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NETAPP/VMWARE TECHNICAL REPORT

Microsoft Exchange 2007 on VMware Infrastructure 3 and NetApp iSCSI Storage

Solution Overview and Workload Characterization

May 2008 | TR-3683

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1. EXECUTIVE SUMMARY

As customers become more advanced in their use of VMware® virtualization technology, they increasingly look for ways to bring the benefits of this technology to their mission-critical applications. With the release of Microsoft® Exchange 2007, customers who are planning an upgrade have an ideal opportunity to transition to a VMware platform built on NetApp® storage to begin leveraging the benefits of a virtual machine technology in the Exchange environment.

Exchange 2007 has undergone a number of architectural changes that make it even better suited than its predecessors to running on a virtualized platform. Most notable among these changes is the new architecture based on server roles (HUB, CAS, mailbox, edge, UM) and the move to a 64-bit platform. Combined with advances in server hardware technology and performance enhancements in VMware ESX 3.5, Exchange 2007 servers are ideal candidates for virtualization.

VMware and NetApp have worked together to design a complete solution for organizations that are looking to deploy Exchange 2007. Extensive performance testing was done on this solution to check that performance of the virtualized Exchange configuration is acceptable for production environments and is well within Microsoft recommendations. It has also been designed and tested with functionality for rapid backup and recovery and disaster recovery. The solution combines VMware Infrastructure 3 with NetApp iSCSI storage and blade server architecture to provide an end-to-end solution for Exchange with increased flexibility and lower costs compared to similar solutions without virtualization.

2. SCOPE

This document describes the architecture of a solution for deploying Exchange 2007 on VMware Infrastructure 3 on NetApp storage. It also discusses sizing the Exchange environment with a building block approach, along with results of performance testing and functional validation of all components including backup, restore, and disaster recovery.

Detailed implementation instructions are beyond scope of this document. Please contact your VMware-NetApp representative for additional information.

3. INTENDED AUDIENCE

The report is intended for messaging and storage professionals who design, test, deploy, and manage corporate messaging infrastructures. It provides detailed information about Exchange 2007 performance running in virtual machines. The solution is designed to serve as a reference architecture for customers, consultants, and others who are considering an Exchange 2007 deployment with VMware and NetApp products.

For methods and procedures mentioned in this technical report, it is assumed that the reader has working knowledge of the following:

- Microsoft Exchange 2007 architecture
- Exchange storage architecture and administration
- VMware Infrastructure 3
- NetApp SnapManager® for Exchange 4.0
- NetApp SnapMirror®
- NetApp Data ONTAP®

4. RELATED DOCUMENTS

For related information, see the following documents. Additional documentation is available on the NetApp and VMware Web sites.

NetApp

- Network Appliance and VMware Infrastructure 3 Storage Best Practices:

- <http://www.netapp.com/us/library/technical-reports/tr-3428.html>
- Microsoft Exchange Server 2007 Best Practices Guide:
<http://media.netapp.com/documents/tr-3578.pdf>
- Exchange Server 2007 Performance Characteristics Using NetApp iSCSI Storage Systems:
<http://media.netapp.com/documents/tr-3565.pdf>
- Storage Block Alignment with VMware Virtual Infrastructure:
<http://media.netapp.com/documents/tr-3593.pdf>

VMware

- Advantages of Virtualizing Exchange 2007 with VMware Infrastructure 3:
http://www.vmware.com/files/pdf/Advantages_Virtualizing_Exchange_2007_final_April_2008.pdf
- SAN System Design and Deployment Guide:
<http://www.vmware.com/resources/techresources/772>
- Performance Tuning Best Practices for ESX Server 3:
<http://www.vmware.com/resources/techresources/707>
- iSCSI Design Considerations and Deployment Guide:
<http://www.vmware.com/resources/techresources/1006>
- VMware High Availability—Concepts, Implementation, and Best Practices:
http://www.vmware.com/files/pdf/VMwareHA_twp.pdf

VMware Web site for Exchange

- <http://www.vmware.com/resources/techresources/1006>

5. INTRODUCTION

This paper examines the results of performance testing of a solution developed by NetApp and VMware for deploying Exchange Server 2007 on a VMware Infrastructure 3 platform. The solution was designed using a modular approach to sizing the Exchange environment. Each building block was designed to support 2,000 users with an “average” mailbox I/O profile and 250MB mailboxes. Performance and scalability of the building block approach was tested for three configurations:

- 2,000 users
- 4,000 users
- 6,000 users

Results of this testing demonstrate that Exchange 2007 performance on VMware Infrastructure 3 and NetApp iSCSI storage in this solution is suitable for production environments, performs well within Microsoft best practice recommendations, and is comparable to a similarly configured native (nonvirtualized) configuration.

Additionally, features of the VMware Infrastructure 3 platform, including VMware VMotion™, DRS, and HA, were tested under the virtual Exchange configuration and demonstrated substantial increases in overall flexibility and availability. NetApp SnapManager for Exchange 4.0 was used as the solution for backup and restore of the virtualized mailbox servers, and SnapMirror was used to test replication of Exchange data to a remote storage controller to provide disaster recovery. This paper explores the results of these tests. For general Exchange Server 2007 best practices, see the NetApp document [Microsoft Exchange Server 2007 Best Practices Guide](#). For in-depth Exchange 2007 information, see the Microsoft document [Technical Architecture of Exchange Server 2007](#).

6. VIRTUALIZATION OF EXCHANGE ENVIRONMENTS

Proper performance in Exchange 2003 environments often depended on proper design of the storage back end. Many Exchange 2003 environments suffered performance problems related to a poorly designed storage subsystem, which often resulted in a negative impact on end-user experience. The 32-bit Windows platform for Exchange 2003 limited to 900MB the amount of database cache that was available to the application. This limited database cache, combined with a small block size (4KB) and random workload,

made Exchange 2003 performance challenging in both virtualized and nonvirtualized deployments due to the heavy I/O demands placed on the storage back end.

To address these concerns, Exchange 2007 now runs exclusively on a 64-bit platform (x64). The Exchange database cache is now limited only by the amount of RAM available to the server. A larger database cache enables more read requests to be satisfied in cache, requiring less access to the disk for reads. The database page size has increased from 4KB to 8KB, and I/O coalescing has increased from 64KB to 1MB, resulting in larger but fewer writes. Exchange 2007 has also increased the number of databases to 50, with 50 storage groups. The larger number of storage groups allows more checkpoint depth per user, which also aids in reducing the need to read from disk by using the dirty pages in memory.

These changes have resulted in a significant reduction in storage I/O in Exchange 2007. 64-bit Windows 2003 (x64) is a fully supported guest OS on VI3, and when running Exchange 2007, workloads can perform comparably with similarly configured native deployments.

When Exchange 2007 launched in early 2007, high-density memory modules were very expensive, and 32GB was the real-world cap for two-CPU socket servers. Today, with increased memory chip availability and multicore CPUs, virtualization of Exchange 2007 mailbox servers is a fast-growing market segment.

7. SOLUTION OVERVIEW

This solution was designed for customers who are looking to deploy Exchange 2007 on a platform built using VMware Infrastructure 3, NetApp FAS storage and data protection solutions, and blade server technology. Using these technologies together can provide a number of benefits over similar configurations without virtualization:

- **Reduced costs through VMware virtualization:** For many organizations, moving to Exchange 2007 without virtualization can result in throwing more server hardware at an application that has already become excessively costly to run. The move to 64-bit architecture with Exchange 2007 offers an opportunity to consolidate Exchange servers onto powerful 64-bit servers with multiple cores and increased memory density. VMware virtualization can unlock the full power of the hardware by running multiple workloads on these systems. This can provide a cost-effective solution and quicker ROI when compared to Exchange 2007 deployments without virtualization.
- **Advanced NetApp iSCSI storage solutions:** Changes in Exchange 2007 have reduced disk I/O requirements. This reduced I/O means that customers can deploy Exchange on storage solutions such as iSCSI, which can provide a very cost-effective storage solution. NetApp FAS storage arrays have been fully tested and certified for use in VMware iSCSI environments.
- **Higher availability without complex clustering:** A VMware-enabled platform can provide high availability for Exchange 2007 without complex and costly clustering solutions. Virtual machines are no longer tied to the underlying server hardware and can be moved across servers at any time with VMware VMotion. VMware HA provides server hardware fault tolerance for every Exchange virtual machine and offers greater levels of availability over solutions designed to protect just the mailbox server.
- **Blade server architecture:** Using blade server technology in conjunction with VMware virtualization enables organizations to maximize the efficiency of their data center by further reducing costs for power, cooling, rack space, floor space, switch ports cables, and more.
- **Advanced backup and disaster recovery solutions:** The solution is built using VMware virtual machine technology with NetApp tools for advanced data protection. Rapid backup with SnapManager for Exchange 4.0 and remote replication for disaster recovery with SnapMirror provide an end-to-end data protection solution.

For more information about the benefits of virtualizing Exchange 2007 on a VMware platform, read this white paper:

http://www.vmware.com/files/pdf/Advantages_Virtualizing_Exchange_2007_final_April_2008.pdf

7.1 VMWARE INFRASTRUCTURE 3

VMware Infrastructure 3 simplifies IT environments so that customers can leverage their storage, network, and computing resources to control costs and respond quickly to changing business needs. The VMware

Infrastructure approach to IT management creates virtual services out of the physical infrastructure, enabling administrators to allocate these virtual resources quickly to the business units that need them most. Some of the most important components of the VI3 Suite are:

- **VMware ESX Server:** Platform for virtualizing servers, storage, and networking
- **VMware VirtualCenter:** Centralized management, automation, and optimization for IT infrastructure
- **VMware VMotion:** Live migration of virtual machines without service interruption
- **VMware High Availability (HA):** Cost-effective high availability for virtual machines
- **VMware DRS:** Dynamic balancing and allocation of resources for virtual machines
- **VMware Consolidated Backup:** Centralized backup software for virtual machines

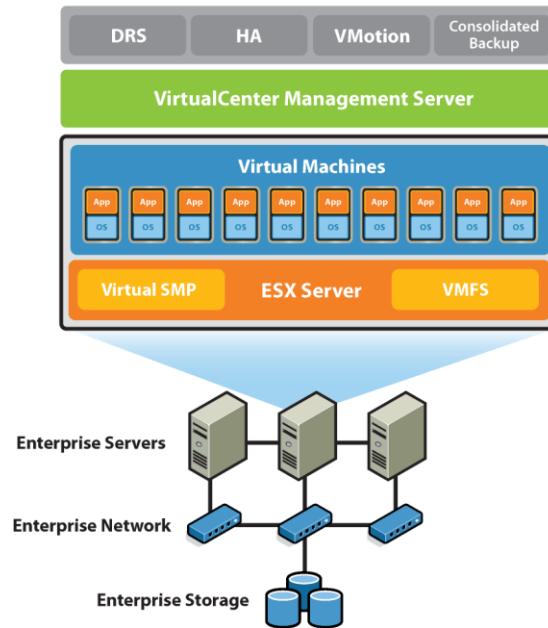


Figure 1) VMware infrastructure.

