Principled Technologies®

TEST REPORT
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Exchange 2007 performance test comparing Dell PowerVault MD3000i iSCSI SAN Array and HP StorageWorks 2000i Modular Smart Array

Executive summary

Dell Inc. (Dell) commissioned Principled Technologies (PT) to compare the Exchange 2007 performance of two entry-level Storage Area Network (SAN) solutions, which we tested with two shelves of disks and list in alphabetical order:

- Dell PowerVault MD3000i SAN Array with Dell PowerVault MD1000 expansion enclosure (Dell PowerVault iSCSI SAN)
- HP StorageWorks 2000i Modular Smart Array with an HP StorageWorks 2000sa Modular Smart Array expansion enclosure (HP StorageWorks iSCSI SAN)

We tested both SAN solutions with Internet Small Computer Systems Interface (iSCSI) protocol. The test storage arrays each included two full shelves of disks, with 15 disks per shelf on the Dell PowerVault iSCSI SAN and 12 disks per shelf on the HP StorageWorks iSCSI SAN.

KEY FINDINGS

- The Dell PowerVault iSCSI SAN delivered higher performance on our Exchange workload tests. It delivered 59 percent faster Achieved IOPS per disk at 156.3 Achieved IOPS per disk compared to the HP StorageWorks iSCSI SAN at 98.6 Achieved IOPS per disk. (See Figure 1.)
- The Dell PowerVault iSCSI SAN delivered 24 percent higher Log IOPS per disk, at 37.0 Log IOPS per disk compared to the HP StorageWorks iSCSI SAN at 29.9 Log IOPS per disk. (See Figure 2.)
- The Dell PowerVault iSCSI SAN delivered 53 percent greater throughput, at 1.50 MB per second per disk compared to the HP StorageWorks iSCSI SAN at 0.98 MB per second per disk. (See Figure 3.)

For this comparison, we selected the primary storage performance tests in the Microsoft Exchange Server Jetstress tool. Jetstress reports the database disk read and write I/O operations per second (Achieved IOPS), log disk write I/O operations per second (Log IOPS), and the megabytes per second throughput that a given Microsoft Exchange 2007 storage solution provides while maintaining satisfactory responsiveness.

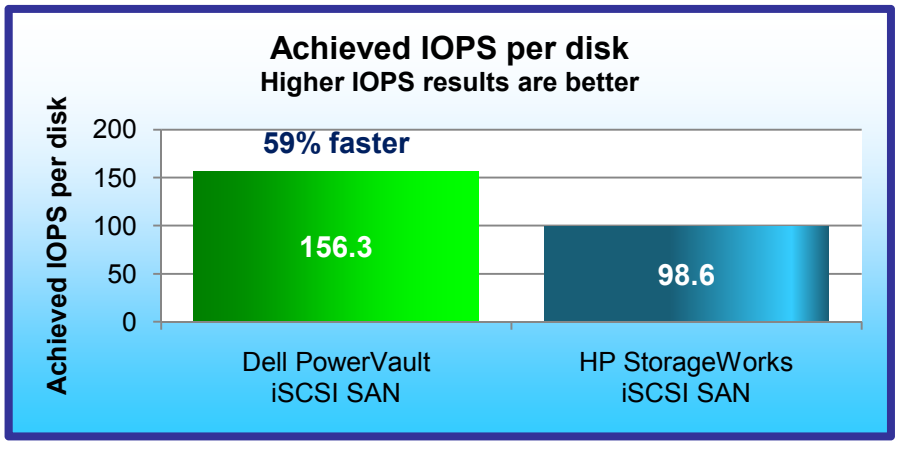

Figure 1: Jetstress performance results, in Achieved IOPS per disk, for two entry-level SAN storage solutions. Results are the Achieved IOPS divided by the number of disks: 30 disks for the Dell PowerVault iSCSI SAN and 24 for the HP StorageWorks iSCSI SAN.

Our goal was to find the maximum I/O operations per second (IOPS) each platform could deliver while providing a satisfactory user experience. To that end, we configured the simulation to demand maximum IOPS by using a large number of relatively small mailboxes, running with high thread counts, and simulating users with heavy mailbox activity. To maximize mailbox count, we selected an average mailbox size of 250 MB and used a production-sized Exchange database that filled 60 percent of the available storage on each test storage system. We allocated half the remaining storage, 20 percent of total available storage, for log files.

We tested with the highest thread count each system could support during the tests while still providing latency results within the standard latency thresholds designated in the Jetstress program. We configured the tests to simulate users with very heavy Microsoft Exchange 2007 activity, which Microsoft defines as requiring approximately 0.5 database I/O operations per second per user.

We ran the test three times to ensure repeatability and report the results from the run that produced the median combined database and Log IOPS results. The overall Jetstress test result is a pass/fail rating based on whether the system's performance fell within acceptable latency thresholds. We report throughput results from runs that passed.

Achieved IOPS is the primary Jetstress throughput result. This result is the sum of the average database disk reads and the database disk writes per second during the test.

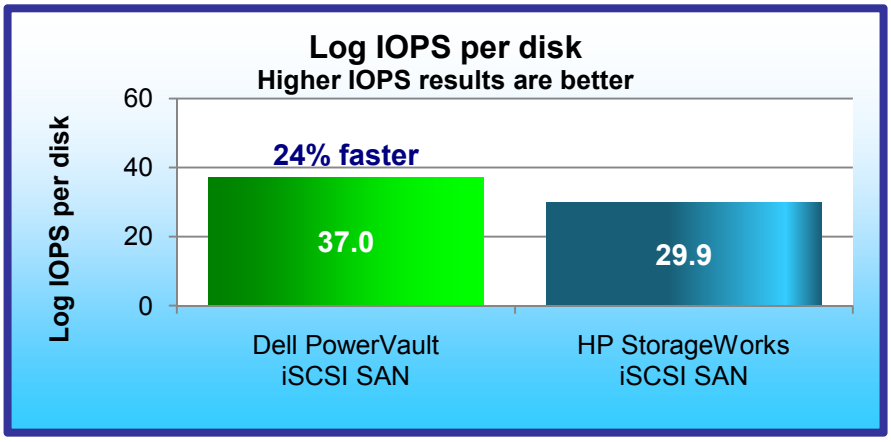

Figure 2: Jetstress performance results, in log write I/O operations per second per disk, for the storage solutions. Results are the log write I/O operations per second divided by the number of disks; 30 disks for the Dell PowerVault iSCSI SAN and 24 for the HP MSA2000i.

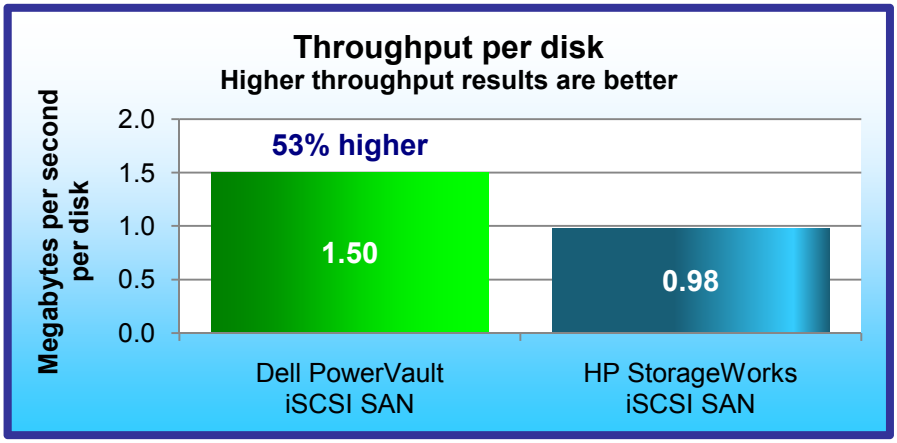

Figure 3: Average disk transfers (in megabytes per second per disk) for the storage arrays during the Jetstress test. Results are megabytes per second for the storage array divided by the number of disks; 30 disks for the Dell PowerVault iSCSI SAN and 24 for the HP MSA2000i.

To provide comparable results for the different disk counts of the systems, we divided the Achieved IOPS that Jetstress reports for the tested storage solution by the number of disks in the solution. We show these results in Figure 1. The disk count includes all disks in both shelves.

As Figure 1 shows, the Dell PowerVault iSCSI SAN delivered 59 percent faster Achieved IOPS per disk: 156.3 Achieved IOPS per disk compared to the HP StorageWorks iSCSI SAN at 98.6 Achieved IOPS per disk.

Achieved IOPS includes only database disk I/O. Jetstress provides separate results for log disk write I/O. Figure 2 shows the average log disk write I/O operations per second during the same runs we show in Figure 1. The Dell PowerVault iSCSI SAN delivered 37.0 Log IOPS per disk, 24 percent faster than the HP StorageWorks iSCSI SAN with 29.9 Log IOPS per disk.

Figure 3 shows the average throughput in average disk transfers, (in megabytes per

second per disk) that the Windows Performance Monitor logged during the same Jetstress runs we show in Figures 1 and 2. The Dell PowerVault iSCSI SAN delivered 53 percent higher throughput, at 1.50 MB per second per disk. The HP StorageWorks iSCSI SAN delivered 0.98 MB per second per disk.

For more information on test results, see Appendix A, which lists test results, and Appendix G, which includes the Jetstress results files.

Test environment

To conduct the tests, we configured a test bed for each storage array. (See Figure 4.)

