Abstract

This white paper examines the use of Microsoft Exchange with enterprise Flash drives, including use cases, performance characteristics, and general guidelines for database file placement.

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EMC Symmetrix DMX-4 Enterprise Flash Drives with Microsoft Exchange
Applied Technology
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Executive summary

EMC has enhanced the latest release of Symmetrix® Enginuity™ version 5773 to integrate enterprise-class Flash drives into the Symmetrix DMX-4 storage array. With Flash drives, EMC has created a new ultra-performance storage tier, “Tier 0,” that removes previous performance limitations imposed by magnetic disk drives.

For years, the most demanding enterprise applications have been limited by the performance of magnetic disk media. Tier 1 performance in storage arrays has been constrained by the physical limitations of hard disk drives. Enterprise Flash drives for Tier 0 deliver unprecedented performance and response times, which are benefits well suited for demanding Microsoft Exchange configurations.

Enterprise Flash drives dramatically increase performance for latency-sensitive applications like Microsoft Exchange. Enterprise Flash drives, also known as solid state drives (SSD), contain no moving parts, which removes much of the storage latency delay associated with traditional magnetic disk drives. A Symmetrix DMX-4 with enterprise Flash drives can deliver single-millisecond application response times and up to 30 times more I/O operations per second (IOPS) than traditional Fibre Channel hard disk drives (HDD). Additionally, because there are no mechanical components, Flash drives consume significantly less energy than hard disk drives. When replacing a larger number of HDD with a lesser number of enterprise Flash drives, energy consumption can be reduced by up to 98 percent for a given IOPS workload.

The high-performance characteristics of enterprise Flash drives eliminate the need for organizations to purchase large numbers of traditional hard disk drives, while only utilizing a small portion of their capacity to satisfy the IOPS requirements of Microsoft Exchange. The practice of underutilizing a hard disk drive for increased performance is commonly referred to as short-stroking. Enterprise Flash drives can increase Microsoft Exchange application performance and eliminate the need to short-stroke drives, thus keeping storage footprint and power consumption to a minimum and reducing total cost of ownership (TCO).

Introduction

This white paper addresses the advantages of deploying enterprise Flash drives in a Microsoft Exchange environment, including the performance, power savings, and consolidation benefits. Use cases and best practices will be examined, and a performance example comparing Flash drives to HDD is also discussed.

Audience

This white paper is intended for Microsoft Exchange database administrators and storage architects who want to understand how enterprise Flash drives can be deployed with Microsoft Exchange.

Technology overview

Symmetrix DMX-4

The Symmetrix DMX-4 system is the next generation in the Symmetrix DMX™ series and extends EMC’s leadership in the high-end enterprise storage market. The DMX-4 delivers support for the latest generation of disk drive technologies including Flash drives and 4 Gb/s FC drives for high performance, along with SATA II drives for high capacity requirements. The Symmetrix DMX-4 is the first and only high-end storage system to support all of these new generations of disk drive technologies, allowing for unprecedented flexibility in performance and tiered storage functionality.
• 96 to 2,400 disks
• 2 to 12 channel directors*
• 2 to 8 4 Gb disk directors*
• Fibre Channel, iSCSI, Gigabit Ethernet, FICON, ESCON connectivity
• Up to 512 (256 usable) GB global memory

*Combinations may be limited or restricted based on configuration

Figure 1. Symmetrix DMX-4: World's largest high-end storage array

• 32 to 360 disks
• 2 or 4 front-end/back-end directors
• FICON, Fibre Channel, iSCSI, Gigabit Ethernet connectivity
• Up to 128 (64 usable) GB global memory

Figure 2. Symmetrix DMX-4 950: Entry point for DMX-4 technology

Enterprise Flash drives

The enterprise-class EMC Flash drives are constructed with nonvolatile semiconductor NAND Flash memory. They are packaged in a standard 3.5-inch disk drive form factor and include a Fibre Channel interface used in existing Symmetrix DMX-4 drive array enclosures. The enterprise Flash drives used in the DMX-4 differ significantly from the solid state technology used in consumer electronics, particularly in their performance and reliability characteristics. To satisfy enterprise-level drive requirements NAND single level cell Flash technology was made more robust with dynamic wear leveling functions, which ensures all cells in the Flash memory are used evenly, to minimize the risk of “wear-out” common to less advanced Flash devices. Additionally, enterprise Flash drives include bad block remapping and multi-bit error correction. Because of these reliability enhancements and the fact that the drive has no moving parts the life expectancy of the Flash drive exceeds that of traditional hard disk drives.

