

# Hitachi Adaptable Modular Storage 2100 Dynamically Provisioned 17,200 User Exchange 2010 Resiliency Storage Solution

Tested with: ESRP – Storage Version 3.0

Test Date: March 2010

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## Overview

This document provides information on a Hitachi Adaptable Modular Storage 2100 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 17,200 users and four servers. This testing used the Hitachi Adaptable Modular Storage 2100 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 2100.

This solution includes Exchange 2010 Mailbox Resiliency by using the new Database Availability Group (DAG) feature. This tested configuration uses four DAGs, each containing two database copies and two servers. The test configuration was capable of supporting 17,200 users with a 0.12 IOPS per user profile and user mailbox size of 1GB. A 2100 with 120 450GB 15K RPM SAS disks, 8GB of cache and 4Gbit/s paths was used for these tests. Testing used four Sun Fire 4270 servers with 32GB of RAM, two quad-core Intel E5540 2.53GHz CPUs, eight Emulex 4Gbit/s Fibre Channel adapters, and Windows Server 2008 R2 Enterprise.

The Hitachi Adaptable Modular Storage 2100 is a medium-sized, high-performance, highly reliable midrange storage system that can scale to 120 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 2100 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 uses the 2100 to meet the needs of a large Exchange Server deployment.

This solution uses Hitachi Dynamic Provisioning software, which is enabled on the 2100 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 2100 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 2100. 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 is 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 is 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 make up 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.

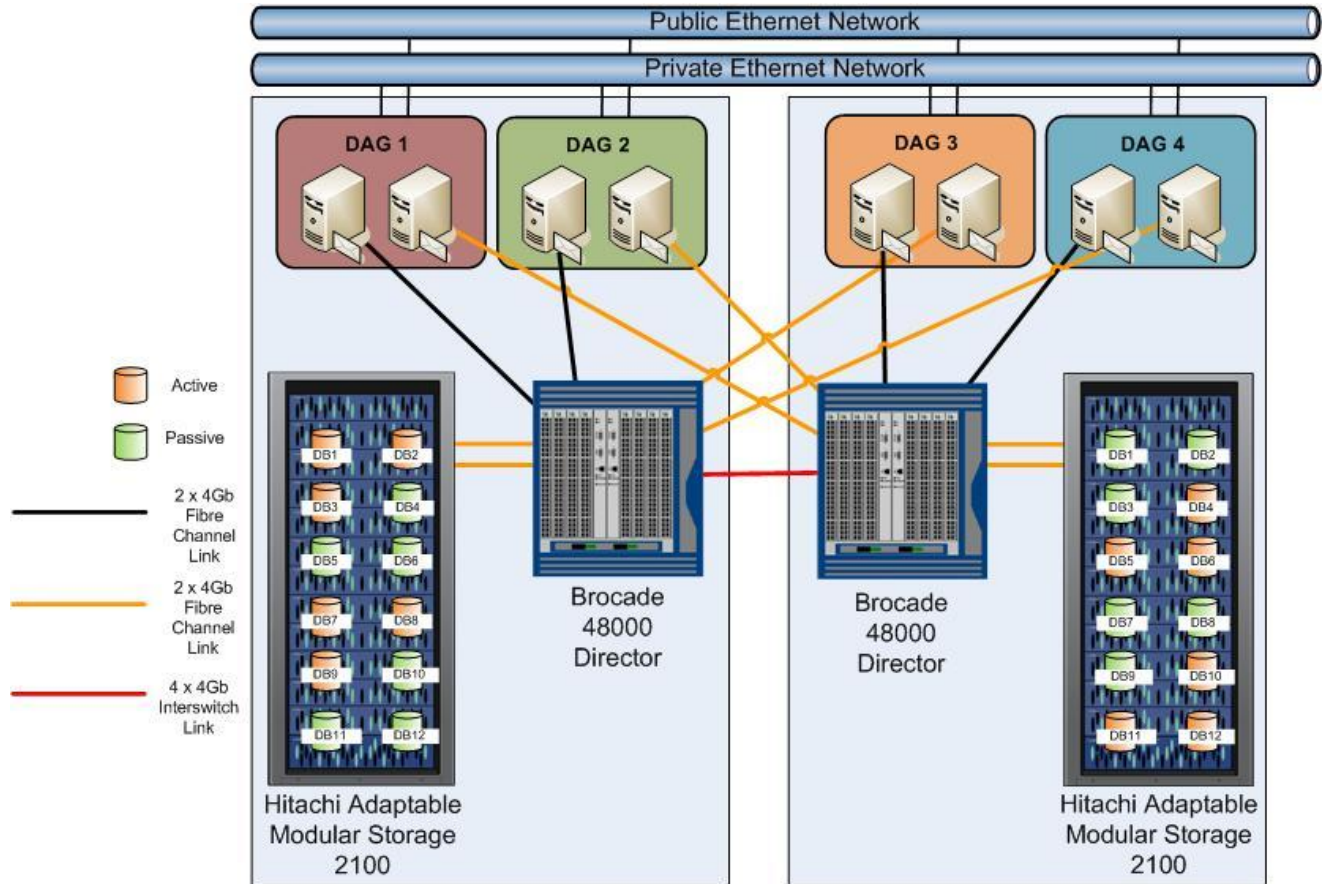
Any server in a DAG can host a copy of a mailbox database from any other server in the DAG. When a server is added to a DAG, it monitors and works with the other servers in the DAG to provide automatic recovery delivering a robust, highly available Exchange solution without the administrative complexities of traditional failover clustering. For more 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 four DAGs, each configured with two servers that host active mailboxes in three databases. To target the 17,200-user resiliency solution, a Hitachi Adaptable Modular Storage 2100 configured with 120 disks (the maximum) and four servers, each configured with 4,300 mailboxes, were used to host the 12 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 2100 and the passive copy on another server connected to a second 2100. 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 2100s. 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 recommended DAG configuration that was simulated.