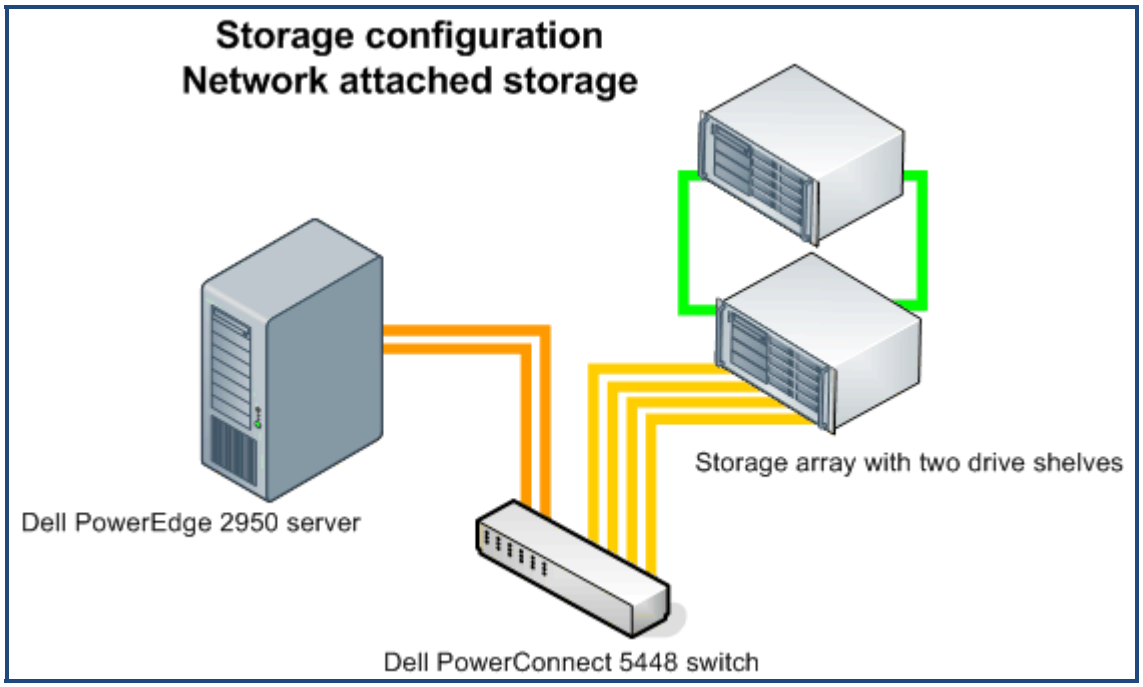

Figure 4: Storage test bed configuration.

Each test bed included the following components:

- One Dell PowerEdge 2950 server (see Figure 5). We attached the server to the switch via two discrete NICs. We ran Jetstress from the server.
- One Dell PowerConnect 5448 switch
- Storage system under test:
  - Dell PowerVault MD3000i SAN Array with Dell PowerVault MD1000 expansion enclosure
  - HP StorageWorks 2000i Modular Smart Array with an HP StorageWorks 2000sa Modular Smart Array expansion shelf

Component	Details
Server	Dell PowerEdge 2950 server
Processors	Two quad-core Intel Xeon E5405 processors at 2.0 GHz
Memory	16 GB of FB-DDR2 PC5300 memory
Internal disk	One 80GB, 7,200 RPM Western Digital WD800AAJS-18SATA 3.0Gb drive
NIC (for iSCSI connections)	Two Intel PRO/1000PT NICs
OS	Windows Server 2003 R2 Enterprise x64 Edition SP2
Test software	Jetstress 08.02.0060, and Ese .08.01.0240.005

Figure 5: Dell PowerEdge 2950 server configuration.

Appendix B provides more detailed information on the test environment.

Storage arrays under test

The storage arrays we tested each included two full shelves of disks. We configured the storage arrays with disks of similar speed and size. Disks were 146 GB, and 15K RPM. We tested both arrays with iSCSI connections.

Figure 6 identifies the systems we tested, their disk counts, the amount of useable storage, and the RAID technology they use.

PT tested both storage arrays using all disks to hold Exchange databases and log files. We followed best practices in choosing RAID technologies for the test systems. The Microsoft Exchange Server 2007 *Planning Your Server and Storage Architecture* instructions on the Microsoft TechNet site (http://technet.microsoft.com/en-us/library/bb738146.aspx) recommend RAID 10 for its speed and performance. We followed these recommendations and configured each array as RAID 10. Formatted storage capacity in Figure 6 shows the amount of useable space that remained.

	Dell PowerVault iSCSI SAN	HP StorageWorks iSCSI SAN
		
Arrays	Dell PowerVault MD3000i SAN Array with Dell PowerVault MD1000 expansion enclosure	HP StorageWorks 2000i Modular Smart Array with an HP StorageWorks 2000sa Modular Smart Array expansion shelf
Disks	30 146GB 15K RPM SAS disks total for the two shelves	24 146GB 15K RPM SAS disks total for the two shelves
Formatted storage capacity	2,042 GB	1,640 GB
Connection	iSCSI	iSCSI
RAID technology	RAID 10	RAID 10

Figure 6: The SANs we tested.

Appendix C provides additional details about the tested storage arrays, and Appendix D shows the data and log file layouts for each.

Test workload

The purpose of the Jetstress primary storage performance tests is to exercise the storage arrays using the maximum sustainable Exchange type of I/O. The tests produce results that show how long it takes the storage under load to respond to an I/O request. The test does not have a single workload; instead, testers create a simulated Exchange mailbox profile that defines the Jetstress workload.

We calculated values for three Jetstress test parameters that define the simulated Exchange mailbox profile: targeted database IOPS per user, average mailbox size, and number of mailboxes.

- **Database IOPS per user.** We based our tested user profile for this report on the Microsoft profile for very heavy Exchange 2007 cached mode users. These users average 30 sent and 120 received messages per day. This load averages 0.5 database IOPS for each user. We used this average as our targeted database IOPS per user.
- **Mailbox size.** We assumed an average mailbox size of 250 MB. We selected this relatively small size because we wanted a large number of mailboxes against which to measure I/O performance.
- **Number of mailboxes.** We formatted each disk and set up the RAID technology for each. We then calculated the mailbox count for each system by determining the number of 250MB mailboxes that would use 60 percent of the remaining disk space on each test system. We selected the 60 percent capacity figure to provide a production-sized database that left room for log files and growth. We rounded the number of mailboxes down to the nearest multiple of 50.

Appendix E provides further details about the Jetstress tests.

Test procedures

We first ran the Jetstress disk subsystem test with automatic tuning to identify a thread count, and then ran the initial performance test using that thread count. If the system passed the initial performance test run, we continued to retest using higher thread counts to push IOPS to the maximum, stopping when Jetstress reported a failing user experience rating. If the system failed the initial performance test run, we retested using lower thread counts until Jetstress reported a passing user experience rating. If the test failed using just a single thread, we reduced the number of mailboxes until Jetstress gave a passing user experience rating. This process identified the highest IOPS score that the system could achieve while receiving a passing user experience rating. We then did two more runs using the settings from the run that produced those results. We ran each test for 2 hours.

Jetstress reports results in I/O operations per second. We gathered the following results from the Jetstress report:

- Database disk reads per second
- Database disk writes per second
- Log writes per second (Log IOPS)
- Achieved IOPS (sum of the database disk reads and writes per second)
- IOPS (calculated by summing the Achieved IOPS and the Log IOPS)

To find the amount of data moved in those operations, Jetstress provides Windows Performance Monitor logs of server performance. We gathered the following results from those logs:

- Average disk transfers per second
- Average disk read MB per second
- Average disk write MB per second
- Average disk transfers MB per second

The results we report in Figures 1 through 3 are the results from the run that produced the median IOPS.

Appendix F provides further details of the test procedures.

Appendix A: Test results

Figure 7 provides test results for the storage arrays, as well as information about the simulated exchange configuration that defines the test workload. We ran the Jetstress primary storage performance test three times for each test system. We summed the disk read, disk write, and log write IOPS, and report that sum as the IOPS value for each run. We report the median of the IOPS values for the three runs in the Median IOPS row. We report the Achieved IOPS and other results from that same run. The body of this report displays the results from that median run.

	Dell PowerVault iSCSI SAN	HP StorageWorks iSCSI SAN
Test workload		
Number disks tested	30	24
Number of mailboxes	5,000	4,000
Total useable space (GB)	2,042	1,640
Initial database size (GB)	1,221	977
Percentage raw disk storage capacity utilization	47%	47%
Mailbox size (MB)	250	250
Initial database percentage storage capacity utilization	60%	60%
Number of storage groups	12	9
Thread count	15	10
Final database size (GB)	1236	984
IOPS (higher is better). IOPS is sum of disk read, disk write, and log write IOPS.		
IOPS - Run 1	5,821.563	3,089.987
IOPS - Run 2	5,798.379	3,082.786
IOPS - Run 3	5,785.379	3,072.709
Achieved IOPS (higher is better). Achieved IOPS is sum of disk read and disk write IOPS.		
Achieved IOPS - Run 1	4,709.946	2,355.520
Achieved IOPS - Run 2	4,688.837	2,365.952
Achieved IOPS - Run 3	4,674.638	2,357.600
Results from median run (higher is better). Median IOPS and other results are from that same run.		
Median IOPS	5,798	3,083
Median Achieved IOPS	4,688.837	2,365.952
Database disk reads per second	2,088.686	1,159.342
Database disk writes per second	2,600.153	1,206.608
Log writes per second	1,109.642	716.836
Average disk transfers per second (from performance logs)	5,696.195	3,070.547
Average disk read MB per second	16.227	9.117
Average disk write MB per second	28.794	14.323
Average disk transfers MB per second	45.00	23.40

Figure 7: Results for the storage arrays.

