ratings of the turbo-charged MD36X0f engine, here's where the rubber meets the road as we examine performance at the application level. The output from each of the industry standard benchmark utilities was analyzed to determine the performance scalability and responsiveness of real-world applications running in a consolidated virtual environment.

Microsoft Exchange

The IO and performance efficiency of Microsoft Exchange have improved significantly over the years. Architectural improvements in Exchange 2010—including a new store schema, larger page sizes (8 KB to 32 KB), improved read/write coalescing, improved pre-read support, and increased cache effectiveness—have reduced the number of IOs per user up to 70% compared to Exchange 2007.[5] ESG Lab typically uses a value of 0.5 IOPS per mailbox to emulate a heavy Exchange user environment when testing with Jetstress 2007. A value of 0.12 IOPS per mailbox was used during Jetstress 2010 testing to reflect the 70% reduction in IOPS compared to Exchange 2007.

The Microsoft Jetstress 2010 utility was used to see how many simulated e-mail users could be supported by the MD36X0f during mixed workload testing. The number of IOPS and response time for each database and log volume was recorded at the end of each Jetstress run. A response time goal of 20 milliseconds or less for database reads is required to pass the test. These values are defined by Microsoft as a limit beyond which end-users will feel that their e-mail system is acting slowly.[6] The results are shown in Figure 9 and itemized in Table 1.

Figure 9. Mixed E-mail Scalability (Response Time)

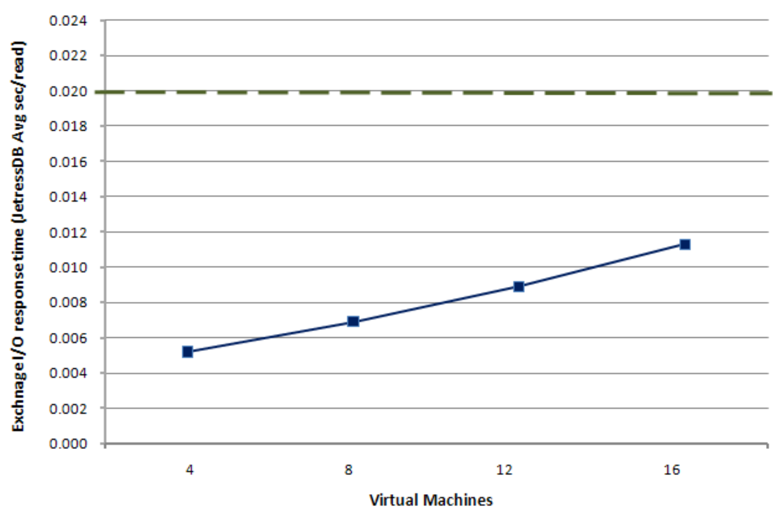


Table 1. Jetstress 2010 Performance Results (One Through Four Tiles)

Virtual Machines	Achieved IO per Seconds	Users (0.12 Profile)	DB Avg. Disk Sec/Read
4	608	5,067	.0052
8	1,265	10,542	.0069
12	1,938	16,150	.0089
16	2,455	20,458	.0113

[5] http://download.microsoft.com/download/D/1/B/D1BE3AEC-A9CD-4459-99F1-B28867FAE20B/Exchange2010TCP_parte8.pdf
[6] http://technet.microsoft.com/en-us/library/bb738152(EXCHG.80).aspx

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

What the Numbers Mean

- The single tile mixed application test supported 5,067 Exchange users with an average DB disk response time of 5.2 milliseconds.
- Performance scaled to 20.458 users while the MD36X0f was busy servicing other applications concurrently.
- As the number of simulated e-mail users was increased, the MD36X0f provided excellent response times that are well within Microsoft's guidelines. Note that response times for database reads are below the Microsoft recommended maximum of 20 milliseconds, which is shown as a dotted line in Figure 9.
- The IO efficiency improvements in Exchange 2010 reduce the cost of delivering e-mail support in mixed virtual server environments. In this case, ESG Lab supported up to 20,458 mailboxes on four virtualized Exchange 2010 servers in a mixed workload environment—more than twice the expected number of supported mailboxes within an Exchange 2007 environment.

Oracle

The Oracle Orion utility was used to measure small transfer (8 KB) response time and large transfer (1 MB) throughput. The small transfer results are used to predict the performance and scalability of response time-sensitive interactive database applications (e.g., OLTP). The large transfer results are used to predict the performance of throughput-intensive online analytical processing (OLAP) and decision support systems (DSS).

ESG used the following guidelines from an Oracle OpenWorld presentation to interpret the results:

> Target 5-10 millisecond for response time critical IO. Start by assuming 30 IOPS per disk for OLTP and 20 MB/sec per disk in DSS. This is way below the theoretical value, but allows for media repair etc.[7]
>
> For new or non-existing applications, use business rules or data model transaction profiles flow to understand what a transaction is and then extrapolate for transactions per second or hour. Optionally, you can use the numbers we have seen in our consulting gigs. Note that these are just guideline values. Use the following as basic guidelines for OLTP:
>
> > Low transaction system – 1,000 IOPS or 200 MB/sec
> >
> > Medium transaction system – 5,000 IOPS or 600 MB/sec
> >
> > High-end transaction system – 10,000 IOPS or 1 GB/sec (rarely achievable)[8]

The results for the four tile Orion test are summarized in Table 2. A sample Orion report is shown in the Appendix.

