

Hitachi Adaptable Modular Storage 2300 Dynamically Provisioned 34,400 User Exchange 2010 Resiliency Storage Solution

Tested with: ESRP – Storage Version 3.0

Test Date: April 2010

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Overview

This document provides information on a Hitachi Adaptable Modular Storage 2300 Resiliency storage solution using Hitachi Dynamic Provisioning software for Microsoft Exchange Server 2010, based on the Microsoft® Exchange Solution Reviewed Program (ESRP) – Storage program. For more information about the contents of this document or Hitachi Data Systems best practice recommendations for Microsoft Exchange Server 2010 storage design, see Hitachi Data Systems [Microsoft Exchange Solutions Web page](#).

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 information about the Microsoft ESRP – Storage program, see [TechNet's overview of the program](#).

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Features

The purpose of this testing was to measure the ESRP 3.0 results on a Microsoft Exchange 2010 environment with 34,400 users and 8 servers. This testing used the Hitachi Adaptable Modular Storage 2300 storage system using Hitachi Dynamic Provisioning software in a two pool RAID-1+0 configuration (one for databases and one for logs) in a resiliency configuration. These results help answer questions about the kind of performance capabilities to expect with a large-scale Exchange deployment on the 2300.

This solution includes Exchange 2010 Mailbox Resiliency by using the new Database Availability Group (DAG) feature. This tested configuration utilizes eight DAGs, each containing two database copies and two servers. The test configuration was capable of supporting 34,400 users with a 0.12 IOPS per user profile and user mailbox size of 1GB. An 2300 with 240 450GB 15K RPM SAS disks, 16 GB of cache and 8 4Gbit/s paths was used for these tests. Testing used eight Sun Fire 4270 servers with 32GB of RAM, two quad-core Intel E5540 2.53GHz CPUs, sixteen Emulex 4Gbit/s Fibre Channel adapters, and Windows Server 2008 R2 Enterprise.

The Hitachi Adaptable Modular Storage 2300 is a medium-sized, high-performance, highly reliable midrange storage system that can scale to 240 disks while maintaining 99.999% availability. It is highly suitable for a variety of applications and host platforms and is modular in scale. With the option of in-system and cross-system replication functionality, the 2300 is fully capable of being used as the core underlying storage platform for high-performance Exchange Server 2010 architectures.

Solution Description

Deploying Microsoft Exchange Server 2010 requires careful consideration of all aspects of the solution architecture. Host servers need to be configured so that they are robust enough to handle the required Exchange load. The storage solution must be designed to provide the necessary performance while also being reliable and easy to administer. Of course, an effective backup and recovery plan should be incorporated into the solution as well. The aim of this solution report is to provide a tested configuration that utilizes the 2300 to meet the needs of a large Exchange Server deployment.

This solution uses Hitachi Dynamic Provisioning software, which is enabled on the 2300 via a license key. In the most basic sense, Hitachi Dynamic Provisioning software is similar to the use of a host-based logical volume manager (LVM), but with several additional features available within the 2300 and without the need to install software on the host or incur host processing overhead. Hitachi Dynamic Provisioning software is a superior solution. Hitachi Dynamic Provisioning software provides for one or more pools of wide striping across many RAID groups within a 2300. One or more Dynamic Provisioning virtual volumes (DP-VOLs) of a user-specified logical size (with no initial physical space allocated) are created against each pool.

Primarily, Hitachi Dynamic Provisioning would be deployed to avoid the routine issue of hot spots that occur on logical units (LUs) from individual RAID groups when the host workload exceeds the IOPS or throughput capacity of that RAID group. By using many RAID groups as members of a striped Dynamic Provisioning pool underneath the virtual or logical volumes seen by the hosts, a host workload will be distributed across many RAID groups which provides a smoothing effect that dramatically reduces hot spots and results in fewer mailbox moves for the Exchange administrator.

Hitachi Dynamic Provisioning software also carries the side benefit of thin provisioning, where physical space is only assigned from the pool to the DP-VOL as needed using 1GB chunks, up to the logical size specified for each DP-VOL. A pool can also be dynamically expanded by adding more RAID groups without disruption or requiring downtime. Upon expansion a Pool can easily be rebalanced so that the data and workload is wide striped evenly across the current and newly added RAID Groups comprising the pool.

High availability is also a part of this solution with the use of the new DAG feature, which is the base component of the high availability and site resilience framework built into Microsoft Exchange Server 2010. A DAG is a group of up to 16 mailbox servers that host a set of databases and logs and uses continuous replication to provide automatic database-level recovery from failures that affect individual servers or databases.

Any server in a DAG can host a copy of a mailbox database from any other server in the DAG. When a server is added to a DAG, it monitors and works with the other servers in the DAG to provide automatic recovery delivering a robust, highly-available Exchange solution without the administrative complexities of traditional failover clustering. For additional information about the DAG feature in Exchange Server 2010 see <http://technet.microsoft.com/en-us/library/dd979799.aspx>

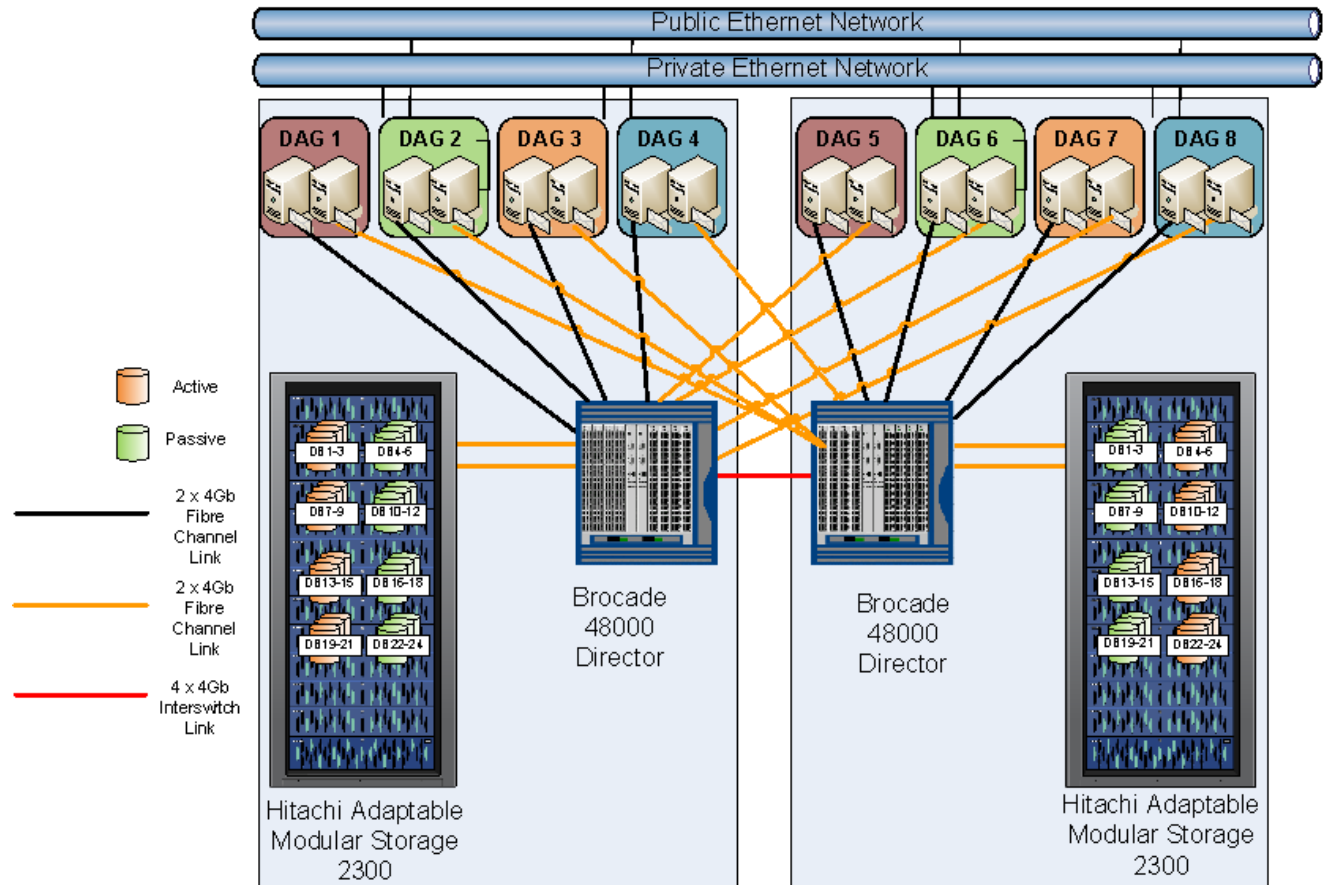
This solution includes two copies of each Exchange database using eight DAGs, each configured with two servers and that host active mailboxes in three databases. To target the 34,400 user resiliency solution, a Hitachi Adaptable Modular Storage 2300 configured with 240 disks (the maximum) and eight host servers, each configured with 4,300 mailboxes, were used to host the 24 active databases and the simulated database copies for the tests