Appendix B: Test environment

We created a test bed in a climate-controlled room for each storage system. Each test bed included the following components connected with Cat6 cables:

- Microsoft Exchange Server—a Dell PowerEdge 2950 server installed with the following software:
  - Microsoft Windows Server 2003 R2 Enterprise Edition x64 SP2
  - Jetstress 08.02.0060
- One Dell PowerConnect 5448 switch
- Storage systems under test:
  - Dell PowerVault MD3000i SAN Array with Dell PowerVault MD1000 expansion enclosure
  - HP StorageWorks 2000i Modular Smart Array with an HP StorageWorks 2000sa Modular Smart Array expansion shelf

Microsoft Exchange Server

Figure 8 provides detailed configuration information for the server.

Server	Dell PowerEdge 2950
General	
Number of processor packages	2
Number of cores per processor package	4
Number of hardware threads per core	1
System Power Management Policy	Always On
CPU	
Vendor	Intel
Name	Xeon E5405
Stepping	6
Socket type	Socket 771-LGA
Core frequency (GHz)	2.0
Front-side bus frequency (MHz)	1,333
L1 cache	32 KB + 32 KB (per core)
L2 cache	12 MB (2 x 6 MB shared)
Platform	
Vendor	Dell Inc.
Motherboard model number	0M332H
Motherboard chipset	Intel 5000X
Motherboard revision number	12
Motherboard serial number	JD6HWG1
BIOS name and version	Dell 2.3.1 (4/29/2008)
BIOS settings	Default
Chipset INF driver	Intel 7.3.0.1010

Server	Dell PowerEdge 2950
Memory module(s)	
Vendor and model number	Samsung M395T5750EZ4-CE66
Type	FB-DDR2 PC5300
Speed (MHz)	667
Speed in the system currently running @ (MHz)	667
Timing/Latency (tCL-tRCD-iRP-tRASmin)	5-5-5-15
Size (MB)	16,384
Number of RAM modules (MB)	8 x 2,048
Chip organization	Double-sided
Channel	Dual
Hard disk	
Vendor and model number	Western Digital WD800AAJS-18
Number of disks in system	1
Size (GB)	80
Buffer size (MB)	8
RPM	7,200 RPM
Type	SATA 3.0 Gbps
Controller	Intel 6321ESB
Controller driver	Intel 7.3.0.1010 (11/18/2005)
Operating system	
Name	Windows Server 2003 R2 Enterprise x64 Edition
Build number	3790
Service Pack	SP2
Microsoft Windows update date	8/26/2008
File system	NTFS
Language	English
Microsoft DirectX version	9.0c
Graphics	
Vendor and model number	ATI ES1000
Chipset	ATI ES1000
BIOS version	BK-ATI VER008.005.028.000
Type	Integrated
Memory size (MB)	16
Resolution	1,024 x 768 x 32-bit
Driver	ATI 8.24.3.0 (4/5/2006)
Network card/subsystem	
Vendor and model number	Intel PRO/1000 PT Server Adapter
Type	Discrete
Driver	9.7.34.0 (2/1/2007)

Server	Dell PowerEdge 2950
Optical drive	
Vendor and model number	TEAC CD-224E-N
Type	CD/DVD-ROM
Interface	SATA
Dual/single layer	Dual
USB ports	
Number of ports	4
Type of ports (USB 1.1, USB 2.0)	2.0

Figure 8: Detailed system configuration information for the test server.

Dell PowerConnect 5448 switch

We used one Dell PowerConnect 5448 switch, as described in Figure 9.

Component	Details
Switch	One Dell PowerConnect 5448 switch
Frame size	Jumbo frames enabled on all connected devices. Size set to 9,014 bytes
Flow control	Flow control set to Generate & Respond on all network interface cards
iSCSI optimization	iSCSI optimization disabled
Receive descriptors	Set to 256 on all network interface cards

Figure 9: Dell PowerConnect 5448 switch configuration.

Individual test beds

The remainder of this appendix shows diagrams of the components in each of the test beds and indicates their connections.

Dell PowerVault iSCSI SAN

The Dell MD3000i has two controllers with two 1Gbps iSCSI ports per controller, one 100Mbps Ethernet management port per controller, and one SAS 4x port per controller. We connected the Dell MD1000 expansion shelf to the controllers in the Dell MD3000i with one SAS 4x cable per controller. We connected the iSCSI switch to two iSCSI ports per controller and one management port per controller. Figure 10 shows the wiring diagram for the Dell MD3000i.

HP StorageWorks iSCSI SAN

The HP StorageWorks iSCSI SAN has two controllers with two 1 Gbps iSCSI ports per controller, one 100Mbps Ethernet management ports per controller, and one SAS 4x port per controller. We used one SAS 4x cable per controller to connect the HP MSA HP StorageWorks 2000i Modular Smart Array to the controllers in the HP StorageWorks 2000sa Modular Smart Array expansion shelf. We connected two iSCSI ports per controller and one management port per controller to the iSCSI switch. Figure 11 shows the wiring diagram for the HP StorageWorks iSCSI SAN.

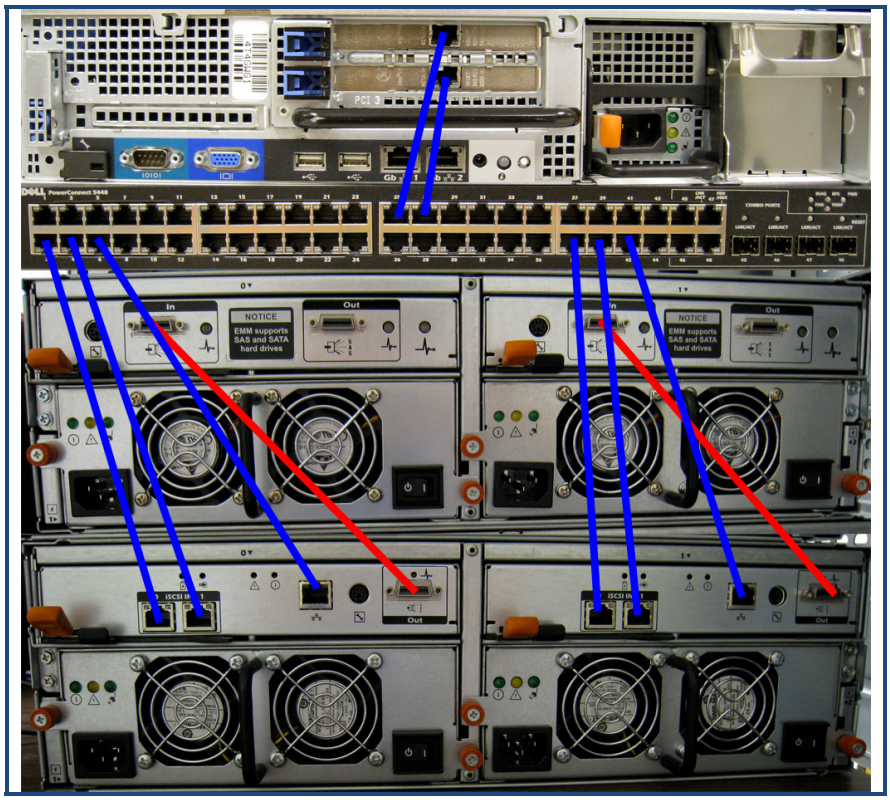

Figure 10: Dell PowerVault iSCSI SAN wiring diagram for the server, switch, and storage. Blue lines represent iSCSI connections between the server and the switch and the switch and the array. Red lines represent SAS 4x connections to different parts of the array.

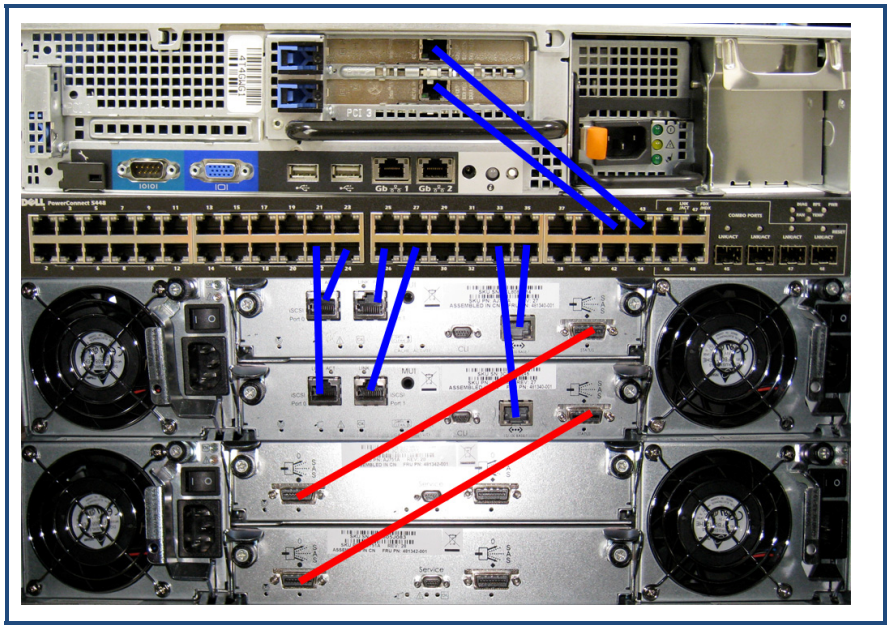

Figure 11: HP StorageWorks iSCSI SAN wiring diagram. Blue lines represent iSCSI connections between the switch and the array. Red lines represent SAS 4x connections to different parts of the array.