Table 2. Orion Four-tile Performance Results

Tile	Small IOPS	Large MBPS	Small Latency (ms)
1	946	218	5.13
2	921	213	5.17
3	929	213	5.14
4	928	212	5.17
	3,724	856	5.15

[7] *Current trends in Database Performance*, Andrew Holdsworth, Oracle OpenWorld, November 2007. http://www.oracle.com/technology/deploy/performance/pdf/PerfTrends_Holdsworth.pdf
[8] *Back of the Envelope Database Storage Design*, Nitin Vengurlekar, RAC/ASM Development, Oracle Open World, November 2007. http://www.oracle.com/technology/products/database/asm/pdf/back%20of%20the%20env%20by%20nitin%20oow%202007.pdf

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

What the Numbers Mean

- The four-tile test achieved a grand total of 3,724 small IOPS and 856 large MBPS while the system was simultaneously running a mix of real-world application workloads.
- Using Oracle's back of the envelope sizing guidelines, this level of IO activity falls between the performance guidelines for a "*low transaction system*" and a "*medium transaction system*."
- The total number of small IOPS processed during the busy four-tile test yielded a rate of 53.5 small IOPS per drive, which dwarfs the conservative Oracle planning guideline of 30 IOPS per drive.
- Orion reported an average latency of 5.15 milliseconds for the small IOPs workload. Given the Oracle guidance of 5 to 10 milliseconds, ESG Lab believes that these are excellent results—especially given the mix of IO-intensive workloads being serviced by the MD36X0f in parallel.

Web Server and Backup Reader

Performance results as reported by the Iometer utility for the web server and backup workloads during the one-, two-, three-, and four-tile tests are listed in Table 3.

Table 3. Iometer Four-tile Performance Results

Active VMs	Web Server (IOPs)	Backup (MB/Sec)
4	889	332
8	1772	637
12	2,655	975
16	3,489	1,260

What the Numbers Mean

- Performance scaled in a nearly linear fashion as the number of virtual machines running in parallel was scaled from four to sixteen.
- Given the cache friendly, read-only nature of web server IO traffic, ESG Lab believes that these results indicate that the MD36X0f has the horsepower required to service tens of thousands of simultaneous page requests.
- Each of the four backup streams sustained at least 300 MB/sec of throughput for the entire duration of the mixed workload test. A stream of this magnitude could service the data needs of a number of simultaneous backup jobs, a very aggressive scan and index job, or a throughput-intensive database table scan.

Much like the electrical system in your home, figuring out how many appliances you can run in parallel before blowing a fuse is not a function of the number of wires behind the walls. What matters more is the design of the circuits used to distribute the right amount of power to appliances. ESG Lab testing indicates that the MD36X0f engine delivers the right amount of power to virtualized applications when needed.

Why This Matters

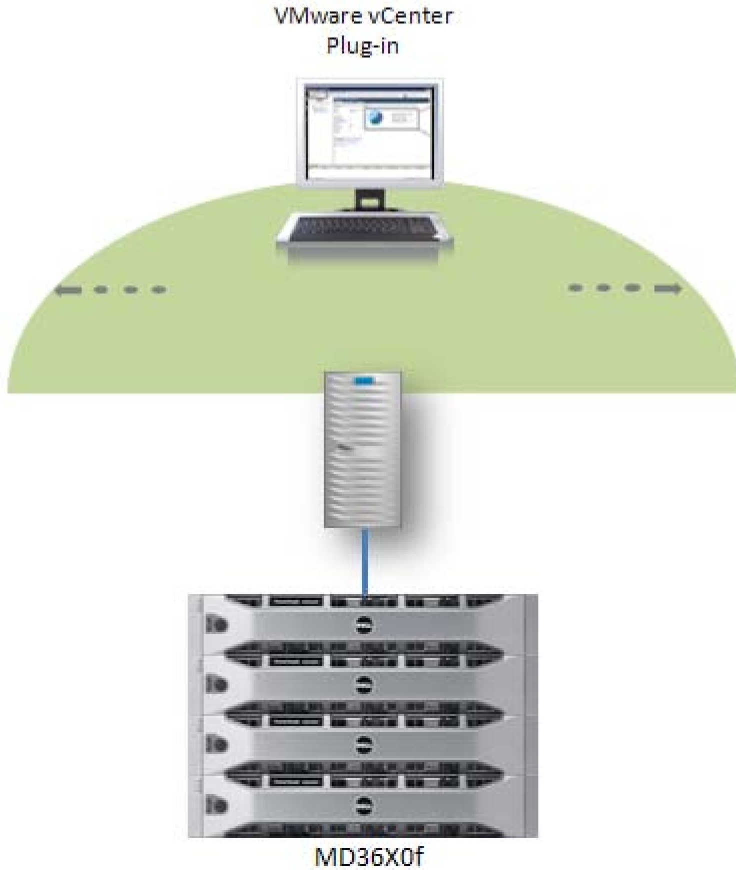
Excessive downtime and slow response time can result in the loss of sales, loss of customer goodwill, loss of productivity, loss of competitiveness, and increased costs. With more and more companies running entire suites of business applications on virtualization solutions like VMware, mixed workload scalability with predictable performance is needed. ESG Lab testing confirmed that the MD36X0f can sufficiently handle a very large number of Exchange users—even as it services other applications and thousands of users with predictably fast response times.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Application Aware Storage and Data Management

