Dell™ PowerEdge™ R510

Nearline SAS

1500 Mailboxes using Mailbox Resiliency

Exchange 2010 Storage Solution

Tested with: ESRP – Storage Version 3.0
Tested Date: April 21, 2011

Content

Overview

This document provides information on Dell's storage solution for Microsoft Exchange Server, based the *Microsoft Exchange Solution Reviewed Program (ESRP) – Storage* program*. For any questions or comments regarding the contents of this document, see Contact for Additional Information.

*The *ESRP – Storage* program was developed by Microsoft Corporation to provide a common storage testing framework for vendors to provide information on its storage solutions for Microsoft Exchange Server software. For more details on the *Microsoft ESRP – Storage* program, please click http://www.microsoft.com/technet/prodtechnol/exchange/2007/esrp.mspx

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Features

This white paper describes a tested and validated storage solution for a 1500 mailbox Exchange 2010 environment with Data Availability Group. A DAG is the new high availability mechanism in Microsoft Exchange 2010. This model of mailbox resiliency supports multiple copies of Exchange database (up to 16) in a DAG. There is only one active copy of a given Exchange 2010 database at any given time. Secondary copies are periodically synched with the primary copy. Mail clients access the primary (active) copy, and database changes to the primary copy are copied to the secondary (passive) copies in the form of transaction logs. The copied log records are played on the secondary copy to keep the secondary database copies consistent with the primary copy. All hosts within a DAG are configured to be identical. The primary and secondary copy storages do not share storage array controllers or disks.

Dell™ PowerEdge™ R510 is a 2-socket 2U, multi-purpose value server, offering an excellent balance of internal storage, redundancy and value in compact 26'' deep chasis. Major features of the server/storage system include:

- Internal capacity for up to 12 3.5-inch, hot-plug, 6.0-Gbps, serial-attached SCSI (SAS) hard drives , 600 GB capacity, and rated at 15K RPM as well as Nearline SAS hard drives (7.2K RPM) with up to 2TB capacity
- Choice of chassis configuration with 4, 8 or 12 front loading drive bays
- Six-Core and Quad-Core Intel® Xeon® Processor

- Integrated RAID support via a PERC H700 adapter
- In-band enclosure management provided through SCSI enclosure services (SES)
- RAID and system management using Dell™ OpenManage™ Server Administrator Storage Management Service

The PowerEdge™ R510 chassis selected for this solution supports (12) 3.5'' each with 1 TB storage capacity for application data. 2 internal 2.5'' drives configured as a RAID 1 container host Windows Server 2008 R2. The solution presented in this paper utilizes 10 of the 3.5" disks configured into 5 RAID 1 pairs each hosting a single Exchange database and its transaction logs. The additional 2 disks are for hot-spare or can be configured as recovery disks.

Solution Description

The Dell™ PowerEdge™ R510 is a high capacity/high value rack server with balance of internal storage of up to (12) 3.5-inch disk drives and redundancy in a single 2U rack able chassis. The front loading built in expansion enclosure can support 2 Terabyte Near-Line SAS (7200 RPM) drives as well as 10/15K RPM SAS drives with capacities up to 600GB.

Dell™ PowerEdge™ R510 Rack Server Product Page

Figure 1:Dell™ PowerEdge™ R510 enclosure with (12) 3.5-inch drives bays no bezel

PERC H700 is the internal host-based RAID controller used to connect to the PowerEdge™ R510 front loading backplane that supports the (12) drive bays including an additional (2) internal 2.5'' drives. The controller supports 6 Gbps Serial Attached SCSI (SAS) as the storage interconnect technology and PCI Express 2.0 (PCI-E) as the host-based interconnect technology.