**Figure 1. Recommended Database Availability Group Configuration**

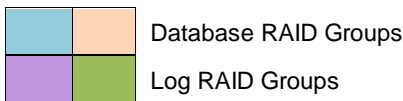


This solution enables organizations to consolidate Exchange Server 2010 DAG deployments on two 2100 storage systems. Using identical hardware and software configurations guarantees that an active database and its replicated copy do not share storage paths, disk spindles or storage controllers, making 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 2100'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 2100 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 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 27 RAID-1+0 RAID groups and the log pool was created from three RAID-1+0 groups. From the database pool, 12 DP-VOLs (each specified to have a 1,750GB size limit) were created for 12 databases (three per server). From the log pool, 12 DP-VOLs (each specified to have a size limit of 175GB) were created for 12 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 2100 Port to Server Layout**

<i>Server</i>	<i>Primary Path</i>	<i>Secondary Path</i>
SUN149	0A	1A
SUN150	0B	1B
SUN151	1A	0A
SUN152	1B	0B

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 2100 Port to Database DP-VOL Layout**

<i>Port</i>	<i>Database</i>	<i>DP-VOL</i>
0A	1-3	0-2
0B	4-6	3-5
1A	7-9	6-8
1B	10-12	9-11

Table 4 outlines the port layout with the log 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 2100 Port to Log DP-VOL Layout**

<i>Port</i>	<i>Log</i>	<i>DP-VOL</i>
0A	1-3	12-14
0B	4-6	15-17
1A	7-9	18-20
1B	10-12	21-23

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 databases and Dynamic Provisioning pool 1 is dedicated for the logs.

**Table 5. Adaptable Modular Storage 2100 Configuration Details**

<i>Host</i>	<i>Pool</i>	<i>Port</i>	<i>DP-VOL</i>	<i>Size (GB)</i>	<i>Description</i>
Sun149	0	0A/1A	0-2	1750	Databases 1-3
Sun150	0	0B/1B	3-5	1750	Databases 4-6
Sun151	0	1A/0A	6-8	1750	Databases 7-9
Sun152	0	1B/0B	9-11	1750	Databases 10-12
Sun149	1	0A/1A	12-14	175	Logs 1-3
Sun150	1	0B/1B	15-17	175	Logs 4-6
Sun151	1	1A/0A	18-20	175	Logs 7-9
Sun152	1	1B/0B	21-23	175	Logs 10-12

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 17,200 Exchange users with the following specifications:

- Eight Exchange servers (four tested, simulating eight for the database copies)
- Two Adaptable Modular Storage 2100s (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>	17,200
<i>Number of database availability groups (DAGs)</i>	4
<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>	17,200GB
<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 2100 Firmware: 0872/B-S WHQL listing: <a href="#">Hitachi Adaptable Modular Storage 2100</a>
<i>Storage cache</i>	8GB
<i>Number of storage controllers</i>	2
<i>Number of storage ports</i>	4
<i>Maximum bandwidth of storage connectivity to host</i>	16Gb/s (4 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>	120
<i>Maximum number of spindles can be hosted in the storage</i>	120

**Table 8. Primary Storage Software**

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

**Table 9. Primary Storage Disk Configuration (Mailbox Store Disks)**

<b>Disk type, speed and firmware revision</b>	SAS Disk 450GB 15K 4C57
<b>Raw capacity per disk (GB)</b>	450GB
<b>Number of physical disks in test</b>	108 (Dynamic Provisioning pool)
<b>Total raw storage capacity (GB)</b>	48,600GB
<b>Disk slice size (GB)</b>	N/A
<b>Number of slices per LUN or number of disks per LUN</b>	N/A
<b>RAID level</b>	RAID 1+0 (2+2) at storage level
<b>Total formatted capacity</b>	21,546GB (Dynamic Provisioning database pool)
<b>Storage capacity utilization</b>	44.3%
<b>Database capacity utilization</b>	43.2%

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

<b>Disk type, speed and firmware revision</b>	SAS Disk 450GB 15K 4C57
<b>Raw capacity per disk (GB)</b>	450GB
<b>Number of spindles in test</b>	12 (Dynamic Provisioning pool)
<b>Total raw storage capacity (GB)</b>	5,400GB
<b>Disk slice size (GB)</b>	N/A
<b>Number of slices per LU or number of disks per LU</b>	N/A
<b>RAID level</b>	RAID 1+0 (2+2) at storage level
<b>Total formatted capacity</b>	2,394GB (Dynamic Provisioning log pool)

# Replication Configuration

The following tables summarize the replication environment.

**Table 11. Replicated Configuration**

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

**Table 12. Replicated Storage Hardware**

<b>Storage connectivity (Fibre Channel, SAS, SATA, iSCSI)</b>	Fibre Channel
<b>Storage model and OS/firmware revision</b>	1 Hitachi Adaptable Modular Storage 2100 Firmware: 0872/B-S WHQL listing: <a href="#">Hitachi Adaptable Modular Storage 2100</a>
<b>Storage cache</b>	8GB
<b>Number of storage controllers</b>	2
<b>Number of storage ports</b>	4
<b>Maximum bandwidth of storage connectivity to host</b>	16Gb/s (4 x 4Gbit/s ports)
<b>Switch type/model/firmware revision</b>	Brocade 5320, Fabric OS v6.3.0b
<b>HBA model and firmware</b>	Emulex LPe11002, FW:2.82A3
<b>Number of HBAs per host</b>	2 dual-ported HBA per host, 1 4Gbit/s port used per HBA
<b>Host server type</b>	Sun Fire 4270 2 2.54GHz quad-core Intel Xeon CPUs, 32GB memory
<b>Total number of disks tested in solution</b>	120
<b>Maximum number of spindles can be hosted in the storage</b>	120

**Table 13. Replicated Storage Software**

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

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

<b>Disk type, speed and firmware revision</b>	SAS Disk 450GB 15K 4C57
<b>Raw capacity per disk (GB)</b>	450GB
<b>Number of physical disks in test</b>	108 (Dynamic Provisioning pool)
<b>Total raw storage capacity (GB)</b>	48,600GB
<b>Disk slice size (GB)</b>	N/A
<b>Number of slices per LUN or number of disks per LUN</b>	N/A
<b>RAID level</b>	RAID 1+0 (2+2) at storage level
<b>Total formatted capacity</b>	21,546GB (Dynamic Provisioning database pool)
<b>Storage capacity utilization</b>	44.3%
<b>Database capacity utilization</b>	43.2%

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

<b>Disk type, speed and firmware revision</b>	SAS Disk 450GB 15K 4C57
<b>Raw capacity per disk (GB)</b>	450GB
<b>Number of spindles in test</b>	12 (Dynamic Provisioning pool)
<b>Total raw storage capacity (GB)</b>	5,400GB
<b>Disk slice size (GB)</b>	N/A
<b>Number of slices per LU or number of disks per LU</b>	N/A
<b>RAID level</b>	RAID 1+0 (2+2) at storage level
<b>Total formatted capacity</b>	2,394GB (Dynamic Provisioning log pool)

