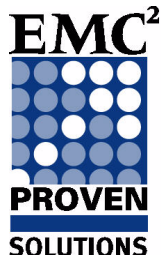


EMC Virtual Infrastructure for Microsoft Applications—Data Center Solution Enabled by EMC Symmetrix V-Max and VMware ESX 3.5

Applied Technology



Abstract

Establishing a virtualization-enabled platform for a multi-application data center can provide a number of technical and operational benefits versus a similar non-virtualized configuration. This white paper presents best practices and validated test results for a virtualized deployment, enabling customers to capitalize on the immediate benefits by implementing a VMware Virtual Infrastructure and EMC[®] Symmetrix[®] V-Max[™] storage.

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Executive summary

Today, doing more with less is the mantra of IT organizations as they continually look for ways to reduce costs for their data center operations. And despite these pressures, IT is expected to deliver higher levels of service to the business.

More and more organizations are turning to server and storage virtualization technologies to leverage their existing investments while proactively managing tremendous data center growth.

EMC helps customers configure and deploy a highly efficient, consolidated application data center on a virtualized infrastructure by providing a solution that has been rigorously tested to ensure predictable and reliable results. This solution leverages the full integration and high availability (HA) features of VMware Virtual Infrastructure and the innovative EMC[®] Symmetrix[®] V-Max[™] storage system to maintain a highly available environment across multiple applications.

Introduction

This white paper outlines the best practices, build considerations and test results for consolidating Microsoft Office SharePoint Server 2007, Microsoft SQL Server 2008, and Microsoft Exchange Server 2007 so that they share the same infrastructure while ensuring business continuity.

In addition to minimizing operational and management costs, this solution demonstrates how a virtualized infrastructure that leverages EMC Symmetrix V-Max and VMware Virtual Infrastructure simplifies management, reduces the number of physical servers, and protects IT against application disruption.

The Symmetrix V-Max storage array is leveraged to address storage and consolidation. EMC brings the power of Symmetrix V-Max advanced virtualization mechanisms coupled with VMware virtual server technology to maintain efficiency across multi-application environments. This solution integrates the EMC Symmetrix Management Console (SMC) for centralized storage management. Additionally, EMC Replication Manager provides seamless backup of Microsoft SQL Server and Microsoft Exchange 2007 databases.

Audience

This white paper is intended for:

- Field personnel who are tasked with implementing a multi-application virtualized data center utilizing EMC Symmetrix V-Max as the storage platform
- Customers, including IT planners, storage architects, and administrators involved in evaluating, acquiring, managing, operating, or designing an EMC multi-application virtualized data center
- Engineering and product development groups
- EMC staff and partners, for guidance and development of proposals

Terminology

Review the following terms for a better understanding of this technical analysis.

Advanced Tiered Storage Management—Allows you to present a large amount of capacity to a host and then consume space only as needed from a shared pool. This improves total cost of ownership (TCO) by reducing initial overallocation of storage capacity and simplifies management by reducing the steps required to support growth.

Autoprovisioning Groups—Provide an easier, faster way to provision storage in Symmetrix V-Max arrays. In virtual server environments applications running on V-Max arrays require a fault-tolerant environment with clustered servers as well as multiple paths to devices for guest VMs. Autoprovisioning Groups were developed to make storage allocation easier and faster, especially in multi-application environments.

Distributed Resource Scheduler (DRS)—A VMware feature to ensure maximum performance and load balancing across an ESX cluster in a reported or automated fashion. VMotion is employed to migrate candidate VMs.

EMC Replication Manager—Coordinates the entire data replication process—from discovery and configuration to the management of multiple application consistent disk-based replicas.

ESX cluster—A group of ESX Servers configured as a single cluster through VirtualCenter to act as a single shared resource.

Raw Device Mapping (RDM)—A method to expose a LUN to a VM without hypervisor translation.

Virtual LUN—Enhanced Virtual LUN Technology enables data migration within an array without host or application disruption. Virtual LUN brings a tiered storage strategy to life by easily moving information throughout the storage system as its value changes over time. It can assist in system reconfiguration.

Virtual (Thin) Provisioning—A feature that provides storage on demand without host reconfiguration.

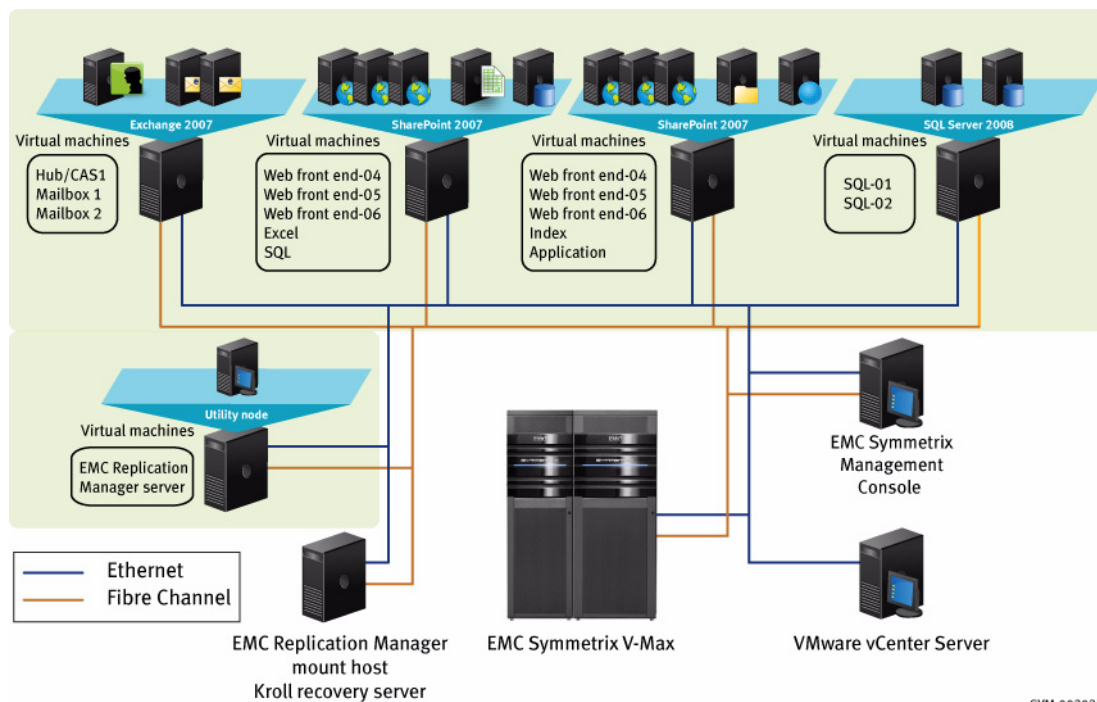
VMware HA (High Availability)—VMware software that offers extended VM protection using quick restart on hardware failure.