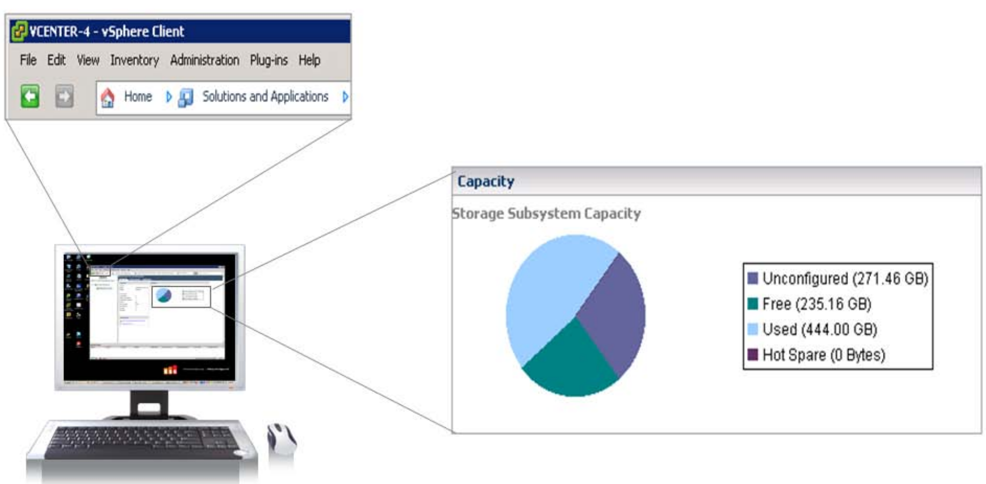
The MD36X0f supports a plug-in for VMware vSphere Client, available as a free download, for application-level management, high availability, and recovery. ESG Lab confirmed that it can be used to monitor, provision, and troubleshoot the storage system from an application perspective.

Figure 10. Application Aware Storage and Data Management



As shown in Figure 11, ESG Lab confirmed that the vSphere Client plug-in can be used to monitor, provision, and troubleshoot the storage system from a virtual server management console.

Figure 11. Monitoring Storage Capacity from the VMware vSphere Client

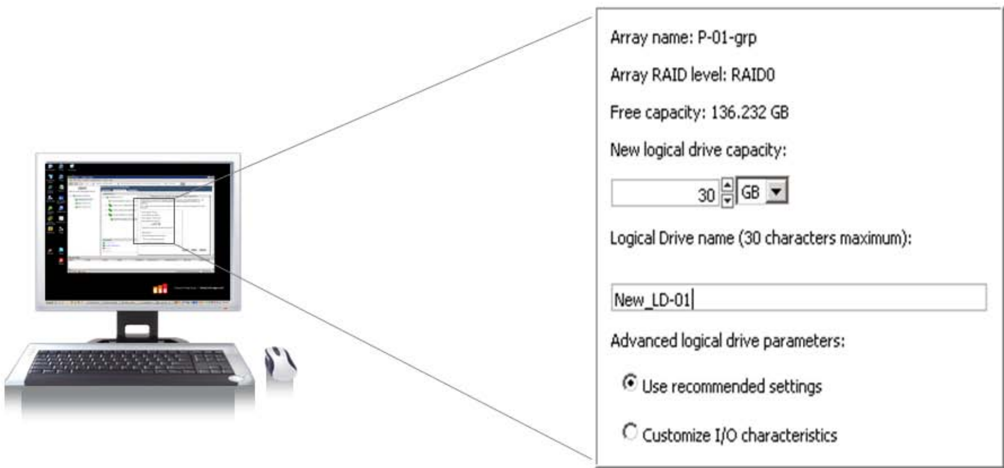


© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Note how storage system specific information, including the number of hot spares, can be monitored without having to switch to the MD36X0f management console.

Application aware storage can not only be used to passively monitor MD36X0f storage systems, it can also be used to actively change storage system settings. In the screen shot shown in Figure 12, a new logical drive is being configured with recommended settings from the VMware management console. Once again, it should be noted that the administrator doesn't need to switch to the storage management console to provision a new volume.

Figure 12. Provisioning Storage from the VMware vSphere Client



Application aware data and storage management can also be used to manage the advanced data protection and recovery capabilities of the MD36X0f. Point in time snapshots can be scheduled and activated at the application level for popular Microsoft applications including Exchange, SQL Server, and SharePoint. Leveraging the Microsoft VSS protocol, snapshots can be managed at the application level for nearly instant data protection and quick and easy recovery of a corrupt application data.