For more information about VMware Infrastructure 3, go to the following Web site:

<http://vmware.com/products/vi/>

7.2 NETAPP STORAGE AND DATA PROTECTION TOOLS

NETAPP FAS3000 STORAGE ARRAYS

The FAS3000 series addresses the core requirements of the midrange enterprise storage market, delivering price, performance, and scalability—and exceptional storage value—for databases, business applications, large-scale file sharing, and technical applications. The compact, modular design provides integrated FC SAN, IP SAN (iSCSI), and NAS storage with scalability to over 500 disk drives. The FAS3000 series supports both FC and SATA disk drives for tiered storage. FAS3000 systems support up to 32 FC ports or 32 Ethernet ports, including support for both 4Gb FC and 10 Gigabit Ethernet.

SNAPMANAGER FOR EXCHANGE 4.0

SnapManager for Exchange 4.0 is integrated with many new Exchange 2007 features, such as up to 50 storage groups and PowerShell™ integration. PowerShell is the scripting interface that Exchange 2007 uses to automate tasks. SnapManager for Exchange 4.0 is tightly integrated with PowerShell. With SnapManager for Exchange 4.0, the integrity check can be offloaded to a remote verification server.

Unlike many software-based VSS backups, SnapManager for Exchange 4.0 can create more than 250 Snapshot™ copies and keep them on disk with negligible performance impact for very quick recovery

(minutes). Other vendors' solutions take a VSS backup, stream it off to tape, and then destroy the volume shadow copy, because keeping more than a couple of shadow copies adversely affects performance on their storage systems. When these tape solutions must be restored, it is from tape, a lengthy and painful process. For more information, see the NetApp document *SnapManager 4.0 for Microsoft Exchange*.

Note: To enable SnapManager for Exchange-aware VSS backups in the VMware environment, this solution used the Microsoft iSCSI initiator running inside the virtual machine for connecting to the Exchange database and log volumes on the NetApp array. (Exchange virtual machines still had their OS and swap drives on VFMS storage.) This solution is also supported using Fibre Channel connections to the ESX server.

SNAPMIRROR

SnapMirror is integrated with SnapManager for Exchange 4.0 and was used to asynchronously replicate the backup to a DR site. SnapMirror uses block-level updates that reduce bandwidth and time requirements, shrinking the replication window. The DR location can keep many Snapshot copies at once, enabling data restoration to a point in time before data corruption. For more information, see the NetApp document [SnapMirror Best Practices Guide](#).

7.3 BLADE SERVER HARDWARE

VMware virtualization technology enables greater use of server resources and can reduce the costs of running a data center: power, cooling, floor space, rack space, switches, cables, and host bus adapters. When combined with blade server architecture, these cost savings can be reduced even further:

- Blade servers can lower acquisition costs and up-front out-of-pocket expenses. Because blades are an integrated solution, they can reduce the number of components that you would have to purchase in a comparable rack solution. Some blade configurations can save up to 40% over the comparable rack solution.
- Blade servers can save valuable floor space. Typically, you can fit more blade servers when compared to their 1U/2U/3U rack server counterparts.
- Blade servers reduce complexity by integrating servers, storage, networking, and management into one infrastructure building block. The more you integrate, the more you can reduce costs.
- As one infrastructure building block, blades reduce the numbers of cables and connectors. This reduces the initial acquisition cost, and it also reduces the number of potential points of failure.
- Blade servers can be much faster and easier to deploy than rack servers. Every rack server requires one or more cables to connect to the network and storage. Blades can simply be inserted into the chassis midplane to make its connection to the network.
- Blade servers can simplify system management. Servers, storage, and networking can be managed from one central point. This simplifies management, and it also eases deployment and redeployment, resulting in lower overall maintenance costs over time.
- Blade servers are more energy efficient than rack servers. Blade servers use a shared power and cooling infrastructure; the power and cooling for each individual blade server reside in the chassis, not the blade, and each blade shares those components. Fewer fans and power supplies mean fewer components that need to be powered, and also fewer components that could fail and require replacement.
- Blade servers provide increased business agility, flexibility, and investment protection over rack servers. As business needs change, adding or updating applications can be much easier in a blade environment than in a rack environment. New blades, switches, and so on can simply be added to the chassis; it's not necessary to replace the entire chassis. Updating a rack server could be a much more labor-intensive undertaking.

This solution was built entirely on blade server architecture using the IBM BladeCenter. The BladeCenter H (and E) uses up to 50% less floor space and up to 35% less energy than rack servers without sacrificing performance and reliability. By employing VMware virtualization on IBM BladeCenter, you can dramatically transform the economics of your IT infrastructure, in addition to reducing costs and increasing ROI during the migration to Exchange 2007.

For more information about IBM blade servers, see the following Web site:

<http://www-03.ibm.com/systems/bladecenter/>.

8. EXCHANGE 2007 VIRTUAL MACHINE “BUILDING BLOCKS”

The virtual solution was designed using a “building block” approach to sizing, with each building block capable of supporting 2,000 users with an “average” I/O profile and 250MB mailboxes. Using this approach makes the solutions highly scalable and takes the guesswork out of sizing the Exchange environment and scaling it in the future to accommodate growth. The Table 1 shows how the Exchange 2,000- user building blocks were configured.

Table 1) 2,000-user Exchange building block.

Number of users	2,000
Number of Exchange mailbox virtual machines	1
Virtual machine OS	Windows 2003 x64 R2 SP2
Virtual machine memory	9GB
Virtual machine CPU	2vCPU
Mailbox I/O profile	0.16 (average) ¹
Mailbox size	250MB
Physical disks for database	20
Physical disk for logs	4
Disk type	144 GB FC – 10K RPM
RAID type	RAID-DP

Note: Although sizing was done for an “average” I/O profile with 9GB RAM, all testing examined later in this report shows that this building block is capable of supporting the “heavy” I/O profile.

8.1 ADVANTAGES OF BUILDING BLOCK DESIGN

The decision to run multiple, smaller virtual machines with 2,000 users each, as opposed to a single server with 6,000 users, was made for the following reasons:

- Exchange 2007 architecture is better suited to a scale-out than to a scale-up model. The current Microsoft recommendations on processor cores (four) and memory (32GB maximum) are outlined in the Microsoft document [Exchange Server 2007 Processor and Memory Recommendations](#). Using the building block approach described in this report can overcome these limitations of the physical platform and has been proven to scale up to 16,000 users on a single physical server².
- Running multiple, smaller virtual machines is well suited to a dynamically load balanced virtual environment. The smaller virtual machines can be moved quickly and easily with VMotion and DRS and can fail over quickly with VMware HA in the event of server hardware failure. The new functional server role decomposition in Exchange 2007 takes full advantage of the DRS feature, because DRS functions most efficiently when distributing multiple small virtual machines.
- Multiple virtual machines can spread users across multiple mailbox servers without requiring additional server hardware. Risk is reduced because fewer users are affected when a mailbox server suffers an outage or requires planned downtime.
- Adding virtual machines in this manner is an easy way to scale the Exchange environment in a predictable manner. Each building block has been tested to provide a predictable performance profile and a simple method for scaling the environment.
- Building blocks allow the user population to be split into multiple mailbox virtual machines based on specific business or technical requirements, without the need to purchase additional servers. Here are some examples of how this ability can be leveraged:

¹ [http://technet.microsoft.com/en-us/library/bb738147\(EXCHG.80\).aspx](http://technet.microsoft.com/en-us/library/bb738147(EXCHG.80).aspx)

² http://www.vmware.com/company/news/releases/ibm_exchange_vmworld.html

- Consolidate mailbox servers by using virtual machines. The building block approach allows mailbox servers to be consolidated on a single physical server while maintaining the flexibility of having users spread across multiple mailbox servers.
- New users coming in via acquisition can be kept in their own mailbox virtual machine to accommodate unexpected growth.
- Individual mailbox virtual machines running on a single ESX server can be matched with their own unique backup and replication strategies to meet different SLAs.
- Users with special compliance requirements can be placed into a separate mailbox virtual machine.
- Users who need to be maintained in a separate Active Directory® domain or forest can be run in their own virtual machine on the same ESX server that is hosting other mailbox servers. Traffic from this virtual machine can be further isolated by using a dedicated NIC on the ESX server.
- Environments that need to maintain legacy Exchange servers can run them as a virtual machine on the same powerful 64-bit servers running Exchange 2007 virtual machines. Legacy hardware can be decommissioned or repurposed for test/dev or DR. 32-bit virtual machines can also be run in virtual machines on the same 64-bit server hardware to enable further consolidation and cost savings.

How to deploy users across virtual machines is a design decision specific to each organization. In this solution, we chose to split users into 2,000-user blocks to highlight the reasons just listed. Each environment has its own unique needs and can break users into separate virtual machines based on their specific requirements. Other organizations may choose to run all users in a single virtual machine, or choose a building block size to match their own requirements. This is possible with the release of ESX 3.5, because each guest operating system can be configured with up to 64GB of RAM.

9. SOLUTION SIZING

The following sections describe the sizing guidelines used in this solution.

9.1 SOLUTION SIZING FOR VMWARE VIRTUAL MACHINES

Sizing for 2,000 users with an “average” I/O profile was based on Microsoft recommendations for CPU and RAM sizing.³ Memory requirements were calculated based on an average user profile, but testing covered later in this report shows that this same configuration has sufficient performance headroom to accommodate the “heavy” user profile as well.

Table 2) Mailbox server memory recommendations.

User Type	Mailbox Server Memory Recommendation
Light	2GB plus 2MB per mailbox
Average	2GB plus 3.5MB per mailbox
Heavy	2GB plus 5MB per mailbox

Based on Table 2, the memory requirement for the 2,000-user mailbox virtual machine is:

$$2\text{GB base} + 3.5\text{MB/user} = 9\text{GB (rounded)}$$

Note: All mailbox servers are configured as standalone systems without MSCS or other software cluster solutions.

Average user profiles can generally support 1,000 users per core, so the 2,000-user virtual machine building block is configured with 2vCPU.

³ <http://technet.microsoft.com/en-us/library/bb738142.aspx>

An important benefit of using virtual machines is the ability to add or remove CPU and/or RAM at any time. This gives the Exchange administrator the ability to fine-tune memory and CPU over time. Resources can initially be provisioned conservatively and increased over time, over provisioning on Exchange server hardware resources can be minimized, and the risk of error in initial sizing can be eliminated. Future growth requirements, which are difficult to estimate, can be easily accommodated at any time. Customers can size conservatively based on current requirements and increase CPU and RAM resources over time as required.