The PERC H700 controller offers:

- 8 port LSI 2108 Chipset
- 512MB of customized DDR2 400MHz, Error-Correcting Code (ECC) cache memory with optional upgrade to 1GB
- 6 Gbps maximum speed for each SAS lane
- Two internal x4 ("by four") mini-SAS wide ports, each aggregating 4 SAS lanes for a total bandwidth per port of 12.0 Gbps
- x8 PCI E host interface for a total bandwidth of 32.0 Gbps
- Up to 72 hours of intelligent, transportable, battery-backed, cache memory

The presented solution is a Data Availability Group solution for up to 4000 mailboxes. It includes a single primary PowerEdge™ R510 server that supports (12) front loading 3.5'' storage enclosures. The secondary server is configured to be identical to the primary. The primary and secondary storage do not share storage array controllers or disks.

The tested user profile was 0.20 IOPS per user with a 3072 MB mailbox size. This IO profile for Exchange 2010 represents about 200 messages (sent/received) per mailbox per day. Sometimes additional applications, such as certain mobile messaging applications, can raise the IOPS profile of a user as high as three or four times that of normal. Using 7.2K RPM drives gives more than enough performance achieving over 20% more than the target of 240 transactional IOPS. Five disk RAID 1 virtual drive were configured in this manner to exhibit each disk's maximum IOPS.