Appendix C: Storage configuration

This appendix includes the formulas we used for Simulated Exchange configuration calculations and the results of those calculations for the tested arrays.

Simulated Exchange configuration calculations

We defined the simulated Exchange configuration using the following guidelines:

- Initial database size, equal to 60 percent of the total formatted capacity.
- To allow for growth in the database files, we allocated 80 percent of useable disk capacity for the database LUNs and the rest to log LUNS.
- We created a new storage group for every 100 GB of the initial database size based on Microsoft Exchange recommendations.
- Average mailbox size of approximately 250 MB with mailbox count rounded down to the nearest 50 mailboxes.
- We assumed one mailbox per user.

We calculated the simulated exchange configuration using the formulas in Figure 12. Figure 13 shows the simulated exchange configuration, Figure 14 shows the primary storage hardware, Figure 15 shows the primary storage software, and Figure 16 shows the primary storage disk configuration.

Item	Value
IOPS per mailbox	0.5 (0.42 is typical of a very heavy user profile plus 20 percent headroom)
Database files capacity utilization percentage	60%
Database LUN capacity utilization percentage	80%
Mailbox size quota	250 MB
Mode	Cached
Number of hosts	1
Number of mailbox stores/storage group	1
Total useable space	The amount of space available for the use of files after formatting
Number of mailboxes	(Database files capacity utilization percentage) x (Total useable space) x (1,024 MB) / (250 MB Mailbox size) (round down to the nearest 50 MB)
Initial database size	Total useable space * database files capacity utilization percentage
Mailbox size	Initial database size / estimated number of mailboxes (round down to nearest 5 MB)
Database LUN size	Total useable space * database LUN capacity utilization percentage
Initial percentage storage capacity utilization	(Database LUN size) / (Initial database size)
Number of storage groups	(Initial database size / 1,024 MB) / 100 GB (round to the nearest integer)

Figure 12: Simulated exchange configurations calculations.

Simulated Exchange configuration

System	Dell PowerVault iSCSI SAN	HP StorageWorks iSCSI SAN
Number of Exchange mailboxes simulated	5,000	4,000
Number of hosts	1	1
Mailbox size (MB)	250	250
Number of storage groups	12	9
Number of mailbox stores/storage group	1	1
Number of mailboxes/mailbox store	417	400
Total number of mailbox store LUNS/storage group	1	1
Simulated profile: I/Os per second per mailbox	0.5	0.5
Database LUN size (GB)	135	145
Log LUN size (GB)	30	35
Initial total database size for performance testing (GB)	1221	977
Percentage formatted capacity used by Exchange database	60%	60%

Figure 13: Simulated Exchange configuration.

Primary storage hardware

System	Dell PowerVault iSCSI SAN	HP StorageWorks iSCSI SAN
Storage connectivity (Fibre Channel, SAS, SATA, iSCSI)	iSCSI	iSCSI
Storage model and OS/firmware revision	PowerVault MD3000 Firmware 06.70.17.60	HP Modular Storage Array 2000i Firmware J210P03
Storage cache	512 MB	1 GB (512 MB per controller)
Number of storage controllers	2	2
Number of storage ports	4 (2 per controller)	4 (2 per controller)
Maximum bandwidth of storage connectivity to host	1 Gb x 4	1 Gb x 4
Switch type/model/firmware revision	Dell PowerConnect 5448 v1.0.0.31	Dell PowerConnect 5448 v1.0.0.31
NIC model and firmware	Intel Pro1000PT NIC with Jumbo Frames enabled	Intel Pro1000PT NIC with Jumbo Frames enabled
Number of NICs/host	2	2
Total number of disks tested in solution	30	24

Figure 14: Primary storage hardware.

Primary storage software

System	Dell PowerVault iSCSI SAN	HP StorageWorks iSCSI SAN
NIC driver	9.7.34.0	9.7.34.0
Multi-pathing	Microsoft iSCSI Software Initiator Version 2.07 integrated MPIO MD Storage Manager 02.71.G6.07	Microsoft iSCSI Software Initiator Version 2.07 integrated MPIO
Host OS	Windows Server 2003 R2 Enterprise x64 Edition SP2	Windows Server 2003 R2 Enterprise x64 Edition SP2
ESE.dll file version	08.01.0240.005	08.01.0240.005

Figure 15: Primary storage software.

Primary storage disk configuration (Mailbox Store and transactional log disks)

System	Dell PowerVault iSCSI SAN	HP StorageWorks iSCSI SAN
Disk type, speed, and firmware revision	15x Seagate SAS 15k, ST3146356SS, HS09; 15x Hitachi SAS 15k, HUS153014VLS300, A4C2	24x Seagate SAS 15k, ST3146855SS
Raw capacity per disk (GB)	146	146
Number of physical disks in test	30	24
Total raw storage capacity (GB)	4,380	3,504
RAID level	RAID 10	RAID 10
Total formatted capacity (GB)	2,042	1,640
Storage capacity utilization	47%	47%
Database capacity utilization	60%	60%

Figure 16: Primary storage disk configuration (Mailbox Store and transactional log disks).

Appendix D: Storage layout

Each storage system had multiple databases, with the mailboxes evenly distributed among the databases. Each database had a corresponding log. We did not assign separate drives to databases and logs; instead, we split the databases into two to four sets and placed the logs for each set of databases on the drives with a different set of databases, keeping each database and its logs separate. This appendix shows the disk layout for each of the tested storage solutions.

Dell PowerVault iSCSI SAN

Figure 17 shows the storage array disk layout for the Dell PowerVault iSCSI SAN.

Dell PowerVault iSCSI SAN				
Enclosure 1				
Drive 0	Drive 3	Drive 6	Drive 9	Drive 12
Drive 1	Drive 4	Drive 7	Drive 10	Drive 13
Drive 2	Drive 5	Drive 8	Drive 11	Drive 14
Enclosure 2				
Drive 0	Drive 3	Drive 6	Drive 9	Drive 12
Drive 1	Drive 4	Drive 7	Drive 10	Drive 13
Drive 2	Drive 5	Drive 8	Drive 11	Drive 14
Disk Group 1 (Controller 0)		**Disk Group 2 (Controller 1)**		
DB1		Log1		
DB2		Log2		
DB3		Log3		
DB4		Log4		
DB5		Log5		
Log6		DB6		
Log7		DB7		
Log8		DB8		
Log9		DB9		
Log10		DB10		
Log11		DB11		
Log12		DB12		

Figure 17: Dell PowerVault iSCSI SAN disk layout.

HP StorageWorks iSCSI SAN

Figure 18 shows the storage array disk layout for the HP StorageWorks iSCSI SAN.

HP StorageWorks iSCSI SAN			
Enclosure 1			
Drive 0	Drive 3	Drive 6	Drive 9
Drive 1	Drive 4	Drive 7	Drive 10
Drive 2	Drive 5	Drive 8	Drive 11
Enclosure 2			
Drive 0	Drive 3	Drive 6	Drive 9
Drive 1	Drive 4	Drive 7	Drive 10
Drive 2	Drive 5	Drive 8	Drive 11
vDisk 1 (Controller A)		**vDisk 2 (Controller B)**	
DB1		Log1	
DB2		Log2	
DB3		Log3	
DB4		Log4	
DB5		Log5	
Log6		DB6	
Log7		DB7	
Log8		DB8	
Log9		DB9	

Figure 18: HP StorageWorks iSCSI SAN disk layout.

Appendix E: Jetstress 2007 performance tests

Jetstress 2007 performance tests

Jetstress 2007 is a tool that Microsoft developed to help administrators verify the performance and stability of the disk subsystem, the subsystem Exchange stresses most, before putting their Exchange server into a production environment. Jetstress simulates the Exchange database and log file loads produced by a specific number of users, thus allowing administrators to verify the performance and stability of their disk subsystem before putting their server into a production environment. Jetstress tests both responsiveness and throughput, giving a pass/fail rating for responsiveness and reporting throughput in I/O operations per second. Jetstress uses read and write latency as its primary measure of responsiveness. Results also report these latency values.

The Jetstress reliability test measures the reliability of the storage array, primary storage performance, and streaming backup/recovery performance. We ran the primary storage performance tests only. The primary storage performance testing identifies the maximum sustainable Exchange I/O that the storage system can handle while providing acceptable responsiveness over a 2-hour period.

Appendix F: Test procedures

We set up our test environment, configured the storage arrays, and installed Windows Server 2003 R2 Enterprise x64 Edition Service Pack 2 and Jetstress 08.02.0060 on the test server.

To get starting values for the first Jetstress performance test run, we ran the Jetstress disk subsystem throughput test and used its estimated thread count as the thread count for the first Jetstress performance test.

We ran the Jetstress performance test multiple times, and with different thread counts, on each storage solution. Our goal was to find the peak IOPS result for each solution. We define the peak result as the result of the run that had the highest IOPS and provided a passing Jetstress score for user experience.

We followed a different process based on whether the first run passed or failed. If the first run passed, we repeated the test with higher mailbox counts until the test failed because of unsatisfactory responsiveness. If the first run failed, we decreased the mailbox count and proportionately increased the average mailbox size. We did so to find the highest mailbox count and correspondingly the highest transactional I/O load that would get a passing Jetstress score.