## 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 2100 running Exchange 2010.

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

### Storage – Mailbox Resiliency

1. When formatting a newly partitioned LU, Hitachi Data Systems recommends setting the ALU to 64K and 4K respectively for the database and log files.
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. LU concatenation is not recommended.
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 2100.
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 16. Individual Server Metrics for Exchange Server (SUN149)**

Database I/O	
<i>Database disk transfers per second</i>	1497
<i>Database disk reads per second</i>	935
<i>Database disk writes per second</i>	562
<i>Average database disk read latency (ms)</i>	6.1
<i>Average database disk write latency (ms)</i>	2.2
Transaction Log I/O	
<i>Log disk writes per second</i>	328
<i>Average log disk write latency (ms)</i>	0.6

**Table 17. Individual Server Metrics for Exchange Server (SUN150)**

Database I/O	
<i>Database disk transfers per second</i>	1501
<i>Database disk reads per second</i>	938
<i>Database disk writes per second</i>	563
<i>Average database disk read latency (ms)</i>	6.1
<i>Average database disk write latency (ms)</i>	2.2
Transaction Log I/O	
<i>Log disk writes per second</i>	330
<i>Average log disk write latency (ms)</i>	0.6

**Table 18. Individual Server Metrics for Exchange Server (SUN151)**

<b>Database I/O</b>	
<i>Database disk transfers per second</i>	1497
<i>Database disk reads per second</i>	935
<i>Database disk writes per second</i>	562
<i>Average database disk read latency (ms)</i>	6.1
<i>Average database disk write latency (ms)</i>	2.2
<b>Transaction Log I/O</b>	
<i>Log disk writes per second</i>	329
<i>Average log disk write latency (ms)</i>	0.6

**Table 19. Individual Server Metrics for Exchange Server (SUN152)**

<b>Database I/O</b>	
<i>Database disk transfers per second</i>	1513
<i>Database disk reads per second</i>	946
<i>Database disk writes per second</i>	567
<i>Average database disk read latency (ms)</i>	6.1
<i>Average database disk write latency (ms)</i>	2.2
<b>Transaction Log I/O</b>	
<i>Log disk writes per second</i>	330
<i>Average log disk write latency (ms)</i>	0.6

### *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 20. Aggregate Performance for Exchange Server 2010**

<b>Database I/O</b>	
<i>Database disk transfers per second</i>	6008
<i>Database disk reads per second</i>	3754
<i>Database disk writes per second</i>	2254
<i>Average database disk read latency (ms)</i>	6.1
<i>Average database disk write latency (ms)</i>	2.2
<b>Transaction Log I/O</b>	
<i>Log disk writes per second</i>	1317
<i>Average log disk write latency (ms)</i>	0.6

## 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 21. Database Read-only Performance**

<i>MB read per second per database</i>	74
<i>MB read per second total per server</i>	222

### *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 was 1MB in size.

**Table 22. Transaction Log Recovery/Replay Performance**

<i>Average time to play one log file (sec)</i>	0.81
--	------

## Conclusion

This document details a tested and robust Exchange Server 2010 Resiliency solution capable of supporting 17,200 users with a 0.12 IOPS per user profile and user mailbox size of 1GB using four DAG's each configured with 2 server nodes. A Hitachi Adaptable Modular Storage 2100, with 8GB of cache and four 4Gbit/s Fibre Channel host paths, using Hitachi Dynamic Provisioning (with two Pools) and 120 450GB 15K RPM SAS disks in a RAID-1+0 configuration was used for these tests. Testing confirmed that the 2100 is more than capable of delivering the IOPS and capacity requirements needed to support the active and replicated databases for 17,200 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 additional protection requirements may affect performance and capacity requirements of the underlying storage configuration, and as such need to be factored into the storage design accordingly.

For more information to 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: 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: SUN149

#### Test Summary

---

<b>Overall Test Result</b>	Pass
<b>Machine Name</b>	SUN149
<b>Test Description</b>	
<b>Test Start Time</b>	3/28/2010 9:29:10 AM
<b>Test End Time</b>	3/28/2010 11:44:13 AM
<b>Collection Start Time</b>	3/28/2010 9:30:16 AM
<b>Collection End Time</b>	3/28/2010 11:30:11 AM
<b>Jetstress Version</b>	14.01.0043.000
<b>Ese Version</b>	14.00.0639.019
<b>Operating System</b>	Windows Server 2008 R2 Enterprise (6.1.7600.0)
<b>Performance Log</b>	C:\ESRP 3.0_1GBMBox_12 IOPS\Performance Test\SS2_th6\with checksum on\Performance_2010_3_28_9_29_16.blg C:\ESRP 3.0_1GBMBox_12 IOPS\Performance Test\SS2_th6\with checksum on\DBChecksum_2010_3_28_11_44_13.blg

---

#### Database Sizing and Throughput

---

<b>Achieved Transactional I/O per Second</b>	1497.341
<b>Target Transactional I/O per Second</b>	516
<b>Initial Database Size (bytes)</b>	4621285392384
<b>Final Database Size (bytes)</b>	4624540172288
<b>Database Files (Count)</b>	3

---

## Jetstress System Parameters

<b>Thread Count</b>	6 (per database)
<b>Minimum Database Cache</b>	96.0 MB
<b>Maximum Database Cache</b>	768.0 MB
<b>Insert Operations</b>	40%
<b>Delete Operations</b>	20%
<b>Replace Operations</b>	5%
<b>Read Operations</b>	35%
<b>Lazy Commits</b>	70%
<b>Run Background Database Maintenance</b>	True
<b>Number of Copies per Database</b>	2

## Database Configuration

<b>Instance3520.1</b>	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
<b>Instance3520.2</b>	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
<b>Instance3520.3</b>	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

## Transactional I/O Performance

<b>MSExchange Database ==&gt; Instance</b>	<b>I/O Database Reads Average Latency (msec)</b>	<b>I/O Database Writes Average Latency (msec)</b>	<b>I/O Database Reads /sec</b>	<b>I/O Database Writes /sec</b>	<b>I/O Database Reads Average Bytes</b>	<b>I/O Database Writes Average Bytes</b>	<b>I/O Log Reads /sec</b>	<b>I/O Log Writes /sec</b>	<b>I/O Log Reads /sec</b>	<b>I/O Log Writes /sec</b>	<b>I/O Log Reads Average Bytes</b>	<b>I/O Log Writes Average Bytes</b>
Instance3520.1	6.461	2.618	310.301	186.343	33058.701	34698.596	0.000	0.597	0.000	109.354	0.000	4483.140
Instance3520.2	5.970	1.935	312.642	187.925	33112.516	34667.960	0.000	0.632	0.000	109.350	0.000	4471.868
Instance3520.3	6.002	1.909	312.377	187.752	33075.879	34669.936	0.000	0.598	0.000	109.648	0.000	4480.190