VMotion—A method to migrate an active (VM) from one ESX host to another with no perceived impact.

Configuration

The design is comprised of a virtualized data center running three mission-critical Microsoft applications:

- Microsoft Exchange Server 2007
- Microsoft Office SharePoint Server 2007
- Microsoft SQL Server 2008



SYM-002037

Figure 1. EMC Virtual Infrastructure for Microsoft applications environment

Common elements in this virtualized data center test environment

It's important to understand the common elements shared between the Exchange Server 2007, SharePoint Server 2007 and Microsoft SQL Server 2008 applications in the EMC virtualized data center.

Typical 24-hour run with each application under load

All three Microsoft applications ran simultaneously under load demonstrating the overall efficiency of the data center. See the application-specific sections for detailed test results:

- ["Typical 24-hour data center run—Exchange 2007 test summary" on page 14](#)
- ["Typical 24-hour data center run—SharePoint Server 2007 test summary" on page 24](#)
- ["Typical 24-hour data center run—SQL Server 2008 test summary" on page 28](#)

Virtual Infrastructure design

The Virtual Infrastructure for Microsoft applications combines three popular Microsoft server platforms into a single VMware server cluster. The VMware cluster provides ample computing resources to power these applications and offers the ability to dynamically reallocate resources on demand. The cluster also affords protection against equipment failures through VMware and Symmetrix V-Max HA features.

The hardware components of the VMware server cluster include computing resources supplied by VMware ESX Servers, storage area network (SAN) fabric connectivity offered by a SAN switch/storage, management tools, and data protection supplied by a Symmetrix V-Max array.

VMware ESX Servers

The VMware infrastructure consists of five server class computers running VMware ESX Server 3.5, Update 3 with the following specifications:

- Memory: 64 GB RAM
- CPUs: 4 quad core, 3 GHz Intel processors with virtualization features
- SAN fabric connections: Four 4 GB host bus adapters (HBAs)
- Network connections:
 - Four 1 GB network adapters
- Fault-tolerant network:
 - Two connections for virtual server transfers (VMotion) and the VMware service console
 - Two connections for application connectivity

VMware ESX Server roles

Each server (or cluster node) in the cluster is assigned a specific function.

Exchange and SQL cluster nodes

Exchange and SQL guest servers occupy a dedicated cluster node for each application. Two SQL Server guest VMs run on the SQL node with each guest VM offering access to a 75,000 user TPC-E like database. The Exchange node hosts two virtual mailbox servers and a HUB/CAS server, providing mailboxes for 8,000 users.

SharePoint cluster nodes

Two more cluster nodes supply resources for the SharePoint environment. One node hosts three web front-end (WFE) servers, an application server, and a SQL database back end for SharePoint. The second SharePoint node hosts three more WFEs, a generic application server, and SharePoint Services such as content search. The SharePoint environment supports 168,000 users.

Utility nodes

The fifth node is a utility node. It offers computing resources to the guest VMs in cases where more resources are needed than is available on the dedicated cluster node. The ability to seamlessly move a guest VM to take advantage of potentially idle resources on another cluster node is enabled by VMware's VMotion software.

Guest VMs may also be automatically migrated to this cluster node in the event of a hardware failure through the use of VMware HA software. This node also hosts a guest VM for EMC Replication Manager server software. The Replication Manager server software assumes the responsibilities of appropriately performing application-aware replication of the Exchange, SQL, and SharePoint data from a single consolidated interface.

Additional non-virtualized servers in the configuration

An additional server was added that is used by Replication Manager to mount the replicas and perform application-specific validation. For example, the replicas of the Exchange servers are mounted, and a consistency check is run against them to ensure database consistency. This server also runs the Kroll tools to extract documents from the SharePoint database replicas.

There are also servers in the configuration to host management tools such as Symmetrix Management Console (SMC) and VMware VirtualCenter; see [Figure 1](#).

EMC Symmetrix V-Max array

The Virtual Infrastructure for Microsoft applications utilizes the EMC Symmetrix V-Max array as its storage platform. The array is configured as follows:

- Two V-Max Engines
- Thirty two Fibre Channel connections
- One storage bay
 - 220 x 300 GB, 15k rpm Fibre Channel disks
 - 20 x 1,000 GB, 7.2k rpm Fibre Channel disks

Symmetrix V-Max Engine

The Symmetrix V-Max provides the ultimate in scalability, including the ability to incrementally develop back-end performance by adding additional directors and storage bays. The V-Max Engine is at the core of the Symmetrix V-Max. Each V-Max Engine contains two directors, and controls eight back-end Fibre Channel loops. Each engine also provides front-end as well as back-end connectivity; see [Figure 2](#).

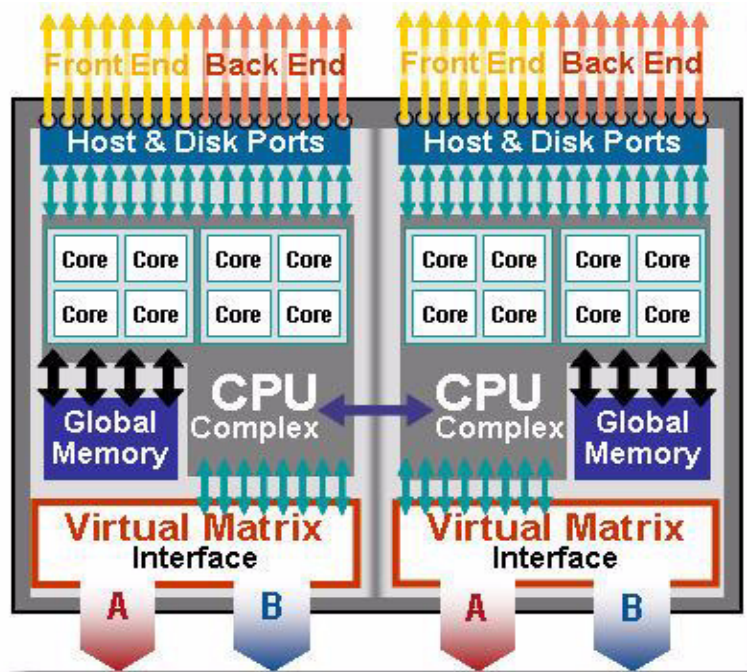


Figure 2. V-Max Engine

V-Max Engine configuration

A Symmetrix V-Max array may have up to eight V-Max Engines, which are integrated into a single system image through their fully redundant Virtual Matrix interfaces. The Virtual Matrix Architecture ensures that any host connected to any V-Max Engine will be able to connect to the necessary storage regardless of which V-Max Engine the storage is connected to.

The Symmetrix V-Max array supporting this virtual data center was comprised of two V-Max Engines connected to one 240-slot drive bay. Each V-Max Engine offers a total of 64 GB of global memory and 32 Fibre Channel front-end connections to the SAN fabric.