Each DAG contained two copies of every database; a local, active copy on a server connected to the primary 2300 and the passive copy on another server connected to a second 2300. This recommended configuration can support both high-availability and disaster-recovery scenarios when the active and passive database

copies are allocated among both DAG members and dispersed across both 2300s. Each simulated DAG server node in this solution maintains a mirrored configuration and possesses adequate capacity and performance capabilities to support the second set of replicated databases.

Figure 1 illustrates the two systems that make up the simulated DAG configuration.

Figure 1. Recommended Database Availability Group Configuration

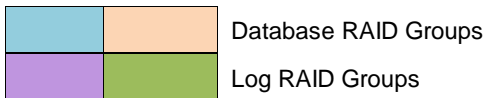


This solution enables organizations to consolidate Exchange Server 2010 DAG deployments on two 2300 storage systems. Using identical hardware and software configurations guarantees that an active database and its replicated copy do not share storage paths, disk spindles or storage controllers, making it a very reliable, high-performing, highly available Exchange Server 2010 solution that is cost effective and easy to manage. This helps ensure that performance and service levels related to storage are maintained regardless of which server is hosting the active database. If further protection is needed in a production environment, additional Exchange Server 2010 mailbox servers can be easily added to support these failover scenarios.

Table 1 illustrates how the 2300's disks were organized into RAID groups for use by either databases or logs. Each set of colored disks represents a RAID-1+0 (2D+2D) group. Except for RKA-0 (with 15 internal SAS disks), each RKA is an external disk enclosure with 15 SAS disks.

Table 1. Adaptable Modular Storage 2300 RAID Groups by RKA Tray Layout

<i>Drive Slot</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>
RKA 15	56	56	56	57	57	57	57	58	58	58	58	59	59	59	59
RKA 14	52	52	53	53	53	53	54	54	54	54	55	55	55	55	56
RKA 13	48	49	49	49	49	50	50	50	50	51	51	51	51	52	52
RKA 12	45	45	45	45	46	46	46	46	47	47	47	47	48	48	48
RKA 11	41	41	41	42	42	42	42	43	43	43	43	44	44	44	44
RKA 10	37	37	38	38	38	38	39	39	39	39	40	40	40	40	41
RKA 9	33	34	34	34	34	35	35	35	35	36	36	36	36	37	37
RKA 8	30	30	30	30	31	31	31	31	32	32	32	32	33	33	33
RKA 7	26	26	26	27	27	27	27	28	28	28	28	29	29	29	29
RKA 6	22	22	23	23	23	23	24	24	24	24	25	25	25	25	26
RKA 5	18	19	19	19	19	20	20	20	20	21	21	21	21	22	22
RKA 4	15	15	15	15	16	16	16	16	17	17	17	17	18	18	18
RKA 3	11	11	11	12	12	12	12	13	13	13	13	14	14	14	14
RKA 2	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11
RKA 1	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7
RKA 0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3



Two Dynamic Provisioning pools were created, one for the databases and the other for the logs. The database pool was created from 54 RAID-1+0 groups and the log pool was created from six RAID-1+0 groups. From the database pool, 24 DP-VOLs (each specified to have a 1,750GB size limit) were created for 24 databases (three per server). From the log pool, 24 DP-VOLs (each specified to have a size limit of 175GB) were created for 24 logs (three per server).

Table 2 outlines the port layout for the primary storage and servers. An identical configuration is deployed on the replicated storage and servers for this solution.

Table 2. Adaptable Modular Storage 2300 Port to Server Layout

<i>Server</i>	<i>Primary Path</i>	<i>Secondary Path</i>
SUN158	0A	1A
SUN159	0B	1B
SUN160	0C	1C
SUN161	0D	1D
SUN169	1A	0A
SUN170	1B	0B
SUN163	1C	0C
SUN164	1D	0D

Table 3 outlines the port layout with the database DP-VOL assignments for the primary storage and servers. An identical configuration is deployed on the replicated storage and servers for this solution.

Table 3. Adaptable Modular Storage 2300 Port to Database DP-VOL Layout

<i>Port</i>	<i>Database</i>	<i>DP-VOL</i>
0A	0 - 2	12 - 14
0B	3 - 5	15 - 17
0C	6 - 8	18 - 20
0D	9 - 11	20 - 23
1A	12 - 14	0 - 2
1B	15 - 17	3 - 5
1C	18 - 20	6 - 8
1D	20 - 23	9 - 11

Table 4 outlines the port layout with the database DP-VOL assignments for the primary storage and servers. An identical configuration is deployed on the replicated storage and servers for this solution.

Table 4. Adaptable Modular Storage 2300 Port to Log DP-VOL Layout

<i>Port</i>	<i>Log</i>	<i>DP-VOL</i>
0A	24 - 26	36 - 38
0B	27 - 29	39 - 41
0C	30 - 32	42 - 44
0D	33 - 35	45 - 47
1A	36 - 38	24 - 26
1B	39 - 41	27 - 29
1C	42 - 44	30 - 32
1D	45 - 47	33 - 35

Table 5 provides the detailed specifications for the storage configuration which uses RAID-1+0 (2+2) groups and 450GB 15K disks. Dynamic Provisioning pool 0 is dedicated for the database and Dynamic Provisioning pool 1 is dedicated for the logs.

Table 5. Adaptable Modular Storage 2300 Configuration Details

<i>Host</i>	<i>Pool</i>	<i>Port</i>	<i>DP-VOL</i>	<i>Size (GB)</i>	<i>Description</i>
SUN158	0	0A/1A	0 - 2	1750	Databases 1-3
SUN159	0	0B/1B	3 - 5	1750	Databases 4-6
SUN160	0	0C/1C	6 - 8	1750	Databases 7-9
SUN161	0	0D/1D	9 - 11	1750	Databases 10-12
SUN169	0	1A/0A	12 - 14	1750	Databases 13-15
SUN170	0	1B/0B	15 - 17	1750	Databases 16-18
SUN163	0	1C/0C	18 - 20	1750	Databases 19-21
SUN164	0	1D/0D	20 - 23	1750	Databases 22-24
SUN158	1	0A/1A	24 - 26	175	Logs 1-3
SUN159	1	0B/1B	27 - 29	175	Logs 4-6
SUN160	1	0C/1C	30 - 32	175	Logs 7-9
SUN161	1	0D/1D	33 - 35	175	Logs 10-12
SUN169	1	1A/0A	36 - 38	175	Logs 13-15
SUN170	1	1B/0B	39 - 41	175	Logs 16-18
SUN163	1	1C/0C	42 - 44	175	Logs 19-21
SUN164	1	1D/0D	45 - 47	175	Logs 22-24

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. These factors also affect server scalability:

- 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

These factors are all beyond the scope of the ESRP – Storage program. Therefore, the number of mailboxes hosted per server as part of the tested configuration might not necessarily be viable for some customer deployments.

For more information about identifying and addressing performance bottlenecks in an Exchange system, see Microsoft's [Troubleshooting Microsoft Exchange Server Performance](#).

Targeted Customer Profile

This solution is designed for medium to large organizations that plan to consolidate their Exchange Server 2010 storage on high-performance, high-reliability storage systems. This configuration is designed to support 34,400 Exchange users with the following specifications:

- 16 Exchange servers (eight tested, simulating 16 for the database copies)
- Two Adaptable Modular Storage 2300 storage systems (one tested)
- 0.1 IOPS per user(0.12 tested for 20 percent growth)
- 1GB mailbox size
- Mailbox resiliency provides high-availability and used as primary data protection mechanism.
- Adaptable Modular Storage RAID protection against physical failure or loss.
- 24x7 background database maintenance enabled

Tested Deployment

The following tables summarize the testing environment.