## Background Database Maintenance I/O Performance

<b>MSExchange Database ==&gt; Instances</b>	<b>Database Maintenance IO Reads/sec</b>	<b>Database Maintenance IO Reads Average Bytes</b>
Instance3520.1	30.496	261925.676
Instance3520.2	31.622	261899.341
Instance3520.3	31.531	261894.612

### Log Replication I/O Performance

MSExchange Database ==> Instances	I/O Log Reads/sec	I/O Log Reads Average Bytes
Instance3520.1	1.993	232562.361
Instance3520.2	1.985	232560.707
Instance3520.3	1.995	232567.442

### Total I/O Performance

MSExchange Database ==> Instance s	I/O Database Read Average Latency (msec)	I/O Database Write 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
Instance3520.1	6.461	2.618	340.797	186.343	53538.409	34698.596	1.599	0.597	1.993	109.354	232562.361	4483.140
Instance3520.2	5.970	1.935	344.264	187.925	54127.196	34667.960	1.631	0.632	1.985	109.350	232560.707	4471.868
Instance3520.3	6.002	1.909	343.908	187.752	54054.819	34669.936	1.637	0.598	1.995	109.648	232567.442	4480.190

### Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	1.290	0.000	3.978
Available MBytes	29720.079	29709.000	29756.000
Free System Page Table Entries	33555130.996	33555130.000	33555131.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	73673523.200	73351168.000	73773056.000
Pool Paged Bytes	119231701.333	118398976.000	122769408.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

### Test Log

```

3/28/2010 9:29:10 AM -- Jetstress testing begins ...
3/28/2010 9:29:10 AM -- Prepare testing begins ...
3/28/2010 9:29:13 AM -- Attaching databases ...
3/28/2010 9:29:13 AM -- Prepare testing ends.
3/28/2010 9:29:13 AM -- Dispatching transactions begins ...
3/28/2010 9:29:13 AM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
3/28/2010 9:29:13 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
3/28/2010 9:29:16 AM -- Database read latency thresholds: (average: 20 msec/read,
maximum: 100 msec/read).
3/28/2010 9:29:16 AM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 100 msec/write).

```

3/28/2010 9:29:21 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%, Replaces 5%, Reads 35%, Lazy Commits 70%.  
3/28/2010 9:29:21 AM -- Performance logging begins (interval: 15000 ms).  
3/28/2010 9:29:21 AM -- Attaining prerequisites:  
3/28/2010 9:30:16 AM -- \MSExchange Database(Jetstresswin)\Database Cache Size, Last: 729030700.0 (lower bound: 724775700.0, upper bound: none)  
3/28/2010 11:30:16 AM -- Performance logging ends.  
3/28/2010 11:44:11 AM -- JetInterop batch transaction stats: 77515, 77495 and 77547.  
3/28/2010 11:44:12 AM -- Dispatching transactions ends.  
3/28/2010 11:44:12 AM -- Shutting down databases ...  
3/28/2010 11:44:13 AM -- Instance3520.1 (complete), Instance3520.2 (complete) and Instance3520.3 (complete)  
3/28/2010 11:44:15 AM -- Performance logging begins (interval: 30000 ms).  
3/28/2010 11:44:15 AM -- Verifying database checksums ...  
3/28/2010 7:16:48 PM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100% processed) and C:\asgluns\sg3 (100% processed)  
3/28/2010 7:16:48 PM -- Performance logging ends.  
3/28/2010 7:16:48 PM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Performance Test\SS2\_th6\with checksum on\DBChecksum\_2010\_3\_28\_11\_44\_13.blg has 904 samples.  
3/28/2010 7:16:51 PM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Performance Test\SS2\_th6\with checksum on\DBChecksum\_2010\_3\_28\_11\_44\_13.html is saved.  
3/28/2010 7:16:51 PM -- Verifying log checksums ...  
3/28/2010 7:16:51 PM -- C:\alogluns\log1 (13 log(s) processed), C:\alogluns\log2 (16 log(s) processed) and C:\alogluns\log3 (14 log(s) processed)  
3/28/2010 7:16:51 PM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Performance Test\SS2\_th6\with checksum on\Performance\_2010\_3\_28\_9\_29\_16.blg has 483 samples.  
3/28/2010 7:16:51 PM -- Creating test report ...  
3/28/2010 7:16:53 PM -- Instance3520.1 has 6.5 for I/O Database Reads Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.1 has 0.6 for I/O Log Writes Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.1 has 0.6 for I/O Log Reads Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.2 has 6.0 for I/O Database Reads Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.2 has 0.6 for I/O Log Writes Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.2 has 0.6 for I/O Log Reads Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.3 has 6.0 for I/O Database Reads Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.3 has 0.6 for I/O Log Writes Average Latency.  
3/28/2010 7:16:53 PM -- Instance3520.3 has 0.6 for I/O Log Reads Average Latency.  
3/28/2010 7:16:53 PM -- Test has 0 Maximum Database Page Fault Stalls/sec.  
3/28/2010 7:16:53 PM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.  
3/28/2010 7:16:53 PM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Performance Test\SS2\_th6\with checksum on\Performance\_2010\_3\_28\_9\_29\_16.xml has 479 samples queried.

## Performance Test Database Checksums Result: SUN149

### Checksum Statistics - All

Database	Seen pages	Bad pages	Correctable pages	Wrong page-number pages	File length / seconds taken
C:\asgluns\sg1\Jetstress001001.edb	47043170	0	0	0	1470099 MBytes / 27153 sec
C:\asgluns\sg2\Jetstress002001.edb	47043426	0	0	0	1470107 MBytes / 16881 sec
C:\asgluns\sg3\Jetstress003001.edb	47043170	0	0	0	1470099 MBytes / 19183 sec
(Sum)	141129766	0	0	0	4410305 MBytes / 27153 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	866.211	0.000	65535.997
C:\asgluns\sg2	0.061	0.000	1393.274	0.000	65536.000
C:\asgluns\sg3	0.063	0.000	1226.157	0.000	65536.000

### Memory System Performance of Checksum

Counter	Average	Minimum	Maximum
% Processor Time	0.963	0.000	3.680
Available MBytes	30517.765	30508.000	30526.000
Free System Page Table Entries	33555131.007	33555131.000	33555133.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	73841111.221	73723904.000	74063872.000
Pool Paged Bytes	121953429.522	120590336.000	122519552.000