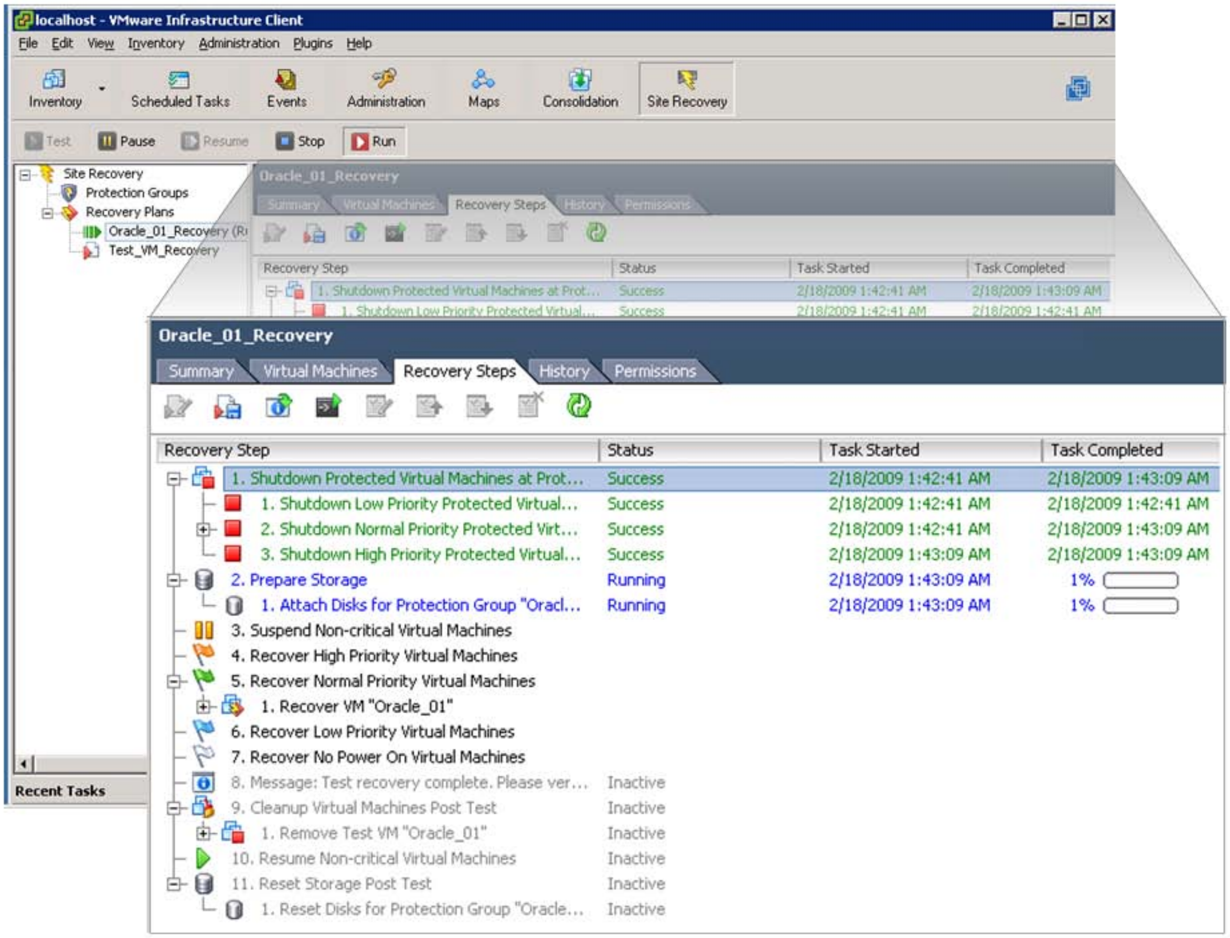
Similarly, application aware data management can be used to automate the recovery of application services after a disaster. For example, the MD36X0f Site Recovery Adapter (SRA) for VMware Site Recovery Manager (SRM) can be used to automate the recovery of applications running in a virtual machine after a site failure. The SRA adapter leverages the remote replication capabilities of the MD36X0f and APIs specified by VMware to create an intuitive management interface that's used to configure, test, and automate the recovery of virtual machines at a remote site.

ESG Lab tested an Oracle application with VMware Site Recovery Manager and the configuration of a complex recovery plan involving multiple virtual machines was wizard-driven and easy. Fifteen minutes after starting a failover with a single mouse click, the entire application environment was up and running at a remote recovery site. Thirty minutes later, the same wizard-driven process was used to fail back to the primary data center. From an end-user perspective, the recovered environment felt exactly the same—regardless of the data center delivering the services. The network addresses, logins, and operating system preferences were the same. No application data was lost. And last, but not least, for the Oracle 11g order entry application tested by ESG Lab, there was no noticeable difference in application performance—even as data was replicated to a recovery site 100 Km away.

ESG Lab performed a failover test to confirm that virtual machines protected by a VMware recovery plan (and the applications running in those virtual machines) can be successfully restarted at the secondary data center. The screen shot shown in Figure 13 shows the progress of the first recovery moments after the *Run* button was clicked. ESG Lab noted that progress was very easy to follow. Successfully completed steps are depicted in green, the currently executing step is blue, and any failed steps are shown in red.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Figure 13. Site Recovery Adapter (SRA) for VMware Site Recovery Manager(SRM)



Why This Matters

IT managers are struggling with explosive data growth and rising management complexity as they deliver application services with ever-increasing performance and availability requirements. As the lines between virtual server, application, and storage administrators blur, a single pane of glass that is familiar to administrators at all levels is needed to improve the delivery, management, and availability of application services.

ESG Lab has confirmed that the growing family of application aware solutions for the MD36X0f can be used to deploy and manage storage from a single pane of glass that is familiar to users at the application level, the virtual server level, and the infrastructure management level.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

ESG Lab Validation Highlights

- ☑ 4.2 GB/sec of aggregate throughput was sustained during characterization testing in a VMware-enabled virtual server environment.
- ☑ A single MD36X0f attached to a pair of servers running a mix of real-world application workloads in 16 virtual machines supports up to:
    - **20,458 mailboxes** using the Microsoft Exchange 2010 Jetstress utility
    - *and* **3,724 database IOs per second** for small OLTP IOs with the Oracle Orion utility
    - *and* **856 MB/sec of throughput** for large OLAP Oracle Orion operations
    - *and* **3,490 simulated web server IOPs**
    - *and* **1,260 MB/sec of throughput** for simulated backup jobs
    - with predictably fast response times and scalability.
- ☑ Management tools were examined with a goal of confirming that provisioning, monitoring, and protecting application data residing on an MD36X0f storage system can be simplified with application aware capabilities including:
    - Storage vCenter vSphere Plug-in.
    - Site Recovery Adapter for VMware Site Recovery Manager (SRM).