Table 6. Simulated Exchange Configuration

<i>Number of Exchange mailboxes simulated</i>	34,400
<i>Number of database availability groups (DAGs)</i>	8
<i>Number of servers per DAG</i>	2
<i>Number of active mailboxes per server</i>	4,300
<i>Number of databases per host</i>	3
<i>Number of copies per database</i>	2
<i>Number of mailboxes per database</i>	1,433
<i>Simulated profile: I/Os per second per mailbox (IOPS, include 20% headroom)</i>	0.12
<i>Database LU size</i>	1750GB
<i>Log LU size</i>	175GB
<i>Total database size for performance testing</i>	34,400GB
<i>% storage capacity used by Exchange database**</i>	79.8%

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

Table 7. Primary Storage Hardware

<i>Storage connectivity (Fibre Channel, SAS, SATA, iSCSI)</i>	Fibre Channel
<i>Storage model and OS/firmware revision</i>	1 Hitachi Adaptable Modular Storage 2300 Firmware: 0872/E-S WHQL listing: Hitachi Adaptable Modular Storage 2300
<i>Storage cache</i>	16GB
<i>Number of storage controllers</i>	2
<i>Number of storage ports</i>	8
<i>Maximum bandwidth of storage connectivity to host</i>	32Gb/s (8 x 4Gbit/s ports)
<i>Switch type/model/firmware revision</i>	Brocade 5320, Fabric OS v6.3.0b
<i>HBA model and firmware</i>	Emulex LPe11002, FW:2.82A3
<i>Number of HBAs per host</i>	2 dual-ported HBA per host, 1 4Gbit/s port used per HBA
<i>Host server type</i>	Sun Fire 4270 2 2.54GHz quad-core Intel Xeon CPUs, 32GB memory
<i>Total number of disks tested in solution</i>	240
<i>Maximum number of spindles can be hosted in the storage</i>	240

Table 8. Primary Storage Software

HBA Driver	STOR Miniport 7.2.0.12
HBA QueueTarget Setting	0
HBA QueueDepth Setting	32
Multipathing	Hitachi Dynamic Link Manager v6.2.0
Host OS	Microsoft Windows Server 2008 R2 Enterprise
ESE.dll file version	14.00.0639.019
Replication solution name/version	N/A

Table 9. Storage Disk Configuration (Mailbox Store Disks)

Disk type, speed and firmware revision	SAS Disk 450GB 15K 4C57
Raw capacity per disk (GB)	450GB
Number of physical disks in test	216 (Dynamic Provisioning pool)
Total raw storage capacity (GB)	97,200GB
Disk slice size (GB)	N/A
Number of slices per LUN or number of disks per LUN	N/A
RAID level	RAID 1+0 (2+2) at storage level
Total formatted capacity	43,092GB (Dynamic Provisioning database pool)
Storage capacity utilization	44.3%
Database capacity utilization	43.2%

Table 10. Primary Storage Disk Configuration (Transaction Log Disks)

Disk type, speed and firmware revision	SAS Disk 450GB 15K 4C57
Raw capacity per disk (GB)	450GB
Number of spindles in test	24 (Dynamic Provisioning pool)
Total raw storage capacity (GB)	10,800GB
Disk slice size (GB)	N/A
Number of slices per LU or number of disks per LU	N/A
RAID level	RAID 1+0 (2+2) at storage level
Total formatted capacity	4,788GB

Replication Configuration

The following tables summarize the replication environment.

Table 11. Replicated Configuration

Replication mechanism	Exchange Server 2010 Database Availability Group (DAG)
Number of links	2
Simulated link distance	N/A
Link type	IP
Link bandwidth	GigE (1Gbps)

Table 12. Replicated Storage Hardware

Storage connectivity (Fibre Channel, SAS, SATA, iSCSI)	Fibre Channel
Storage model and OS/firmware revision	1 Hitachi Adaptable Modular Storage 2300 Firmware: 0872/E-S WHQL listing: Hitachi Adaptable Modular Storage 2300
Storage cache	16GB
Number of storage controllers	2
Number of storage ports	8
Maximum bandwidth of storage connectivity to host	32Gb/s (8 x 4Gbit/s ports)
Switch type/model/firmware revision	Brocade 5320, Fabric OS v6.3.0b
HBA model and firmware	Emulex LPe11002, FW:2.82A3
Number of HBAs per host	2 dual-ported HBA per host, 1 4Gbit/s port used per HBA
Host server type	Sun Fire 4270 2 2.54 GHz quad-core Intel Xeon CPUs, 32 GB memory
Total number of disks tested in solution	240
Maximum number of spindles can be hosted in the storage	240

Table 13. Replicated Storage Software

HBA Driver	STOR Miniport 7.2.0.12
HBA QueueTarget Setting	0
HBA QueueDepth Setting	32
Multipathing	Hitachi Dynamic Link Manager v6.2.0
Host OS	Microsoft Windows Server 2008 R2 Enterprise
ESE.dll file version	14.00.0639.019
Replication solution name/version	Exchange Server 2010 Database Availability Group (DAG)

Table 14. Replicated Storage Disk Configuration (Mailbox Store Disks)

Disk type, speed and firmware revision	SAS Disk 450GB 15K 4C57
Raw capacity per disk (GB)	450GB
Number of physical disks in test	216 (Dynamic Provisioning pool)
Total raw storage capacity (GB)	97,200GB
Disk slice size (GB)	N/A
Number of slices per LUN or number of disks per LUN	N/A
RAID level	RAID 1+0 (2+2) at storage level
Total formatted capacity	43,092GB (Dynamic Provisioning database pool)
Storage capacity utilization	44.3%
Database capacity utilization	43.2%

Table 15. Replicated Storage Disk Configuration (Transaction Log Disks)

Disk type, speed and firmware revision	SAS Disk 450GB 15K 4C57
Raw capacity per disk (GB)	450GB
Number of spindles in test	24 (Dynamic Provisioning pool)
Total raw storage capacity (GB)	10,800GB
Disk slice size (GB)	N/A
Number of slices per LU or number of disks per LU	N/A
RAID level	RAID 1+0 (2+2) at storage level
Total formatted capacity	4,788GB

Best Practices

Microsoft Exchange Server 2010 is a disk-intensive application. It presents two distinct workload patterns to the storage, with 32KB random read/write operations to the databases, and sequential write operations of varying size (between 512 bytes up to the log buffer size) to the transaction logs. For this reason, designing an optimal storage configuration can prove challenging in practice. Based on the testing run using the ESRP framework, Hitachi Data Systems recommends these best practices to improve the performance of the Hitachi Adaptable Modular Storage 2300 running Exchange 2010.

For more information about Exchange 2010 best practices for storage design, see the Microsoft TechNet article ["Mailbox Server Storage Design."](#)

Core Storage

1. When formatting a newly partitioned LU, Hitachi Data Systems recommends that for database and log files the ALU is set to 64K and 4K respectively.
2. Disk alignment is no longer required when using Microsoft Windows Server 2008.
3. Keep the Exchange workload isolated from other applications. Mixing another I/O intensive application whose workload differs from Exchange can cause the performance for both applications to degrade.