The lack of moving parts also offers additional benefits. As previously discussed, enterprise Flash drives can deliver unprecedented performance, especially well suited for applications that require consistently low read/write response times. Additionally enterprise Flash drives consume considerably less power when compared to traditional rotating media.

The following figures offer an introductory overview to the IOPS and power benefits offered by enterprise Flash drives. Figure 3 shows the general IOPS rates for various drive technologies that can be expected to deliver suitable response times for Microsoft Exchange. It can be seen that while short-stroking conventional hard disk drives can deliver slightly more IOPS over a fully stroked drive, the performance attained is only a fraction of what is possible with enterprise Flash drive technology.
Figure 3. IOPS for different drive types

Figure 4 outlines, in addition to the performance benefits, the power savings that can be achieved when comparing enterprise Flash drives against traditional hard disk drives. The replacement of a larger number of short-stroked HDDs with a reduced number of enterprise Flash drives can deliver a significant reduction in power and cooling requirements. The savings in power will clearly depend on the exact configuration, and to what extent the traditional HDDs have been short-stroked, as well as the total number of HDDs being replaced. For more detailed information, consult with an EMC representative for specific power usage derived from the EMC Power Calculator.

Figure 4. Flash drive vs. HDD power consumption
Microsoft Exchange on enterprise Flash drives

Exchange environments best suited for enterprise Flash drives

Exchange Server administrators, in certain environments, have found it necessary to short-stroke traditional hard disk drives to achieve the required number of IOPS at the desired latencies. The downside of short-stroking hard disk drives is the total number of drives as well as the total number of storage arrays are increased significantly. This increased number of components causes not only higher power consumption but places a stress on both cooling requirements and data center floor space. The introduction of enterprise Flash drives to such an environment can lead to both increased performance and also a consolidation of storage units. A reduction in the total number of drives and arrays will extend the power, cooling, and space savings benefits. The following paragraphs describe Exchange environments best suited for enterprise Flash drives from a performance and consolidation perspective.

All I/O requests from a host are serviced by the Symmetrix from its global cache, regardless of the underlying disk technology. Under normal operating conditions, write requests are written directly to cache and incur no delay due to physical disk access. For read requests, if the requested data is in global cache, either because of a recent read or write, or due to sequential prefetch, the request is immediately serviced without accessing disk. This is referred to as a read hit. If the requested data is not in global cache (an event referred to as a read miss) the Symmetrix must retrieve the data from disk. The result of a read miss is an increased I/O response time due to the mechanical delays of hard disk drives. Enterprise Flash drives are therefore ideally suited for workloads with random small block I/O requests that exhibit low Symmetrix cache hit rates.

Microsoft Exchange environments exhibit random small block I/O, either 4K (Exchange 2003) or 8K (Exchange 2007), and generally exhibit low cache hit rates, making them prime candidates for enterprise Flash drives. In order to fully understand if enterprise Flash drives are a good fit for a particular Exchange environment, additional factors should be taken into account.

One such factor is the read/write workload in the Exchange environment. With Exchange 2003, most customers will see a predominately (70 percent) random read workload, which will benefit greatly from enterprise Flash drives. Exchange 2007 introduces several database engine improvements including a larger database page size, as well as support for larger server memory configurations. Due to these changes it is possible for the read/write ratio to change to a 50/50 ratio in some Exchange 2007 environments. As write operations are initially serviced from Symmetrix cache under normal conditions, write heavy workloads will generally not see a direct performance benefit from enterprise Flash drives.