For example, this configuration was sized based on an average I/O profile with 9GB RAM and 2vCPU. This configuration can be deployed in production and monitored over time. If performance remains acceptable, you can run additional workloads on the ESX server to maximize the CPU and RAM resources on the server. If Exchange performance degrades over time as more users are added to the system, non-Exchange workloads can be moved off the ESX server and additional CPU and RAM can be allocated to the mailbox virtual machine. Figure 2 shows how a virtual machine is allocated additional memory.

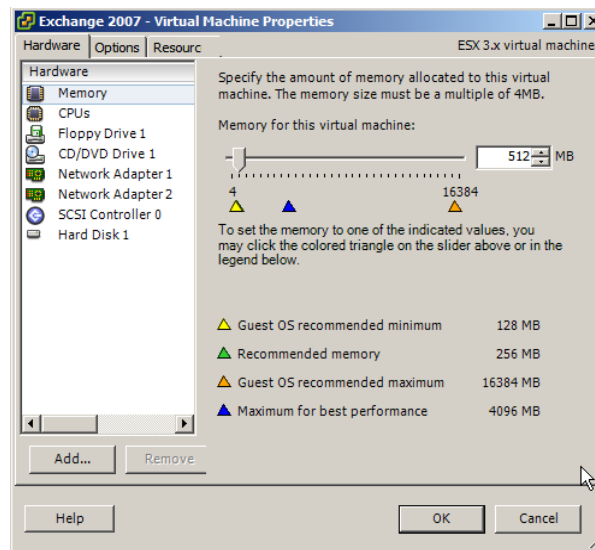


Figure 2) Allocating additional RAM to a virtual machine.

A single domain controller with a single Active Directory forest and domain was deployed with 2vCPU and 2GB RAM. The Exchange HUB and CAS roles were deployed in a single virtual machine with 2vCPU and 2GB RAM. The memory and CPU allocations of these servers can be adjusted if performance requirements change.

9.2 SOLUTION SIZING FOR NETAPP STORAGE

Exchange mailbox virtualization does not change storage best practices from an Exchange Server 2007 perspective. Creating LUNs that provide adequate performance is only half of the solution. The LUNs must be provisioned with enough capacity as well. The same performance and scalability aspects described in the Microsoft [Planning Storage Configurations](#) guide apply to virtualized mailbox servers. Basically, it is important to be sure that the disk subsystem is sized with adequate headroom to handle both performance (transactional and nontransactional I/O) and capacity requirements. The Microsoft [Exchange 2007 Storage Requirements Calculator](#) can help isolate performance and capacity metrics in the proposed environment. You can use this information, with a NetApp representative, to accurately size the Exchange storage.

The first best practice is to make sure that the transaction logs and databases are in separate aggregates. For both performance (mixing workloads) and reliability, do not place the transaction logs and databases on the same physical disks. In some cases, mixing workloads does not affect the performance of the storage. From a reliability perspective, do not place the transaction logs and database files from the same storage group on the same physical disks. Proper testing should be run to validate any configuration. The general Microsoft Exchange best practice is that similar workloads can share spindles, even between Exchange Servers.

Another best practice when creating volumes in the aggregate is to use NetApp FlexVol[®] volumes and to create a separate flexible volume for each storage group. FlexVol volumes are equally spread across every disk in the aggregate, and they are the layer where Snapshot copies are created. When a separate FlexVol volume is created for each storage group in the database aggregate and the log aggregate, the VSS restores do not affect any other storage group. Each storage group's database should be placed in its own LUN, although the transaction logs can be placed in the same LUN.

Mountpoints can be used to accommodate more than 24 LUNs, and the best practice is to create a placeholder LUN for drive letter assignment, and then use mountpoints for all transaction log and database LUNs under a single drive letter.

Two identical storage configurations were used in the testing, one for the VMware virtualized ESX environment and one used for testing the native (nonvirtualized) environment for comparison purposes.

- Each environment had the mailbox servers connected to an Exchange database and log volumes using iSCSI with Gigabit Ethernet in an MPIO configuration over two paths to the FAS3040 controller running Data ONTAP 7.23.
- Each virtual machine had six storage groups, with 333 users each. DB and log LUNs were presented as mountpoints.
- Each FAS3040 had two aggregates, one log and one DB, using NetApp RAID-DP[®].
- Each aggregate had six NetApp FlexVol volumes, one for each storage group.
- Each database was ~90GB in size.

With 144GB disks and 250MB mailboxes, the storage was capacity bound. For capacity, proper Exchange sizing must be done to determine the size of the database and transaction log LUNs. NetApp Snapshot backup sizing involves factoring in the number of Snapshot copies taken daily and the number of Snapshot copies to be kept online for immediate restore. Finally, the daily change rate of the data affects the size of the volume being backed up. Two customer profiles were used, one with five online Snapshot copies and one with two online Snapshot copies.

2000-user Jetstress and LoadGen:

- Log aggregate: 4 x 144GB FC disks
- DB aggregate: 20 x 144GB FC disks
- 5 online Snapshot copies

4000-user Jetstress:

- Log aggregate: 8 x 144GB FC disks
- DB aggregate: 40 x 144GB FC disks
- 5 online Snapshot copies

6000-user Jetstress virtual/standalone:

- Log aggregate: 12 x 144GB FC disks
- DB aggregate: 60 x 144GB FC disks
- 5 online Snapshot copies

6000-user LoadGen virtual/standalone:

- Log aggregate: 7 x 144GB FC disks
- DB aggregate: 49 x 144GB FC disks
- 2 online Snapshot copies

9.3 SOLUTION SIZING FOR BLADE SERVER HARDWARE

The entire Active Directory and Exchange environment was deployed on virtual machines running on IBM BladeCenter. Blade server architecture is ideally suited to virtual machines and helps to reduce space requirements in the data center.

This solution leverages blade servers to optimize the following aspects of the Exchange environment:

- Having all the Active Directory and Exchange components in virtual machines on the blade chassis means that certain types of network traffic between these systems can be kept off the physical network and localized in the blade chassis.

- In this solution, the domain controller was running in a virtual machine on its own blade. Some customers choose to deploy additional domain controllers in separate virtual machines on the same ESX server as the mailbox virtual machines. The domain controller can be configured on the same virtual switch to keep traffic in a single blade and running at bus speeds.
- Additional HUB and CAS servers can be deployed in a similar fashion to contain traffic in a single blade.

Two types of blades were used in the solution:

- LS20:
 - 2 x AMD Opteron 2.6 GHz
 - 3GB RAM
 - ESX 3.5
- LS41:
 - 4 x dual-core AMD Opteron 2.4Ghz
 - 32GB RAM
 - ESX 3.5

LS20 blades were used to hold all supporting infrastructure virtual machines such as the domain controller, global catalog, HUB, and CAS roles. Additional LS20 blades were used as LoadGen clients.

Two LS41 blades were used for the mailbox server roles. One for the VMware environment and one for testing the native (nonvirtualized) environment for comparison purposes:

10. TEST SCENARIOS AND RESULTS

Table 3 shows all tests that were conducted to validate this solution. Initial tests were designed to validate the performance of a single 2,000-user building block. This building block was then used to scale up to 4,000 and 6,000 users by using a simple and predictable approach to mailbox server sizing.

Additional tests were conducted to validate the VMware VMotion and VMware HA features. The goal of these tests was to validate that these tools can be used in production on heavily loaded mailbox servers. SnapManager for Exchange was used to test local backup and recovery of Exchange databases, and SnapMirror was used to test remote replication for disaster recovery solutions.

Table 3) Validation tests performed.

Test ID	Platform	User Count	Type
A-1	Virtual	2000	Jetstress
A-2	Native	2000	Jetstress
A-3	Virtual	2000	LoadGen
A-4	Native	2000	LoadGen
B-1	Virtual	4000	Jetstress
B-2	Virtual	4000	LoadGen
C-1	Virtual	6000	Jetstress
C-2	Native	6000	Jetstress
C-3	Virtual	6000	LoadGen
C-4	Native	6000	LoadGen
D-1	Virtual	6000	VMware VMotion

D-2	Virtual	6000	VMware HA
E-1	Virtual	2,000	SnapManager
E-2	Virtual	2,000	SnapMirror

10.1 TEST OBJECTIVES

There were four primary objectives for testing this solution:

- Make sure that performance in the virtualized Exchange configuration is suitable for production environments and is well within Microsoft's recommendations.
- Demonstrate how Exchange 2007 performance on VMware Infrastructure 3 in this solution compares to a similarly configured native configuration. To test this, a second test harness was built using identical hardware (without virtualization) and results were compared to the virtual configuration.
- Test the primary VMware Infrastructure 3 features (VMware VMotion, DRS, and HA) in an Exchange 2007 environment to check that they performed as expected and were suitable for production environments.
- Test the primary NetApp business continuance tools to provide backup and restore with SnapManager for Exchange 4.0 on the local storage controller and to provide replication with SnapMirror to another storage controller.

Figure 3 shows how the test environment was built at the NetApp labs in Raleigh, NC. Mailbox virtual machines using the 2,000-user building block approach were tested in the VMware environment on an LS41 blade running ESX 3.5. For comparison purposes, a second test harness without virtualization was run on an identical LS41 blade on a similar storage configuration.