4. Use Hitachi Dynamic Link Manager multipathing software to provide fault tolerance and high availability for host connectivity.
5. Use Hitachi Dynamic Provisioning software to simplify storage management of the Exchange database and log volumes
6. Due to the difference in I/O patterns, isolate the Exchange database from the log groups. Create a dedicated Dynamic Provisioning pool for the databases and a separate pool for the logs.
7. Hitachi Data Systems recommends RAID-5 or RAID-1+0 groups for both the database pools and for the log pool. Use of RAID-1+0 allows more writes at a lower response time under heavier loads. RAID-1+0 also supports a shorter RAID group rebuild time on failure of a disk.
8. The Log LUs should be at least 10 percent of the size of the database LUs.
9. Hitachi Data Systems does not recommend LU concatenation.
10. Hitachi Data Systems recommends implementing Mailbox Resiliency using the Exchange Server 2010 Database Availability Group feature.
11. Ensure that each DAG maintains at least two database copies to provide high-availability
12. Isolate active databases and their replicated copies in separate Dynamic Provisioning pools or ensure that they are located on a separate 2300.
13. Use fewer, larger LUs for Exchange 2010 databases (up to 2TB) with Background Database Maintenance (24x7) enabled.
14. Size storage solutions for Exchange based primarily on performance criteria. The number of disks, RAID level and percent utilization of each disk directly affect the level of achievable performance. Factor in capacity requirements only after performance is addressed.
15. Disk size is unrelated to performance with regards to IOPS or throughput rates. Disk size is related to the usable capacity of all of the LUs from a RAID group, which is a choice users make.
16. The number of spindles, coupled with the RAID level, determines the physical IOPS capacity of the RAID group and all of its LUs. If the disk has too few spindles, the response times grow to large values very quickly.

Storage-based Replication

N/A

Backup Strategy

N/A

Test Result Summary

This section provides a high-level summary of the test data from ESRP and the link to the detailed HTML reports that are generated by ESRP testing framework.

Reliability

A number of tests in the framework check reliability spanning a 24-hour window. The goal is to verify the storage can handle high I/O load for a long period of time. Following these stress tests, both log and database files are analyzed for integrity to ensure that no database or log corruption occurs.

- No errors were reported in the event log file for the storage reliability testing
- No errors were reported for the [database](#) and [log](#) checksum process
- Backup to disk test is N/A
- Database checksum on the remote storage database is N/A

Storage [Performance](#) Results

Primary storage performance testing exercises the storage with maximum sustainable Exchange type of I/O for two hours. The test shows how long it takes for the storage to respond to an I/O under load. The following data is the sum of all of the logical disk I/Os and average of all the logical disks I/O latency in the two-hour test duration.

Individual Server Metrics

Individual server metrics show the sum of I/Os across database and the average latency across all databases on a per-server basis.

Table 10. Individual Server Metrics for Exchange Server (SUN158)

Database I/O	
<i>Database disk transfers per second</i>	1344
<i>Database disk reads per second</i>	871
<i>Database disk writes per second</i>	473
<i>Average database disk read latency (ms)</i>	7.3
<i>Average database disk write latency (ms)</i>	2.6
Transaction Log I/O	
<i>Log disk writes per second</i>	273
<i>Average log disk write latency (ms)</i>	1.0

Table 11. Individual Server Metrics for Exchange Server (SUN159)

Database I/O	
<i>Database disk transfers per second</i>	1116
<i>Database disk reads per second</i>	733
<i>Database disk writes per second</i>	383
<i>Average database disk read latency (ms)</i>	8.4
<i>Average database disk write latency (ms)</i>	2.5
Transaction Log I/O	
<i>Log disk writes per second</i>	263
<i>Average log disk write latency (ms)</i>	1.0

Table 12. Individual Server Metrics for Exchange Server (SUN160)

Database I/O	
<i>Database disk transfers per second</i>	1346
<i>Database disk reads per second</i>	872
<i>Database disk writes per second</i>	473
<i>Average database disk read latency (ms)</i>	7.3
<i>Average database disk write latency (ms)</i>	2.6
Transaction Log I/O	
<i>Log disk writes per second</i>	272
<i>Average log disk write latency (ms)</i>	1.0

Table 13. Individual Server Metrics for Exchange Server (SUN161)

Database I/O	
<i>Database disk transfers per second</i>	1336
<i>Database disk reads per second</i>	866
<i>Database disk writes per second</i>	470
<i>Average database disk read latency (ms)</i>	7.3
<i>Average database disk write latency (ms)</i>	2.6
Transaction Log I/O	
<i>Log disk writes per second</i>	271
<i>Average log disk write latency (ms)</i>	1.0

Table 14. Individual Server Metrics for Exchange Server (SUN169)

Database I/O	
<i>Database disk transfers per second</i>	1331
<i>Database disk reads per second</i>	863
<i>Database disk writes per second</i>	468
<i>Average database disk read latency (ms)</i>	7.4
<i>Average database disk write latency (ms)</i>	2.6
Transaction Log I/O	
<i>Log disk writes per second</i>	270
<i>Average log disk write latency (ms)</i>	1.0

Table 15. Individual Server Metrics for Exchange Server (SUN170)

Database I/O	
<i>Database disk transfers per second</i>	1333
<i>Database disk reads per second</i>	864
<i>Database disk writes per second</i>	469
<i>Average database disk read latency (ms)</i>	7.4
<i>Average database disk write latency (ms)</i>	2.7
Transaction Log I/O	
<i>Log disk writes per second</i>	272
<i>Average log disk write latency (ms)</i>	1.0

Table 16. Individual Server Metrics for Exchange Server (SUN163)

Database I/O	
<i>Database disk transfers per second</i>	1362
<i>Database disk reads per second</i>	883
<i>Database disk writes per second</i>	480
<i>Average database disk read latency (ms)</i>	7.2
<i>Average database disk write latency (ms)</i>	2.7
Transaction Log I/O	
<i>Log disk writes per second</i>	276
<i>Average log disk write latency (ms)</i>	1.0

Table 17. Individual Server Metrics for Exchange Server (SUN164)

Database I/O	
<i>Database disk transfers per second</i>	1334
<i>Database disk reads per second</i>	865
<i>Database disk writes per second</i>	469
<i>Average database disk read latency (ms)</i>	7.4
<i>Average database disk write latency (ms)</i>	2.7
Transaction Log I/O	
<i>Log disk writes per second</i>	270
<i>Average log disk write latency (ms)</i>	1.1

Aggregate Performance Across All Servers Metrics

The aggregate performance across all server metrics shows the sum of I/Os across all servers in the solution and the average latency across all servers in the solution.

Table 18. Aggregate Performance for Exchange Server 2010

Database I/O	
<i>Database disk transfers per second</i>	10502
<i>Database disk reads per second</i>	6817
<i>Database disk writes per second</i>	3685
<i>Average database disk read latency (ms)</i>	7.5
<i>Average database disk write latency (ms)</i>	2.6
Transaction Log I/O	
<i>Log disk writes per second</i>	2167
<i>Average log disk write latency (ms)</i>	1.0

Database Backup and Recovery Performance

This section has two tests: The first measures the sequential read rate of the database files and the second measures recovery/replay performance (playing transaction logs in to the database).

Database Read-only Performance

This test measures the maximum rate at which databases can be backed up via VSS. The following tables show the average rate for a single database file.

Table 19. Database Read-only Performance

<i>MB read per second per database</i>	43
<i>MB read per second total per server</i>	130

Transaction Log Recovery/Replay Performance

This test measures 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 Database. Each log file is 1MB in size.

Table 20. Transaction Log Recovery/Replay Performance

<i>Average time to play one log file (sec)</i>	1.2
--	-----

Conclusion

This document details a tested a robust Exchange Server 2010 Resiliency solution capable of supporting 34,400 users with a 0.12 IOPS per user profile and user mailbox size of 1GB using eight DAGs, each configured with two server nodes. A Hitachi Adaptable Modular Storage 2300, with 16GB of cache and eight 4Gbit/s Fibre Channel host paths, using Hitachi Dynamic Provisioning software (with two pools) and 240 450GB 15K RPM SAS disks in a RAID-1+0 configuration, was used for these tests. Testing confirmed that the 2300 is more than capable of delivering the IOPS and capacity requirements needed to support the active and replicated databases for 34,400 Exchange mailboxes configured with the specified user profile, while maintaining additional headroom to support peak throughput.

The solution outlined in this document does not include data protection components, such as VSS snapshot or clone backups, and relies on the built-in Mailbox Resiliency features of Exchange Server 2010 coupled with Adaptable Modular Storage RAID technology to provide high-availability and protection from logical and physical failures. Adding protection requirements might affect performance and capacity requirements of the underlying storage configuration, and as such needs to be factored into the storage design accordingly.

For additional information about planning Exchange Server 2010 storage architectures for the Hitachi Adaptable Modular Storage 2000 family, see <http://www.hds.com/assets/pdf/hitachi-ams-2000-family.pdf>.