Issues to Consider

- ☑ Generally accepted best practices and predominantly default VMware storage settings were used during the design of this test. As expected after any benchmark test of this magnitude, deep analysis of the results indicates that tuning would probably yield slighter higher absolute results. Given that the goal of this test was not to generate a big number, ESG Lab is confident that the results presented in this report meet the objective of estimating performance scalability and responsiveness as a growing number of virtual machines share a consolidated pool of MD36X0f storage.
- ☑ The test results/data presented in this document are based on industry-standard benchmarks deployed together in a controlled environment. Due to the many variables in each production data center environment, it is still important to perform capacity planning and testing in your own environment to validate a storage system configuration.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

The Bigger Truth

Server virtualization is being deployed by a growing number of organizations to lower costs, improve resource utilization, provide non-disruptive upgrades, and increase availability. Each benefit is fundamentally enabled by de-coupling servers, applications, and data from specific physical assets. Storage virtualization takes those very same benefits and extends them from servers to the underlying storage domain—bringing IT organizations one step closer to the ideal of a completely virtualized IT infrastructure.

While the benefits of a completely virtualized infrastructure are obvious to most IT managers, performance and manageability are real concerns. Server, storage, and application administrators are looking for answers to a number of questions:

- Can we meet performance service level agreements for a mix of business-critical applications?
- Does the storage system have the horsepower to serve mixed real-world applications?
- Can the storage system scale to accommodate future growth and consolidation?
- Can storage management be simplified with tools that we are familiar with?

The MD36X0f, with next generation 6 Gbps SAS back-end technology and a flexible mix of SAS and Fibre Channel host connectivity options, is ideally suited for consolidation and virtualization in medium-sized businesses, mid-range environments, and remote sites.

ESG Lab confirmed that the performance and scalability of the MD36X0f is well suited for a mix of applications running in a consolidated virtual server environment in small to medium-sized businesses. A single MD36x0f simultaneously supported 20,458 simulated Exchange 2010 mailboxes *and* 3,724 Oracle Orion small database IOs per second a*nd* 856 MB/sec of throughput for large OLAP Oracle Orion operations *and* 3490 simulated web server IOPs *and* 1,260 MB/sec of throughput for bandwidth-intensive backup jobs—all while delivering predictably fast response times.

ESG Lab confirmed that the growing family of freely available MD36X0f application aware plug-ins can be used to provision and manage data and storage from an application perspective. The VMware vCenter plug-in makes it easy to monitor and provision storage from a VMware virtual server administration console. The site recovery adapter for VMware site recovery manager makes it easy to define, automate, and test the remote recovery of applications running in virtual machines. These capabilities, along with a growing family of application-specific snapshot and cluster failover tools, can be used to simplify storage management using a single pane of glass that administrators are familiar with.

ESG Lab is pleased to report that the Dell PowerVault MD36X0f, with a growing suite of application aware management interfaces, delivers balanced and predictable performance that is well suited for a mix of real-world business applications running in a VMware-enabled virtual server infrastructure.

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Appendix

Table 4. Test Bed Overview

Storage	
Dell PowerVault MD3620f	88 450G 15K 10K SAS drives (plus 4 spares)
Servers	
Two multi-core Xeon servers	Dual quad core 2.67 GHz Xeon processors, 71 GB of RAM
Host Connectivity	
QLogic 8 Gb FC Dual-port HBA	
Fibre Channel Switches	
QLogic Sanbox 5802v	
Virtualization Software and Guest Operating Systems	
Server Virtualization	VMware vSphere ESXi 4.1.0, build 260247
Guest OS	Windows Server 2008 R2 Enterprise Edition 64 bit

Virtual Machine and Drive Configuration

MD36X0f disk capacity was used for all storage capacity including VMware virtual disk files (VMDK), Windows Server 2008 R2 operating system images, application executables, and application data. The operating system images were installed on VMDK volumes. All of the application data volumes under test were configured as mapped raw LUNs (also known as raw device mapped, or RDM, volumes).

Application data and log volumes were configured as four drive RAID-1 volumes. Guest operating system volumes were configured using four-drive RAID-5 volumes. Volume ownership was balanced across the dual controllers and distributed evenly over the eight host interfaces. The volumes were spread evenly over two VMware host groups with a multipath policy of most recently used (MRU). The drive configuration is summarized in Table 5.

Table 5. Drive Configuration

Application	Number of LUNs	Number of Drives	Usable Capacity (GB)
Exchange DB	4	16	3,349
Exchange log	4	8	1,647
Oracle	4	16	3,349
Web server	4	16	3,349
Backup reader	4	16	3,349
Vmdk/OS	4	16	3,349
Hot Spare	N/A	4	N/A
Total	24	92	18,419

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Table 6. Benchmark Utilities/Workload Generators