Exchange 2007 workloads or write heavy workloads in general, however, can also benefit from enterprise Flash drives. Enterprise Flash drives have been optimized for writes and can deliver significantly better write performance than rotating media. As previously discussed, write requests will be written directly to Symmetrix cache and destaged to disk at a later time. Writes that have been accepted in cache but not written to disk are commonly referred to as “write pending.” Symmetrix will allow for a certain number of pending writes, at both the Symmetrix device level and system level. Should either a device or system maximum write pending level be reached, new writes will have to wait for cache slots to be freed, which may cause a performance impact. If a given configuration has Symmetrix cache pressure to the point of device or system write pending maximums, enterprise Flash drives will allow for a faster destage of those writes from cache, thus mitigating the performance impact. Reads will also perform well during write pending events when considering the high performance capabilities of the enterprise Flash drives.

A second factor is that Microsoft Exchange environments, from a storage performance perspective, are generally sized based on a forecasted number of IOPS per user. The IOPS metric can vary dramatically depending on user profiles and mailbox clients (cached mode Outlook, BlackBerry, and others), as well as Microsoft Exchange version (Exchange 2003 vs. Exchange 2007). In addition, the size of each user mailbox limits the number of users available to generate a workload against a given number of drives. In other words, as mailbox sizes grow, a smaller number of users will be available to drive a workload against a given number of disks.
For example, a fully utilized 146 GB 15k rpm drive will yield roughly 134 GB of usable space and sustain roughly 200 IOPS at a reasonable latency when fully stroked. A 1 GB mailbox quota would allow storage capacity for 134 users to drive the workload against the mirrored pair, while a 100 MB mailbox quota would yield 10 times the number of users for the same amount of space. If the assumed profile is 1 IOPS per user, the 134 1 GB mailbox count (134 IOPS) would perform well, while the 1,340 100 MB mailboxes (1,340 IOPS) would easily overwhelm the pair of conventional hard disk drives. To extend this example, if the assumed profile was 3 IOPS per user due to heavy BlackBerry usage in the environment, then even the 134 1 GB mailbox count, when taking RAID protection overhead into account, would exceed the processing capacity of the mirrored pair. The calculations for this example follow:

Assumptions are as follows:
- A single fully stroked 15k HDD can sustain 200 random 4K IOPS at a desirable latency
- Exchange workload is 70 percent read and 30 percent write
- The formula to calculate required number of physical drives is:
  \[
  \text{Required Drives} = \frac{\text{IOPS} \times \%R + \text{WP} \times (\text{IOPS} \times \%W)}{\text{Drive IOPS}}
  \]
  - IOPS = expected I/O operations per second
  - \%R = percentage of IOPS that are reads
  - \%W = percentage of IOPS that are writes
  - WP = RAID Write Penalty (RAID 1 or RAID 10 = 2, RAID 5 = 4)

The following examples do not take into account several additional factors when sizing storage for Exchange, including full-text indexing, deleted item retention, or free space requirements. The examples have been simplified to emphasize how mailbox sizes, in combination with user counts, impact the required number of drives to support a given workload.

**Example 1: 1 GB mailbox profile with 1 IOPS per user**
134 GB usable space / 1 GB usable space per user = 134 users
134 users x 1 IOPS per user = 134 IOPS
(134 x .7) + 2 (134 x .3) / 200 = 1 Required Drive = 2 Drives for RAID 1

**Example 2: 1 GB mailbox profile with 3 IOPS per user**
134 GB usable space / 1 GB usable space per user = 134 users
134 users x 3 IOPS per user = 402 IOPS
(402 x .7) + 2 (402 x .3) / 200 = 3 Required Drives = 4 Drives for RAID 1

**Example 3: 100 MB mailbox profile with 1 IOPS per user**
134 GB usable space / .1 GB usable space per user = 1340 users
1340 users x 1 IOPS per user = 1340 IOPS
(1340 x .7) + 2 (1340 x .3) / 200 = 9 Required Drives = 10 Drives for RAID 1

**Example 4: 100 MB mailbox profile with 3 IOPS per user**
134 GB usable space / .1 GB usable space per user = 1340 users
1340 users x 3 IOPS per user = 4020 IOPS
(4020 x .7) + 2 (4020 x .3) / 200 = 27 Required Drives = 28 Drives for RAID 1

It is in these latter environments (Example 2 thru 4) where mailbox density in combination with IOPS requirements push conventional hard disk drives past their performance capabilities where enterprise Flash drives are well suited. Enterprise Flash drives in such an environment will allow for greater performance in a smaller footprint, creating power, cooling, and data center floor space efficiencies.