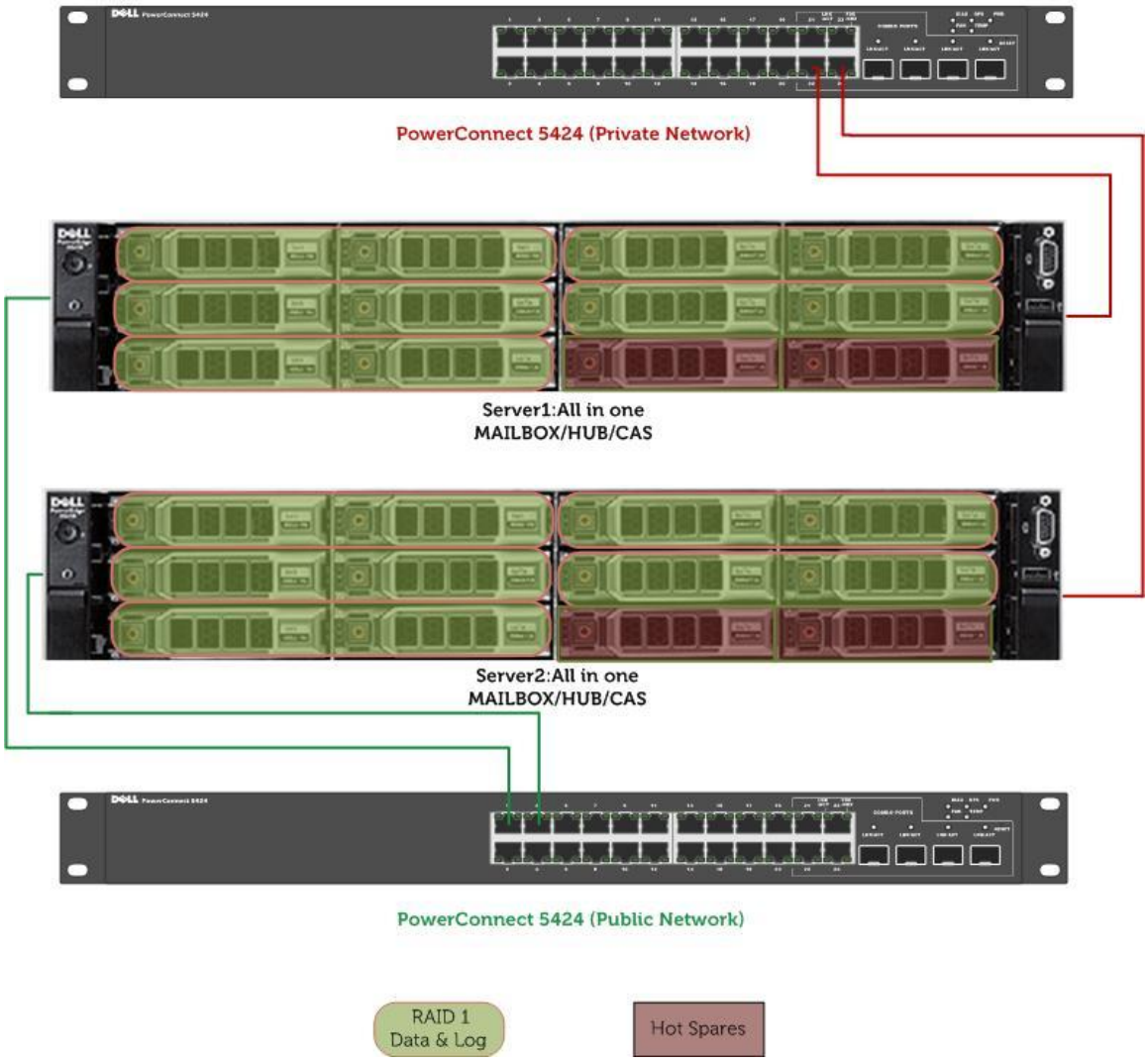

Figure 2: Test Setup Diagram

Microsoft Exchange Server System:

Server	Dell™ PowerEdge™ R510
CPU	2 Intel®Xeon®CPU;5570@2.93GHz
Memory	96 GB DDR2 ECC
NIC	Broadcom NeXtreme II
RAID Controller	PERC H700 (FW Version 2.100.03-1062)
Internal Disks	2 Seagate 146GB 15K RPM SAS(ST9146852SS)

Built in Storage System:

Storage System	Dell™ PowerEdge™ R510
Disks	12 Seagate 2TB 7.2K RPM NL-SAS (ST32000444SS) Drives
RAID Controller	PERC H700 4.31.1.64

Storage Configuration:

The storage configuration per enclosure was as follows:

- RAID 1 volumes were created from physical disk pairs 0 through 9 on the front loading PowerEdge™ R510 bays. These volumes were used for Exchange Server 2010 databases and transaction logs.

The ESRP-Storage program focuses on storage solution testing to address performance and reliability issues with storage design. However, storage is not the only factor to take into consideration when designing a scale up Exchange solution.

Other factors which affect the server scalability are:

- Server processor utilization
- Server physical and virtual memory limitations
- Resource requirements for other applications
- Directory and network service latencies
- Network infrastructure limitations
- Replication and recovery requirements
- Client usage profiles

All these factors are beyond the scope for ESRP-Storage. Therefore, the number of mailboxes hosted per server as part of the tested configuration may not necessarily be viable for some customer deployment. For more information on identifying and addressing performance bottlenecks in an Exchange system, please refer to

Microsoft's Troubleshooting Microsoft Exchange Server Performance, available at http://go.microsoft.com/fwlink/?LinkId=23454.

Targeted Customer Profile

This solution is intended for small to mid-size organizations hosting up to 1500 Exchange 2010 mailboxes. The configuration used for testing was as follows:

- Number of mailboxes : 1500
- Number of hosts attached to the storage system: 1
- User IO profile: 0.20 I/O Operation per second
- 3072 MB Mailbox quota per mailbox
- 24x7 Background Database Maintenance enabled
- Data Availability Group (DAG) for Mailbox Resiliency (2 copies simulated)

The table below summarizes the testing environment.

Simulated Exchange Configuration

Number of Exchange mailboxes simulated	1500
Number of Database Availability Groups (DAGs)	1
Number of servers/DAG	2
Number of active mailboxes/server	1500
Number of databases/host	5
Number of copies/database	2
Number of mailboxes/database	300
Simulated profile: I/O's per second per mailbox (IOPS, include 20% headroom)	0.20
Database LUN size	1863.68 GB
Log LUN size	N/A
Total database size for performance testing	4,582.315 GB
% storage capacity used by Exchange database**	40.67%

**Storage performance characteristics change based on the percentage utilization of the individual disks. Tests that use a small percentage of the storage (~25%) may exhibit reduced throughput if the storage capacity utilization is significantly increased beyond what is tested in this paper.