Characterization	Iometer, version 2006.07.27 Dynamo clients ran within sixteen guest VMs running on a pair of Intel 2.67GHz Xeon based servers with Windows Server 2008 R2 Enterprise Edition as the guest operating system. Forty-eight LUNs, built with 88 SAS drives, were tested. Each of the LUNs was tested as physical drive over raw device mapped volumes in a VMware vSphere environment (ESX 4.1). Maximum throughput was measured using 1 MB sequential reads. One worker, sixteen outstanding IOs per physical drive.
E-Mail	Microsoft Jetstress, version 08.02.0060.000 • Mailboxes – 4,500 • Mailbox size – 180 MB • IOPS per mailbox – 0.12 • Thread – 32 • Log buffers – 9000 • Min DB cache – 64 MB • Max DB cache – 512 MB • Insert operations – 40% • Delete operations – 30% • Replace operations – 5% • Read operations – 25% • Lazy commits – 55%
Database Workload Generator	Oracle Orion, version 10.2.0.1.0 • Small IO size: 8 KB • Large IO size: 1024 KB • IO Types: Small Random, Large Random • Simulated Array Type: RAID 0 • Num_disks: 5 • Stripe Depth: 1024 KB • Write: 30% • Duration for each Data Point: 150 seconds
Web Server	Iometer, version 2006.07.27 Four workers, four outstanding IOs per physical drive 100% random reads, assorted block sizes
Backup Reader	Iometer, version 2006.07.27 One worker, one outstanding IO per physical drive 100% 256 KB sequential reads

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Figure 14. E-mail Results

This is an example of the output created by the Jetstress utility. It shows the performance for one of four Jetstress tests running in parallel. Specifically, this report was created by the Jetstress utility running on a virtual machine within the fourth tile of the four tile test.

Microsoft Exchange Jetstress 2010

Performance Test Result Report

Test Summary

Overall Test Result	Pass
Machine Name	JETSTRESS_01
Test Description	
Test Start Time	11/19/2010 10:55:54 AM
Test End Time	11/19/2010 12:56:53 PM
Collection Start Time	11/19/2010 10:56:51 AM
Collection End Time	11/19/2010 12:56:45 PM
Jetstress Version	14.01.0180.003
Ese Version	14.00.0639.019
Operating System	Windows Server 2008 R2 Enterprise (6.1.7600.0)
Performance Log	C:\JetStress-Results\Tile-4\Performance_2010_11_19_10_55_57.blg

Database Sizing and Throughput

Achieved Transactional I/O per Second	568.938
Target Transactional I/O per Second	540
Initial Database Size (bytes)	857745195008
Final Database Size (bytes)	858852491264
Database Files (Count)	1

Jetstress System Parameters

Thread Count	7 (per database)
Minimum Database Cache	32.0 MB
Maximum Database Cache	256.0 MB
Insert Operations	40%
Delete Operations	20%
Replace Operations	5%
Read Operations	35%
Lazy Commits	70%
Run Background Database Maintenance	True
Number of Copies per Database	1

Database Configuration

Instance2308.1	Log Path: F:\ Database: E:\Jetstress001001.edb

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Transactional I/O Performance

MSExchange Database ==> Instances	I/O Database Reads Average Latency (msec)	I/O Database Writes Average Latency (msec)	I/O Database Reads/sec	I/O Database Writes/sec	I/O Database Reads Average Bytes	I/O Database Writes Average Bytes	I/O Log Reads Average Latency (msec)	I/O Log Writes Average Latency (msec)	I/O Log Reads/sec	I/O Log Writes/sec	I/O Log Reads Average Bytes	I/O Log Writes Average Bytes
Instance2308.1	11.975	3.332	354.775	214.164	32836.081	34254.581	0.000	1.220	0.000	111.283	0.000	4878.843

Background Database Maintenance I/O Performance

MSExchange Database ==> Instances	Database Maintenance IO Reads/sec	Database Maintenance IO Reads Average Bytes
Instance2308.1	28.484	261612.878

Log Replication I/O Performance

MSExchange Database ==> Instances	I/O Log Reads/sec	I/O Log Reads Average Bytes
Instance2308.1	0.000	0.000

Total I/O Performance

MSExchange Database ==> Instances	I/O Database Reads Average Latency (msec)	I/O Database Writes Average Latency (msec)	I/O Database Reads/sec	I/O Database Writes/sec	I/O Database Reads Average Bytes	I/O Database Writes Average Bytes	I/O Log Reads Average Latency (msec)	I/O Log Writes Average Latency (msec)	I/O Log Reads/sec	I/O Log Writes/sec	I/O Log Reads Average Bytes	I/O Log Writes Average Bytes
Instance2308.1	11.975	3.332	383.259	214.164	49838.856	34254.581	0.000	1.220	0.000	111.283	0.000	4878.843

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	2.397	1.406	18.386
Available MBytes	3031.785	3015.000	3039.000
Free System Page Table Entries	33555094.871	33555092.000	33555606.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	24904925.867	24670208.000	25210880.000
Pool Paged Bytes	113510596.267	113451008.000	113770496.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