This document is developed by Hitachi Data Systems and reviewed by Microsoft Exchange Product team. The test results and data presented in this document are based on the tests introduced in the ESRP test framework. Do not quote the data directly for pre-deployment verification. It is still necessary to validate the storage design for a specific customer environment.

The ESRP program is not designed to be a benchmarking program; tests do not generate the maximum throughput for a given solution. Rather, it is focused on producing recommendations from vendors for Exchange application. Thus, do not use the data presented in this document for direct comparisons among the solutions.

Appendix A: Test Reports

This appendix contains Jetstress test results for one of the servers used in testing this storage solution. These test results are representative of the results obtained for all of the servers tested.

Performance Test Result: SUN158

Test Summary

Overall Test Result	Pass
Machine Name	SUN158
Test Description	
Test Start Time	4/2/2010 5:31:28 PM
Test End Time	4/2/2010 7:42:30 PM
Collection Start Time	4/2/2010 5:32:43 PM
Collection End Time	4/2/2010 7:32:29 PM
Jetstress Version	14.01.0043.000
Ese Version	14.00.0639.019
Operating System	Windows Server 2008 R2 Enterprise (6.1.7600.0)
Performance Log	C:\1GB MBox\Perf Test\Performance_2010_4_2_17_31_35.blg C:\1GB MBox\Perf Test\DBChecksum_2010_4_2_19_42_30.blg

Database Sizing and Throughput

Achieved Transactional I/O per Second	1255.58
Target Transactional I/O per Second	516
Initial Database Size (bytes)	4619230183424
Final Database Size (bytes)	4621931315200
Database Files (Count)	3

Jetstress System Parameters

Thread Count	6 (per database)
Minimum Database Cache	96.0 MB
Maximum Database Cache	768.0 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

Instance2364.1	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
Instance2364.2	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
Instance2364.3	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

Transactional I/O Performance

MSExchange Database ==> Instance	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
Instance2364.1	7.559	3.088	260.411	156.924	33131.087	35020.441	0.000	0.968	0.000	90.664	0.000	4580.563
Instance2364.2	7.230	2.320	260.898	157.669	33213.394	35021.133	0.000	1.063	0.000	90.258	0.000	4633.184
Instance2364.3	7.184	2.509	261.589	158.088	33176.683	35030.985	0.000	0.969	0.000	91.586	0.000	4592.864

Background Database Maintenance I/O Performance

MSExchange Database ==> Instances	Database Maintenance IO Reads/sec	Database Maintenance IO Reads Average Bytes
Instance2364.1	29.171	261840.323
Instance2364.2	29.436	261854.947
Instance2364.3	29.467	261876.859

Log Replication I/O Performance

MSExchange Database ==> Instances	I/O Log Reads/sec	I/O Log Reads Average Bytes
Instance2364.1	1.691	232559.250
Instance2364.2	1.706	232563.061
Instance2364.3	1.714	232557.126

Total I/O Performance

MSExchange => Instance	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
Instance2 364.1	7.559	3.088	289.582	156.924	56169.983	35020.441	2.665	0.968	1.691	90.664	232559.250	4580.563
Instance2 364.2	7.230	2.320	290.334	157.669	56394.839	35021.133	3.189	1.063	1.706	90.258	232563.061	4633.184
Instance2 364.3	7.184	2.509	291.056	158.088	56330.794	35030.985	2.829	0.969	1.714	91.586	232557.126	4592.864

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	1.140	0.000	3.621
Available MBytes	30019.756	30008.000	30030.000
Free System Page Table Entries	33555644.994	33555643.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	70215880.952	70033408.000	70324224.000
Pool Paged Bytes	90336784.033	90243072.000	90402816.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

Test Log

```

4/2/2010 5:31:28 PM -- Jetstress testing begins ...
4/2/2010 5:31:28 PM -- Prepare testing begins ...
4/2/2010 5:31:31 PM -- Attaching databases ...
4/2/2010 5:31:31 PM -- Prepare testing ends.
4/2/2010 5:31:31 PM -- Dispatching transactions begins ...
4/2/2010 5:31:32 PM -- Database cache settings: (minimum: 96.0 MB, maximum: 768.0 MB)
4/2/2010 5:31:32 PM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
4/2/2010 5:31:35 PM -- Database read latency thresholds: (average: 20 msec/read, maximum: 100 msec/read).
4/2/2010 5:31:35 PM -- Log write latency thresholds: (average: 10 msec/write, maximum: 100 msec/write).
4/2/2010 5:31:40 PM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
4/2/2010 5:31:40 PM -- Performance logging begins (interval: 15000 ms).
4/2/2010 5:31:40 PM -- Attaining prerequisites:
4/2/2010 5:32:43 PM -- \MSExchange Database(Jetstresswin)\Database Cache Size, Last: 727752700.0 (lower bound: 724775700.0, upper bound: none)
4/2/2010 7:32:43 PM -- Performance logging ends.
4/2/2010 7:42:26 PM -- JetInterop batch transaction stats: 64223, 64452 and 64869.
4/2/2010 7:42:27 PM -- Dispatching transactions ends.

```

4/2/2010 7:42:27 PM -- Shutting down databases ...
 4/2/2010 7:42:30 PM -- Instance2364.1 (complete), Instance2364.2 (complete) and Instance2364.3 (complete)
 4/2/2010 7:42:31 PM -- Performance logging begins (interval: 30000 ms).
 4/2/2010 7:42:31 PM -- Verifying database checksums ...
 4/3/2010 5:25:21 AM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100% processed) and C:\asgluns\sg3 (100% processed)
 4/3/2010 5:25:21 AM -- Performance logging ends.
 4/3/2010 5:25:21 AM -- C:\1GB MBox\Perf Test\DBChecksum_2010_4_2_19_42_30.blg has 1165 samples.
 4/3/2010 5:25:24 AM -- C:\1GB MBox\Perf Test\DBChecksum_2010_4_2_19_42_30.html is saved.
 4/3/2010 5:25:24 AM -- Verifying log checksums ...
 4/3/2010 5:25:25 AM -- C:\alogluns\log1 (12 log(s) processed), C:\alogluns\log2 (11 log(s) processed) and C:\alogluns\log3 (12 log(s) processed)
 4/3/2010 5:25:25 AM -- C:\1GB MBox\Perf Test\Performance_2010_4_2_17_31_35.blg has 483 samples.
 4/3/2010 5:25:25 AM -- Creating test report ...
 4/3/2010 5:25:27 AM -- Instance2364.1 has 7.6 for I/O Database Reads Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.1 has 1.0 for I/O Log Writes Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.1 has 1.0 for I/O Log Reads Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.2 has 7.2 for I/O Database Reads Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.2 has 1.1 for I/O Log Writes Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.2 has 1.1 for I/O Log Reads Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.3 has 7.2 for I/O Database Reads Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.3 has 1.0 for I/O Log Writes Average Latency.
 4/3/2010 5:25:27 AM -- Instance2364.3 has 1.0 for I/O Log Reads Average Latency.
 4/3/2010 5:25:27 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.
 4/3/2010 5:25:27 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
 4/3/2010 5:25:27 AM -- C:\1GB MBox\Perf Test\Performance_2010_4_2_17_31_35.xml has 478 samples queried.