**Placing “Heavy” Exchange users onto Flash drives**
A common practice for Exchange administrators is to categorize users and their related mailbox activities into profiles. Such categorization is important when considering user activity and has a direct impact on storage sizing, including IOPS, as previously discussed. Many standard guidelines and sizing calculators
will break users down into three such profiles: Heavy, Medium or Light. Additionally, some environments may need to include “Very Heavy” or “BlackBerry” profiles to represent even higher user activity.

Depending on the number of users and their respective profiles, it may not be practical to utilize enterprise Flash drives for all Exchange databases in an environment. In such an environment, a subset of heavy, very heavy, or BlackBerry users can be placed onto specific storage groups and databases that reside on Flash drives. Segregating the most active users onto enterprise Flash drives has several benefits. The most obvious benefit is the performance gain and enhanced experience those specific users will see by having their mailboxes on enterprise Flash drives. Additionally, non-heavy users will benefit when considering the removal of the heavier workload from the non-Flash storage. By removing the heavy user workload from HDD, the remaining users on HDD will see better performance and subsequently an enhanced user experience.

The method of placing or moving heavy users specifically onto enterprise Flash drives is a manual process for creating storage tiers in the environment. An additional, complementary method for creating storage tiers is to utilize an archiving product such as EMC EmailXtender®. EMC EmailXtender is discussed in the section “EMC EmailXtender for Information Lifecycle Management” on page 11.

**Exchange on Flash recommendations**

**Exchange log and database file placement**

The Exchange log workload is sequential write activity, under normal mailbox processing. Since writes are serviced from Symmetrix cache as previously discussed, the writes to the Exchange log will not generally benefit from Flash drives. In an effort to optimally utilize the enterprise Flash drive space with the most appropriate workload, it is reasonable to place the Exchange logs onto HDD. Placing the logs on HDD allows more space to be used by the Exchange database files, the best candidate for use on enterprise Flash drives.

**RAID protection**

It is recommended to use RAID 5 as the protection mechanism for the database files when deployed on enterprise Flash drives. RAID 5 is the optimal trade-off of protection, cost, and performance for enterprise Flash drives. While RAID 5 volumes have additional overhead of recalculating parity on write operations, this penalty is negligible in comparison to the high performance characteristics of the enterprise Flash drives. On the other hand, with the Exchange log workload on HDD, it is recommended for the log LUNs to be in a RAID 1 or RAID 10 configuration.

**Enterprise Flash drives vs. HDD Exchange performance**

Testing was performed to show the benefit of enterprise Flash drives compared to traditional hard disk drives. Three configurations were created with the goal of emulating 8,000 users at a profile of 2 IOPS per user:

- 8 x 73 GB enterprise Flash drives in a RAID 5 (7+1) configuration
- 8 x 15k 300 GB HDD in a mirrored configuration
- 16 x 15k 300 GB HDD in a mirrored configuration

Only the Exchange database files were placed on these drives and subsequently compared for performance. The log files for both the enterprise Flash test as well as the HDD tests were placed on the same pool of 15k 300 GB HDD in a mirrored configuration. The exact same hyper size and total number of hypers (32) were utilized across each configuration. The enterprise Flash drives used for testing were 73 GB in size and fully allocated for the tests, which means the comparable configuration created on the 300 GB HDD led the 15k drives to be significantly short-stroked (less than half-stroked for the 8 HDD and less than quarter-stroked for the 16 HDD).
The workload for the test was generated by Jetstress version 08.02.0060. Along with this version of Jetstress, the Exchange 2003 SP2 ESE libraries were used. Additionally, the default Jetstress profile was slightly modified to generate closer to a 70/30 read/write workload. The profile used was:

- 15% insert operations
- 5% delete operations
- 50% replace operations
- 30% read operations
- 80% lazy commits

Each drive configuration received the same number of Jetstress threads (16) for each test.