### Test Log

```
3/28/2010 9:29:10 AM -- Jetstress testing begins ...
3/28/2010 9:29:10 AM -- Prepare testing begins ...
3/28/2010 9:29:13 AM -- Attaching databases ...
3/28/2010 9:29:13 AM -- Prepare testing ends.
3/28/2010 9:29:13 AM -- Dispatching transactions begins ...
3/28/2010 9:29:13 AM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
3/28/2010 9:29:13 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
3/28/2010 9:29:16 AM -- Database read latency thresholds: (average: 20 msec/read,
maximum: 100 msec/read).
3/28/2010 9:29:16 AM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 100 msec/write).
3/28/2010 9:29:21 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
3/28/2010 9:29:21 AM -- Performance logging begins (interval: 15000 ms).
3/28/2010 9:29:21 AM -- Attaining prerequisites:
3/28/2010 9:30:16 AM -- \MSExchange Database(Jetstresswin)\Database Cache Size,
Last: 729030700.0 (lower bound: 724775700.0, upper bound: none)
3/28/2010 11:30:16 AM -- Performance logging ends.
3/28/2010 11:44:11 AM -- JetInterop batch transaction stats: 77515, 77495 and
77547.
3/28/2010 11:44:12 AM -- Dispatching transactions ends.
3/28/2010 11:44:12 AM -- Shutting down databases ...
3/28/2010 11:44:13 AM -- Instance3520.1 (complete), Instance3520.2 (complete) and
Instance3520.3 (complete)
3/28/2010 11:44:15 AM -- Performance logging begins (interval: 30000 ms).
3/28/2010 11:44:15 AM -- Verifying database checksums ...
3/28/2010 7:16:48 PM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100%
processed) and C:\asgluns\sg3 (100% processed)
3/28/2010 7:16:48 PM -- Performance logging ends.
3/28/2010 7:16:48 PM -- C:\ESRP 3.0_1GBMBox_.12 IOPS\Performance
Test\SS2_th6\with checksum on\DBChecksum_2010_3_28_11_44_13.blg has 904 samples.
```

# Stress Test Database Performance Result: SUN149

## Test Summary

---

<b>Overall Test Result</b>	Pass
<b>Machine Name</b>	SUN149
<b>Test Description</b>	
<b>Test Start Time</b>	3/28/2010 8:28:21 PM
<b>Test End Time</b>	3/29/2010 8:49:58 PM
<b>Collection Start Time</b>	3/28/2010 8:29:24 PM
<b>Collection End Time</b>	3/29/2010 8:29:22 PM
<b>Jetstress Version</b>	14.01.0043.000
<b>Ese Version</b>	14.00.0639.019
<b>Operating System</b>	Windows Server 2008 R2 Enterprise (6.1.7600.0)
<b>Performance Log</b>	C:\ESRP 3.0_1GBMBox_12 IOPS\Stress Test\Stress_2010_3_28_20_28_27.blg C:\ESRP 3.0_1GBMBox_12 IOPS\Stress Test\DBChecksum_2010_3_29_20_49_58.blg

---

## Database Sizing and Throughput

---

<b>Achieved Transactional I/O per Second</b>	1501.12
<b>Target Transactional I/O per Second</b>	516
<b>Initial Database Size (bytes)</b>	4624540172288
<b>Final Database Size (bytes)</b>	4659461947392
<b>Database Files (Count)</b>	3

---

## Jetstress System Parameters

---

<b>Thread Count</b>	6 (per database)
<b>Minimum Database Cache</b>	96.0 MB
<b>Maximum Database Cache</b>	768.0 MB
<b>Insert Operations</b>	40%
<b>Delete Operations</b>	20%
<b>Replace Operations</b>	5%
<b>Read Operations</b>	35%
<b>Lazy Commits</b>	70%
<b>Run Background Database Maintenance</b>	True
<b>Number of Copies per Database</b>	2

---

## Database Configuration

<b>Instance3520.1</b>	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
<b>Instance3520.2</b>	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
<b>Instance3520.3</b>	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

## Transactional I/O Performance

<b>MSExchange Database ==&gt; Instances</b>	<b>I/O Database Reads Average Latency (msec)</b>	<b>I/O Database Writes Average Latency (msec)</b>	<b>I/O Database Reads /sec</b>	<b>I/O Database Writes /sec</b>	<b>I/O Database Reads Average Bytes</b>	<b>I/O Database Writes Average Bytes</b>	<b>I/O Log Reads Average Latency (msec)</b>	<b>I/O Log Writes Average Latency (msec)</b>	<b>I/O Log Reads /sec</b>	<b>I/O Log Writes /sec</b>	<b>I/O Log Reads Average Bytes</b>	<b>I/O Log Writes Average Bytes</b>
Instance3520.1	6.466	2.615	311.791	188.005	33037.378	34335.037	0.000	0.591	0.000	108.243	0.000	4442.831
Instance3520.2	5.952	1.920	312.394	188.589	33087.957	34321.575	0.000	0.635	0.000	108.086	0.000	4448.702
Instance3520.3	5.975	1.918	311.969	188.372	33075.707	34317.532	0.000	0.592	0.000	108.016	0.000	4439.657

## Background Database Maintenance I/O Performance

<b>MSExchange Database ==&gt; Instances</b>	<b>Database Maintenance IO Reads/sec</b>	<b>Database Maintenance IO Reads Average Bytes</b>
Instance3520.1	30.533	261878.455
Instance3520.2	31.621	261881.916
Instance3520.3	31.597	261877.519

## Log Replication I/O Performance

<b>MSExchange Database ==&gt; Instances</b>	<b>I/O Log Reads/sec</b>	<b>I/O Log Reads Average Bytes</b>
Instance3520.1	1.954	232560.688
Instance3520.2	1.953	232561.477
Instance3520.3	1.948	232560.446

## 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
Instance3520.1	6.466	2.615	342.325	188.005	53448.602	34335.037	1.694	0.591	1.954	108.243	232560.688	4442.831
Instance3520.2	5.952	1.920	344.015	188.589	54118.230	34321.575	1.706	0.635	1.953	108.086	232561.477	4448.702
Instance3520.3	5.975	1.918	343.566	188.372	54118.339	34317.532	1.705	0.592	1.948	108.016	232560.446	4439.657

## Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	1.321	0.000	5.016
Available MBytes	29679.959	29630.000	29702.000
Free System Page Table Entries	33555130.994	33555124.000	33555133.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	73563034.952	73453568.000	73756672.000
Pool Paged Bytes	122012329.718	119169024.000	124411904.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