Performance Test Database Checksums Result: SUN158

Checksum Statistics - All

Database	Seen pages	Bad pages	Correctable pages	Wrong page-number pages	File length / seconds taken
C:\asgluns\sg1\Jetstress001001.edb	47016546	0	0	0	1469267 MBytes / 34969 sec
C:\asgluns\sg2\Jetstress002001.edb	47016802	0	0	0	1469275 MBytes / 29788 sec
C:\asgluns\sg3\Jetstress003001.edb	47016802	0	0	0	1469275 MBytes / 34418 sec
(Sum)	141050150	0	0	0	4407817 MBytes / 34969 sec

Disk Subsystem Performance of Checksum

Logical Disk	Avg. Disk sec/Read	Avg. Disk sec/Write	Disk Reads/sec	Disk Writes/sec	Avg. Disk Bytes/Read
C:\asgluns\sg1	0.091	0.000	672.161	0.000	65536.000
C:\asgluns\sg2	0.085	0.000	789.029	0.000	65536.000
C:\asgluns\sg3	0.088	0.000	682.366	0.000	65536.000

Memory System Performance of Checksum

Counter	Average	Minimum	Maximum
% Processor Time	0.727	0.000	3.807
Available MBytes	30828.820	30813.000	30845.000
Free System Page Table Entries	33555643.041	33555643.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	70529140.024	70410240.000	70717440.000
Pool Paged Bytes	90857394.651	90218496.000	92549120.000

Test Log

4/2/2010 5:31:28 PM -- Jetstress testing begins ...
4/2/2010 5:31:28 PM -- Prepare testing begins ...
4/2/2010 5:31:31 PM -- Attaching databases ...
4/2/2010 5:31:31 PM -- Prepare testing ends.
4/2/2010 5:31:31 PM -- Dispatching transactions begins ...
4/2/2010 5:31:32 PM -- Database cache settings: (minimum: 96.0 MB, maximum: 768.0 MB)
4/2/2010 5:31:32 PM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
4/2/2010 5:31:35 PM -- Database read latency thresholds: (average: 20 msec/read, maximum: 100 msec/read).
4/2/2010 5:31:35 PM -- Log write latency thresholds: (average: 10 msec/write, maximum: 100 msec/write).
4/2/2010 5:31:40 PM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
4/2/2010 5:31:40 PM -- Performance logging begins (interval: 15000 ms).
4/2/2010 5:31:40 PM -- Attaining prerequisites:
4/2/2010 5:32:43 PM -- \MSExchange Database(Jetstresswin)\Database Cache Size, Last: 727752700.0 (lower bound: 724775700.0, upper bound: none)
4/2/2010 7:32:43 PM -- Performance logging ends.
4/2/2010 7:42:26 PM -- JetInterop batch transaction stats: 64223, 64452 and 64869.
4/2/2010 7:42:27 PM -- Dispatching transactions ends.
4/2/2010 7:42:27 PM -- Shutting down databases ...
4/2/2010 7:42:30 PM -- Instance2364.1 (complete), Instance2364.2 (complete) and Instance2364.3 (complete)
4/2/2010 7:42:31 PM -- Performance logging begins (interval: 30000 ms).
4/2/2010 7:42:31 PM -- Verifying database checksums ...
4/3/2010 5:25:21 AM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100% processed) and C:\asgluns\sg3 (100% processed)
4/3/2010 5:25:21 AM -- Performance logging ends.
4/3/2010 5:25:21 AM -- C:\1GB MBox\Perf Test\DBChecksum_2010_4_2_19_42_30.blg has 1165 samples.

Stress Test Database Performance Result: SUN158

Test Summary

Overall Test Result	Pass
Machine Name	SUN158
Test Description	
Test Start Time	4/3/2010 6:07:09 AM
Test End Time	4/4/2010 7:39:30 AM
Collection Start Time	4/3/2010 6:08:22 AM
Collection End Time	4/4/2010 6:08:11 AM
Jetstress Version	14.01.0043.000
Ese Version	14.00.0639.019
Operating System	Windows Server 2008 R2 Enterprise (6.1.7600.0)
Performance Log	C:\1GB MBox\Stress Test\Stress_2010_4_3_6_7_16.blg C:\1GB MBox\Stress Test\DBChecksum_2010_4_4_7_39_30.blg

Database Sizing and Throughput

Achieved Transactional I/O per Second	896.784
Target Transactional I/O per Second	516
Initial Database Size (bytes)	4621931315200
Final Database Size (bytes)	4654202290176
Database Files (Count)	3

Jetstress System Parameters

Thread Count	6 (per database)
Minimum Database Cache	96.0 MB
Maximum Database Cache	768.0 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

Instance2716.1	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
Instance2716.2	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
Instance2716.3	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

Transactional I/O Performance

MSExchange Database ==> Instance	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
Instance2716.1	9.464	2.857	188.152	110.760	33062.948	35045.798	0.000	0.869	0.000	87.719	0.000	4814.233
Instance2716.2	8.901	2.118	188.046	110.739	33121.814	35048.971	0.000	0.927	0.000	86.765	0.000	4872.081
Instance2716.3	8.949	2.297	188.196	110.891	33118.148	35051.139	0.000	0.870	0.000	87.315	0.000	4848.883

Background Database Maintenance I/O Performance

MSExchange Database ==> Instances	Database Maintenance IO Reads/sec	Database Maintenance IO Reads Average Bytes
Instance2716.1	29.289	261866.355
Instance2716.2	29.632	261876.373
Instance2716.3	29.585	261864.302

Log Replication I/O Performance

MSExchange Database ==> Instances	I/O Log Reads/sec	I/O Log Reads Average Bytes
Instance2716.1	1.721	232560.784
Instance2716.2	1.724	232562.018
Instance2716.3	1.726	232560.777

Total I/O Performance

MSExchange => Instance	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
Instance2 716.1	9.464	2.857	217.441	110.760	63882.431	35045.798	2.693	0.869	1.721	87.719	232560.784	4814.233
Instance2 716.2	8.901	2.118	217.678	110.739	64261.546	35048.971	2.653	0.927	1.724	86.765	232562.018	4872.081
Instance2 716.3	8.949	2.297	217.782	110.891	64193.172	35051.139	2.572	0.870	1.726	87.315	232560.777	4848.883

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	1.025	0.000	4.692
Available MBytes	30015.317	30002.000	30032.000
Free System Page Table Entries	33555640.412	33555632.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	70324752.195	70254592.000	70426624.000
Pool Paged Bytes	91632152.025	90009600.000	93474816.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

Test Log

```

4/3/2010 6:07:09 AM -- Jetstress testing begins ...
4/3/2010 6:07:09 AM -- Prepare testing begins ...
4/3/2010 6:07:12 AM -- Attaching databases ...
4/3/2010 6:07:12 AM -- Prepare testing ends.
4/3/2010 6:07:12 AM -- Dispatching transactions begins ...
4/3/2010 6:07:13 AM -- Database cache settings: (minimum: 96.0 MB, maximum: 768.0 MB)
4/3/2010 6:07:13 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
4/3/2010 6:07:16 AM -- Database read latency thresholds: (average: 20 msec/read, maximum: 200 msec/read).
4/3/2010 6:07:16 AM -- Log write latency thresholds: (average: 10 msec/write, maximum: 200 msec/write).
4/3/2010 6:07:21 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
4/3/2010 6:07:21 AM -- Performance logging begins (interval: 15000 ms).
4/3/2010 6:07:21 AM -- Attaining prerequisites:
4/3/2010 6:08:22 AM -- \MSExchange Database(Jetstresswin)\Database Cache Size, Last: 727437300.0 (lower bound: 724775700.0, upper bound: none)
4/4/2010 6:08:22 AM -- Performance logging ends.
4/4/2010 7:39:28 AM -- JetInterop batch transaction stats: 764772, 765398 and 765942.

```

4/4/2010 7:39:28 AM -- Dispatching transactions ends.
 4/4/2010 7:39:28 AM -- Shutting down databases ...
 4/4/2010 7:39:30 AM -- Instance2716.1 (complete), Instance2716.2 (complete) and Instance2716.3 (complete)
 4/4/2010 7:39:32 AM -- Performance logging begins (interval: 30000 ms).
 4/4/2010 7:39:32 AM -- Verifying database checksums ...
 4/4/2010 5:16:25 PM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100% processed) and C:\asgluns\sg3 (100% processed)
 4/4/2010 5:16:25 PM -- Performance logging ends.
 4/4/2010 5:16:25 PM -- C:\1GB MBox\Stress Test\DBChecksum_2010_4_4_7_39_30.blg has 1153 samples.
 4/4/2010 5:16:29 PM -- C:\1GB MBox\Stress Test\DBChecksum_2010_4_4_7_39_30.html is saved.
 4/4/2010 5:16:29 PM -- Verifying log checksums ...
 4/4/2010 5:16:29 PM -- C:\alogluns\log1 (12 log(s) processed), C:\alogluns\log2 (12 log(s) processed) and C:\alogluns\log3 (12 log(s) processed)
 4/4/2010 5:16:29 PM -- C:\1GB MBox\Stress Test\Stress_2010_4_3_6_7_16.blg has 5758 samples.
 4/4/2010 5:16:29 PM -- Creating test report ...
 4/4/2010 5:16:51 PM -- Instance2716.1 has 9.5 for I/O Database Reads Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.1 has 0.9 for I/O Log Writes Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.1 has 0.9 for I/O Log Reads Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.2 has 8.9 for I/O Database Reads Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.2 has 0.9 for I/O Log Writes Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.2 has 0.9 for I/O Log Reads Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.3 has 8.9 for I/O Database Reads Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.3 has 0.9 for I/O Log Writes Average Latency.
 4/4/2010 5:16:51 PM -- Instance2716.3 has 0.9 for I/O Log Reads Average Latency.
 4/4/2010 5:16:51 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.
 4/4/2010 5:16:51 PM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
 4/4/2010 5:16:51 PM -- C:\1GB MBox\Stress Test\Stress_2010_4_3_6_7_16.xml has 5753 samples queried.