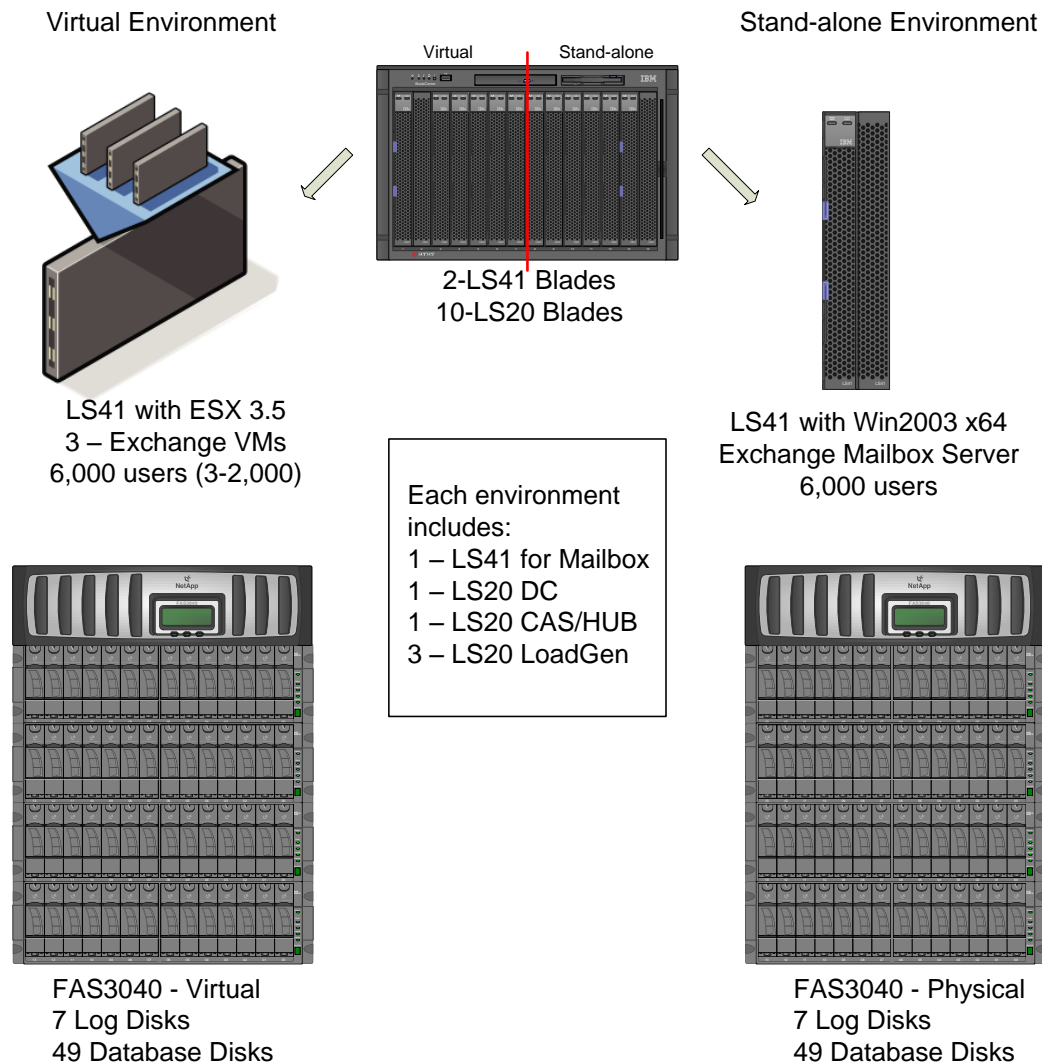


Figure 3) Lab setup for testing virtual and native performance.

10.2 TEST TOOLKIT

Performance testing was done using Microsoft Jetstress and LoadGen tools. Both of these tools are industry standard for validating performance of Exchange environments.

Jetstress

Jetstress tests were run to validate the I/O requirements for the 2,000-user virtual machine building block. Additional Jetstress tests were done on the 4,000-user and 6,000-user configurations for linear scalability.

Native tests were run on an identical IBM LS41 physical blade server running Windows Server 2003 x64 SP2. The results were used to determine the differences in scalability, I/O performance, and server and memory efficiencies between the two environments (physical and virtual). Unless otherwise noted, other than simple pass/fail criteria, the CPU and memory counters are not considered relevant during Jetstress testing because the tool is designed to exercise only the storage subsystem.

The following areas were measured during Jetstress testing:

- Resulting IOPS (random I/O test)

- Disk read and write latencies (random I/O test)

Each test followed these conditions:

- Achieve 0.5 IOPS per user mailbox
- Maintain database latency less than 20ms
- Maintain transaction log write latency less than 10ms

LoadGen

LoadGen testing ran a series of load generation tests to validate the building blocks, beginning with 2,000 users and scaling up to 4,000- and 6,000-user configurations. Similar to the process used in Jetstress testing, comparison testing of the various building block tiers was performed on a native platform. The testing used a heavy mailbox profile to generate sufficient CPU, memory, and disk I/O. The mailbox profile defines the mailbox tasks and actions that each mailbox user performs during the simulated LoadGen test.

Measured areas during LoadGen testing included:

- Measure CPU and memory metrics in the native setup using Perfmon
- Measure CPU and memory metrics on ESX server using esxtop
- Measure and compare latency for metrics reported by LoadGen

Each test followed these conditions:

- Validate acceptable Exchange 2007 performance in VMware environment using Microsoft LoadGen
- Maintain acceptable CPU utilization on ESX servers
- Maintain comparable performance between virtual and native configurations

Additional performance data was collected by using Windows Performance Monitor and VMware esxtop.

10.3 2,000-USER JETSTRESS AND LOADGEN TESTING (A1 - A4)

For the 2,000-user testing, a single 2,000-user Exchange virtual machine was configured on the IBM LS41 blade running ESX 3.5. The virtual machine was configured according to the specifications in Figure 4.

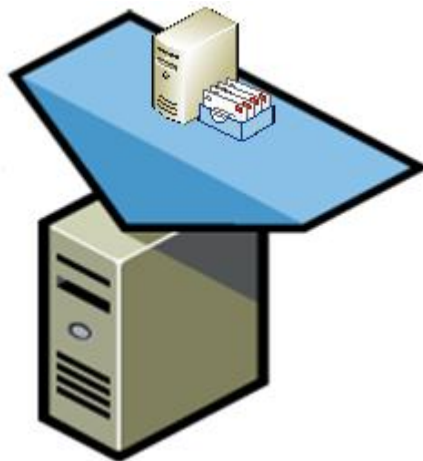


Figure 4) LS41 blade and one 2,000-user mailbox virtual machine.

A second LS41 blade was configured on a separate test harness and used to run a 2,000 user-workload without virtualization. The purpose of this test was to demonstrate that Jetstress and LoadGen performance on the VMware platform were comparable with a native configuration.

Jetstress success criteria:

- Exceed 1,000 IOPS (2,000 users at 0.5 IOPS per user)
- Maintain acceptable disk latency (under 20ms)
- Maintain comparable performance between virtual and native configuration

Figure 5 shows summarized results from running Jetstress on the 2,000-user virtual machine building block and compares results to a nonvirtualized configuration running on identical server and storage hardware. Both configurations provide sufficient I/O performance to support 2,000 users.

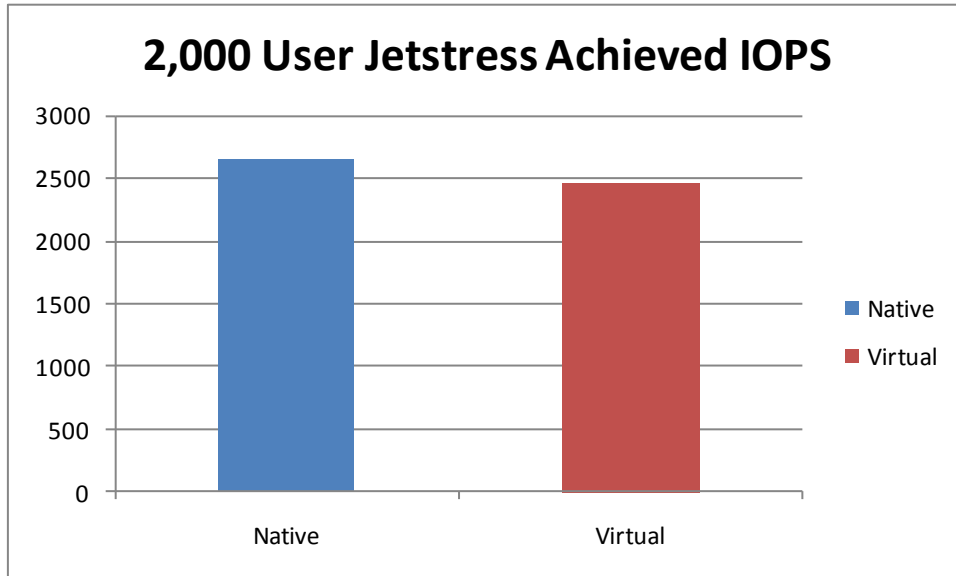


Figure 5) Achieved IOPS from 2,000-user Jetstress testing, comparing VMware configuration to native configuration running on identical server and storage hardware.

Figure 6 shows the average read and write latency on the Exchange databases for both virtual and native testing.

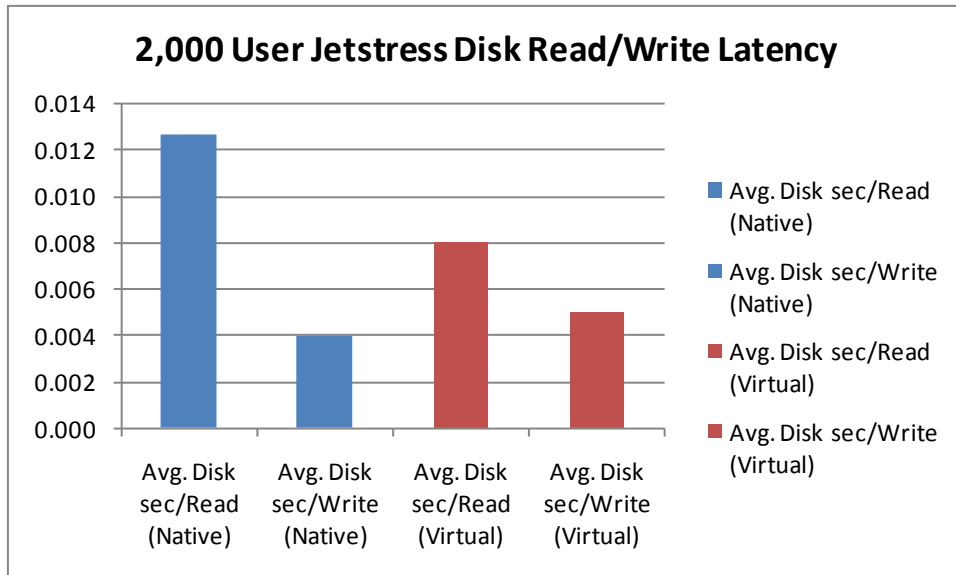


Figure 6) Jetstress average disk read and write latency for virtual and native testing.

Note: Each mailbox virtual machine was configured with six databases. For display purposes, latency values shown in Figure 6 are the average across all six databases. Results are very comparable in terms of achieved IOPS and latency and are well within acceptable limits of Microsoft best practices.

Both native and virtual testing met and exceeded the minimum required IOPS to support 2,000 Exchange mailboxes under the Microsoft “average” profile and maintained latency under 20ms.

LoadGen testing was conducted against the 2,000-user virtual machine to check that latency was within acceptable limits. Also, latency measures were compared to the native configuration to check that performance was comparable. Finally, esxtop was used to measure CPU utilization on the ESX server.

LoadGen success criteria:

- Acceptable latency on a par with native configuration
- Acceptable CPU utilization on ESX server

Note: LoadGen reports on a number of metrics. For simplicity, the rest of this paper examines the SendMail stat. For full results, see the appendixes.

Figure 7 shows SendMail latency for 2,000-user virtual and native configurations. Both are well within acceptable limits.