## Test Log

```

3/28/2010 8:28:21 PM -- Jetstress testing begins ...
3/28/2010 8:28:21 PM -- Prepare testing begins ...
3/28/2010 8:28:24 PM -- Attaching databases ...
3/28/2010 8:28:24 PM -- Prepare testing ends.
3/28/2010 8:28:24 PM -- Dispatching transactions begins ...
3/28/2010 8:28:24 PM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
3/28/2010 8:28:24 PM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
3/28/2010 8:28:27 PM -- Database read latency thresholds: (average: 20 msec/read,
maximum: 200 msec/read).
3/28/2010 8:28:27 PM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 200 msec/write).
3/28/2010 8:28:32 PM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
3/28/2010 8:28:32 PM -- Performance logging begins (interval: 15000 ms).
3/28/2010 8:28:32 PM -- Attaining prerequisites:
3/28/2010 8:29:24 PM -- \MSExchange Database(Jetstresswin)\Database Cache Size,
Last: 728559600.0 (lower bound: 724775700.0, upper bound: none)
3/29/2010 8:29:25 PM -- Performance logging ends.
3/29/2010 8:49:57 PM -- JetInterop batch transaction stats: 826978, 827576 and
826047.
3/29/2010 8:49:57 PM -- Dispatching transactions ends.
3/29/2010 8:49:57 PM -- Shutting down databases ...
3/29/2010 8:49:58 PM -- Instance3520.1 (complete), Instance3520.2 (complete) and

```

Instance3520.3 (complete)  
 3/29/2010 8:49:59 PM -- Performance logging begins (interval: 30000 ms).  
 3/29/2010 8:49:59 PM -- Verifying database checksums ...  
 3/30/2010 4:34:16 AM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100% processed) and C:\asgluns\sg3 (100% processed)  
 3/30/2010 4:34:16 AM -- Performance logging ends.  
 3/30/2010 4:34:16 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Stress  
 Test\DBChecksum\_2010\_3\_29\_20\_49\_58.blg has 928 samples.  
 3/30/2010 4:34:18 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Stress  
 Test\DBChecksum\_2010\_3\_29\_20\_49\_58.html is saved.  
 3/30/2010 4:34:18 AM -- Verifying log checksums ...  
 3/30/2010 4:34:19 AM -- C:\alogluns\log1 (15 log(s) processed), C:\alogluns\log2 (15 log(s) processed) and C:\alogluns\log3 (14 log(s) processed)  
 3/30/2010 4:34:19 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Stress  
 Test\Stress\_2010\_3\_28\_20\_28\_27.blg has 5759 samples.  
 3/30/2010 4:34:19 AM -- Creating test report ...  
 3/30/2010 4:34:41 AM -- Instance3520.1 has 6.5 for I/O Database Reads Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.1 has 0.6 for I/O Log Writes Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.1 has 0.6 for I/O Log Reads Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.2 has 6.0 for I/O Database Reads Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.2 has 0.6 for I/O Log Writes Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.2 has 0.6 for I/O Log Reads Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.3 has 6.0 for I/O Database Reads Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.3 has 0.6 for I/O Log Writes Average Latency.  
 3/30/2010 4:34:41 AM -- Instance3520.3 has 0.6 for I/O Log Reads Average Latency.  
 3/30/2010 4:34:41 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.  
 3/30/2010 4:34:41 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.  
 3/30/2010 4:34:41 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Stress  
 Test\Stress\_2010\_3\_28\_20\_28\_27.xml has 5755 samples queried.

## Stress Test Database Checksums Result: SUN149

### Checksum Statistics - All

Database	Seen pages	Bad pages	Correctable pages	Wrong page-number pages	File length / seconds taken
C:\asgluns\sg1\Jetstress001001.edb	47398498	0	0	0	1481203 MBytes / 27856 sec
C:\asgluns\sg2\Jetstress002001.edb	47399010	0	0	0	1481219 MBytes / 16858 sec
C:\asgluns\sg3\Jetstress003001.edb	47397986	0	0	0	1481187 MBytes / 19777 sec
(Sum)	142195494	0	0	0	4443609 MBytes / 27856 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	851.081	0.000	65535.997
C:\asgluns\sg2	0.061	0.000	1405.551	0.000	65536.000
C:\asgluns\sg3	0.064	0.000	1197.203	0.000	65536.000

### Memory System Performance of Checksum

Counter	Average	Minimum	Maximum
% Processor Time	0.956	0.000	3.885
Available MBytes	30481.025	30469.000	30489.000
Free System Page Table Entries	33555131.002	33555131.000	33555133.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	74268676.414	74141696.000	74448896.000
Pool Paged Bytes	122872015.448	119169024.000	125165568.000

### Test Log

```

3/28/2010 8:28:21 PM -- Jetstress testing begins ...
3/28/2010 8:28:21 PM -- Prepare testing begins ...
3/28/2010 8:28:24 PM -- Attaching databases ...
3/28/2010 8:28:24 PM -- Prepare testing ends.
3/28/2010 8:28:24 PM -- Dispatching transactions begins ...
3/28/2010 8:28:24 PM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
3/28/2010 8:28:24 PM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3 MB)
3/28/2010 8:28:27 PM -- Database read latency thresholds: (average: 20 msec/read,
maximum: 200 msec/read).
3/28/2010 8:28:27 PM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 200 msec/write).
3/28/2010 8:28:32 PM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
3/28/2010 8:28:32 PM -- Performance logging begins (interval: 15000 ms).
3/28/2010 8:28:32 PM -- Attaining prerequisites:
3/28/2010 8:29:24 PM -- \MSExchange Database(Jetstresswin)\Database Cache Size,
Last: 728559600.0 (lower bound: 724775700.0, upper bound: none)
3/29/2010 8:29:25 PM -- Performance logging ends.
3/29/2010 8:49:57 PM -- JetInterop batch transaction stats: 826978, 827576 and
826047.
3/29/2010 8:49:57 PM -- Dispatching transactions ends.
3/29/2010 8:49:57 PM -- Shutting down databases ...
3/29/2010 8:49:58 PM -- Instance3520.1 (complete), Instance3520.2 (complete) and
Instance3520.3 (complete)
3/29/2010 8:49:59 PM -- Performance logging begins (interval: 30000 ms).
3/29/2010 8:49:59 PM -- Verifying database checksums ...
3/30/2010 4:34:16 AM -- C:\asgluns\sg1 (100% processed), C:\asgluns\sg2 (100%
processed) and C:\asgluns\sg3 (100% processed)
3/30/2010 4:34:16 AM -- Performance logging ends.
3/30/2010 4:34:16 AM -- C:\ESRP 3.0_1GBMBox_.12 IOPS\Stress
Test\DBChecksum_2010_3_29_20_49_58.blg has 928 samples.