Stress Test Database Checksums Result: SUN158

Checksum Statistics - All

Database	Seen pages	Bad pages	Correctable pages	Wrong page-number pages	File length / seconds taken
C:\asgluns\sg1\Jetstress001001.edb	47344226	0	0	0	1479507 MBytes / 34613 sec
C:\asgluns\sg2\Jetstress002001.edb	47345250	0	0	0	1479539 MBytes / 29730 sec
C:\asgluns\sg3\Jetstress003001.edb	47345506	0	0	0	1479547 MBytes / 34369 sec
(Sum)	142034982	0	0	0	4438593 MBytes / 34613 sec

Disk Subsystem Performance of Checksum

Logical Disk	Avg. Disk sec/Read	Avg. Disk sec/Write	Disk Reads/sec	Disk Writes/sec	Avg. Disk Bytes/Read
C:\asgluns\sg1	0.090	0.000	683.708	0.000	65536.000
C:\asgluns\sg2	0.084	0.000	796.185	0.000	65536.000
C:\asgluns\sg3	0.087	0.000	688.653	0.000	65536.000

Memory System Performance of Checksum

Counter	Average	Minimum	Maximum
% Processor Time	0.657	0.000	3.193
Available MBytes	30820.402	30804.000	30835.000
Free System Page Table Entries	33555643.252	33555642.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	70981463.258	70934528.000	71081984.000
Pool Paged Bytes	92445817.672	91480064.000	93167616.000

Test Log

4/3/2010 6:07:09 AM -- Jetstress testing begins ...
4/3/2010 6:07:09 AM -- Prepare testing begins ...
4/3/2010 6:07:12 AM -- Attaching databases ...
4/3/2010 6:07:12 AM -- Prepare testing ends.
4/3/2010 6:07:12 AM -- Dispatching transactions begins ...
4/3/2010 6:07:13 AM -- Database cache settings: (minimum: 96.0 MB, maximum: 768.0 MB)
4/3/2010 6:07:13 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
4/3/2010 6:07:16 AM -- Database read latency thresholds: (average: 20 msec/read, maximum: 200 msec/read).
4/3/2010 6:07:16 AM -- Log write latency thresholds: (average: 10 msec/write, maximum: 200 msec/write).
4/3/2010 6:07:21 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.
4/3/2010 6:07:21 AM -- Performance logging begins (interval: 15000 ms).
4/3/2010 6:07:21 AM -- Attaining prerequisites:
4/3/2010 6:08:22 AM -- \MSExchange Database(Jetstresswin)\Database Cache Size, Last: 727437300.0 (lower bound: 724775700.0, upper bound: none)
4/4/2010 6:08:22 AM -- Performance logging ends.
4/4/2010 7:39:28 AM -- JetInterop batch transaction stats: 764772, 765398 and 765942.
4/4/2010 7:39:28 AM -- Dispatching transactions ends.
4/4/2010 7:39:28 AM -- Shutting down databases ...
4/4/2010 7:39:30 AM -- Instance2716.1 (complete), Instance2716.2 (complete) and Instance2716.3 (complete)
4/4/2010 7:39:32 AM -- Performance logging begins (interval: 30000 ms).
4/4/2010 7:39:32 AM -- Verifying database checksums ...
4/4/2010 5:16:25 PM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100% processed) and C:\asgluns\sg3 (100% processed)
4/4/2010 5:16:25 PM -- Performance logging ends.
4/4/2010 5:16:25 PM -- C:\1GB MBox\Stress Test\DBChecksum_2010_4_4_7_39_30.b1g has 1153 samples.

Database Backup Test Result: SUN158

Database Backup Statistics - All

Database Instance	Database Size (MBytes)	Elapsed Backup Time	MBytes Transferred/sec
Instance3324.1	1479499.09	09:24:58	43.64
Instance3324.2	1479531.09	09:33:01	43.03
Instance3324.3	1479539.09	09:35:42	42.83

Jetstress System Parameters

Thread Count	6 (per database)
Minimum Database Cache	96.0 MB
Maximum Database Cache	768.0 MB
Insert Operations	40%
Delete Operations	20%
Replace Operations	5%
Read Operations	35%
Lazy Commits	70%

Database Configuration

Instance3324.1	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
Instance3324.2	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
Instance3324.3	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

Transactional I/O Performance

MSExchange Database => Instance s	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
Instance3324.1	7.138	0.000	174.568	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3324.2	8.075	0.000	171.869	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3324.3	8.041	0.000	170.753	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	0.492	0.000	2.644
Available MBytes	30851.879	30841.000	30856.000
Free System Page Table Entries	33555643.398	33555643.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	70871253.704	70868992.000	70893568.000
Pool Paged Bytes	94527676.772	93114368.000	95399936.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

Test Log

```

4/4/2010 8:42:33 PM -- Jetstress testing begins ...
4/4/2010 8:42:33 PM -- Prepare testing begins ...
4/4/2010 8:42:37 PM -- Attaching databases ...
4/4/2010 8:42:37 PM -- Prepare testing ends.
4/4/2010 8:42:43 PM -- Performance logging begins (interval: 30000 ms).
4/4/2010 8:42:43 PM -- Backing up databases ...
4/5/2010 6:18:26 AM -- Performance logging ends.
4/5/2010 6:18:26 AM -- Instance3324.1 (100% processed), Instance3324.2 (100%
processed) and Instance3324.3 (100% processed)
4/5/2010 6:18:26 AM -- C:\1GB MBox\Backup\DatabaseBackup_2010_4_4_20_42_37.b1g
has 1150 samples.
4/5/2010 6:18:26 AM -- Creating test report ...

```

Soft Recovery Test Result: SUN158

Soft Recovery Statistics - All

Database Instance	Log files replayed	Elapsed seconds
Instance2832.1	511	617.3866844
Instance2832.2	500	606.5134653
Instance2832.3	500	577.6066146

Database Configuration

Instance2832.1	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
Instance2832.2	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
Instance2832.3	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

Transactional I/O Performance

MSExchange Database Instance	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
Instance2832.1	27.32	15.57	883.64	4.956	36115.949	32123.384	10.55	0.000	7.434	0.000	225793.913	0.000
Instance2832.2	26.06	16.83	912.92	4.949	35915.895	32440.320	9.907	0.000	7.424	0.000	229569.836	0.000
Instance2832.3	27.40	15.27	910.75	5.207	36050.799	32424.280	11.21	0.002	7.819	0.021	228269.032	1.790

Background Database Maintenance I/O Performance

MSExchange Database Instances	Database Maintenance IO Reads/sec	Database Maintenance IO Reads Average Bytes
Instance2832.1	25.650	261704.729
Instance2832.2	25.975	261979.634
Instance2832.3	25.733	261866.799

Total I/O Performance

MSExchange => Instance	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
Instance2 832.1	27.32	15.57	909.29	4.956	42479.587	32123.384	10.55	0.000	7.434	0.000	225793.913	0.000
Instance2 832.2	26.06	16.83	938.90	4.949	42170.053	32440.320	9.907	0.000	7.424	0.000	229569.836	0.000
Instance2 832.3	27.40	15.27	936.48	5.207	42255.850	32424.280	11.21	0.002	7.819	0.021	228269.032	1.790