Primary Storage Hardware

Storage Connectivity (Fiber Channel, SAS, SATA, iSCSI)	SAS
Storage model and OS/firmware revision	PowerEdge™ R510 + PERC H700 Firmware 2.100.03.1062
Storage cache	1GB – PERC H700 RAID controller cache
Number of storage controllers	1
Number of storage ports	2
Maximum bandwidth of storage connectivity to host	6GBit

Switch type/model/firmware revision	N/A
HBA model and firmware	PERC H700 (RAID controller) (FW Version 2.100.03-1062)
Number of HBA's/host	1
Host server type	Dell™ PowerEdge™ R510 2 Intel®Xeon®CPU; X5650@2.67GHz 96GB memory
Total number of disks tested in solution	10 total
Maximum number of spindles can be hosted in server	12total

Storage Software

HBA driver	Dell™ PERC H700
HBA QueueTarget Setting	N/A
HBA QueueDepth Setting	N/A
Multi-Pathing	N/A
Host OS	Windows Server 2008 R2 Enterprise X64 Edition
ESE.dll file version	**14.01.0218.012**
Replication solution name/version	N/A

Primary Storage Disk Configuration (Mailbox Store Disks)

Disk type, speed and firmware revision	Seagate 2TB 7.2K RPM NL-SAS (ST32000444SS) Drives
Raw capacity per disk (GB)	2048GB
Number of physical disks in test	10
Total raw storage capacity (GB)	20480 GB
Disk slice size (GB)	N/A
Number of slices per LUN or number of disks per LUN	10
Raid level	RAID 1
Total formatted capacity	11,150GB
Storage capacity utilization	91%
Database capacity utilization	40.67 %

Replication Configuration

Replication mechanism	Exchange 2010 Data Availability Group Mailbox Resiliency(simulated)
Number of links	2
Simulated link distance	LAN
Link type	IP
Link bandwidth	Gigabit Ethernet (1 Gbps)

Best Practices

Exchange Server 2007 and 2010 overcome the memory limitations of previous Exchange versions by providing support as a 64-bit application capable of running on supported x64 platforms. On Windows Server 2008 R2 x64 Edition about 2TB of addressable memory is available for the kernel mode and the user mode applications. Both the application and kernel can have sufficient memory for operations, allowing the Extensible Storage Engine (ESE) in Exchange Server 2010 to utilize more memory to buffer data pages. The result is a reduction in the number of I/Os, specifically the read operations, required to the disk sub-system. The total number of database disk I/O operations for a given user load is dependent on the available system memory. For a given load, the total database disk I/O operations required per second (IOPS) decreases over a period with increase in system memory. This decrease in database IOPS is primarily caused by a decrease in database reads.

Even with the decrease in database IOPS using larger server memory, Exchange server remains a disk I/O intensive application. The disk subsystem should be capable to support both the capacity and I/O throughput demands of the application. Based on testing using the ESRP framework, we would recommend the following best practices to help improve the I/O subsystem performance:

1. Exchange 2010 is an IO intensive application. Sharing Exchange 2010 storage resources with other applications may negatively impact the performance of Exchange 2010 deployment and therefore is not recommended.
2. In our testing, the database and log folders shared the same physical disk. Other testing indicated that separating the database folders from log folders on to different set of disks does not provide a noticeable performance advantage.

In an Exchange Server 2010 resiliency solution, separating the database and log folders is no longer a required best practice.

3. For Exchange 2010 Database, it is recommended that the size of elements within a RAID stripe be set 256K for best performance.
4. Windows NTFS allocation unit size for Exchange 2010 database partitions should be set to 64K for best performance. For log partitions, if separated from database, the default allocation unit size should be used.
5. Exchange Server 2010 storage latencies are most often related the number of disks available for given a workload. Windows Performance Monitor may be used to monitor Exchange Server 2010 database counters. Average database read latencies (Avg. Disk sec/Read) should not exceed 20ms.

For Exchange Server 2010 Mailbox Storage Design, please visit
http://technet.microsoft.com/en-us/library/dd346703.aspx

Backup strategy

To protect e-mail data from potential disasters having a well designed and implemented backup solution is critical. Depending on the requirements of an environment different backup strategies may be implemented such as:

- Backup to tape
- LAN/SAN based backup etc.