Storage configuration procedure

- We used all disks for database and log files except for disks vendors reserve for parity. We formatted each array as a RAID 10 array.
- If an array did not automatically balance the load between its RAID controllers, we created two or more aggregates to balance the load as evenly as possible. If possible, we used cross-referencing to maximize capacity and performance by placing each database volume and its corresponding log volume (e.g., log1 and db1) on separate aggregates.
- We used Diskpart to align all Exchange-related disks on a 64KB boundary.
- We tested each array after it completed background operations for the initial configuration, RAID expansion, RAID-level change, group expansion, and disk failure recovery.

Creating the volumes

Dell PowerVault iSCSI SAN

1. Run the PowerVault storage manager.
2. Select the Configure tab.
3. Click Create Virtual Disk.
4. Select Unconfigured capacity.
5. Click Next.
6. Select Manual.
7. Click Next.
8. Select RAID 1 as the RAID level.
9. Select 7 drives from each enclosure.
10. Click Add.
11. Click Calculate Capacity.
12. Click Next.
13. Type `130` as the capacity of the first virtual disk.
14. Type `db1` as the name.
15. Click Next.
16. Select Map Now.
17. Click Finish.
18. Click Create Virtual Disk.
19. Select Free Capacity.
20. Expand the menu next to Disk Group 1.
21. Click Free Capacity.
22. Click Next.

23. Type `130` as the capacity for the virtual disk.
24. Type `db#` (start at `2`) as the name.
25. Click Next.
26. Select Map Now.
27. Click Finish.
28. Repeat steps 18 through 27 three times, changing the db# each time.
29. Click Create Virtual Disk.
30. Select Free Capacity.
31. Expand the menu next to Disk Group 1.
32. Click Free Capacity.
33. Click Next.
34. Type `30` as the capacity for the virtual disk.
35. Type `log#` (start at `6`) as the name.
36. Click Next.
37. Select Map Now.
38. Click Finish.
39. Repeat steps 29 through 39 six times, changing the log# each time.
40. Click Create Virtual Disk.
41. Select Unconfigured capacity.
42. Click Next.
43. Select Manual.
44. Click Next.
45. Select RAID 1 as the RAID level.
46. Select 8 drives from each enclosure.
47. Click Add.
48. Click Calculate Capacity.
49. Click Next.
50. Type `130` as the capacity of the first virtual disk.
51. Type `db6` as the name.
52. Click Next.
53. Select Map Now.
54. Click Finish.
55. Click Create Virtual Disk.
56. Select Free Capacity.
57. Expand the menu next to Disk Group 2.
58. Click Free Capacity.
59. Click Next.
60. Type `130` as the capacity for the virtual disk.
61. Type `db#` (start at `6`) as the name.
62. Click Next.
63. Select Map Now.
64. Click Finish.
65. Repeat steps 18 through 27 six times, changing the db# each time.
66. Click Create Virtual Disk.
67. Select Free Capacity.
68. Expand the menu next to Disk Group 2.
69. Click Free Capacity.
70. Click Next.
71. Type `30` as the capacity for the virtual disk.
72. Type `log#` (start at `1`) as the name.
73. Click Next.
74. Select Map Now.
75. Click Finish.
76. Repeat steps 29 through 39 four times, changing the log# each time.

77. Run Microsoft iSCSI Initiator:
    a. Select the Discovery tab.
    b. Click Add.
    c. Enter the IP Address for the array.
    d. Select the Targets tab.
    e. Click the Refresh button.
    f. Select the first Inactive Target listed.
    g. Click Log On.
    h. Check the Automatically restore this connection when the system boots checkbox.
    i. Check the Enable multi-path check box.
    j. Click OK.
    k. Repeat steps f through j for the second Inactive Target listed.
78. Open a command prompt.
79. Type `cd c:\windows\system32`.
80. Type `diskpart.exe`.
81. Type `List Disk` to determine the name of the RAID array.
82. Type `Select Disk #` where Disk # is the name of the RAID array.
83. Type `Create partition primary align=64`.
84. Repeat steps 82 and 83 with every log and database volume.
85. Type `Exit`.
86. In Windows, click Start, right-click My Computer, and select Manage.
87. Click Disk Management.
88. Right-click each of the new partitions, and select Format.
89. Name each disk db# or log#, and format the disks as NTFS.
90. Mount the database volumes:
    a. Right-click the first 130GB drive, and select Change Drive Letter and paths.
    b. Click Add.
    c. Select Mount in the following empty NTFS folder.
    d. Click Browse.
    e. Click the C:\ drive.
    f. Click New Folder.
    g. Type `db#` as the name.
    h. Click OK.
    i. Click OK.
    j. Click OK.
    k. Repeat steps a through j 11 times, changing the db# name each time.
91. Mount the log volumes:
    a. Right-click the first 30GB drive, and select Change Drive Letter and paths.
    b. Click Add.
    c. Select Mount in the following empty NTFS folder.
    d. Click Browse.
    e. Click the C:\ drive.
    f. Click New Folder.
    g. Type `log#` as the name.
    h. Click OK.
    i. Click OK.
    j. Click OK.
    k. Repeat steps a through j 11 times, changing the log# name each time.

HP StorageWorks iSCSI SAN

1. Log into the management interface.
2. Click Manage.
3. Click Virtual Disk Config.
4. Click Create a Vdisk.

5. Select Manual Virtual Disk Creation.
6. Type `vDisk1` as the virtual disk name.
7. Select RAID 10 as the RAID type.
8. Click Create New Virtual Disk.
9. Select 6 drives on one enclosure and 6 drives on the other enclosure.
10. Select No for the dedicated spare option.
11. Click Continue.
12. Set the number of volumes to 18.
13. Click OK.
14. Type `133,120` for the size of the first five volumes, and name them `db1-5`.
15. Type `30,270` for the size of the last five volumes, and name them `log6-9`.
16. Click Create Virtual Disk.
17. Repeat steps 4 through 16, naming the volumes `db6-9` and `log1-5` using `vDisk2` as the virtual disk name.
18. Run Microsoft iSCSI Initiator:
    a. Select the Discovery tab.
    b. Click Add.
    c. Enter the IP Address for the array.
    d. Select the Targets tab.
    e. Click the Refresh button.
    f. Select the first Inactive Target listed.
    g. Click Log On.
    h. Check the Automatically restore this connection when the system boots checkbox.
    i. Check the Enable multi-path check box.
    j. Click OK.
    k. Repeat steps f through j once for the second Inactive Target.
19. Open a command prompt.
20. Type `cd c:\windows\system32`.
21. Type `diskpart.exe`.
22. Type `List Disk` to determine the name of the RAID array.
23. Type `Select Disk #` where Disk # is the name of the RAID array.
24. Type `Create partition primary align=64`.
25. Repeat steps 23 and 24 with every log and database volume.
26. Type `Exit`.
27. In Windows, click Start, right-click My Computer, and select Manage.
28. Click Disk Management.
29. Right-click each of the new partitions, and select Format.
30. Name each disk db# or log#, and format the disks as NTFS.
31. Mount the database volumes:
    a. Right-click the first 130GB drive, and select Change Drive Letter and paths.
    b. Click Add.
    c. Select Mount in the following empty NTFS folder.
    d. Click Browse.
    e. Click the C:\ drive.
    f. Click New Folder.
    g. Type `db#` as the name.
    h. Click OK.
    i. Click OK.
    j. Click OK.
    k. Repeat steps a through j 8 times, changing the db# name each time.
32. Mount the log volumes:
    a. Right-click the first 30GB drive, and select Change Drive Letter and paths.
    b. Click Add.
    c. Select Mount in the following empty NTFS folder.

d. Click Browse.
e. Click the C:\ drive.
f. Click New Folder.
g. Type `log#` as the name.
h. Click OK.
i. Click OK.
j. Click OK.
k. Repeat steps a through j 8 times, changing the log# name each time.

Installing Windows Server 2003 R2 Enterprise x64 Edition Service Pack 2 on the server

We began our testing by installing a fresh copy of Windows Server 2003 R2 Enterprise x64 Edition Service Pack 2 on the server. We followed this process for each installation:

1. Assign a computer name of `Server`.
2. For the licensing mode, use the default setting of five concurrent connections.
3. Enter a password for the administration logon.
4. Select Eastern Time Zone.
5. Use typical settings for the Network installation.
6. Assign a name of `Testbed` for the workgroup.

Note: We used the default BIOS settings on the server.

Installing Jetstress on the server

We followed this process to install Jetstress on the test server:

1. Download the Microsoft .Net Framework Version 2.0 Redistributable Package (x64) from http://www.microsoft.com/DOWNLOADS/details.aspx?familyid=B44A0000-ACF8-4FA1-AFFB-40E78D788B00&displaylang=en.
2. Run NetFx64.exe.
3. Click Next.
4. Accept the terms of the License Agreement, and click Next.
5. Click Finish.
6. Download the Microsoft Exchange Server Jetstress Tool (64-bit) v. 08.02.0060 from http://www.microsoft.com/downloads/details.aspx?FamilyID=73dfe056-0900-4dbb-b14a-0932338cecac&DisplayLang=en.
7. Run Jetstress.msi.
8. Click Next.
9. Accept the terms of the License Agreement, and click Next.
10. Click Next.
11. Click Next.
12. Click Close.
13. Copy the following files from an Exchange 2007 SP1 64-bit installation disk:
    - ese.dll
    - eseperf.dll
    - eseperf.hxx
    - eseperf.ini
14. Paste the files in C:\Program Files\Exchange Jetstress.
15. Run JetstressWin.exe.
16. Click Start new test.
17. Click Exit.