SAN fabric connectivity

EMC recommends that each cluster node uses a minimum of two physical HBAs connected to at least two different front-end ports on different directors. This configuration ensures continued connectivity even if a front-end port on a director, or even an entire director, becomes unavailable.

NOTE: The HBAs should be connected to different directors on different V-Max Engines; see [Figure 3](#).

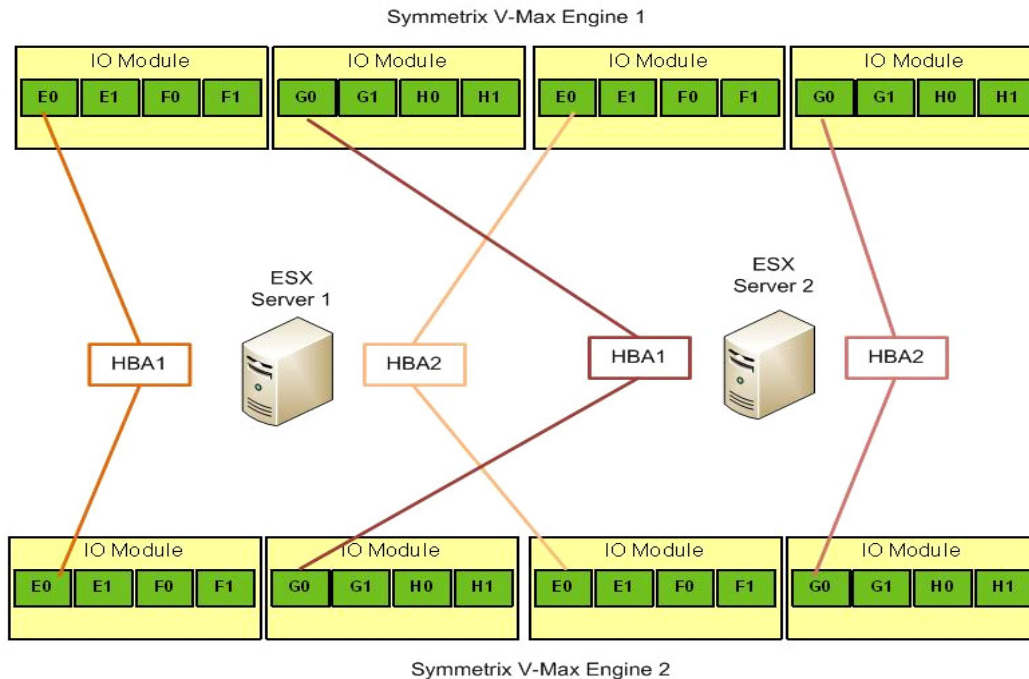


Figure 3. HBA connections to multiple directors

Autoprovisioning Groups

Autoprovisioning Groups provide a fast and easy way to provision storage, especially in clustered and virtualized environments. Previous versions of EMC Solutions Enabler required a separate command for each host initiator and port combination. However, with Solutions Enabler version 7.0, these functions occur simultaneously.

Creating device masking objects

With this version of Solutions Enabler, users can create the following device masking objects with either the command line interface or Symmetrix Management Console (SMC); see [Figure 4](#):

- A group of devices (storage group)
- A group of front-end director ports (port group)
- A group of host initiators (initiator group)
- A group that contains a storage group, port group, and initiator group to complete the masking operation (masking view)

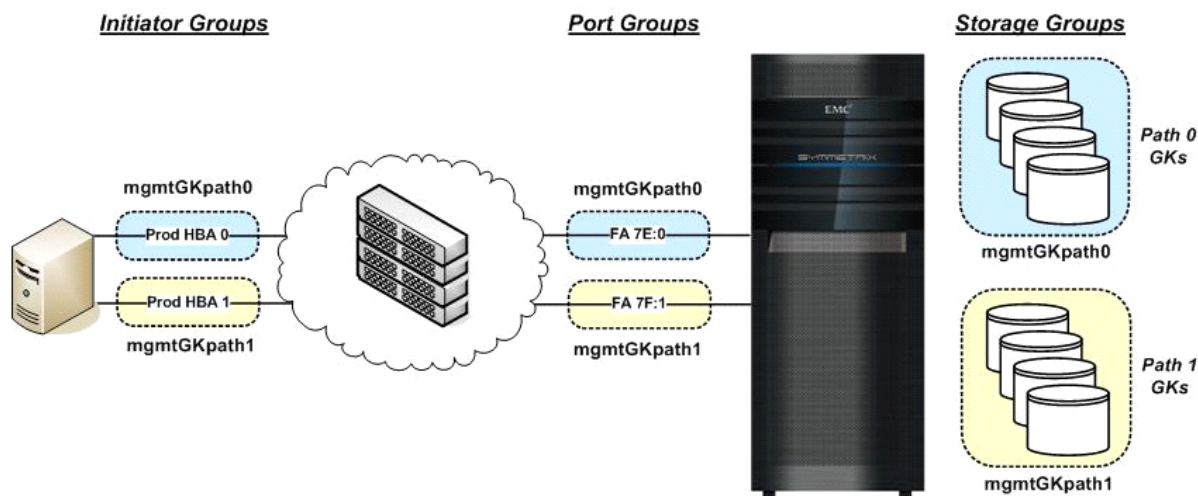


Figure 4. Creating masking view objects

Dynamic LUN addressing

Autoprovisioning Groups automatically map Symmetrix volumes to the server HBA in a consistent manner. LUN addresses (the LUN ID the host uses to identify the volume) are dynamically assigned when the volume is mapped. Autoprovisioning assures the LUN ID does not conflict with any others on the front-end port, but does not assure consistency from front-end port to front-end port. This can result in the same LUN presented as different LUN IDs depending on the front-end port.

NOTE: In virtual environments prior to ESX Server 3.5 U2, the LUN addresses must be consistent from port to port to be recognized as the same device by VMware ESX Servers. This applies to LUNs within a server and across servers. The LUN ID can be set manually through either the command line interface or SMC.

Microsoft Exchange Server 2007 configuration

The combination of Symmetrix V-Max and VMware can be very powerful for many companies in handling the challenges that Microsoft Exchange 2007 can present.