In this solution, DAG is used to maintain a passive database copy on a separate storage system. This passive copy of the database may be used to perform to tape or disk.

The tests performed for backup include: backup-to-disk (read only) and log replay. The backup-to-disk test measures the read I/O performance by running a checksum on all the databases and log files. This test can help determine what kind of database read throughput can be achieved during backups. The backup speed and throughput achieved will depend upon the backup device used. The log replay test was used to measure the maximum rate at which the log files can be played against the databases. This is used to determine the restore times and also database write throughput can be achieved during a log recovery.

Contact for Additional Information

For additional information please visit Dell™ and Exchange Server 2010

Test Result Summary

This section provides a high level summary of the test data from ESRP and the link to the detailed html reports which are generated by ESRP testing framework. Please click on the underlined headings below to view the html report for each test.

Reliability

A number of tests in the framework are to check Reliability tests runs for 24 hours. The goal is to verify the storage can handle high IO load for a long period of time. Both log and database files will be analyzed for integrity after the stress test to ensure no database/log corruption.

The following list provides an overview: (click on the underlined word will show the html report after the reliability tests run)

- Any errors reported in the saved event log file? No errors reported on event log.
  No
- Any errors reported in during the database and log checksum process?
  No

Storage Performance Results

The Primary Storage performance testing is designed to exercise the storage with maximum sustainable Exchange type of IO for 2 hours. The test is to show how long it takes for the storage to respond to an IO under load. The data below is the sum of all of the logical disk I/O's and average of all the logical disks I/O latency in the 2 hours test duration. Each server is listed separately and the aggregate numbers across all servers is listed as well.

Individual Server Metrics:

Database I/O	
Database Disks Transfers/sec	475.18
Total Database Disks Reads/sec	287.67
Total Database Disks Writes/sec	187.508
Average Database Disk Read Latency (ms)	16.874
Average Database Disk Write Latency (ms)	5.307
Transaction Log I/O	
Log Disks Writes/sec	154.462
Average Log Disk Write Latency (ms)	2.068

Database Backup/Recovery Performance

There are two tests reports in this section. The first one is to measure the sequential read rate of the database files, and the second is to measure the recovery/replay performance (playing transaction logs in to the database).

Database Read-only Performance

The test is to measure the maximum rate at which databases could be backed up via VSS. The following table shows the average rate for a single database file.

MB read/sec per database	132.156
MB read/sec total per server	660.78

Transaction Log Recovery/Replay Performance

The test is to measure the maximum rate at which the log files can be played against the databases. The following table shows the average rate for 500 log files played in a single storage group. Each log file is 1 MB in size.

Average time to play one Log file (sec)	3.64

Conclusion

This document is developed by storage solution providers, and reviewed by Microsoft Exchange Product team. The test results/data presented in this document is based on the tests introduced in the ESRP test framework. Customer should not quote the data directly for his/her pre-deployment verification. It is still necessary to go through the exercises to validate the storage design for a specific customer environment.

ESRP program is not designed to be a benchmarking program; tests are not designed to getting the maximum throughput for a giving solution. Rather, it is focused on producing recommendations from vendors for Exchange application. So the data presented in this document should not be used for direct comparisons among the solutions.

Appendix A: Stress Testing

Microsoft Exchange Server Jetstress Tool

Stress Test Result Report

Overall Test Result	**Pass**
Machine Name	WIN-OKTLONN7HPM
Test Description	R510 5 RAID1 - 2x 2TB 7200k RPM 2 Global Hotspares 1500 mailboxes 3072MB mailbox limit 0.20 IOPS 4Threads per database 24 hours run time
Test Start Time	5/2/2011 2:02:51 PM
Test End Time	5/3/2011 2:06:18 PM
Collection Start Time	5/2/2011 2:06:04 PM
Collection End Time	5/3/2011 2:06:05 PM
Jetstress Version	14.01.0225.017
ESE Version	14.01.0218.012
Operating System	Windows Server 2008 R2 Enterprise (6.1.7600.0)