Figure 5 shows the IOPS performance for each database LUN for the three configurations. Each configuration had four database LUNs configured as eight-member metavolumes. As the figure shows (when aggregating the IOPS for each LUN), the Flash drives can easily maintain the targeted 16,000 total front-end IOPS. As expected, the 16 HDD configuration can only maintain roughly 5,700 front-end IOPS, and the 8 HDD configuration can only maintain roughly 2,600 front-end IOPS. It should be noted that the enterprise Flash drives were not driven to 100 percent utilization for these tests, so these numbers are not representative of enterprise Flash drive maximum performance.

Figure 5. IOPS comparison between enterprise Flash drives and HDD

Figure 6 shows the corresponding read response times for the results shown in Figure 5. Despite the much higher workload maintained by the enterprise Flash drives, read response times to the host stayed extremely low at an average of 2 ms. The short-stroked 15k HDD performed admirably; however, they could not
maintain the targeted IOPS for the test, and they also exhibited much higher read response times despite the lower total workload when compared to the enterprise Flash drives.

Figure 6. Response time comparison between enterprise Flash drives and HDD

It is important to reiterate that the HDD configurations used in this comparison were given considerable advantages. Not only were the HDD extremely short-stroked, but they were also mirrored, compared to the RAID 5 enterprise Flash configuration. Had the HDD been fully stroked and in a RAID 5 configuration, the performance difference (response time as well as IOPS) would have been even more dramatic.

Additional information about the configuration and performance test results can be found within the Jetstress performance test result reports included in the section “Appendix: Jetstress results” on page 14.

Extending the value of enterprise Flash drives

The deployment of enterprise Flash drives, as seen from the previous example, delivers unprecedented performance for Microsoft Exchange. Generally speaking, newly added mailbox items will be more frequently accessed and will generate the highest workload for enterprise Flash storage. Efficient space utilization of the enterprise Flash drives therefore requires the movement of less frequently accessed, that is, older, mailbox items on to a more cost-effective tier of storage. The following section discusses how EMC EmailXtender can be used to help create a tiering and Information Lifecycle Management strategy with Microsoft Exchange.

EMC EmailXtender for Information Lifecycle Management

EMC EmailXtender is an e-mail archiving solution designed to help companies automate the management of their e-mail environment. EmailXtender can assist with storage management, and reduce the cost and risk of legal discovery, as well as assist in creating e-mail retention and disposal policies to meet regulatory
requirements. In the context of enterprise Flash drives, EmailXtender can provide an Information Lifecycle Management strategy (ILM) to help make the most efficient use of enterprise Flash drive resources.

The main function of EmailXtender is to copy unique messages and attachments from e-mail servers and retain them within the EmailXtender repository. The repository can reside on denser, more cost-effective storage, providing a second storage tier within the Exchange environment. With messages stored independently, e-mails and associated attachments can be truncated or “shortcut” within the Exchange databases to reference the copy stored within the repository. When this shortcutting ability is applied to older messages and attachments that are not frequently accessed, space is freed within the Exchange database, functionally increasing user mailbox quota. By extension, the space available on the enterprise Flash drives will be increased and allow for new, more frequently accessed messages to be stored.

Figure 7. Original attachment size

![Figure 7. Original attachment size](image)

**Attachments:** Symmetrix Solution Guide version 2.doc (9 MB)

Figure 8. Attachment size after shortcut with EmailXtender

![Figure 8. Attachment size after shortcut with EmailXtender](image)

**Attachments:** Symmetrix Solution Guide version 2.doc (173 B)
It is easy to see between Figure 7 and Figure 8 that a significant amount of space savings can be achieved within the enterprise Flash tier of storage by implementing EmailXtender. By combining the use of EmailXtender along with enterprise Flash drives, an ILM strategy emerges that allows for the most efficient use of an ultra-performance Tier 0, while allowing for a more cost-effective tier of storage for long-term retention.

**Conclusion**

Incorporation of enterprise Flash drives into Symmetrix DMX-4 with Enginuity 5773 provides a new Tier 0 storage layer that is capable of delivering very high I/O performance at a very low latency, which can dramatically improve storage performance for Microsoft Exchange. Traditional magnetic disk drive technology no longer defines the performance boundaries for mission-critical storage environments. The costly approach of spreading workloads over dozens or hundreds of underutilized disk drives is no longer necessary. Depending on the Exchange environment, enterprise Flash drives can lead to increased performance and savings in power, cooling, and data center floor space requirements.