A breakdown of the Microsoft Exchange 2007 and VMware configuration used for the solution testing includes:

- Number of Exchange users: 8,000
- Number of Exchange mailbox VMs: 2
- Exchange user profile: 0.50 IOPs with 400 MB mailboxes
- Number of Exchange HUB/CAS VMs: 1
- Exchange HUB/CAS VM configuration: 4 CPUs and 12 GB memory
- Exchange ESX Server configuration: 16 CPUs and 64 GB memory

Design considerations for Exchange 2007 in an EMC virtualized data center

Some of the major considerations and questions to consider when planning a well-performing, virtualized Exchange 2007 mailbox server include:

- How many users per Exchange Mailbox VM?
 - With ESX 3.5 a total of four CPUs are supported per VM
 - 1,000 very heavy (0.50 IOPs) users per VM core (4,000 users per VM with 4 vCPUs)
- How many VMs per ESX?
 - This will depend on the server type, core, and memory requirements
- How much memory is required per VM and ESX Server?
 - Use Microsoft best practice of 5 MB per user, plus 2 GB
 - Need additional memory based on ESX Server memory overhead best practices
- How many drives per Exchange server and VM? How should they be configured?
 - Exchange OS should be on a VMFS volume
 - Exchange database and logs should reside on RDMS in physical compatibility mode
 - Database spindle IOPs calculation:
$$\frac{(\text{IOPs} \times \%R + \text{WP} (\text{IOPs} \times \%W))}{\text{Physical Disk Speed}} = \text{Required Physical Disks}$$
- How many ESGs per server?
 - Depends on a number of issues, including backup and restore requirements, online maintenance (OLM) performance
 - A 200 GB Exchange database worked well in our environment
 - May need to add multiple ESGs per LUN (due to ESX LUN limit of 256 and 60 LUNs per VM)

Exchange VMware building block

The building-block approach defines the amount of resources required to support a certain number of Exchange 2007 users. An Exchange 2007/VMware building block was created based on design considerations in the previous section, "[Design considerations for Exchange 2007 in an EMC virtualized data center.](#)" Once the initial Exchange 2007/VMware building block is designed it is easily reproduced to support the required number of total users. It is also useful when future growth is expected, as adding to the environment is straight forward and easy.

The building block tested and documented here is based on 4,000 very heavy Exchange 2007 users with 400 MB mailboxes. Each of the 4,000 users occupied a single Exchange 2007 mailbox server VM and was divided among 10 ESGs.

Local HA was provided by VMware HA and a second ESX Server. Each Mailbox server's Exchange data was backed up using a single Replication Manager job to a single clone replica created by EMC TimeFinder®.

[Table 1](#) lists parameters applied in this environment.

Table 1. Microsoft Exchange mailbox Virtualized Building Block

Parameter	Value
Number of users per building block	4,000
User profile	400 MB mailbox, 0.50 IOPs per user
VM CPU and memory requirements	4 CPUs, 24 GB memory
Number of ESGs per server	10
Number of users per Exchange Storage Group (ESG)	400 users per ESG
Database LUN design	210 GB database LUN (400 MB * 400 MB = 160 GB * 30%)
Log LUN design	Ten 30 GB Log LUNs
Total space requirements per VM	Ten 210 GB database LUNs = 2100 GB, Ten 30 GB log LUNs = 300 GB, Total space = 2,400 GB
Drive requirements per server: Number of physical drives/size, RAID type, and speed	Twenty 300 GB drives, RAID 1/0, 15k rpm, totals 2,600 GB

Local data protection for Exchange 2007 using EMC Symmetrix V-Max and Replication Manager

In any Exchange design, backup and restore are critical components. In this solution Replication Manager and its Exchange 2007 agent were used to make VSS clone replicas of the ESGs. The replicas were mounted onto a separate mount host and an integrity check was run against the Exchange data. The data can then be sent off to an EMC Disk Library if required.

Replication Manager configuration

- Replication Manager version: 5.2 SP1
- Number of Replication Manager application sets per Exchange server: 1
- Total number of Replication Manager jobs: 2 (1 per Exchange server)
- Total number of disks required for clones per Exchange Server: 16 300 GB drives, 10k rpm

Replication Manager performance summary

The Replication Manager design implemented and tested one Replication Manager job per Exchange server. This simplified configuration and management.

NOTE: Any successful Replication Manager implementation for Exchange relies on proper planning and scheduling based on build requirements. EMC recommends that you do not run a Replication Manager job while Exchange OLM is running.

- Time for each Replication Manager job to complete: 1 hr. 10 mins
- Rate of Exchange data consistency check (eseutil): Approximately 35 mins or 40 GB per min.
- Approximate amount of Exchange data per job\server: 1.4 TB
- Clone Resync rate: 7.8 GB

Validation of the virtualized Exchange 2007 environment

The following sections validate the efficiency of Exchange 2007 operations in the virtualized data center.

Typical 24-hour data center run—Exchange 2007 test summary

Exchange, EMC storage, and VMware performance data was logged for analysis during a 24-hour test run. This data presents an account of how the Microsoft Exchange mailbox servers, HUB/CAS servers, and domain controllers within each VMware guest performed.

These simulations tested:

- Exchange mailbox server VM's ability to support the users
- The ESX Server's ability to support the Exchange VMs
- HUB transport server VM's ability to send and receive e-mail
- Client access server (CAS) capability to accept the total number of clients' connections for the configuration.
- DC/GC server ability to handle the global catalog lookups during the test run
- Replication Manager's ability to back up and restore Exchange data

Microsoft Exchange Load Generator

Microsoft Exchange Load Generator (LoadGen) is a simulation tool to measure the impact of MAPI, OWA, IMAP, POP and SMTP clients on Exchange servers. LoadGen tests how a server running Exchange responds to an e-mail load.

LoadGen performance results

The LoadGen very heavy profile produced approximately 19 log files per user for a total of around 76,000 logs per mailbox server during the 10-hour test run. In an effort to stress the environment as much as possible, the LoadGen test was run in Online mode. The LoadGen profile executed 178 tasks per user for a total of 1.42 million tasks during a test run.

The Exchange user latency was excellent, during the LoadGen testing. This can be seen by the low average RPC latency during the LoadGen run; see [Figure 5](#). The RPC averaged latency remained around 3 ms, and the RPC requests outstanding averaged two requests.

These two counters are an indicator of the excellent user experience.

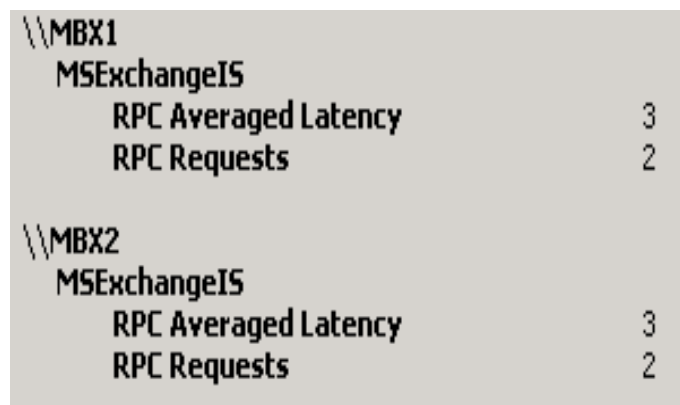


Figure 5. Exchange user latency results

LoadGen VM CPU utilization results

Two of the primary performance counters are ESX and VM CPU utilization. [Figure 6](#) represents the CPU utilization on the Exchange ESX Server with two mailbox VMs, and one Exchange HUB/CAS VM on it during the daytime hours of the 24-hour test.