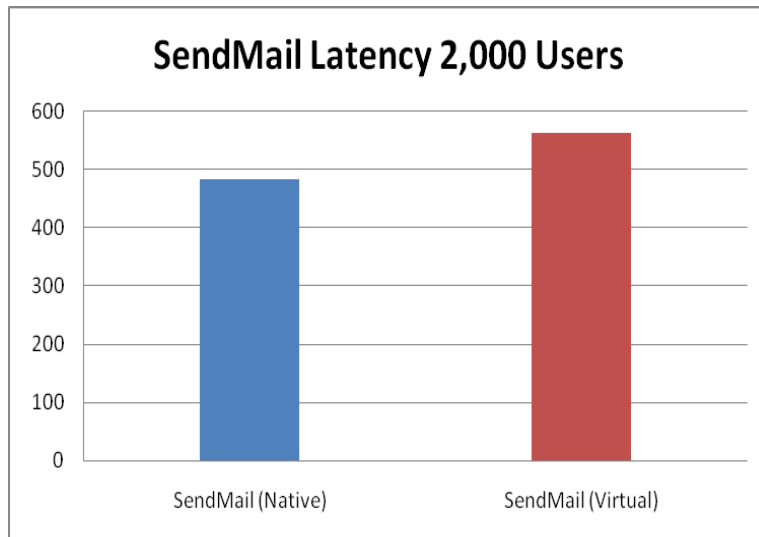


Figure 7: SendMail latency for 2,000-user LoadGen testing (95th percentile latency).

The system under test for the virtual environment was an IBM LS41 with dual quad-core CPUs. The single virtual machine was configured with only 2vCPU. To measure CPU utilization, esxtop was run during the LoadGen test. Table 4 shows the data analyzed by using esxtop and validates that only two physical CPU cores are being stressed by the virtual machine with 2vCPU.

Table 4) CPU utilization on LS41 blade (eight cores) running LoadGen against a single 2,000-user virtual machine.

CPU #	0	1	2	3	4	5	6	7	Total
Average utilization (percent)	45	46	1	0	1	1	0	0	12

Average across all eight cores was 12%; the two cores used by the virtual machine averaged 45% and 46%.

Note: The virtual machine was running on an LS41 blade with eight processor cores and 32GB RAM, but it was allocated only 9GB RAM and 2vCPU. Conversely, the native test harness ran Jetstress for 2,000 users with access to all eight cores and the full 32GB RAM. A properly sized virtual machine with 2vCPU and 9GB RAM performed comparably with the native configuration, even though the native configuration had access to all CPU and RAM resources on the blade server. Customers using virtual machines could therefore run additional virtual machine workloads on this server to take advantage of this extra CPU and RAM headroom.

10.4 4,000 USER JETSTRESS AND LOADGEN (B1 – B2)

Scaling up to 4,000 users was done by creating a second mailbox virtual machine on the LS41 blade according to the specifications in Figure 8. The NetApp storage was configured with an additional 20 disks for database and 4 disks for logs. Two virtual machines were tested on the LS41 blade as Exchange mailbox servers, each designed to support 2,000 users.

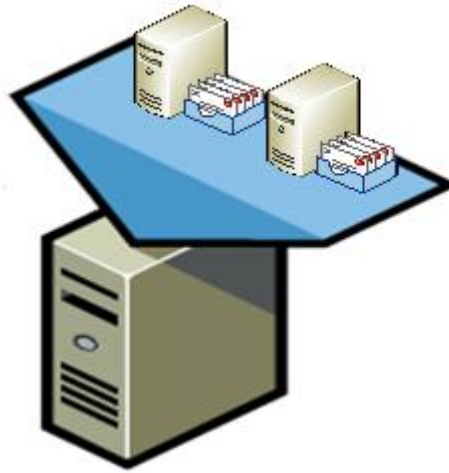


Figure 8) LS41 blade and two 2,000-user mailbox virtual machines.

Jetstress success criteria:

- Both virtual machines exceed 1,000 IOPS each
- Both virtual machines maintain disk latency below 20ms

Note: Testing on the native platform was done only for 2,000-user and 6,000-user configurations. No comparisons were done for 4,000 users.

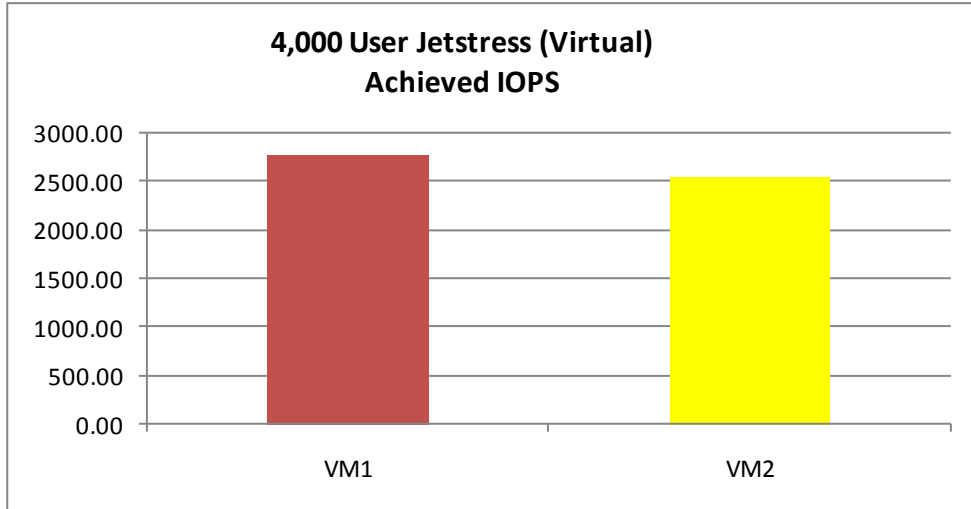


Figure 9) Jetstress achieved IOPS for 4,000-user design (two mailbox virtual machines running 2,000 users each).

Both virtual machines (VM1 and VM2) running simultaneously on the LS41 blade provide sufficient IOPS to support 2,000 users each.

The disk read and write latency were also within acceptable limits (20ms) for both mailbox virtual machines.

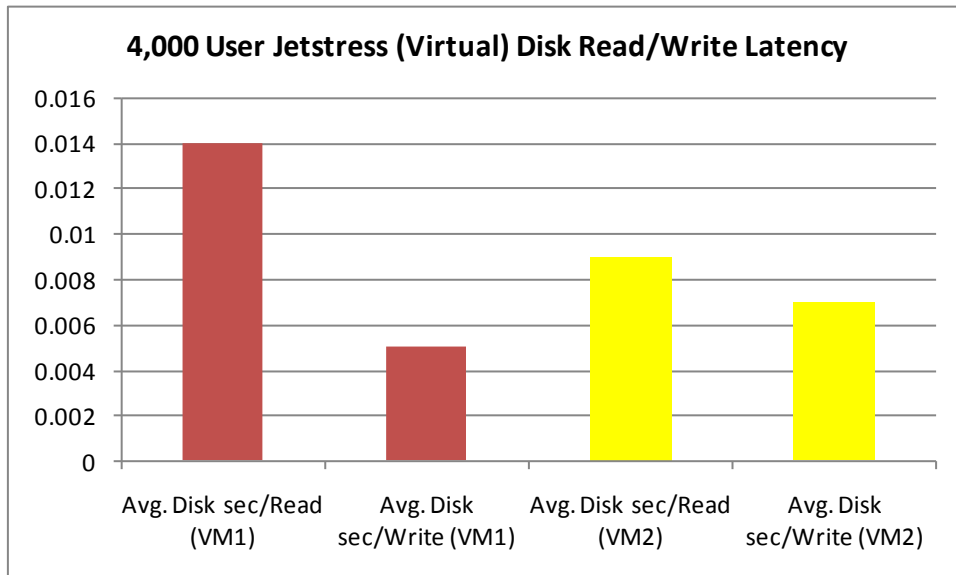


Figure 10) Jetstress average disk read and write latency for 4,000-user design (two mailbox virtual machines running 2,000 users each).

Note: Each mailbox virtual machine was configured with six databases. For display purposes, latency values shown in Figure 10 are the average across all six databases.

Results demonstrate satisfactory Jetstress performance for the 4,000-user design using two building blocks.

Scaling up to two building blocks was also validated with LoadGen. Figure 11 shows SendMail latency for the 4,000-user design running two virtual machines, each supporting 2,000 users. Full results are listed in the appendixes.

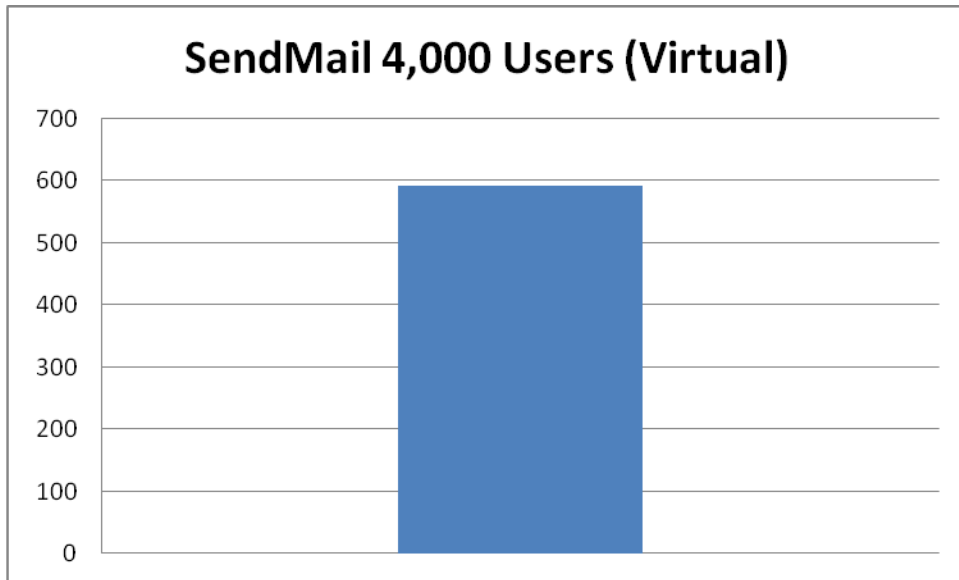


Figure 11) SendMail latency for 4,000-user LoadGen testing (95th percentile latency).

Running two virtual machines, each with 2vCPU, should show CPU load on four physical cores on the LS41 blade. This is validated by examining the esxtop data collected during the LoadGen testing.

Table 5) CPU utilization on LS41 blade (eight cores) running LoadGen against a two mailbox virtual machines supporting 4,000 users.

CPU #	0	1	2	3	4	5	6	7	Total
Average utilization (percent)	45	47	46	46	2	2	1	1	24

As expected, four cores are being used on the LS41 blade. Average across all four was approximately 46%. Average across all eight cores on the ESX server was 24%.