```

## Database Backup Test Result: SUN149

### *Database Backup Statistics - All*

<b>Database Instance</b>	<b>Database Size (MBytes)</b>	<b>Elapsed Backup Time</b>	<b>MBytes Transferred/sec</b>
Instance3520.1	1481195.09	05:37:47	73.08
Instance3520.2	1481211.09	05:31:50	74.39
Instance3520.3	1481179.09	05:32:41	74.20

### *Jetstress System Parameters*

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

### *Database Configuration*

<b>Instance3520.1</b>	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
<b>Instance3520.2</b>	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
<b>Instance3520.3</b>	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
Instance3520.1	5.076	0.000	292.172	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3520.2	4.766	0.000	297.604	0.000	262144.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instance3520.3	4.865	0.000	296.878	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	0.975	0.000	3.992
Available MBytes	30482.919	30474.000	30485.000
Free System Page Table Entries	33555131.000	33555131.000	33555131.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	73824604.919	73818112.000	73854976.000
Pool Paged Bytes	124314807.561	122290176.000	125521920.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

### Test Log

```

3/30/2010 5:05:53 AM -- Jetstress testing begins ...
3/30/2010 5:05:53 AM -- Prepare testing begins ...
3/30/2010 5:05:57 AM -- Attaching databases ...
3/30/2010 5:05:57 AM -- Prepare testing ends.
3/30/2010 5:06:03 AM -- Performance logging begins (interval: 30000 ms).
3/30/2010 5:06:03 AM -- Backing up databases ...
3/30/2010 10:43:51 AM -- Performance logging ends.
3/30/2010 10:43:51 AM -- Instance3520.1 (100% processed), Instance3520.2 (100%
processed) and Instance3520.3 (100% processed)
3/30/2010 10:43:51 AM -- C:\ESRP 3.0_1GBMBox_.12 IOPS\Database
Backup\DatabaseBackup_2010_3_30_5_5_57.blg has 675 samples.

```

## Soft Recovery Test Result: SUN149

### Soft-Recovery Statistics - All

Database Instance	Log files replayed	Elapsed seconds
Instance3520.1	510	423.2755434
Instance3520.2	500	406.8331145
Instance3520.3	501	407.3635155

### Database Configuration

<b>Instance3520.1</b>	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
<b>Instance3520.2</b>	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
<b>Instance3520.3</b>	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
Instance3520.1	20.190	11.454	1255.179	7.246	36046.827	32611.215	4.635	0.000	10.870	0.000	231513.001	0.000
Instance3520.2	18.471	10.900	1327.774	7.402	35963.715	32604.975	4.714	0.002	11.102	0.007	231219.834	2.547
Instance3520.3	17.894	10.349	1317.760	7.406	36006.891	32604.975	4.529	0.000	11.120	0.007	231203.781	2.547

### Background Database Maintenance I/O Performance

MSExchange Database Instances	Database Maintenance IO Reads/sec	Database Maintenance IO Reads Average Bytes
Instance3520.1	28.745	261914.873
Instance3520.2	29.582	261871.837
Instance3520.3	29.649	261999.242

### 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
Instance3 520.1	20.190	11.454	1283.924	7.246	41103.641	32611.215	4.635	0.000	10.870	0.000	231513.001	0.000
Instance3 520.2	18.471	10.900	1357.356	7.402	40887.183	32604.975	4.714	0.002	11.102	0.007	231219.834	2.547
Instance3 520.3	17.894	10.349	1347.409	7.406	40979.758	32604.975	4.529	0.000	11.120	0.007	231203.781	2.547

### Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	3.840	0.000	26.986
Available MBytes	29673.581	29653.000	30412.000
Free System Page Table Entries	33555131.381	33555131.000	33555133.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	78610763.581	74649600.000	79405056.000
Pool Paged Bytes	125066249.752	125005824.000	125214720.000
Database Page Fault Stalls/sec	0.012	0.000	0.994

### Test Log

```

3/30/2010 10:55:53 AM -- Jetstress testing begins ...
3/30/2010 10:55:53 AM -- Prepare testing begins ...
3/30/2010 10:55:57 AM -- Attaching databases ...
3/30/2010 10:55:57 AM -- Prepare testing ends.
3/30/2010 10:55:57 AM -- Dispatching transactions begins ...
3/30/2010 10:55:57 AM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
3/30/2010 10:55:57 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3
MB)
3/30/2010 10:56:00 AM -- Database read latency thresholds: (average: 20
msec/read, maximum: 100 msec/read).
3/30/2010 10:56:00 AM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 100 msec/write).
3/30/2010 10:56:03 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
3/30/2010 10:56:03 AM -- Performance logging begins (interval: 15000 ms).
3/30/2010 10:56:03 AM -- Generating log files ...
3/30/2010 11:32:23 AM -- C:\alogluns\log1 (102.0% generated), C:\alogluns\log2
(100.2% generated) and C:\alogluns\log3 (100.4% generated)
3/30/2010 11:32:23 AM -- Performance logging ends.
3/30/2010 11:32:23 AM -- JetInterop batch transaction stats: 21884, 21905 and
21787.
3/30/2010 11:32:24 AM -- Dispatching transactions ends.
3/30/2010 11:32:24 AM -- Shutting down databases ...

```

3/30/2010 11:32:24 AM -- Instance3520.1 (complete), Instance3520.2 (complete) and Instance3520.3 (complete)  
 3/30/2010 11:32:24 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Soft Recovery\Performance\_2010\_3\_30\_10\_56\_0.blg has 145 samples.  
 3/30/2010 11:32:24 AM -- Creating test report ...  
 3/30/2010 11:32:25 AM -- Instance3520.1 has 6.5 for I/O Database Reads Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.1 has 0.5 for I/O Log writes Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.1 has 0.5 for I/O Log Reads Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.2 has 6.2 for I/O Database Reads Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.2 has 0.5 for I/O Log writes Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.2 has 0.5 for I/O Log Reads Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.3 has 6.2 for I/O Database Reads Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.3 has 0.5 for I/O Log writes Average Latency.  
 3/30/2010 11:32:25 AM -- Instance3520.3 has 0.5 for I/O Log Reads Average Latency.  
 3/30/2010 11:32:25 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.  
 3/30/2010 11:32:25 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.  
 3/30/2010 11:32:25 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Soft Recovery\Performance\_2010\_3\_30\_10\_56\_0.xml has 144 samples queried.  
 3/30/2010 11:32:25 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Soft Recovery\Performance\_2010\_3\_30\_10\_56\_0.html is saved.  
 3/30/2010 11:36:40 AM -- Performance logging begins (interval: 2000 ms).  
 3/30/2010 11:36:40 AM -- Recovering databases ...  
 3/30/2010 11:43:43 AM -- Performance logging ends.  
 3/30/2010 11:43:43 AM -- Instance3520.1 (423.2755434), Instance3520.2 (406.8331145) and Instance3520.3 (407.3635155)  
 3/30/2010 11:43:44 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Soft Recovery\SoftRecovery\_2010\_3\_30\_11\_36\_37.blg has 210 samples.  
 3/30/2010 11:43:44 AM -- Creating test report ...