During this test, LoadGen ran at a very heavy load for the first 10 hours. As can be seen from the ESX **Performance** tab, the mailbox VMs averaged around 30 percent CPU utilization with spikes up to 50 percent while LoadGen was running. The ESX Servers averaged around 20 percent CPU utilization, based on this and previous testing with Exchange on VMware this ESX Server could handle two more Exchange 2007/VMware building blocks from a CPU perspective.

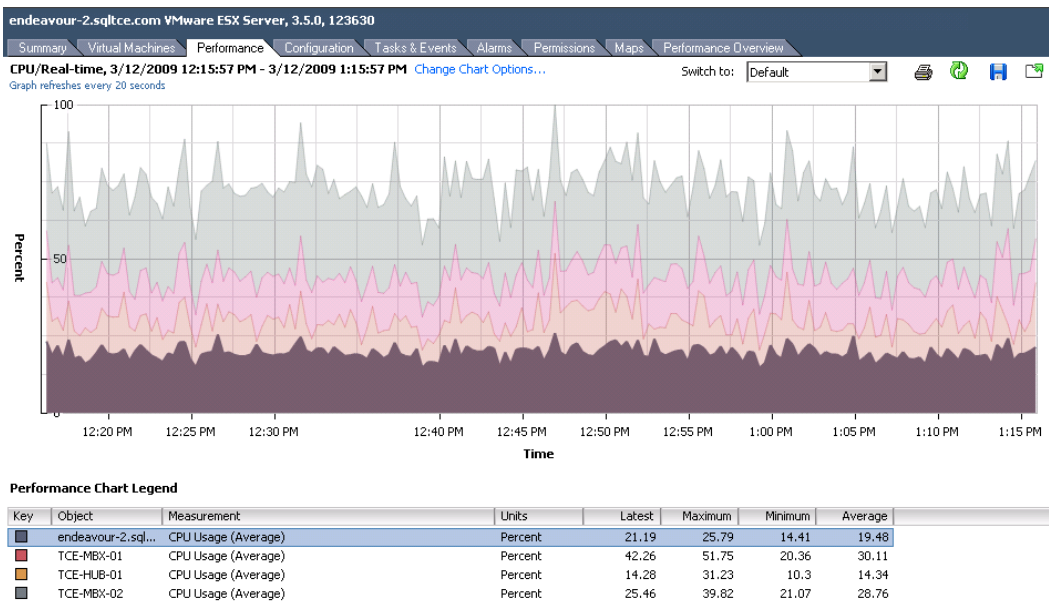


Figure 6. CPU utilization on the Exchange server

CPU utilization on the three Exchange VMs

Figure 7 shows the CPU usage by the three Exchange VMs for the length of the 24-hour test. Also, Figure 7 identifies the two heavy usage periods for Exchange as follows:

- 10-hr LoadGen Simulation daytime period
- During the time Exchange Online Maintenance (OLM) runs

In summary, the ESX Server easily handled the load produced.

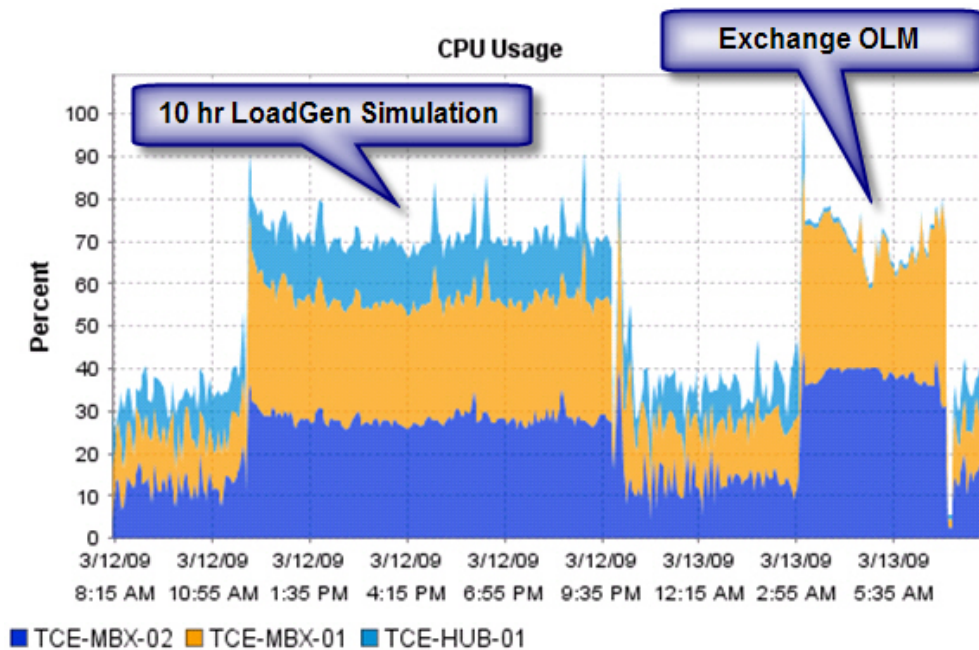


Figure 7. CPU usage analysis for Exchange VMs

VMware HA and VMotion performance testing with Microsoft Exchange Server 2007

One of the significant benefits of using VMware is the ability to move an OS seamlessly from one physical server to another. The technology is called VMotion and it involves using the migrate function within VMware.

In our testing, it took 9 minutes to migrate the Exchange servers from one physical ESX Server to another. It should be noted that while this was happening, Exchange servers were able to send and receive e-mail without interruption, and that the OS memory was transferred to the target ESX Server along with the OS.

Another powerful VMware tool that is useful in an Exchange environment is VMware HA. In the event of a physical ESX Server failure this provides the ability for VMware to bring the VMs up on another ESX Server without human intervention; see [Table 2](#).

Table 2. VMware HA performance results for Exchange Server 2007

Exchange server type	OS return to online status	Exchange servers return to online status
Exchange HUB/CAS	3 mins	4 mins
Exchange mailbox	4 mins	5 mins

SharePoint Server 2007 overview

Microsoft Office SharePoint Server (MOSS) 2007 is a server program, part of the 2007 Microsoft Office system. Organizations can use Office SharePoint Server 2007 to facilitate collaboration, provide content management features, implement business processes, and provide access to information that is essential to organizational goals and processes. In terms of adoption, SharePoint 2007 is Microsoft's fastest growing application; see http://www.microsoft.com/msft/reports/ar08/10k_sl_eng.html.