Preparing for the test

To prepare for the test, we first ran a Jetstress disk subsystem throughput test to find a starting point for tuning the mailbox profile.

1. Run JetstressWin.exe.
2. Click Start new Test.
3. Click Next.

4. Select Create a new test configuration file.
5. Name the file `ArrayName_Initial_Run.xml`.
6. Click Next.
7. Select Test disk subsystem throughput.
8. Click Next.
9. Change the value to `60` in the Size the database storage capacity percentage box.
10. Leave the default value of 100 in the Target IOPS using throughput capacity percentage box.
11. Click Next.
12. Select Performance.
13. Click Next.
14. Set the test duration to 2 hours.
15. Click Next.
16. Set the number of storage groups using the following calculations:
    - **Database files capacity utilization percentage:** 60 percent. We allocated 60 percent of useable disk capacity for initial database files, or as close as we could get to 60 percent with increments of 50 mailboxes.
    - **Total useable space:** The amount of space available for the use of files, after accounting for parity drives and formatting.
    - **Initial database size:** Total useable space multiplied by Database files capacity utilization percentage.
    - **Number of storage groups:** (Initial database size / 1,024 MB) divided by 100 GB (round to the nearest integer).
17. Leave the number of databases set to 1.
18. Click Next.
19. Select Create new databases.
20. Click Execute Test.
21. Once the test has finished, record the thread count from the disk subsystem throughput. We use this value as the thread count for the first Jetstress test run in step 14 below.

Running the test

Before testing, we ensured that all Ethernet ports were active and connected at 1 Gb to the iSCSI switches for maximum performance and availability. We then followed this process for each test:

1. Run JetstressWin.exe.
2. Click Start new Test.
3. Click Next.
4. Select Create a new test configuration file.
5. Name the file `ArrayName_Run#.xml`.
6. Click Next.
7. Select Test an Exchange mailbox profile.
8. Enter a description in the text box.
9. Click Next.
10. Set the number of mailboxes using the following formula (rounding the result down to the nearest 50):

$$\frac{\text{60 percent database files capacity utilization x formatted capacity x 1,024 MB}}{\text{250MB mailbox size}}$$

11. Type `.5` for IOPS/mailbox.
12. Set the Mailbox size to `250 MB`.
13. Check the Suppress tuning checkbox.
14. For the first run, enter the number of threads that the automatic tuning from the Disk subsystem throughput test chose. For subsequent runs, use the thread count that the test run calculates in step 24.
15. Click Next.
16. Select the Performance test type.

17. Click Next.
18. Set the test duration to 2 hours.
19. Set the number of storage groups to the amount used in the preparatory Jetstress disk subsystem throughput test.
20. Click Next.
21. Select Create new databases.
22. Click Next.
23. Click Execute Test.
24. Wait for the test to finish; then check the output files to see if the run reported errors or failed by exceeding the Jetstress latency thresholds for the log or database files.
    a. If the run had errors or the latency exceeded the thresholds, proceed based on whether the run prior to this run passed or also failed:
        i. If the previous run was successful, its results show the maximum IOPS score. Save those results as Run 1 results.
        ii. If the previous run also had errors or exceeded the latency thresholds, decrease the number of threads by 1, and perform another run.
    b. If the run succeeded, perform the following steps:
        i. Save from the following files:
            - Application event log from each server as `servername_application.evt`, and include in result package
            - System event log from each server as `servername_system.evt`, and include in result package
            - The Jetstresswin configuration file used (e.g., ServerName_Run#.xml)
            - Performance_(TimeStamp).html
            - Performance_(TimeStamp).blg
            - DBChecksum_(TimeStamp).html
            - DBChecksum_(TimeStamp).blg
        ii. Record the items that we show in Appendix A, Figure 7: Results for the storage arrays.
        iii. Check the results for the run prior to this run, and proceed based on whether that run passed or failed.
            1. If the previous run was successful, increase the number of threads by 1, and perform another run.
            2. If the previous run had errors or exceeded the latency thresholds, the current runs results show the maximum IOPS score. Save those results as the Run 1 results.
25. Repeat the test two more times using the thread count from the run that produced the results saved as Run 1 results in step 24.

Appendix G: Jetstress results files

Dell PowerVault iSCSI SAN

Microsoft Exchange Server Jetstress

Performance Test Result Report

Test Summary

Overall Test Result	**Pass**
Machine Name	SVCTAG-1F6HWG1
Test Description	Dell MD3000i + MD1000 5000 Users 250MB Mailbox
Test Start Time	9/24/2008 7:48:01 AM
Test End Time	9/24/2008 7:22:08 PM
Jetstress Version	08.02.0060.000
Ese Version	08.01.0240.005
Operating System	Microsoft Windows Server 2003 R2 Service Pack 2 (5.2.3790.131072)
Performance Log	C:\Documents and Settings\Administrator\Performance_2008_9_24_17_14_21.blg C:\Documents and Settings\Administrator\DBChecksum_2008_9_24_19_22_8.blg

Database Sizing and Throughput

Achieved I/O per Second	4688.837
Target I/O per Second	2500
Initial database size	1310746411008
Final database size	1327259385856
Database files (count)	12

Jetstress System Parameters

Thread count	15 (per-storage group)
Log buffers	9000
Minimum database cache	384.0 MB
Maximum database cache	3072.0 MB
Insert operations	40%
Delete operations	30%
Replace operations	5%
Read operations	25%
Lazy commits	55%

Disk Subsystem Performance

LogicalDisk	Avg. Disk sec/Read	Avg. Disk sec/Write	Disk Reads/sec	Disk Writes/sec	Avg. Disk Bytes/Write
Database (c:\db1)	0.019	0.009	174.043	216.570	(n/a)
Database (c:\db2)	0.017	0.009	172.721	215.010	(n/a)
Database (c:\db3)	0.016	0.009	174.075	216.359	(n/a)
Database (c:\db4)	0.016	0.009	173.225	216.321	(n/a)
Database (c:\db5)	0.018	0.009	175.561	218.622	(n/a)
Database (c:\db6)	0.020	0.009	172.801	216.706	(n/a)
Database (c:\db7)	0.015	0.009	173.869	217.032	(n/a)
Database (c:\db8)	0.014	0.009	173.480	216.893	(n/a)
Database (c:\db9)	0.014	0.009	174.718	215.822	(n/a)
Database (c:\db10)	0.014	0.009	175.682	218.035	(n/a)
Database (c:\db11)	0.014	0.009	173.294	215.099	(n/a)
Database (c:\db12)	0.016	0.009	175.217	217.684	(n/a)
Log (c:\log1)	0.000	0.005	0.000	92.832	5702.515
Log (c:\log2)	0.000	0.004	0.000	93.025	5654.639
Log (c:\log3)	0.000	0.005	0.000	93.257	5636.333
Log (c:\log4)	0.000	0.004	0.000	93.430	5657.283
Log (c:\log5)	0.000	0.004	0.000	93.594	5713.674
Log (c:\log6)	0.000	0.004	0.000	93.384	5670.072
Log (c:\log7)	0.000	0.005	0.000	91.578	5737.178
Log (c:\log8)	0.000	0.005	0.000	92.284	5696.305
Log (c:\log9)	0.000	0.005	0.000	91.253	5729.158
Log (c:\log10)	0.000	0.004	0.000	92.310	5736.353
Log (c:\log11)	0.000	0.005	0.000	91.184	5735.493
Log (c:\log12)	0.000	0.004	0.000	91.511	5777.231

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	7.553	5.859	9.141
Available MBytes	11820.675	11368.000	11843.000
Free System Page Table Entries	16753445.000	16753445.000	16753445.000
Transition Pages RePurposed/sec	0.000	0.000	0.000

Pool Nonpaged Bytes	91099955.200	90718208.000	91615232.000
Pool Paged Bytes	55126681.600	55087104.000	55721984.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