EMC Symmetrix now combines the performance and power efficiency of enterprise Flash drive technology with traditional disk drive technology in a single array managed with a single set of software tools, to deliver advanced functionality, ultra-performance, and expanded storage tiering options. In addition, by utilizing EMC EmailXtender, storage management is further enhanced and automated to create even more efficiencies in the environment.

**References**

The following documents can be found on EMC.com and Powerlink®.

**White papers**

- *Implementing EMC Symmetrix DMX-4 Flash Drives with Oracle Databases*
- *EMC Symmetrix DMX-4 Ultra-Performance Tier 0 Using Flash Drives*
- *Microsoft Exchange 2007 and EMC EmailXtender: Unifying the Platforms for Compliance, Storage Management, and Client Productivity*
- *Microsoft Exchange Server on EMC Symmetrix Storage Systems Solutions Guide*

**Feature Sheet**

- *Flash Solid State Drives for Symmetrix DMX-4*
Appendix: Jetstress results

Jetstress results for 8 RAID 5 (7+1) enterprise Flash drives

Microsoft Exchange Server Jetstress

Performance Test Result Report
Test Summary
Overall Test Result  Pass
Machine Name  LICOC218
Test Description
Test Start Time  7/28/2008 10:53:53 PM
Test End Time  7/28/2008 11:25:21 PM
Jetstress Version  08.02.0060.000
Ese Version  6.5.7638.2
Operating System  Microsoft Windows Server 2003 Service Pack 2 (5.2.3790.131072)
Performance Log  C:\Program Files\Exchange\Jetstress\Flash\Performance_2008_7_28_22_54_3.blg
  C:\Program Files\Exchange\Jetstress\Flash\DBChecksum_2008_7_28_23_25_21.blg

Database Sizing and Throughput
Achieved I/O per Second  16178.57
Capacity Percentage  100%
Throughput Percentage  100%
Initial database size  34226362776
Final database size  344650186752
Database files (count)  4

Jetstress System Parameters
Thread count  16 (per-storage group)
Log buffers  9000
Minimum database cache  512.0 MB
Maximum database cache  900.0 MB
Insert operations  15%
Delete operations  5%
Replace operations  50%
Read operations  30%
Lazy commits  80%
## Disk Subsystem Performance

<table>
<thead>
<tr>
<th>LogicalDisk</th>
<th>Avg. Disk sec/Read</th>
<th>Avg. Disk sec/Write</th>
<th>Disk Reads/sec</th>
<th>Disk Writes/sec</th>
<th>Avg. Disk Bytes/Write</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database (C:\Flash\DataSG1)</td>
<td>0.002</td>
<td>0.001</td>
<td>2757.347</td>
<td>1298.046</td>
<td>(n/a)</td>
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<tr>
<td>Database (C:\Flash\DataSG2)</td>
<td>0.002</td>
<td>0.001</td>
<td>2747.189</td>
<td>1295.313</td>
<td>(n/a)</td>
</tr>
<tr>
<td>Database (C:\Flash\DataSG3)</td>
<td>0.002</td>
<td>0.001</td>
<td>2747.283</td>
<td>1294.081</td>
<td>(n/a)</td>
</tr>
<tr>
<td>Database (C:\Flash\DataSG4)</td>
<td>0.002</td>
<td>0.001</td>
<td>2746.560</td>
<td>1292.751</td>
<td>(n/a)</td>
</tr>
<tr>
<td>Log (C:\Flash\LogsSG1)</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>318.628</td>
<td>13480.784</td>
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<tr>
<td>Log (C:\Flash\LogsSG2)</td>
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<td>0.001</td>
<td>0.000</td>
<td>317.773</td>
<td>13475.301</td>
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<tr>
<td>Log (C:\Flash\LogsSG3)</td>
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<td>0.000</td>
<td>317.162</td>
<td>13482.175</td>
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<tr>
<td>Log (C:\Flash\LogsSG4)</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>317.823</td>
<td>13457.446</td>
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</tbody>
</table>