10.5 6,000-USER JETSTRESS AND LOADGEN (C1 – C4)

Scaling up to 6,000 users was done by creating a third mailbox virtual machine according to the specifications in Figure 12. The NetApp storage was configured with an additional 20 disks for database and 4 disks for logs. Three virtual machines were run on the LS41 blade as standalone Exchange mailbox servers, each designed to support 2,000 users.

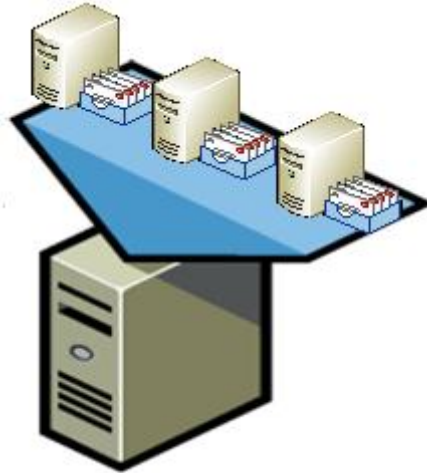


Figure 12) LS41 blade and three 2,000-user mailbox virtual machines.

Figure 13 shows the results of Jetstress testing all three virtual machines simultaneously on the LS41 blade. Results of native testing are also shown for comparison. This test was designed to validate that each of the three mailbox virtual machines could provide sufficient IOPS (1,000 or greater) to support 2,000 users at 0.5 IOPS per user.

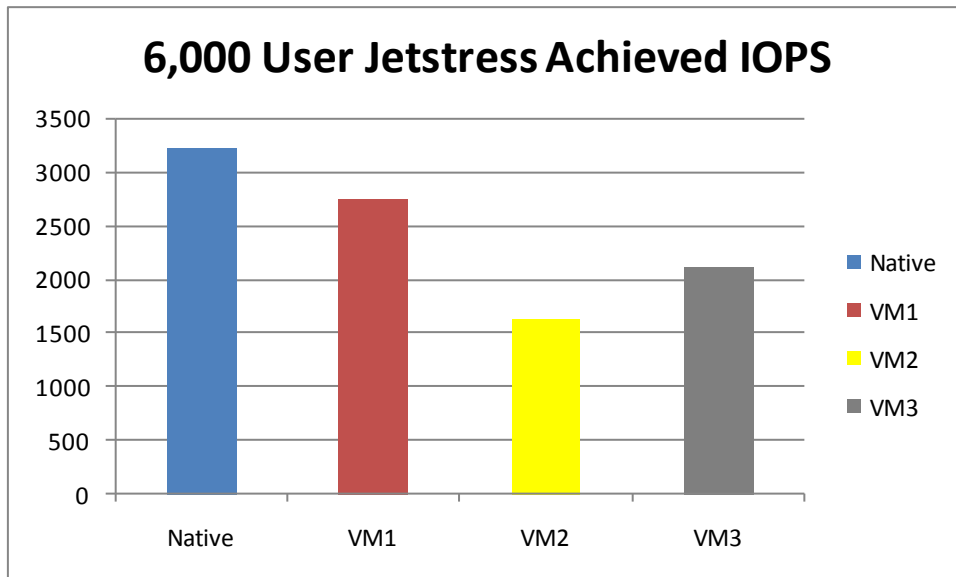


Figure 13) Jetstress virtual and native achieved IOPS for 6,000 users. Virtual configuration used three 2,000-user building blocks.

Achieved IOPS again exceeded criteria for each building block and maintained performance comparable with a 6,000-user native configuration.

Note: Aggregate IOPS from all three virtual machines were over 6,000 (VM1 + VM2 + VM3), indicating significant I/O headroom for future growth.

Figure 15 validates that read and write latency for each virtual machine remained well under 20ms.

Average utilization (percent)	52	53	52	52	54	55	5	5	41
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Average across all eight cores was 41%. The six cores used by mailbox virtual machines averaged just over 50%.

10.6 VMWARE VMOTION AND HA TESTING (D1 – D2)

VMotion provides the ability to migrate live, running virtual machines across ESX servers with no loss of service. This ability can be extremely useful in the Exchange environment for a number of reasons. Avoiding planned downtime for server hardware maintenance and moving Exchange virtual machines onto more powerful server hardware are just two examples of how VMotion can be extremely valuable for the Exchange administrator.

The objective of these tests was to validate that VMware VMotion can be used to move the Exchange virtual machines in this configuration across ESX servers with no loss of service. Testing was set up by running LoadGen simultaneously on all three virtual machines to simulate a full 6,000-user load. All three virtual machines were then simultaneously migrated onto a separate ESX server while LoadGen was running.

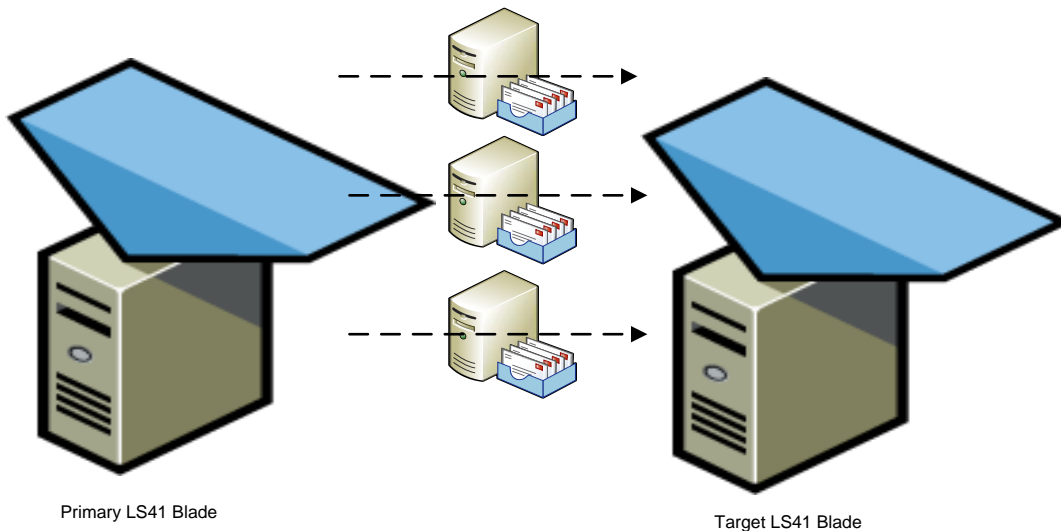


Figure 16) Migrating mailbox server virtual machines across ESX servers with VMware VMotion.

To observe the impact of VMotion, the LoadGen task queues were monitored. Additionally, all mailbox servers were continuously pinged during the move. A total of 12 migrations were conducted during the LoadGen test, and no impact was observed. LoadGen queues remained near zero, and all servers responded to ping requests at all times.

Figure 17 shows CPU utilization on the primary ESX server when LoadGen is running against 6,000 users, spread across three virtual machines. The initial utilization of around 50% drops off completely as the mailbox virtual machines are moved to another ESX server with VMotion.

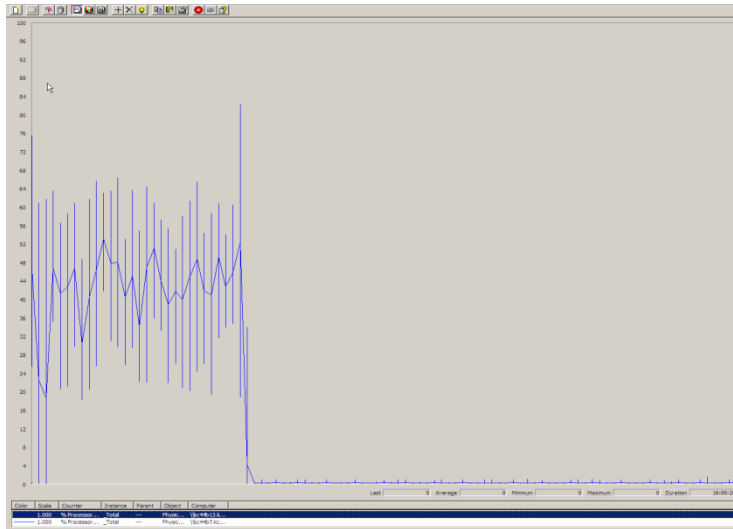


Figure 17) Esxtop data showing CPU utilization on the primary ESX server before mailbox server migration.

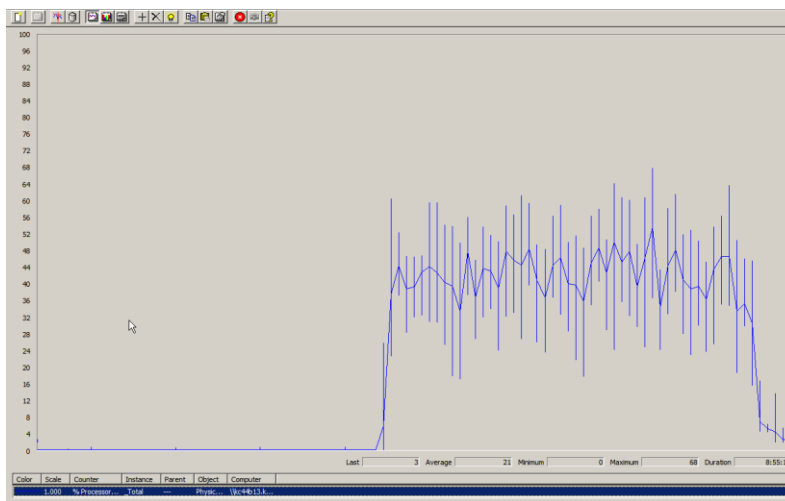


Figure 18) Esxtop data showing CPU utilization on target ESX server after mailbox server migration.

Looking at esxtop data from the target server shows CPU picking up to 50% as the virtual machines are moved across. All of these migrations were completely transparent to the LoadGen test, which was running the heavy workload (MMB4) against the three virtual machines. The LoadGen test completed a full 12-hour run during the VMotion testing and maintained performance levels consistent with previous testing where VMotion was not used.