11/19/2010 10:55:54 AM -- Jetstress testing begins ...
11/19/2010 10:55:54 AM -- Prepare testing begins ...
11/19/2010 10:55:56 AM -- Attaching databases ...
11/19/2010 10:55:56 AM -- Prepare testing ends.
11/19/2010 10:55:56 AM -- Dispatching transactions begins ...
11/19/2010 10:55:56 AM -- Database cache settings: (minimum: 32.0 MB, maximum: 256.0 MB)
11/19/2010 10:55:56 AM -- Database flush thresholds: (start: 2.5 MB, stop: 5.1 MB)
11/19/2010 10:55:57 AM -- Database read latency thresholds: (average: 20 msec/read, maximum: 100 msec/read).
11/19/2010 10:55:57 AM -- Log write latency thresholds: (average: 10 msec/write, maximum: 100 msec/write).
11/19/2010 10:56:00 AM -- Operation mix: Sessions 7, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
11/19/2010 10:56:00 AM -- Performance logging begins (interval: 15000 ms).
11/19/2010 10:56:00 AM -- Attaining prerequisites:
11/19/2010 10:56:51 AM -- \MSExchange Database(JetstressWin)\Database Cache Size, Last: 241778700.0 (lower bound: 241591900.0, upper bound: none)
11/19/2010 12:56:51 PM -- Performance logging ends.
11/19/2010 12:56:51 PM -- JetInterop batch transaction stats: 78235.
11/19/2010 12:56:51 PM -- Dispatching transactions ends.
11/19/2010 12:56:51 PM -- Shutting down databases ...
11/19/2010 12:56:53 PM -- Instance2308.1 (complete)
11/19/2010 12:56:53 PM -- C:\JetStress-Results\Tile-4\Performance_2010_11_19_10_55_57.blg has 483 samples.
11/19/2010 12:56:53 PM -- Creating test report ...
11/19/2010 12:56:54 PM -- Instance2308.1 has 12.0 for I/O Database Reads Average Latency.
11/19/2010 12:56:54 PM -- Instance2308.1 has 1.2 for I/O Log Writes Average Latency.
11/19/2010 12:56:54 PM -- Instance2308.1 has 1.2 for I/O Log Reads Average Latency.
11/19/2010 12:56:54 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.
11/19/2010 12:56:54 PM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
11/19/2010 12:56:54 PM -- C:\JetStress-Results\Tile-4\Performance_2010_11_19_10_55_57.xml has 479 samples queried.

Figure 15. Database Results

This is an example of the output created by the Oracle Orion utility for the database workloads. This example shows the performance of the four database VMs which ran in parallel during the mixed workload four tile test.

ORION VERSION 10.2.0.1.0
Commandline:
-run advanced -testname vmware -num_disks 5 -size_small 8 -size_large 1024 -type rand -simulate raid0 -write 30 -duration 150 -matrix basic

This maps to this test:
Test: vmware
Small IO size: 8 KB
Large IO size: 1024 KB
IO Types: Small Random IOs, Large Random IOs
Simulated Array Type: RAID 0
Stripe Depth: 1024 KB
Write: 30%
Cache Size: Not Entered
Duration for each Data Point: 150 seconds
Small Columns:, 0
Large Columns:, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Total Data Points: 36

Name: \\.\E: Size: 1070596096
1 FILEs found.

Maximum Large MBPS=218.90 @ Small=0 and Large=10
Maximum Small IOPS=946 @ Small=25 and Large=0
Minimum Small Latency=5.13 @ Small=1 and Large=0

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Figure 16. Web Server Results

This is an example of the output created by the Iometer utility for the web server workload. This example shows the performance of the four web server VMs which ran in parallel during the mixed workload four tile test.

'Test Type	Test Description										
0	Mixed_Reader										
'Version											
2006.07.27											
'Time Stamp											
2010-11-19 10:56:04:146											
'Access specifications											
'Access specifi	default assignment										
Reader	0										
'size	% of size	% reads	% random	delay	burst	align	reply				
262144	100	100	0	0	1	0	0				
'End access specifications											
'Results											
'Target Type	Target Na	Access Specification Name	# Managers	# Workers	# Disks	IOps	Read IOps	Write IOp	MBps	Read MBps	Write MBps
ALL	All	Reader	4	4	4	5041.715	5041.7148	0	1260.429	1260.4287	0
MANAGER	Reader_0	Reader		1	1	1267.887	1267.8866	0	316.9717	316.97165	0
PROCESSOR	CPU 0										
PROCESSOR	CPU 1										
WORKER	Worker 1	Reader			1	1267.887	1267.8866	0	316.9717	316.97165	0
DISK	PHYSICALDRIVE:1					1267.887	1267.8866	0	316.9717	316.97165	0
MANAGER	Reader_0	Reader		1	1	1252.671	1252.6711	0	313.1678	313.16779	0
PROCESSOR	CPU 0										
PROCESSOR	CPU 1										
WORKER	Worker 1	Reader			1	1252.671	1252.6711	0	313.1678	313.16779	0
DISK	PHYSICALDRIVE:1					1252.671	1252.6711	0	313.1678	313.16779	0
MANAGER	Reader_0	Reader		1	1	1254.553	1254.5535	0	313.6384	313.63836	0
PROCESSOR	CPU 0										
PROCESSOR	CPU 1										
WORKER	Worker 1	Reader			1	1254.553	1254.5535	0	313.6384	313.63836	0
DISK	PHYSICALDRIVE:1					1254.553	1254.5535	0	313.6384	313.63836	0
MANAGER	READER_0	Reader		1	1	1266.604	1266.6036	0	316.6509	316.65091	0
PROCESSOR	CPU 0										
PROCESSOR	CPU 1										
WORKER	Worker 1	Reader			1	1266.604	1266.6036	0	316.6509	316.65091	0
DISK	PHYSICALDRIVE:1					1266.604	1266.6036	0	316.6509	316.65091	0
'Time Stamp											
2010-11-19 14:58:46:126											

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Figure 17. Backup Reader Results

This is an example of the output created by the Iometer utility for the backup reader workload. This example shows the performance of the four backup jobs which ran in parallel during the mixed workload four tile test.