Due to high adoption rates of SharePoint 2007 by both organizations and users, this leads to two challenges:

- How can an organization that quickly needs to implement SharePoint 2007 accurately determine the correct SharePoint infrastructure and storage design to support their needs?
- How can an organization ensure that problems due to unprecedented data growth can be eliminated while minimizing initial storage costs?

These challenges are met by combining the EMC Symmetrix V-Max array's rich feature set.

SharePoint Server 2007 configuration

A breakdown of the SharePoint 2007 configuration follows.

Table 3 lists parameters applied in this environment.

Table 3. Microsoft SharePoint Server 2007 environment profile

Parameter	Value
SharePoint farm scale	168,000 Heavy users
Portal configuration	1 site collection with 15 sites
Portal type	Publishing/collaboration
Estimated overall content size	1 TB
Number of content databases	15
Production drive size and speed	300 GB, 15k, RAID 5

Microsoft Office SharePoint Server 2007 design considerations

In this SharePoint 2007 environment design, the major configuration highlights include:

- The SharePoint farm used two of the five ESX Servers.
- WFEs were also configured as query servers in order to improve query performance through a balanced load (recommended for enterprise-level SharePoint farms).
- User request load was balanced across all available WFEs by using a context sensitive network switch.

The following sections define the SharePoint Server 2007 application architecture for the virtualized data center.

Three-tier web application architecture

Multi-server SharePoint Server 2007 farms use a three-tier web application architecture, as follows:

- **Web server tier**—Coordinates user requests and serves web content.
- **Application tier**—Services specific requests (for example, Excel, document conversion, central admin, content indexing).
- **Database tier**—Manages document content, SharePoint farm configuration, and search databases.

SharePoint 2007 farm VM configurations

- **Six WFE VMs**—This division of resources offers the best search performance and redundancy in a virtualized SharePoint farm. As WFE and query roles are CPU intensive roles, the WFE VMs were allocated four vCPUs with 4 GB of memory. The query (Search) volume was configured as 80 GB and attached as an RDM.
- **Index Server**—The Index server was configured as the sole indexer for the portal along with a dedicated WFE role. This means that while the Index VM is crawling for content, it can use itself as the WFE to crawl. This minimizes network traffic and ensures that SharePoint farm performance does not suffer when a user-addressable WFE is being affected by the indexing load.

Four vCPUs and 6 GB of memory were allocated for the index server. The Indexing process needs to merge index content that requires double disk space, thus a 160 GB RDM search disk was allocated.

- **Application Excel Servers**—Two vCPUs and 2 GB of memory were allocated for the Application and Excel servers as these roles require less resources.
- **SQL Server**—Four vCPUs and 16 GB of memory were allocated for the SQL Server VM as CPU utilization and memory requirements for SQL in a SharePoint farm are high. With more memory allocated to the SQL VM, the SQL Server becomes more effective in caching SharePoint user data, leading to less required physical IOPs for storage and better performance. SQL database storage was attached as RDM devices (physical compatibility mode) to the SQL VM.

VM configuration and resource allocation

Table 4 details the VM configuration of the SharePoint farm with allocated resources.

Table 4. VMs configuration and resource summary

Server role	Quantity	vCPUs	Memory (GB)	Boot disk (GB)	Search disk (GB)
WFE servers	6	4	4	40	80
Index server	1	4	6	50	160
Application server	1	2	2	35	Not applicable
Excel server	1	2	2	35	Not applicable
SQL Server 2005	1	4	16	50	Not applicable

To summarize, in this virtualized environment, SharePoint Infrastructure resource allocations totalled:

- vCPUs: 36
- Memory: 50 GB
- Boot disk: 410 GB
- Search disk: 640 GB

Testing approach—SharePoint farm user load profile

During validation, a Microsoft heavy user load profile was used to determine the maximum user count that the Microsoft SharePoint 2007 server farm could sustain while ensuring that average response times remained within acceptable limits. Microsoft standards state that a heavy user performs 60 requests per hour; that is, a request every 60 seconds.

The user profiles in this testing consisted of three user operations:

- 80% browse
- 10% search
- 10% modify

NOTE: Microsoft publishes default service level agreement (SLA) response time for each operation, and these response times were met or exceeded.

KnowledgeLake DocLoaderLite was used to populate SharePoint with random user data, while Microsoft Visual Studio Team System (VSTS) emulated client user load. Third-party vendor code was used to ensure unbiased and validated test approach.

Emulating SharePoint data growth

The KnowledgeLake DocLoader was also used to provide continual data population during testing to simulate SharePoint user data growth. The intention was to prove that EMC Symmetrix Virtual LUN technology can continue to provide additional storage as SharePoint user data capacity requirements increase.

The document population rate was controlled to around 360 documents per minute, which generated daily data growths of 14.4 GB (600 MB document data per hour). This data population rate depicted an accelerated growth and lifecycle of a SharePoint 2007 farm.

Virtual Provisioning content storage for SharePoint 2007

In this virtualized SharePoint environment, EMC Symmetrix Virtual Provisioning™ was leveraged to provide storage for SharePoint content databases. SharePoint content databases are the ideal candidate for Virtual Provisioning as these databases typically tend to start small (as opposed to other applications where bulk data is imported from migration) and continue to grow to very large sizes over time, where the final growth figure is as yet unknown. Virtual Provisioning provides that ability to provide storage as SharePoint user data grows beyond initial expectations.

Another great example of where Virtual Provisioning is extremely effective for SharePoint 2007 is when IT architects are faced with the difficult task of deciding on storage requirements to host the SSP Search Database. Microsoft's guidelines state that 30 percent of the overall content size should be provisioned, but typically (through proven testing) the actual capacity required could be as low as 5 percent. Virtual Provisioning provides that ability to provision storage as required and not to overcommit storage where it turns out to be unnecessary.

Symmetrix thin devices are host accessible devices that can be used in many of the same ways that Symmetrix devices have traditionally been used. Unlike regular host accessible Symmetrix devices, thin devices do not need to have physical storage completely allocated at the time the device is created and presented to a host. The physical storage that is used to supply disk space to thin devices comes from a shared storage pool called a thin pool. The thin pool is comprised of devices called data devices that provide the actual physical storage to support the thin device allocations.

When a write is performed to a part of the thin device for which physical storage has not yet been allocated, the Symmetrix allocates physical storage from the thin pool for that portion of the thin device only. The Symmetrix operating environment, Enginuity, satisfies the requirement by providing a block of storage from the thin pool called a thin device extent. This approach allows for on-demand allocation from the thin pool and reduces the amount of storage that is consumed or otherwise dedicated.

The size of the host accessible thin device can be independent of the amount of storage available in the thin device pool. For example, in this test, the SharePoint content database SQL data volumes were formatted to 100 GB each, where in reality only 10 GB of actual storage was initially allocated within the thin pool. In terms of Virtual Provisioning, this technique is called "oversubscription."