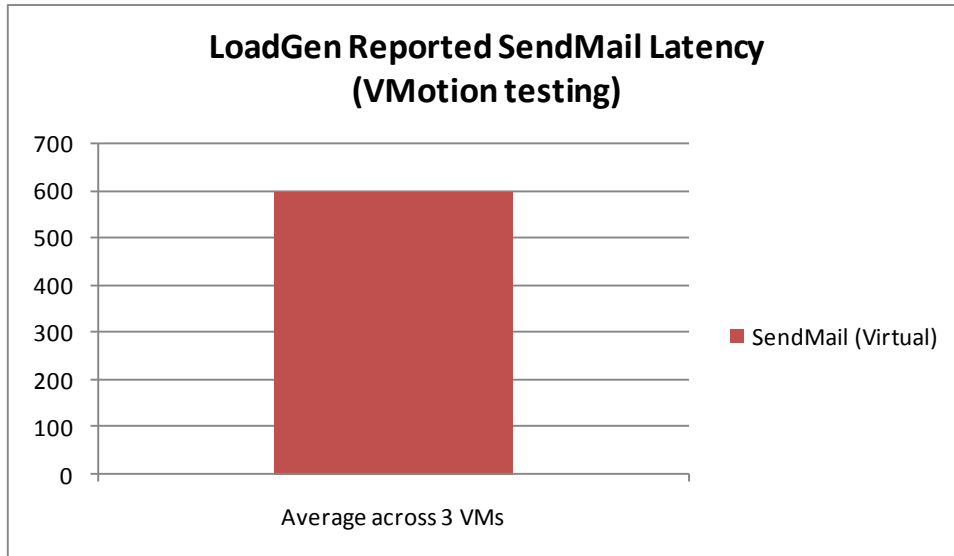


Figure 19) SendMail latency (95th percentile) reported by LoadGen after VMotion testing.

Results validate that VMotion can be used even on heavily loaded mailbox virtual machines with no loss of service while maintaining the Exchange database cache and causing no impact to latency (Figure 19).

Note: Most software cluster solutions (Single Copy Cluster, Continuous Cluster Replication, and so on) require the Exchange database cache to be rebuilt on the target server after a cluster failover, which can result in degraded performance.

This solution was designed using standalone virtual machines and does not use any software clustering solutions, such as MSCS, Symantec, and so on. High availability is provided entirely by VMware HA. In addition to protecting critical mailbox virtual machines, VMware HA also protects every other Exchange virtual machine from server hardware failure by restarting virtual machines on surviving ESX servers.

For more information about VMware HA solutions for high availability, go to

http://www.vmware.com/pdf/vmware_ha_wp.pdf

To test VMware HA in this solution, LoadGen was once again configured to run on all three mailbox virtual machines with the “heavy” profile (MMB4). A server hardware failure was simulated on the IBM LS41 blade by instantly powering off the server through the IBM BladeCenter management console. A second LS41 blade was configured with ESX 3.5 and had sufficient capacity to host all three mailbox virtual machines during failover testing.

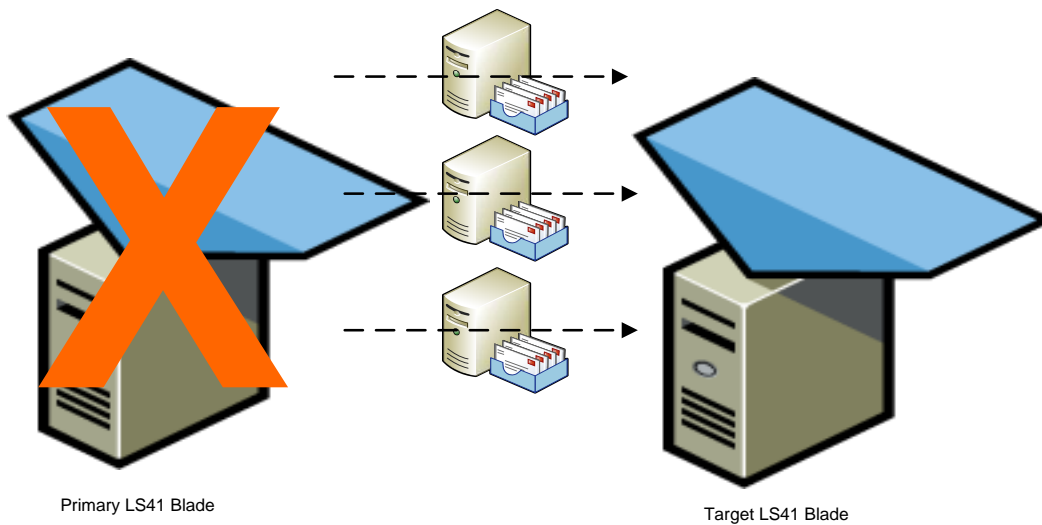


Figure 20) VMware HA restarting mailbox virtual machines during simulated server hardware failure.

It is not a requirement to have identical hardware standing by for VMware HA. The mailbox virtual machines can restart on any surviving ESX servers as long as there is sufficient capacity in the VMware HA/DRS cluster. An advantage of the building block approach, which splits mailbox servers into smaller virtual machines (9GB RAM and 2vCPU each) means that any ESX server with enough free capacity can host a mailbox server during a server hardware failure.

Simulating a failure on the primary ESX server caused all three mailbox virtual machines to restart on the surviving ESX server. Unlike VMware VMotion, which migrates a live virtual machine, VMware HA must restart the virtual machine's operating system on the target system during failover. During this time, Exchange services are not available. For this reason, LoadGen queues built up significantly until the virtual machines restarted and the Exchange services were started. Once restarted, LoadGen queues gradually worked their way back down to normal levels.

Note: It is important to understand how VMware HA automatically protects every virtual machine from server hardware failure, not just the mailbox server. A key weakness with most software cluster solution is their protection of the mailbox server only. Other critical systems (HUB, CAS, Edge, domain controller, and so on) are vulnerable to outage during hardware failure. In a solution built on a VMware Infrastructure 3 platform, the overall availability of Exchange services can be increased because every workload running in a VMware virtual machine is protected from server hardware failure.

There are a number of ways to provide high availability for Exchange servers, each with varying levels of cost and complexity. This solution uses VMware HA with standalone virtual machines (that is, no cluster software such as MSCS). In this solution, Exchange services are not available after server failure while the virtual machines restart and Exchange services come online. This could take several minutes, depending on the environment. During this time, mail is queued until the mailbox servers are back online. These effects can be reduced when running Outlook® clients in cached mode.

This solution is designed for customers who prefer the simplicity of standalone systems over software clusters. It provides a robust high-availability solution for every Exchange virtual machine, not just the mailbox servers. VMware HA can also be combined with traditional MSCS solutions such as CCR and LCR for customers who require advanced enhanced levels of availability beyond what VMware HA provides on its own.

10.7 TESTING BACKUP WITH SNAPMANAGER FOR EXCHANGE 4.0 (E1)

To enable SnapManager for Exchange-aware VSS backups in the VMware environment, this solution used the Microsoft iSCSI initiator running on the virtual machine (Figure 21) to connect to the Exchange database

and log volumes on the NetApp array. (Exchange virtual machines still had their OS and swap drives on VFMS storage.) This solution is also supported by using Fibre Channel connections to the ESX server.

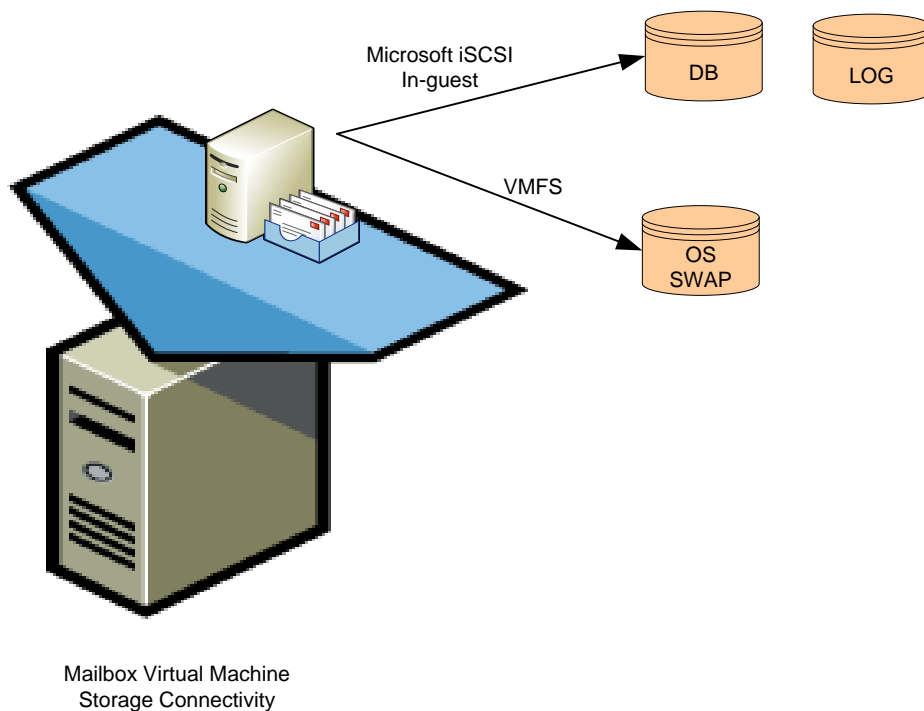


Figure 21) Mailbox virtual machine using Microsoft iSCSI initiator to access Exchange database and logs. Enables VSS backups by using SnapManager for Exchange 4.0.

SnapManager was used to validate the backup and restore functionality of mailbox virtual machines. The following tests were completed:

- Test VSS backup of Exchange databases by using VMware virtual machine and SnapManager for Exchange 4.0
- Mount VSS snapshot to alternate host and run consistency check using eseutil
- VSS restore of Exchange storage group
- Recover individual mailbox and message
- Integrate with SnapMirror to replicate data to remote array

All tests were performed successfully on the VMware configuration. Using array-based VSS backups provides rapid backup and restore capability with no performance impact on production servers.

10.8 TESTING REMOTE REPLICATION AND DISASTER RECOVERY WITH SNAPMIRROR (E2)

The solution for Exchange 2007 disaster recovery that was tested as part of this solution combines the benefits of SnapMirror technology, VMware Infrastructure 3, and the Exchange 2007 “database portability” feature to create an effective disaster recovery solution. The disaster recovery solution is built on the following process (Figure 22):

1. SnapManager for Exchange 4.0 is used at the primary site to create a VSS copy of the production Exchange databases.
2. The VSS copy is checked for consistency on an alternate host (also deployed as a virtual machine in this configuration). Offloading the consistency checks to an alternate virtual machine minimizes the impact on mailbox servers.

3. If the consistency check completes successfully, data is replicated to a remote NetApp controller via SnapMirror. The remote array is ideally deployed at a disaster recovery site.
4. Testing was used to demonstrate recovery for a single 2,000-user virtual machine (the process is identical regardless of how many building blocks are in the solution). A single mailbox server virtual machine was configured at the DR site and was used to connect to the replicated Exchange databases on the remote storage controller by using the Exchange 2007 database portability feature. See Appendix A for details about the commands for connecting databases at the remote site with both SnapManager for Exchange and database portability scripts.

Note: Lab testing was used only to demonstrate recovering a single mailbox server. A real-world deployment would probably contain additional virtual machines at the remote site required to bring up the entire infrastructure. Examples include domain controller, DNS, and other required Exchange server roles.