Test Log

9/24/2008 7:48:01 AM -- Jetstress testing begins ...
9/24/2008 7:48:01 AM -- Prepare testing begins ...
9/24/2008 7:48:01 AM -- Creating c:\db1\Jetstress1.edb.
9/24/2008 7:48:01 AM -- Database cache settings: (minimum: 32.0 MB, maximum: 256.0 MB)
9/24/2008 7:48:01 AM -- Database flush thresholds: (start: 2.6 MB, stop: 5.1 MB)
9/24/2008 8:21:27 AM -- 60.0% of 101.7 GB complete (12419465 records inserted).
9/24/2008 8:58:35 AM -- 100.0% of 101.7 GB complete (21594005 records inserted).
9/24/2008 8:58:39 AM -- Duplicating 11 databases:
9/24/2008 5:13:51 PM -- 100.0% of 1.1 TB complete (1.1 TB duplicated).
9/24/2008 5:14:04 PM -- Attaching databases ...
9/24/2008 5:14:04 PM -- Prepare testing ends.
9/24/2008 5:14:04 PM -- Dispatching transactions begins ...
9/24/2008 5:14:04 PM -- Database cache settings: (minimum: 384.0 MB, maximum: 3.0 GB)
9/24/2008 5:14:04 PM -- Database flush thresholds: (start: 30.7 MB, stop: 61.4 MB)
9/24/2008 5:14:21 PM -- Database read latency thresholds: (average: 0.02 seconds/read, maximum: 0.05 seconds/read).
9/24/2008 5:14:21 PM -- Log write latency thresholds: (average: 0.01 seconds/write, maximum: 0.05 seconds/write).
9/24/2008 5:14:22 PM -- Operation mix: Sessions 15, Inserts 40%, Deletes 30%, Replaces 5%, Reads 25%, Lazy Commits 55%.
9/24/2008 5:14:22 PM -- Performance logging begins (interval: 15000 ms).
9/24/2008 5:14:22 PM -- Attaining prerequisites:
9/24/2008 5:22:05 PM -- \MSExchange Database(JetstressWin)\Database Cache Size, Last: 2902335000.0 (lower bound: 2899103000.0, upper bound: none)
9/24/2008 7:22:06 PM -- Performance logging ends.
9/24/2008 7:22:06 PM -- JetInterop batch transaction stats: 44946, 44667, 44724, 44930, 45330, 44654, 44852, 44678, 44782, 45071, 44743, and 45126.
9/24/2008 7:22:07 PM -- Dispatching transactions ends.
9/24/2008 7:22:07 PM -- Shutting down databases ...
9/24/2008 7:22:08 PM -- Instance3036.1 (complete), Instance3036.2 (complete), Instance3036.3 (complete), Instance3036.4 (complete), Instance3036.5 (complete), Instance3036.6 (complete), Instance3036.7 (complete), Instance3036.8 (complete), Instance3036.9 (complete), Instance3036.10 (complete), Instance3036.11 (complete), and Instance3036.12 (complete)
9/24/2008 7:22:09 PM -- Performance logging begins (interval: 30000 ms).
9/24/2008 7:22:09 PM -- Verifying database checksums ...
9/24/2008 10:12:08 PM -- c:\db1 (100% processed), c:\db2 (100% processed), c:\db3 (100% processed), c:\db4 (100% processed), c:\db5 (100% processed), c:\db6 (100% processed), c:\db7 (100% processed), c:\db8 (100% processed), c:\db9 (100% processed), c:\db10 (100% processed), c:\db11 (100% processed), and c:\db12 (100% processed)
9/24/2008 10:12:10 PM -- Performance logging ends.
9/24/2008 10:12:10 PM -- C:\Documents and Settings\Administrator\DBChecksum_2008_9_24_19_22_8.blg has 339 samples.
9/24/2008 10:12:32 PM -- C:\Documents and Settings\Administrator\DBChecksum_2008_9_24_19_22_8.html is saved.
9/24/2008 10:12:32 PM -- Verifying log checksums ...
9/24/2008 10:12:51 PM -- c:\log1 (2 logs passed), c:\log2 (2 logs passed), c:\log3 (2 logs passed), c:\log4 (2 logs passed), c:\log5 (2 logs passed), c:\log6 (2 logs passed), c:\log7 (2 logs passed), c:\log8 (2 logs passed), c:\log9 (2 logs passed), c:\log10 (2 logs passed), c:\log11 (2 logs passed), and c:\log12 (2 logs passed)
9/24/2008 10:12:51 PM -- C:\Documents and Settings\Administrator\Performance_2008_9_24_17_14_21.blg has 510 samples.
9/24/2008 10:12:51 PM -- Creating test report ...

9/24/2008 10:13:05 PM -- Volume c:\db1 has 0.0191 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db2 has 0.0171 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db3 has 0.0165 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db4 has 0.0164 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db5 has 0.0175 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db6 has 0.0200 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db7 has 0.0152 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db8 has 0.0141 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db9 has 0.0136 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db10 has 0.0138 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db11 has 0.0142 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\db12 has 0.0156 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log1 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log1 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log2 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log2 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log3 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log3 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log4 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log4 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log5 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log5 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log6 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log6 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log7 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log7 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log8 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log8 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log9 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log9 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log10 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log10 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log11 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log11 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Volume c:\log12 has 0.0045 for Avg. Disk sec/Write.
9/24/2008 10:13:05 PM -- Volume c:\log12 has 0.0000 for Avg. Disk sec/Read.
9/24/2008 10:13:05 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.
9/24/2008 10:13:05 PM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
9/24/2008 10:13:05 PM -- C:\Documents and Settings\Administrator\Performance_2008_9_24_17_14_21.xml has 479 samples queried.

HP StorageWorks iSCSI SAN

Microsoft Exchange Server Jetstress

Performance Test Result Report

Test Summary

Overall Test Result	**Pass**
Machine Name	SVCTAG-1F6HWG1
Test Description	HP MSA 2000i 4000 Users 250MB Mailbox Size
Test Start Time	9/23/2008 8:23:55 AM
Test End Time	9/23/2008 3:36:48 PM
Jetstress Version	08.02.0060.000
Ese Version	08.01.0240.005
Operating System	Microsoft Windows Server 2003 R2 Service Pack 2 (5.2.3790.131072)
Performance Log	C:\Program Files\Exchange Jetstress\Performance_2008_9_23_13_29_18.blg C:\Program Files\Exchange Jetstress\DBChecksum_2008_9_23_15_36_48.blg

Database Sizing and Throughput

Achieved I/O per Second	2365.952
Target I/O per Second	2000
Initial database size	1048630542336
Final database size	1057639907328
Database files (count)	9

Jetstress System Parameters

Thread count	10 (per-storage group)
Log buffers	9000
Minimum database cache	288.0 MB
Maximum database cache	2304.0 MB
Insert operations	40%
Delete operations	30%
Replace operations	5%
Read operations	25%
Lazy commits	55%

Disk Subsystem Performance

LogicalDisk	Avg. Disk sec/Read	Avg. Disk sec/Write	Disk Reads/sec	Disk Writes/sec	Avg. Disk Bytes/Write

Database (c:\db1)	0.016	0.015	129.793	134.948	(n/a)
Database (c:\db2)	0.019	0.016	128.617	133.066	(n/a)
Database (c:\db3)	0.017	0.016	128.204	133.598	(n/a)
Database (c:\db4)	0.019	0.017	129.027	135.005	(n/a)
Database (c:\db5)	0.017	0.017	129.231	134.603	(n/a)
Database (c:\db6)	0.014	0.013	128.468	132.526	(n/a)
Database (c:\db7)	0.013	0.013	128.424	134.021	(n/a)
Database (c:\db8)	0.013	0.014	128.558	134.592	(n/a)
Database (c:\db9)	0.014	0.015	129.020	134.249	(n/a)
Log (c:\log1)	0.000	0.002	0.000	80.913	4701.538
Log (c:\log2)	0.000	0.002	0.000	80.639	4675.684
Log (c:\log3)	0.000	0.002	0.000	81.102	4701.679
Log (c:\log4)	0.000	0.002	0.000	82.204	4719.775
Log (c:\log5)	0.000	0.002	0.000	81.234	4701.329
Log (c:\log6)	0.000	0.003	0.000	77.183	4878.653
Log (c:\log7)	0.000	0.003	0.000	77.422	4912.244
Log (c:\log8)	0.000	0.003	0.000	77.994	4900.661
Log (c:\log9)	0.000	0.003	0.000	78.145	4913.707

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	4.095	2.930	4.987
Available MBytes	12836.200	12284.000	12904.000
Free System Page Table Entries	16756358.000	16756358.000	16756358.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	51294446.933	51269632.000	51359744.000
Pool Paged Bytes	46102050.133	46059520.000	46641152.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

Test Log

```
9/22/2008 11:26:43 PM -- Jetstress testing begins ...
9/22/2008 11:26:43 PM -- Prepare testing begins ...
9/22/2008 11:26:43 PM -- Creating c:\db1\Jetstress1.edb.
9/22/2008 11:26:43 PM -- Database cache settings: (minimum: 32.0 MB, maximum: 256.0 MB)
9/22/2008 11:26:43 PM -- Database flush thresholds: (start: 2.6 MB, stop: 5.1 MB)
9/23/2008 12:07:48 AM -- 60.0% of 108.5 GB complete (13247908 records inserted).
9/23/2008 12:42:45 AM -- 100.0% of 108.5 GB complete (20619025 records inserted).
9/23/2008 12:42:49 AM -- Duplicating 8 databases:
```