One of the benefits of oversubscribing a thin pool is the ability to configure a maximum volume size as formatted and seen by the host. Because of this, no host filesystem reconfiguration is necessary in order to manage growth. Growth will be managed via the thin pool, where additional storage can be added to the virtual device pool as required. Multiple virtual device thin pools can be configured to support multiple application sets and requirements.

Storage efficiency through Virtual Provisioning

For example in this use case, there were fifteen SharePoint content databases (each with an initial content size set of 6 GB for the SQL data file, and 1 GB for the log file). In order to support the initial configuration and population of the SharePoint farm, just fifteen 10 GB Symmetrix data devices for SQL data, and fifteen 3 GB Symmetrix devices for SQL Log were required. These devices were added to two thin pools (one for each device size).

Initial storage savings

Table 5 summarizes the initial storage requirements if Virtual Provisioning is not implemented.

Table 5. Initial storage requirements without Virtual Provisioning

SQL content database	Quantity	Symmetrix device size	Total storage requirement
Data file (6 GB file)	15	15 x 150 GB	2,250 GB
Log file (1 GB file)	15	15 x 15 GB	225 GB

Table 6 summarizes the content database storage requirements with Virtual Provisioning implemented.

Table 6. SharePoint content database virtual pool

SQL content database	Quantity	Symmetrix thin device size	Total storage requirement
Data file (6 GB file)	15	15 x 10 GB	150 GB
Log file (1 GB file)	15	15 x 3 GB	45 GB

A savings of 2.28 TB on the initial production content data storage requirement was made through Virtual Provisioning. It is important to note that the same savings were realized by using Virtual Provisioning for the Symmetrix TimeFinder Clones that protected the content data via Replication Manager.

With either scripting or SMC, reporting can be created on the current state of thin pools and user advice and alerting can occur when and where is it advisable to add more storage to the device pool to support growth.

Virtual Provisioning testing approach

For the purposes of this test, the thin pool for SharePoint was not oversubscribed. The amount of storage assigned to each SharePoint host via thin devices was supported by a thin pool with the equivalent amount of space available. Therefore that meant the Symmetrix could automatically assign more available thin device extents from the thin pool as required, up to the full size of the thin LUNs presented to the hosts.

Prior to running the 24-hour SharePoint load tests, each SharePoint Content site (database) was populated with 6 GB in order to emulate a newly deployed SharePoint 2007 environment with a nominal amount of content data.

A potential target size of the SharePoint user content was set to 1 TB, which equaled 66 GB per content database. In reality, there is no way to measure what a customer's maximum SharePoint content data set size will be, unless enforcement of user and site quotas are applied, which can stunt collaboration and natural growth of an organization dependent on SharePoint.

During testing, each SQL content database data file grew at an accelerated rate from 6 GB upwards, while Symmetrix Virtual LUN technology continued to provision additional storage with minimal management requirements. Of course, content database log files were accommodated for growth with an initial size set to 3 GB with a maximum LUN size growing to 15 GB. With the correct SQL log file maintenance plans, log file growth can be minimized.

Testing proved that as a direct result of EMC Virtual Provisioning it was possible to drastically reduce initial storage costs to support this solution. Total storage (production and clone devices) savings of 4.56 TB were achieved while continuing to support future data growth through on-demand storage allocation. These cost savings on initial storage make it a very compelling reason to use Virtual Provisioning.

For further information on Virtual Provisioning, refer to the *Implementing Virtual Provisioning on EMC Symmetrix DMX with Microsoft SQL Server 2005* white paper accessible from the Resource Library on <http://www.emc.com>.

Local data protection design for SharePoint Server 2007 using EMC Symmetrix V-Max and Replication Manager

While Replication Manager does not offer native support for SharePoint today, it can provide SQL-based rapid protection of SharePoint SQL content databases (for example, documents, BLOBs, etc.).

Protection at this data size level is actually recommended by Microsoft to be SQL-based backups and recovery due to performance limitations of SharePoint STSADM when dealing with larger enterprise-level SharePoint data sizes.

Replication Manager configuration summary

The SQL SharePoint VM was configured as a Replication Manager production client. Two different protection configurations were built and used within Replication Manager.

Replication Manager job options:

- Symmetrix Clone
- Consistent Split with Pre-Copy
- With mount option

Two configuration models used in SharePoint RM testing

Testing was based on two separate configurations. The first configuration included:

- A single Replication Manager application set and job to protect all 15 content databases in a single, consistent VSS session.
- Scheduled to run every 5 hours, while the SharePoint farm was under load, the data change rate was roughly 4.5 GB between jobs.

This job took on average 51 minutes to complete. This included Symmetrix track synchronization, a VDI VSS session across all 30 database volumes, and mounting/unmount. During this time there was no impact to SharePoint functionality or access to those SQL databases.

The second configuration included:

- Five Replication Manager application sets and five Replication Manager jobs were used to protect three content databases. These were configured to execute sequentially.
- A schedule was created for the first job and the remaining jobs were configured as linked jobs to the previous job. This meant that all jobs ran as quickly as possible, within a minimal time window.

The reason for this second job configuration was to show Replication Manager's flexibility in configuration and execution of jobs with the advent of the linked jobs feature in Replication Manager 5.2.

Single time recovery for SharePoint 2007

PowerControls™ was implemented in this solution to augment the power of rapid off-host EMC VSS backups through Replication Manager while also showing that item-level recovery is still possible. This offers a “best of both worlds” situation for the SharePoint administrator, who does not want lengthy, disruptive SharePoint backups but still wants to be able to offer users granular recovery.

PowerControls works by reverse-indexing the SQL Content Database data files (.mdf and .ldf) to build a browsable index of what documents, folder, items, list items and libraries are contained with that database. The user can then select to restore the document to local storage as a file (with metadata) or directly back into SharePoint as a directed restore; see [Figure 8](#).