'Test Type	Test Description										
0	Tile4-Mixed-WebServer-Results										
'Version											
2006.07.27											
'Time Stamp											
2010-11-19 10:56:07:216											
'Access specifications											
'Access sp	default assignment										
WebServe	0										
'size	% of size	% reads	% random	delay	burst	align	reply				
512	22	100	100	0	1	0	0				
1024	15	100	100	0	1	0	0				
2048	8	100	100	0	1	0	0				
4096	23	100	100	0	1	0	0				
8192	15	100	100	0	1	0	0				
16384	2	100	100	0	1	0	0				
32768	6	100	100	0	1	0	0				
65536	7	100	100	0	1	0	0				
131072	1	100	100	0	1	0	0				
262144	1	100	100	0	1	0	0				
'End access specifications											
'Results											
'Target Ty	Target Na	Access Specification Name	# Managers	# Workers	# Disks	IOps	Read IOps	Write IOps	MBps	Read MBps	Write MBps
ALL	All	WebServer	4	16	16	3489.647	3489.647	0	44.63651	44.636513	0
MANAGEF	WebServe	WebServer		4	4	837.8436	837.843629	0	10.72138	10.721383	0
PROCESSC	CPU 0										
PROCESSC	CPU 1										
WORKER	Worker 1	WebServer			1	209.5578	209.557773	0	2.683138	2.683138	0
DISK	PHYSICALDRIVE:1					209.5578	209.557773	0	2.683138	2.683138	0
WORKER	Worker 2	WebServer			1	209.4202	209.420249	0	2.678188	2.678188	0
DISK	PHYSICALDRIVE:1					209.4202	209.420249	0	2.678188	2.678188	0
WORKER	Worker 3	WebServer			1	209.392	209.392045	0	2.681067	2.681067	0
DISK	PHYSICALDRIVE:1					209.392	209.392045	0	2.681067	2.681067	0
WORKER	Worker 4	WebServer			1	209.4736	209.473561	0	2.678991	2.678991	0
DISK	PHYSICALDRIVE:1					209.4736	209.473561	0	2.678991	2.678991	0
MANAGEF	WebServe	WebServer		4	4	883.5313	883.531253	0	11.29689	11.29689	0
PROCESSC	CPU 0										
PROCESSC	CPU 1										
WORKER	Worker 1	WebServer			1	220.8251	220.825103	0	2.820592	2.820592	0
DISK	PHYSICALDRIVE:1					220.8251	220.825103	0	2.820592	2.820592	0
WORKER	Worker 2	WebServer			1	220.8515	220.851531	0	2.82735	2.82735	0
DISK	PHYSICALDRIVE:1					220.8515	220.851531	0	2.82735	2.82735	0
WORKER	Worker 3	WebServer			1	220.9625	220.962466	0	2.824546	2.824546	0
DISK	PHYSICALDRIVE:1					220.9625	220.962466	0	2.824546	2.824546	0
WORKER	Worker 4	WebServer			1	220.8922	220.892153	0	2.824403	2.824403	0
DISK	PHYSICALDRIVE:1					220.8922	220.892153	0	2.824403	2.824403	0
MANAGEF	WEBSERVI	WebServer		4	4	885.6772	885.677235	0	11.32445	11.324448	0
PROCESSC	CPU 0										
PROCESSC	CPU 1										
WORKER	Worker 1	WebServer			1	221.5038	221.503781	0	2.830144	2.830144	0
DISK	PHYSICALDRIVE:1					221.5038	221.503781	0	2.830144	2.830144	0
WORKER	Worker 2	WebServer			1	221.2178	221.21781	0	2.825243	2.825243	0
DISK	PHYSICALDRIVE:1					221.2178	221.21781	0	2.825243	2.825243	0
WORKER	Worker 3	WebServer			1	221.3782	221.37821	0	2.838897	2.838897	0
DISK	PHYSICALDRIVE:1					221.3782	221.37821	0	2.838897	2.838897	0
WORKER	Worker 4	WebServer			1	221.5774	221.577433	0	2.830165	2.830165	0
DISK	PHYSICALDRIVE:1					221.5774	221.577433	0	2.830165	2.830165	0
MANAGEF	WebServe	WebServer		4	4	882.5949	882.594886	0	11.29379	11.293791	0
PROCESSC	CPU 0										
PROCESSC	CPU 1										
WORKER	Worker 1	WebServer			1	220.6774	220.677434	0	2.826407	2.826407	0
DISK	PHYSICALDRIVE:1					220.6774	220.677434	0	2.826407	2.826407	0
WORKER	Worker 2	WebServer			1	220.4748	220.474833	0	2.816435	2.816435	0
DISK	PHYSICALDRIVE:1					220.4748	220.474833	0	2.816435	2.816435	0
WORKER	Worker 3	WebServer			1	220.682	220.682025	0	2.823298	2.823298	0
DISK	PHYSICALDRIVE:1					220.682	220.682025	0	2.823298	2.823298	0
WORKER	Worker 4	WebServer			1	220.7606	220.760593	0	2.827653	2.827653	0
DISK	PHYSICALDRIVE:1					220.7606	220.760593	0	2.827653	2.827653	0
'Time Stamp											
2010-11-19 14:58:49:837											

© 2011, Enterprise Strategy Group, Inc. All Rights Reserved.

Enterprise Strategy Group | **Getting to the bigger truth.**

20 Asylum Street | Milford, MA 01757 | Tel:508.482.0188 Fax: 508.482.0218 | www.enterprisestrategygroup.com