Database Sizing and Throughput

Achieved Transactional I/O per Second	466.917
Target Transactional I/O per Second	300
Initial Database Size (bytes)	4868255580160
Final Database Size (bytes)	4885393506304
Database Files (Count)	5

Jetstress System Parameters

Thread Count	4 (per database)
Minimum Database Cache	160.0 MB
Maximum Database Cache	1280.0 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	2

Database Configuration

Instance424.1 Log path: D:\DB1
Database: D:\DB1\Jetstress001001.edb

Instance424.2 Log path: E:\DB2
Database: E:\DB2\Jetstress002001.edb

Instance424.3 Log path: F:\DB3
Database: F:\DB3\Jetstress003001.edb

Instance424.4 Log path: G:\DB4
Database: G:\DB4\Jetstress004001.edb

Instance424.5 Log path: H:\DB5
Database: H:\DB5\Jetstress005001.edb

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
Instance424.1	18.028	1.629	56.424	36.831	34728.420	35218.194	0.000	1.423	0.000	30.630	0.000	4648.019
Instance424.2	17.009	2.492	56.413	36.828	34828.268	35222.048	0.000	1.538	0.000	30.374	0.000	4678.680
Instance424.3	17.066	5.198	56.730	37.082	34671.824	35221.146	0.000	1.913	0.000	30.490	0.000	4707.464
Instance424.4	18.313	9.047	56.387	36.799	34538.547	35234.016	0.000	2.682	0.000	30.103	0.000	4747.607
Instance424.5	18.774	8.324	56.515	36.908	34426.251	35237.378	0.000	3.027	0.000	29.970	0.000	4775.896

Test Log5/2/2011 2:02:51 PM -- Jetstress testing begins ...
5/2/2011 2:02:51 PM -- Preparing for testing ...
5/2/2011 2:02:56 PM -- Attaching databases ...
5/2/2011 2:02:56 PM -- Preparations for testing are complete.
5/2/2011 2:02:56 PM -- Starting transaction dispatch ..
5/2/2011 2:02:56 PM -- Database cache settings: (minimum: 160.0 MB, maximum: 1.2 GB)
5/2/2011 2:02:56 PM -- Database flush thresholds: (start: 12.8 MB, stop: 25.6 MB)
5/2/2011 2:03:01 PM -- Database read latency thresholds: (average: 20 msec/read, maximum: 100 msec/read).
5/2/2011 2:03:01 PM -- Log write latency thresholds: (average: 10 msec/write, maximum: 100 msec/write).
5/2/2011 2:03:08 PM -- Operation mix: Sessions 4, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
5/2/2011 2:03:08 PM -- Performance logging started (interval: 15000 ms).
5/2/2011 2:03:08 PM -- Attaining prerequisites:
5/2/2011 2:06:04 PM -- \MSExchange Database(JetstressWin)\Database Cache Size, Last: 1208627000.0 (lower bound: 1207960000.0, upper bound: none)
5/3/2011 2:06:05 PM -- Performance logging has ended.
5/3/2011 2:06:05 PM -- JetInterop batch transaction stats: 242434, 242171, 243584, 242178 and 243120.
5/3/2011 2:06:05 PM -- Dispatching transactions ends.
5/3/2011 2:06:05 PM -- Shutting down databases ...
5/3/2011 2:06:18 PM -- Instance424.1 (complete), Instance424.2 (complete), Instance424.3 (complete),