## Soft Recovery Test Performance Result: SUN149

### Test Summary

<b>Overall Test Result</b>	Pass
<b>Machine Name</b>	SUN149
<b>Test Description</b>	
<b>Test Start Time</b>	3/30/2010 10:55:53 AM
<b>Test End Time</b>	3/30/2010 11:32:24 AM
<b>Collection Start Time</b>	3/30/2010 10:56:18 AM
<b>Collection End Time</b>	3/30/2010 11:32:19 AM
<b>Jetstress Version</b>	14.01.0043.000
<b>Ese Version</b>	14.00.0639.019
<b>Operating System</b>	Windows Server 2008 R2 Enterprise (6.1.7600.0)
<b>Performance Log</b>	C:\ESRP 3.0_1GBMBox_.12 IOPS\Soft Recovery\Performance_2010_3_30_10_56_0.blg

### Database Sizing and Throughput

**Achieved Transactional I/O per Second** 1510.715

---

<b>Capacity Percentage</b>	100%
<b>Throughput Percentage</b>	100%
<b>Initial Database Size (bytes)</b>	4659461947392
<b>Final Database Size (bytes)</b>	4660401471488
<b>Database Files (Count)</b>	3

---

### *Jetstress System Parameters*

---

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

---

### *Database Configuration*

---

<b>Instance3520.1</b>	Log Path: C:\alogluns\log1 Database: C:\asgluns\sg1\Jetstress001001.edb
<b>Instance3520.2</b>	Log Path: C:\alogluns\log2 Database: C:\asgluns\sg2\Jetstress002001.edb
<b>Instance3520.3</b>	Log Path: C:\alogluns\log3 Database: C:\asgluns\sg3\Jetstress003001.edb

---

### Transactional I/O Performance

MSExchange Database => Instance	I/O Database Read Average Latency (msec)	I/O Database Write 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
Instance3 520.1	6.483	3.271	308.843	196.168	32794.549	34262.934	0.000	0.511	0.000	113.733	0.000	4531.975
Instance3 520.2	6.188	2.272	309.490	196.128	32796.250	34305.014	0.000	0.522	0.000	112.772	0.000	4490.443
Instance3 520.3	6.198	2.173	305.989	194.097	32793.328	34301.524	0.000	0.514	0.000	112.747	0.000	4505.225

### Host System Performance

Counter	Average	Minimum	Maximum
% Processor Time	1.409	0.000	4.268
Available MBytes	29669.524	29660.000	30205.000
Free System Page Table Entries	33555131.000	33555131.000	33555131.000
Transition Pages RePurposed/sec	0.000	0.000	0.000
Pool Nonpaged Bytes	73998674.979	73801728.000	74166272.000
Pool Paged Bytes	124927491.531	124903424.000	125046784.000
Database Page Fault Stalls/sec	0.000	0.000	0.000

### Test Log

```

3/30/2010 10:55:53 AM -- Jetstress testing begins ...
3/30/2010 10:55:53 AM -- Prepare testing begins ...
3/30/2010 10:55:57 AM -- Attaching databases ...
3/30/2010 10:55:57 AM -- Prepare testing ends.
3/30/2010 10:55:57 AM -- Dispatching transactions begins ...
3/30/2010 10:55:57 AM -- Database cache settings: (minimum: 96.0 MB, maximum:
768.0 MB)
3/30/2010 10:55:57 AM -- Database flush thresholds: (start: 7.7 MB, stop: 15.3
MB)
3/30/2010 10:56:00 AM -- Database read latency thresholds: (average: 20
msec/read, maximum: 100 msec/read).
3/30/2010 10:56:00 AM -- Log write latency thresholds: (average: 10 msec/write,
maximum: 100 msec/write).
3/30/2010 10:56:03 AM -- Operation mix: Sessions 6, Inserts 40%, Deletes 20%,
Replaces 5%, Reads 35%, Lazy Commits 70%.
3/30/2010 10:56:03 AM -- Performance logging begins (interval: 15000 ms).
3/30/2010 10:56:03 AM -- Generating log files ...
3/30/2010 11:32:23 AM -- C:\alogluns\log1 (102.0% generated), C:\alogluns\log2
(100.2% generated) and C:\alogluns\log3 (100.4% generated)
3/30/2010 11:32:23 AM -- Performance logging ends.
3/30/2010 11:32:23 AM -- JetInterop batch transaction stats: 21884, 21905 and
21787.
3/30/2010 11:32:24 AM -- Dispatching transactions ends.
3/30/2010 11:32:24 AM -- Shutting down databases ...

```

3/30/2010 11:32:24 AM -- Instance3520.1 (complete), Instance3520.2 (complete) and Instance3520.3 (complete)  
3/30/2010 11:32:24 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Soft Recovery\Performance\_2010\_3\_30\_10\_56\_0.blg has 145 samples.  
3/30/2010 11:32:24 AM -- Creating test report ...  
3/30/2010 11:32:25 AM -- Instance3520.1 has 6.5 for I/O Database Reads Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.1 has 0.5 for I/O Log writes Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.1 has 0.5 for I/O Log Reads Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.2 has 6.2 for I/O Database Reads Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.2 has 0.5 for I/O Log writes Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.2 has 0.5 for I/O Log Reads Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.3 has 6.2 for I/O Database Reads Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.3 has 0.5 for I/O Log writes Average Latency.  
3/30/2010 11:32:25 AM -- Instance3520.3 has 0.5 for I/O Log Reads Average Latency.  
3/30/2010 11:32:25 AM -- Test has 0 Maximum Database Page Fault Stalls/sec.  
3/30/2010 11:32:25 AM -- Test has 0 Database Page Fault Stalls/sec samples higher than 0.  
3/30/2010 11:32:25 AM -- C:\ESRP 3.0\_1GBMBox\_.12 IOPS\Soft Recovery\Performance\_2010\_3\_30\_10\_56\_0.xml has 144 samples queried.



---

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ESRP-053-00 March 2010