### Jetstress results for 16 Mirrored HDD

**Microsoft Exchange Server Jetstress**

**Performance Test Result Report**

Test Summary

- **Overall Test Result**: Pass
- **Machine Name**: LICOC219
- **Test Description**:  
- **Test Start Time**: 7/28/2008 10:52:02 PM
- **Test End Time**: 7/28/2008 11:24:25 PM
- **Jetstress Version**: 08.02.0060.000
- **Ese Version**: 6.5.7638.2
- **Operating System**: Microsoft Windows Server 2003 Service Pack 2 (5.2.3790.131072)
- **Performance Log**:  
  - C:\Program Files\Exchange Jetstress\HDD\Performance_2008_7_28_22_52_13.blg
  - C:\Program Files\Exchange Jetstress\HDD\DBChecksum_2008_7_28_23_24_25.blg

Database Sizing and Throughput

- **Achieved I/O per Second**: 5671.833
<table>
<thead>
<tr>
<th><strong>Capacity Percentage</strong></th>
<th>100%</th>
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</thead>
<tbody>
<tr>
<td><strong>Throughput Percentage</strong></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Initial database size</strong></td>
<td>343387701248</td>
</tr>
<tr>
<td><strong>Final database size</strong></td>
<td>344215027712</td>
</tr>
<tr>
<td><strong>Database files (count)</strong></td>
<td>4</td>
</tr>
</tbody>
</table>

Jetstress System Parameters

<table>
<thead>
<tr>
<th><strong>Thread count</strong></th>
<th>16 (per-storage group)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Log buffers</strong></td>
<td>9000</td>
</tr>
<tr>
<td><strong>Minimum database cache</strong></td>
<td>512.0 MB</td>
</tr>
<tr>
<td><strong>Maximum database cache</strong></td>
<td>900.0 MB</td>
</tr>
<tr>
<td><strong>Insert operations</strong></td>
<td>15%</td>
</tr>
<tr>
<td><strong>Delete operations</strong></td>
<td>5%</td>
</tr>
<tr>
<td><strong>Replace operations</strong></td>
<td>50%</td>
</tr>
<tr>
<td><strong>Read operations</strong></td>
<td>30%</td>
</tr>
<tr>
<td><strong>Lazy commits</strong></td>
<td>80%</td>
</tr>
</tbody>
</table>
Jetstress results for 8 Mirrored HDD

Jetstress results for 8 Mirrored HDD

Microsoft Exchange Server Jetstress

Performance Test Result Report

Test Summary

Overall Test  Fail
Machine Name  LICOC219
Test Description
Test Start Time  7/28/2008 1:52:56 PM
Test End Time  7/28/2008 2:26:17 PM
Jetstress Version  08.02.0060.000
Ese Version  6.5.7638.2
Operating System  Microsoft Windows Server 2003 Service Pack 2 (5.2.3790.131072)
Performance Log  C:\Program Files\Exchange
Jetstress\HDD\Performance_2008_7_28_13_53_8.blg
C:\Program Files\Exchange
Jetstress\HDD\DBChecksum_2008_7_28_14_26_17.blg

Test Issues
Fail Process has average database read latencies higher than 0.020.
Database Sizing and Throughput

**Achieved I/O per Second**: 2594.719
**Capacity Percentage**: 100%
**Throughput Percentage**: 100%
**Initial database size**: 342825664512
**Final database size**: 343225171968
**Database files (count)**: 4

Jetstress System Parameters

**Thread count**: 16 (per-storage group)
**Log buffers**: 9000
**Minimum database cache**: 512.0 MB
**Maximum database cache**: 900.0 MB
**Insert operations**: 15%
**Delete operations**: 5%
**Replace operations**: 50%
**Read operations**: 30%
**Lazy commits**: 80%

Disk Subsystem Performance

<table>
<thead>
<tr>
<th>LogicalDisk</th>
<th>Avg. Disk sec/Read</th>
<th>Avg. Disk sec/Write</th>
<th>Disk Reads/sec</th>
<th>Disk Writes/sec</th>
<th>Avg. Disk Bytes/Write</th>
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<td>Database (C:\HDD\DataSG1)</td>
<td>0.025</td>
<td>0.002</td>
<td>465.046</td>
<td>184.752</td>
<td>(n/a)</td>
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<td>0.002</td>
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