Instance424.4 (complete) and Instance424.5 (complete)
5/3/2011 2:06:18 PM -- C:\Program Files\Exchange Jetstress\Performance_2011_5_2_14_3_1.blg has 5763 samples.
5/3/2011 2:06:18 PM -- Creating test report ...
5/3/2011 2:06:47 PM -- Instance424.1 has 18.0 for I/O Database Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.1 has 1.4 for I/O Log Writes Average Latency.
5/3/2011 2:06:47 PM -- Instance424.1 has 1.4 for I/O Log Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.2 has 17.0 for I/O Database Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.2 has 1.5 for I/O Log Writes Average Latency.
5/3/2011 2:06:47 PM -- Instance424.2 has 1.5 for I/O Log Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.3 has 17.1 for I/O Database Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.3 has 1.9 for I/O Log Writes Average Latency.
5/3/2011 2:06:47 PM -- Instance424.3 has 1.9 for I/O Log Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.4 has 18.3 for I/O Database Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.4 has 2.7 for I/O Log Writes Average Latency.
5/3/2011 2:06:47 PM -- Instance424.4 has 2.7 for I/O Log Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.5 has 18.8 for I/O Database Reads Average Latency.
5/3/2011 2:06:47 PM -- Instance424.5 has 3.0 for I/O Log Writes Average Latency.
5/3/2011 2:06:47 PM -- Instance424.5 has 3.0 for I/O Log Reads Average Latency.
5/3/2011 2:06:47 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.
5/3/2011 2:06:47 PM -- The test has 0 Database Page Fault Stalls/sec samples higher than 0.
5/3/2011 2:06:47 PM -- C:\Program Files\Exchange Jetstress\Performance_2011_5_2_14_3_1.xml has 5751 samples

Appendix B: Performance Testing

Microsoft Exchange Server Jetstress Tool

Performance Test Result Report

Overall Test Result	**Pass**
Machine Name	WIN-OKTLONN7HPM
Test Description	R510 5 RAID1 - 2x 2TB 7200k RPM 2 Global Hotspares 1500 mailboxes 3072MB mailbox limit 0.20 IOPS 4Threads per database 2 hours run time
Test Start Time	5/9/2011 10:28:12 AM
Test End Time	5/9/2011 12:31:41 PM
Collection Start Time	5/9/2011 10:31:27 AM
Collection End Time	5/9/2011 12:31:25 PM
Jetstress Version	14.01.0225.017
ESE Version	14.01.0218.012
Operating System	Windows Server 2008 R2 Enterprise (6.1.7600.0)

Database Sizing and Throughput

Achieved Transactional I/O per Second	475.18
Target Transactional I/O per Second	300
Initial Database Size (bytes)	4885393506304
Final Database Size (bytes)	4886895067136
Database Files (Count)	5

Jetstress System Parameters

Thread Count	4 (per database)
Minimum Database Cache	160.0 MB
Maximum Database Cache	1280.0 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	2

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
Instance424.1	16.548	1.075	57.671	37.552	34853.448	35203.734	0.000	1.268	0.000	31.445	0.000	4670.049
Instance424.2	15.794	2.221	57.923	37.781	34685.795	35194.168	0.000	1.387	0.000	31.391	0.000	4664.746
Instance424.3	17.336	10.875	58.292	38.074	34400.348	35110.329	0.000	2.544	0.000	31.016	0.000	4644.588
Instance424.4	15.474	0.888	55.773	36.283	35315.349	35246.471	0.000	1.359	0.000	30.099	0.000	4707.654
Instance424.5	19.217	11.474	58.013	37.818	34279.463	35185.304	0.000	3.783	0.000	30.511	0.000	4767.569