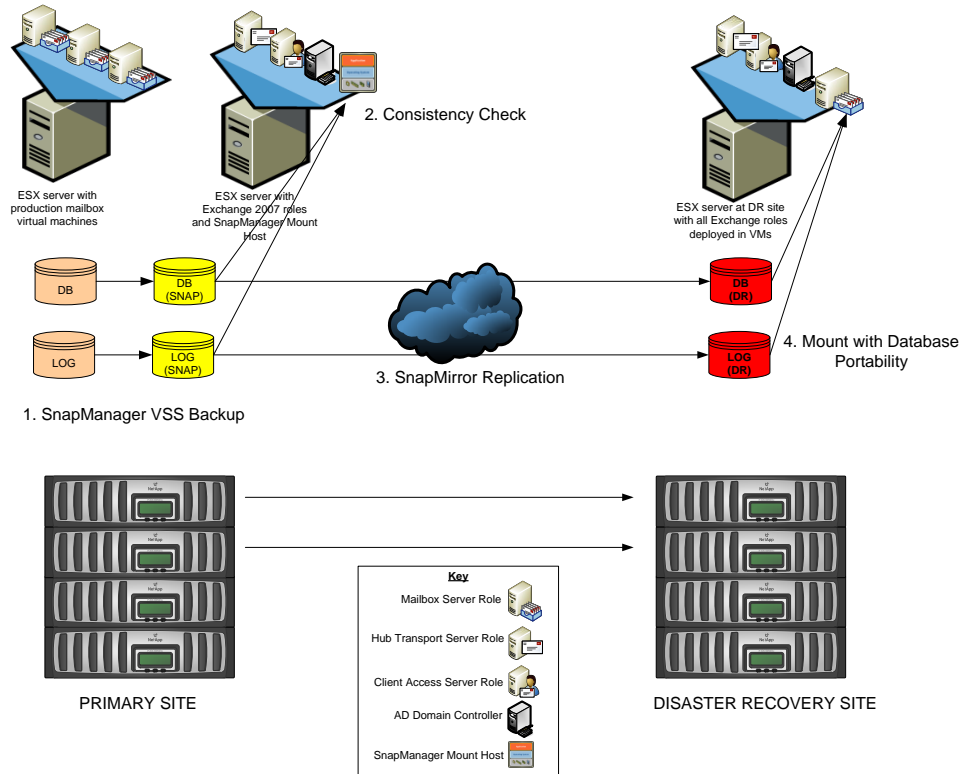


Figure 22) Disaster recovery solution using VMware virtual machines, SnapMirror replication, and Exchange 2007 database portability.

This solution provides an effective disaster recovery strategy that can be implemented with minimal server hardware at the remote site. The configuration in Figure 22 shows an example where all Exchange roles (mailbox, HUB, CAS) and a single domain controller are deployed in virtual machines on a single ESX server at the DR site.

Testing at the NetApp labs validated that the Exchange data can be brought online quickly by using this configuration. Having standby virtual machines configured at the DR site enables rapid recovery during a disaster. Exchange 2007 database portability makes it easy to keep standby mailbox servers available at all times that can easily take over and connect to replicated databases.

- Archive to disk or tape (not shown) can be done either at the primary site or at the remote site.
- The RPO and RTO depend on the bandwidth between sites and frequency of replication and can easily be designed to meet SLAs of one hour or less.

Hosting servers at a DR site for Exchange can be a costly solution, especially when these systems are required only during infrequent outages. Many customers use these systems for other purposes when they

are not required for Exchange DR. Examples include virtual machines for test and development environments. This allows the hardware to be fully used, and these workloads can be quickly shut down during an Exchange disaster to free up resources for Exchange servers.

10.9 TEST OBSERVATIONS

Although the mailbox virtual machine building blocks had CPU and RAM sized based on an “average” user profile, with two 2vCPU and 9GB RAM, all testing with Jetstress and LoadGen showed performance capable of supporting “heavy” users. A benefit of virtual machines over native servers is the ability to add CPU RAM, which means that Exchange virtual machines can be sized conservatively and scaled at any time. For an explanation of Exchange user profiles and sizing, see

<http://technet.microsoft.com/en-us/library/bb738142.aspx>

Only one minor issue was observed during the testing process. When testing VMware HA by simulating server hardware failure, mailbox virtual machines consistently restarted on a surviving ESX server. The guest operating system (Windows 2003 x64 R2 SP2) came up every time, but Exchange services did not start automatically. This is due to an issue with Exchange 2007; the workaround used in testing can be found at <http://support.microsoft.com/default.aspx?scid=kb:EN-US:940845>.

This issue will probably be fixed through an Exchange 2007 service pack or hot fix.

11. SUMMARY

Many customers who are using virtualization today with great success are considering VMware Infrastructure 3 as the next-generation platform for their Exchange 2007 environment. This report describes how a building block approach can be used to size an environment that leverages a virtualized platform for flexibility and is easily scalable by adding blocks at any time. Performance testing was done to validate performance of the building block approach and to demonstrate that the new x64 Exchange architecture performs extremely well when virtualized on a VMware Infrastructure 3 platform.

VMotion offers significant increases in flexibility for the Exchange servers and was shown to seamlessly move a heavily loaded mailbox virtual machine across ESX servers with no loss of service. VMware VMotion can be a valuable tool for the Exchange administrator for increased flexibility and avoiding planned downtime.

VMware HA was used as the solution for Exchange high availability and provides a robust solution for protecting every Exchange server in the organization from server hardware failure, without requiring complex clustering software. For customers who have increased availability requirements, VMware HA can be combined with other software clustering solutions such as Exchange CCR, LCR, and SCR.

SnapManager for Exchange was used for rapid backup of Exchange databases at the local site. The mailbox server virtual machines were configured to access Exchange database and log volumes on the NetApp array using the Microsoft iSCSI initiator running inside the guest operating system. This configuration is currently the only supported method for providing VSS backups with SnapManager and VMware virtual machines; however, a future version of SnapManager will enable this functionality through other storage initiator choices.

SnapMirror was used to extend this solution to include remote replication for disaster recovery. Virtual machines were used at the DR site and connected to replicated databases by using the new database portability feature in Exchange 2007. The solution provides a simple and effective method for Exchange 2007 disaster recovery.

The configuration as a whole represents an end-to-end solution for deploying Exchange 2007 on a next-generation platform built on VMware Infrastructure 3, NetApp storage, and blade server hardware. The solution provides a method for simple and scalable sizing by using the building block approach, rapid VSS backups using SnapManager for Exchange 4.0, and effective disaster recovery with SnapMirror replication.

12. NEXT STEPS

For more information about this solution, contact your VMware or NetApp representative.

13. MICROSOFT SUPPORT CONSIDERATIONS

Because Exchange is a powerful business tool that is a core part of daily business for some companies, it is strongly encouraged that administrators understand Microsoft's current support policies before undertaking this implementation. The following options are available to customers:

- Many VMware OEM partners provide end-to-end support for Microsoft applications running in VMware virtual machines. This solution was built on IBM blade server hardware; for customers who purchase VMware products with IBM hardware and an IGS support agreement, IBM provides end-to-end support, including the VMware software and licensed Microsoft software that run in virtual machines.
- Many other OEMs also offer end-to-end support. For the latest information, see http://www.vmware.com/support/policies/ms_support_statement.htm.
- For customers with Premier-level support, Microsoft uses "commercially reasonable efforts" to investigate issues with Microsoft applications running with non-Microsoft hardware virtualization software (see the Microsoft Knowledge Base article [Q897615](http://www.microsoft.com/kb/897615)).
- For customers who purchase VMware products directly (or from an authorized reseller) and who do not have a Microsoft Premier-level support agreement, Microsoft's level of support is more restrictive. Microsoft support specialists may request that customers first replicate the issue on a physical machine. Item #897615 in the Microsoft Knowledge Base describes this policy: <http://www.support.microsoft.com/kb/897615>

NetApp support:

- NetApp fully supports ESX 3.5, and it is listed on our VMware compatibility guides for both NetApp iSCSI ESX Host Utilities 3.1 and NetApp FCP ESX Host Utilities 3.1.
- NetApp fully supports Exchange 2007 and Exchange 2007 SP1.
- NetApp software such as SnapMirror, SnapDrive®, and SnapManager for Exchange are listed in the Microsoft Windows catalog.
- NetApp supports Exchange 2007 on ESX 3.5 but does not and cannot resolve issues that are determined to be between Microsoft and VMware.

This technical report is not a guarantee by NetApp to provide broader support for Microsoft Exchange Server 2007 and VMware ESX 3.5 than provided by Microsoft and VMware. NetApp fully supports VMware ESX 3.5, and it is listed in NetApp's VMware compatibility guides for both NetApp iSCSI ESX Host Utilities 3.1 and NetApp FCP ESX Host Utilities 3.1.

14. APPENDIX A: EXCHANGE RECOVERY PROCEDURE

SnapManager for Exchange 4.0

SnapManager for Exchange (4.0 and 5.0) can be used at the DR site on the standby Exchange Server to quickly restore the Snapshot copy that was replicated with SnapMirror, move the users, and mount the databases.

1. Restore the backup that was created on a different server.
2. Select the source Exchange Server.
3. Point to the SnapInfo directory path (on the LOG LUN).
4. Select the backup you want to restore.
5. Select "Recover and mount database after restore."
Select "Update user accounts associated with mailboxes in restored databases to point to mailbox server with the new name."
6. Click Start.

PowerShell™ v1 Scripts

If SnapManager for Exchange is not installed on the target Exchange Server, custom scripts must be created and used to leverage the database portability functionality that is built into Exchange 2007.

Create Mailbox Database PowerShell Script

This script was used at the DR site to create the target database:

```
New-MailboxDatabase -Name <Database_Name> -StorageGroup  
<Server_Name>\<StorageGroup_Name>  
New-MailboxDatabase -Name DB1 -StorageGroup VM6\SG1
```

Mount Database PowerShell Script:

This script was used at the DR site to mount the target database:

```
Mount-Database -Identity <Database_Name>  
Mount-Database -Identity VM6\DB1
```

Database Portability PowerShell Script:

This script was used at the DR site to move the users from the primary database (VM3\DB1) to the target database at the DR site (VM6\DB1):

```
Get-Mailbox -Database <old database> | move-mailbox -targetdatabase <new  
database> -configurationonly:$true  
Get-Mailbox -Database VM3\DB1 | move-mailbox -targetdatabase VM6\DB1 -  
configurationonly:$true
```

15. APPENDIX B: ADDITIONAL PERFORMANCE DATA

Each virtual machine in the 6,000-user test was designed to support 2,000 users. The following table shows additional performance metrics measured during the 6,000-user LoadGen testing.

Database Cache Size	7563
RPC Avg Latency	21.1
RPC Operations	181
RPC Requests	1.65
Msg Delivered/sec	1.598
Context Switches	2045
Log Avg Disk Sec Write	0.004

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