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	4.871	0.000	37.887
Available MBytes	30068.474	30046.000	30785.000
Free System Page Table Entries	33555644.971	33555637.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	74934927.895	71168000.000	75415552.000
Pool Paged Bytes	94267873.882	94244864.000	94289920.000
Database Page Fault Stalls/sec	0.005	0.000	0.497

Test Log

```

4/5/2010 11:06:00 AM -- Jetstress testing begins ...
4/5/2010 11:06:00 AM -- Prepare testing begins ...
4/5/2010 11:06:03 AM -- Attaching databases ...
4/5/2010 11:06:03 AM -- Prepare testing ends.
4/5/2010 11:06:03 AM -- Dispatching transactions begins ...
4/5/2010 11:06:03 AM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
4/5/2010 11:06:03 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
4/5/2010 11:06:06 AM -- Database read latency thresholds: (average: 20 msec/read,
maximum: 100 msec/read).
4/5/2010 11:06:06 AM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 100 msec/write).
4/5/2010 11:06:10 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
4/5/2010 11:06:10 AM -- Performance logging begins (interval: 15000 ms).
4/5/2010 11:06:10 AM -- Generating log files ...
4/5/2010 11:48:18 AM -- C:\alogluns\log1 (102.4% generated), C:\alogluns\log2
(100.2% generated) and C:\alogluns\log3 (100.2% generated)
4/5/2010 11:48:18 AM -- Performance logging ends.

```

4/5/2010 11:48:18 AM -- JetInterop batch transaction stats: 22181, 22158 and 21912.
 4/5/2010 11:48:18 AM -- Dispatching transactions ends.
 4/5/2010 11:48:18 AM -- Shutting down databases ...
 4/5/2010 11:48:19 AM -- Instance2832.1 (complete), Instance2832.2 (complete) and Instance2832.3 (complete)
 4/5/2010 11:48:19 AM -- C:\1GB MBox\Soft Recovery\Performance_2010_4_5_11_6_6.blg has 168 samples.
 4/5/2010 11:48:19 AM -- Creating test report ...
 4/5/2010 11:48:20 AM -- Instance2832.1 has 7.5 for I/O Database Reads Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.1 has 0.8 for I/O Log Writes Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.1 has 0.8 for I/O Log Reads Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.2 has 6.9 for I/O Database Reads Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.2 has 0.9 for I/O Log Writes Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.2 has 0.9 for I/O Log Reads Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.3 has 7.1 for I/O Database Reads Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.3 has 0.8 for I/O Log Writes Average Latency.
 4/5/2010 11:48:20 AM -- Instance2832.3 has 0.8 for I/O Log Reads Average Latency.
 4/5/2010 11:48:20 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.
 4/5/2010 11:48:20 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
 4/5/2010 11:48:20 AM -- C:\1GB MBox\Soft Recovery\Performance_2010_4_5_11_6_6.xml has 167 samples queried.
 4/5/2010 11:48:20 AM -- C:\1GB MBox\Soft Recovery\Performance_2010_4_5_11_6_6.html is saved.
 4/5/2010 12:45:12 PM -- Performance logging begins (interval: 2000 ms).
 4/5/2010 12:45:12 PM -- Recovering databases ...
 4/5/2010 12:55:30 PM -- Performance logging ends.
 4/5/2010 12:55:30 PM -- Instance2832.1 (617.3866844), Instance2832.2 (606.5134653) and Instance2832.3 (577.6066146)
 4/5/2010 12:55:30 PM -- C:\1GB MBox\Soft Recovery\SoftRecovery_2010_4_5_12_45_9.blg has 306 samples.
 4/5/2010 12:55:30 PM -- Creating test report ...

Soft Recovery Test Performance Result: SUN158

Test Summary

Overall Test Result	Pass
Machine Name	SUN158
Test Description	
Test Start Time	4/5/2010 11:06:00 AM
Test End Time	4/5/2010 11:48:19 AM
Collection Start Time	4/5/2010 11:06:25 AM
Collection End Time	4/5/2010 11:48:11 AM
Jetstress Version	14.01.0043.000
Ese Version	14.00.0639.019
Operating System	Windows Server 2008 R2 Enterprise (6.1.7600.0)
Performance Log	C:\1GB MBox\Soft Recovery\Performance_2010_4_5_11_6_6.blg

Database Sizing and Throughput

Achieved Transactional I/O per Second	1300.717
Capacity Percentage	100%
Throughput Percentage	100%
Initial Database Size (bytes)	4654202290176
Final Database Size (bytes)	4655125037056
Database Files (Count)	3

Jetstress System Parameters

Thread Count	6 (per database)
Minimum Database Cache	96.0 MB
Maximum Database Cache	768.0 MB
Insert Operations	40%
Delete Operations	20%
Replace Operations	5%
Read Operations	35%
Lazy Commits	70%

Database Configuration

Instance2832.1	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
Instance2832.2	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
Instance2832.3	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

Transactional I/O Performance

MSEXchange Database => Instance s	I/O Database Read s Average Latency (msec)	I/O Database Write s Average Latency (msec)	I/O Database Reads /sec	I/O Database Writes /sec	I/O Database Average Reads Bytes	I/O Database Average Writes 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
Instance2 832.1	7.512	4.121	267.675	171.487	32790.710	34306.497	0.000	0.774	0.000	97.258	0.000	4571.710
Instance2 832.2	6.917	2.697	264.974	169.152	32787.114	34255.817	0.000	0.948	0.000	93.375	0.000	4655.405
Instance2 832.3	7.094	2.902	260.905	166.525	32788.404	34319.429	0.000	0.780	0.000	94.525	0.000	4605.879

Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	1.209	0.000	3.865
Available MBytes	30079.101	30063.000	30615.000
Free System Page Table Entries	33555644.488	33555643.000	33555645.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	71291099.429	70860800.000	71446528.000
Pool Paged Bytes	94126787.048	94019584.000	94208000.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

Test Log

```

4/5/2010 11:06:00 AM -- Jetstress testing begins ...
4/5/2010 11:06:00 AM -- Prepare testing begins ...
4/5/2010 11:06:03 AM -- Attaching databases ...
4/5/2010 11:06:03 AM -- Prepare testing ends.
4/5/2010 11:06:03 AM -- Dispatching transactions begins ...
4/5/2010 11:06:03 AM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
4/5/2010 11:06:03 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
4/5/2010 11:06:06 AM -- Database read latency thresholds: (average: 20 msec/read,
maximum: 100 msec/read).
4/5/2010 11:06:06 AM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 100 msec/write).
4/5/2010 11:06:10 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
4/5/2010 11:06:10 AM -- Performance logging begins (interval: 15000 ms).
4/5/2010 11:06:10 AM -- Generating log files ...
4/5/2010 11:48:18 AM -- C:\alogluns\log1 (102.4% generated), C:\alogluns\log2
(100.2% generated) and C:\alogluns\log3 (100.2% generated)
4/5/2010 11:48:18 AM -- Performance logging ends.
4/5/2010 11:48:18 AM -- JetInterop batch transaction stats: 22181, 22158 and
21912.

```

4/5/2010 11:48:18 AM -- Dispatching transactions ends.
4/5/2010 11:48:18 AM -- Shutting down databases ...
4/5/2010 11:48:19 AM -- Instance2832.1 (complete), Instance2832.2 (complete) and Instance2832.3 (complete)
4/5/2010 11:48:19 AM -- C:\1GB MBox\Soft Recovery\Performance_2010_4_5_11_6_6.blg has 168 samples.
4/5/2010 11:48:19 AM -- Creating test report ...
4/5/2010 11:48:20 AM -- Instance2832.1 has 7.5 for I/O Database Reads Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.1 has 0.8 for I/O Log Writes Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.1 has 0.8 for I/O Log Reads Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.2 has 6.9 for I/O Database Reads Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.2 has 0.9 for I/O Log Writes Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.2 has 0.9 for I/O Log Reads Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.3 has 7.1 for I/O Database Reads Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.3 has 0.8 for I/O Log writes Average Latency.
4/5/2010 11:48:20 AM -- Instance2832.3 has 0.8 for I/O Log Reads Average Latency.
4/5/2010 11:48:20 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.
4/5/2010 11:48:20 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.
4/5/2010 11:48:20 AM -- C:\1GB MBox\Soft Recovery\Performance_2010_4_5_11_6_6.xml has 167 samples queried.



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