9/23/2008 4:27:32 AM -- 100.0% of 868.1 GB complete (868.1 GB duplicated).
9/23/2008 4:27:41 AM -- Attaching databases ...
9/23/2008 4:27:41 AM -- Prepare testing ends.
9/23/2008 4:27:41 AM -- Dispatching transactions begins ...
9/23/2008 4:27:41 AM -- Database cache settings: (minimum: 288.0 MB, maximum: 2.2 GB)
9/23/2008 4:27:41 AM -- Database flush thresholds: (start: 23.0 MB, stop: 46.1 MB)
9/23/2008 4:27:53 AM -- Database read latency thresholds: (average: 0.02 seconds/read, maximum: 0.05 seconds/read).
9/23/2008 4:27:53 AM -- Log write latency thresholds: (average: 0.01 seconds/write, maximum: 0.05 seconds/write).
9/23/2008 4:27:54 AM -- Operation mix: Sessions 10, Inserts 40%, Deletes 30%, Replaces 5%, Reads 25%, Lazy Commits 55%.
9/23/2008 4:27:54 AM -- Performance logging begins (interval: 15000 ms).
9/23/2008 4:27:54 AM -- Attaining prerequisites:
9/23/2008 4:35:16 AM -- \MSExchange Database(JetstressWin)\Database Cache Size, Last: 2177057000.0 (lower bound: 2174327000.0, upper bound: none)
9/23/2008 6:35:17 AM -- Performance logging ends.
9/23/2008 6:35:17 AM -- JetInterop batch transaction stats: 34345, 34257, 34158, 33864, 34082, 34091, 34207, 34401, and 34223.
9/23/2008 6:35:17 AM -- Dispatching transactions ends.
9/23/2008 6:35:17 AM -- Shutting down databases ...
9/23/2008 6:35:19 AM -- Instance336.1 (complete), Instance336.2 (complete), Instance336.3 (complete), Instance336.4 (complete), Instance336.5 (complete), Instance336.6 (complete), Instance336.7 (complete), Instance336.8 (complete), and Instance336.9 (complete)
9/23/2008 6:35:19 AM -- Performance logging begins (interval: 30000 ms).
9/23/2008 6:35:19 AM -- Verifying database checksums ...
9/23/2008 7:58:04 AM -- c:\db1 (100% processed), c:\db2 (100% processed), c:\db3 (100% processed), c:\db4 (100% processed), c:\db5 (100% processed), c:\db6 (100% processed), c:\db7 (100% processed), c:\db8 (100% processed), and c:\db9 (100% processed)
9/23/2008 7:58:05 AM -- Performance logging ends.
9/23/2008 7:58:05 AM -- **C:\Program Files\Exchange Jetstress\DBChecksum_2008_9_23_6_35_19.blg** has 165 samples.
9/23/2008 7:58:12 AM -- **C:\Program Files\Exchange Jetstress\DBChecksum_2008_9_23_6_35_19.html** is saved.
9/23/2008 7:58:12 AM -- Verifying log checksums ...
9/23/2008 7:58:14 AM -- c:\log1 (3 logs passed), c:\log2 (2 logs passed), c:\log3 (2 logs passed), c:\log4 (2 logs passed), c:\log5 (2 logs passed), c:\log6 (2 logs passed), c:\log7 (3 logs passed), c:\log8 (2 logs passed), and c:\log9 (2 logs passed)
9/23/2008 7:58:14 AM -- **C:\Program Files\Exchange Jetstress\Performance_2008_9_23_4_27_53.blg** has 509 samples.
9/23/2008 7:58:14 AM -- Creating test report ...
9/23/2008 7:58:25 AM -- Volume c:\db1 has 0.0173 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db2 has 0.0193 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db3 has 0.0175 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db4 has 0.0196 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db5 has 0.0169 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db6 has 0.0142 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db7 has 0.0131 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db8 has 0.0132 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\db9 has 0.0142 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log1 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log1 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log2 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log2 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log3 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log3 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log4 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log4 has 0.0000 for Avg. Disk sec/Read.

9/23/2008 7:58:25 AM -- Volume c:\log5 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log5 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log6 has 0.0033 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log6 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log7 has 0.0033 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log7 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log8 has 0.0033 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log8 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Volume c:\log9 has 0.0033 for Avg. Disk sec/Write.
9/23/2008 7:58:25 AM -- Volume c:\log9 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 7:58:25 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.
9/23/2008 7:58:25 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
9/23/2008 7:58:25 AM -- **C:\Program Files\Exchange Jetstress\Performance_2008_9_23_4_27_53.xml** has 479 samples queried.
9/23/2008 7:58:25 AM -- **C:\Program Files\Exchange Jetstress\Performance_2008_9_23_4_27_53.html** is saved.
9/23/2008 7:58:25 AM -- Jetstress testing ends.
9/23/2008 8:23:55 AM -- Jetstress testing begins ...
9/23/2008 8:23:55 AM -- Prepare testing begins ...
9/23/2008 8:23:56 AM -- Creating c:\db1\Jetstress1.edb.
9/23/2008 8:23:56 AM -- Database cache settings: (minimum: 32.0 MB, maximum: 256.0 MB)
9/23/2008 8:23:56 AM -- Database flush thresholds: (start: 2.6 MB, stop: 5.1 MB)
9/23/2008 9:05:04 AM -- 60.0% of 108.5 GB complete (13248307 records inserted).
9/23/2008 9:43:00 AM -- 100.0% of 108.5 GB complete (23033458 records inserted).
9/23/2008 9:43:04 AM -- Duplicating 8 databases:
9/23/2008 1:28:56 PM -- 100.0% of 868.1 GB complete (868.1 GB duplicated).
9/23/2008 1:29:05 PM -- Attaching databases ...
9/23/2008 1:29:05 PM -- Prepare testing ends.
9/23/2008 1:29:05 PM -- Dispatching transactions begins ...
9/23/2008 1:29:05 PM -- Database cache settings: (minimum: 288.0 MB, maximum: 2.2 GB)
9/23/2008 1:29:05 PM -- Database flush thresholds: (start: 23.0 MB, stop: 46.1 MB)
9/23/2008 1:29:18 PM -- Database read latency thresholds: (average: 0.02 seconds/read, maximum: 0.05 seconds/read).
9/23/2008 1:29:18 PM -- Log write latency thresholds: (average: 0.01 seconds/write, maximum: 0.05 seconds/write).
9/23/2008 1:29:19 PM -- Operation mix: Sessions 10, Inserts 40%, Deletes 30%, Replaces 5%, Reads 25%, Lazy Commits 55%.
9/23/2008 1:29:19 PM -- Performance logging begins (interval: 15000 ms).
9/23/2008 1:29:19 PM -- Attaining prerequisites:
9/23/2008 1:36:44 PM -- \MSExchange Database(JetstressWin)\Database Cache Size, Last: 2177237000.0 (lower bound: 2174327000.0, upper bound: none)
9/23/2008 3:36:45 PM -- Performance logging ends.
9/23/2008 3:36:45 PM -- JetInterop batch transaction stats: 32402, 32130, 32253, 32480, 32485, 32246, 32319, 32288, and 32412.
9/23/2008 3:36:47 PM -- Dispatching transactions ends.
9/23/2008 3:36:47 PM -- Shutting down databases ...
9/23/2008 3:36:48 PM -- Instance336.1 (complete), Instance336.2 (complete), Instance336.3 (complete), Instance336.4 (complete), Instance336.5 (complete), Instance336.6 (complete), Instance336.7 (complete), Instance336.8 (complete), and Instance336.9 (complete)
9/23/2008 3:36:49 PM -- Performance logging begins (interval: 30000 ms).
9/23/2008 3:36:49 PM -- Verifying database checksums ...
9/23/2008 4:59:34 PM -- c:\db1 (100% processed), c:\db2 (100% processed), c:\db3 (100% processed), c:\db4 (100% processed), c:\db5 (100% processed), c:\db6 (100% processed), c:\db7 (100% processed), c:\db8 (100% processed), and c:\db9 (100% processed)
9/23/2008 4:59:35 PM -- Performance logging ends.
9/23/2008 4:59:35 PM -- **C:\Program Files\Exchange Jetstress\DBChecksum_2008_9_23_15_36_48.blg** has 165 samples.
9/23/2008 4:59:42 PM -- **C:\Program Files\Exchange**

Jetstress\DBChecksum_2008_9_23_15_36_48.html is saved.
9/23/2008 4:59:42 PM -- Verifying log checksums ...
9/23/2008 4:59:44 PM -- c:\log1 (2 logs passed), c:\log2 (3 logs passed), c:\log3 (2 logs passed), c:\log4 (2 logs passed), c:\log5 (2 logs passed), c:\log6 (2 logs passed), c:\log7 (3 logs passed), c:\log8 (2 logs passed), and c:\log9 (3 logs passed)
9/23/2008 4:59:44 PM -- **C:\Program Files\Exchange Jetstress\Performance_2008_9_23_13_29_18.blg** has 509 samples.
9/23/2008 4:59:44 PM -- Creating test report ...
9/23/2008 4:59:55 PM -- Volume c:\db1 has 0.0164 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db2 has 0.0189 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db3 has 0.0170 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db4 has 0.0191 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db5 has 0.0165 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db6 has 0.0140 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db7 has 0.0130 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db8 has 0.0130 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\db9 has 0.0141 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\log1 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 4:59:55 PM -- Volume c:\log1 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\log2 has 0.0024 for Avg. Disk sec/Write.
9/23/2008 4:59:55 PM -- Volume c:\log2 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\log3 has 0.0024 for Avg. Disk sec/Write.
9/23/2008 4:59:55 PM -- Volume c:\log3 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\log4 has 0.0024 for Avg. Disk sec/Write.
9/23/2008 4:59:55 PM -- Volume c:\log4 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\log5 has 0.0025 for Avg. Disk sec/Write.
9/23/2008 4:59:55 PM -- Volume c:\log5 has 0.0001 for Avg. Disk sec/Read.
9/23/2008 4:59:55 PM -- Volume c:\log6 has 0.0032 for Avg. Disk sec/Write.
9/23/2008 4:59:56 PM -- Volume c:\log6 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:56 PM -- Volume c:\log7 has 0.0032 for Avg. Disk sec/Write.
9/23/2008 4:59:56 PM -- Volume c:\log7 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:56 PM -- Volume c:\log8 has 0.0032 for Avg. Disk sec/Write.
9/23/2008 4:59:56 PM -- Volume c:\log8 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:56 PM -- Volume c:\log9 has 0.0032 for Avg. Disk sec/Write.
9/23/2008 4:59:56 PM -- Volume c:\log9 has 0.0000 for Avg. Disk sec/Read.
9/23/2008 4:59:56 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.
9/23/2008 4:59:56 PM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
9/23/2008 4:59:56 PM -- **C:\Program Files\Exchange Jetstress\Performance_2008_9_23_13_29_18.xml** has 479 samples queried.

About Principled Technologies

We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help you assess how it will fare against its competition, its performance, whether it's ready to go to market, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

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