Test Log5/9/2011 10:28:12 AM -- Jetstress testing begins ...
5/9/2011 10:28:12 AM -- Preparing for testing ...
5/9/2011 10:28:17 AM -- Attaching databases ...
5/9/2011 10:28:17 AM -- Preparations for testing are complete.
5/9/2011 10:28:17 AM -- Starting transaction dispatch ..
5/9/2011 10:28:17 AM -- Database cache settings: (minimum: 160.0 MB, maximum: 1.2 GB)
5/9/2011 10:28:17 AM -- Database flush thresholds: (start: 12.8 MB, stop: 25.6 MB)
5/9/2011 10:28:23 AM -- Database read latency thresholds: (average: 20 msec/read, maximum: 100 msec/read).
5/9/2011 10:28:23 AM -- Log write latency thresholds: (average: 10 msec/write, maximum: 100 msec/write).
5/9/2011 10:28:29 AM -- Operation mix: Sessions 4, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
5/9/2011 10:28:29 AM -- Performance logging started (interval: 15000 ms).
5/9/2011 10:28:29 AM -- Attaining prerequisites:
5/9/2011 10:31:27 AM -- \MSExchange Database(JetstressWin)\Database Cache Size, Last: 1208664000.0 (lower bound: 1207960000.0, upper bound: none)
5/9/2011 12:31:28 PM -- Performance logging has ended.
5/9/2011 12:31:28 PM -- JetInterop batch transaction stats: 21198, 21281, 21272, 20734 and 21164.
5/9/2011 12:31:28 PM -- Dispatching transactions ends.
5/9/2011 12:31:28 PM -- Shutting down databases ...
5/9/2011 12:31:41 PM -- Instance424.1 (complete), Instance424.2 (complete), Instance424.3 (complete), Instance424.4 (complete) and Instance424.5 (complete)
5/9/2011 12:31:41 PM -- C:\Program Files\Exchange Jetstress\Performance_2011_5_9_10_28_23.blg has 491 samples.
5/9/2011 12:31:41 PM -- Creating test report ...
5/9/2011 12:31:43 PM -- Instance424.1 has 16.5 for I/O Database Reads Average Latency.
5/9/2011 12:31:43 PM -- Instance424.1 has 1.3 for I/O Log Writes Average Latency.
5/9/2011 12:31:43 PM -- Instance424.1 has 1.3 for I/O Log Reads Average Latency.
5/9/2011 12:31:43 PM -- Instance424.2 has 15.8 for I/O Database Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.2 has 1.4 for I/O Log Writes Average Latency.
5/9/2011 12:31:44 PM -- Instance424.2 has 1.4 for I/O Log Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.3 has 17.3 for I/O Database Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.3 has 2.5 for I/O Log Writes Average Latency.
5/9/2011 12:31:44 PM -- Instance424.3 has 2.5 for I/O Log Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.4 has 15.5 for I/O Database Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.4 has 1.4 for I/O Log Writes Average Latency.
5/9/2011 12:31:44 PM -- Instance424.4 has 1.4 for I/O Log Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.5 has 19.2 for I/O Database Reads Average Latency.
5/9/2011 12:31:44 PM -- Instance424.5 has 3.8 for I/O Log Writes Average Latency.

5/9/2011 12:31:44 PM -- Instance424.5 has 3.8 for I/O Log Reads Average Latency.
5/9/2011 12:31:44 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.
5/9/2011 12:31:44 PM -- The test has 0 Database Page Fault Stalls/sec samples higher than 0.
5/9/2011 12:31:44 PM -- C:\Program Files\Exchange Jetstress\Performance_2011_5_9_10_28_23.xml has 479 samples queried.

Appendix C Backup Testing

Database backup Test Result Report

Database Backup Statistics - All

Database Instance	Database Size (MBytes)	Elapsed Backup Time	MBytes Transferred/sec
Instance3040.1	938010.09	02:00:02	130.23
Instance3040.2	938042.09	02:02:18	127.83
Instance3040.3	938074.09	01:55:58	134.81
Instance3040.4	938066.09	01:59:04	131.30
Instance3040.5	938098.09	01:54:27	136.61

Jetstress System Parameters

Thread Count	4 (per database)
Minimum Database Cache	160.0 MB
Maximum Database Cache	1280.0 MB
Insert Operations	40%
Delete Operations	20%
Replace Operations	5%
Read Operations	35%
Lazy Commits	70%

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
Instance3040.1	2.743	0.000	521.009	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3040.2	2.797	0.000	511.237	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3040.3	2.650	0.000	539.256	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3040.4	2.724	0.000	525.014	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3040.5	2.609	0.000	546.471	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix D Soft Recovery Testing

SoftRecovery Test Result Report

Soft-Recovery Statistics - All

Database Instance	Log files replayed	Elapsed seconds
Instance3040.1	501	2096.6436826
Instance3040.2	508	1813.8151858
Instance3040.3	509	1829.6960137
Instance3040.4	502	1700.5277868
Instance3040.5	514	1782.06913