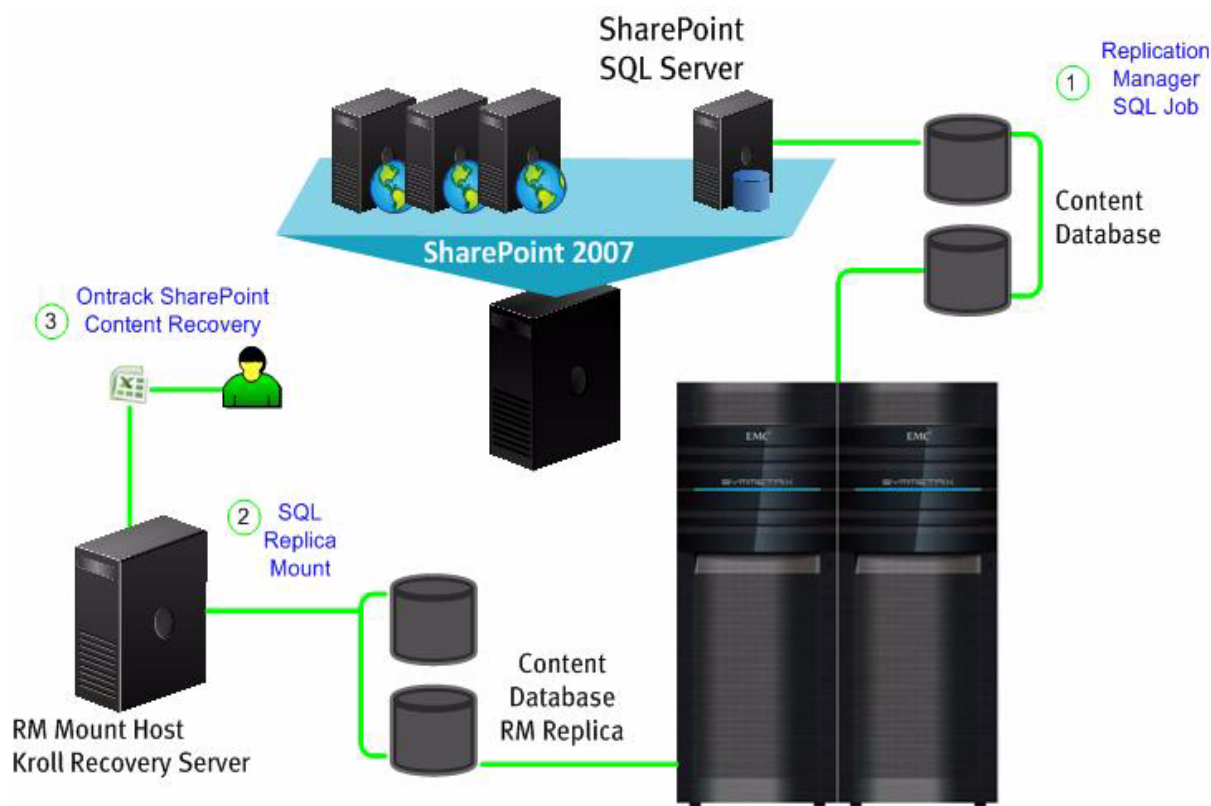


Figure 8. Rapid off-host EMC VSS backups using Replication Manager and Kroll

Replication Manager with PowerControls proves a powerful combination in providing this level of recovery through quick and easy access to existing SharePoint replicas. Replication Manager offers minimal lead time in providing the replicated SQL data files to Kroll™, which reduces time to recovery.

In this solution, the average time required to recover a single document or folder for the entire operation was less than 11 minutes, and involved:

- The user selecting to restore the document
- Mounting an existing Replication Manager SQL replica
- PowerControls scanning the database, and providing the user a browsable index of SharePoint content
- Restoring the document or item (folder, etc.) to local storage or directly back into SharePoint

Validation of the virtualized SharePoint Server 2007 environment

The following sections validate the efficiency of SharePoint Server 2007 operations in the virtualized data center.

Typical 24-hour data center run—SharePoint Server 2007 test summary

SharePoint, EMC storage, and VMware performance data were logged for analysis during a 24-hour test run. This data presents an account of results from VSTS for SharePoint performance, while considering that Symmetrix V-Max array continued to service both SQL and Exchange loads.

VSTS performance results

The average SharePoint farm processed 28 user requests per second over the duration of the 24-hour duration test. Microsoft’s acceptable user response times were comfortably met at all times.

NOTE: This 24-hour run test was configured with realistic user values and user load concurrency counts. The aim of this test was not to run the farm at maximum performance capacity, but to run the farm at capacity with acceptable headroom for additional operations. The SharePoint user workload translated to back-end SQL Server CPU Utilization of 40 percent or less, and memory and I/O subsystem suffered no pressure and had ample headroom. Average test response time stayed well within acceptable parameters.

Throughout the duration of the 24-hour load tests, SharePoint performance remained stable. Some peaks and dips were recorded due to systematic SharePoint timer jobs executing causing additional peak load on the farm; see Figure 9.

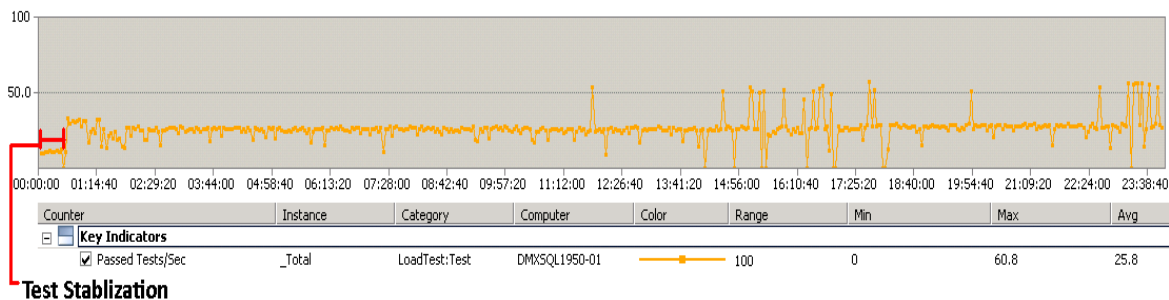


Figure 9. VSTS test performance graph depicting stable SharePoint performance over 24 hours

Table 7 shows the maximum capacity calculated for this test farm.

Table 7. Maximum capacity achieved

Content mix Browse / Search / Modify	Requests per second (RPS)	Concurrency %	Maximum user capacity	Average response time (sec) Browse / Search / Modify
80/10/10	28	1 %	168,000	<2 <1 <2

ESX Server utilization results

The two ESX Servers that were provisioned to SharePoint for this test proved to have adequate hardware resources in order to sustain acceptable SharePoint throughput and response time performance. The following is an account of ESX Server hardware utilization over an average of 24 hours; see [Table 8](#).

Table 8. Maximum capacity achieved

Hardware resource	SharePoint ESX Server 1	Average response time (sec) Browse / Search / Modify
CPU	65.2 %	57 %
Memory	32.5 %	44.2 %
Network	198 Mb/s	135 Mb/s

VMware High Availability functional testing with SharePoint Server 2007

VMware testing focused on each major feature of VMware in providing high availability to the SharePoint environment. Features included:

- VMotion through Live VM migration
- VMware HA through sudden loss of an ESX Server
- DRS through hardware load balancing of poorly positioned VMs in a SharePoint farm

In this virtualized SharePoint 2007 farm there were a total of 10 VMs evenly distributed on two of the five ESX cluster servers.

VMotion test results

VMotion was used to migrate a WFE VM from one ESX Server to another while under load. Average time to migrate the WFE VM via VMotion was 2 minutes, 33 seconds, proving that live migration can occur quickly with no perceived disruption to SharePoint 2007 service.

VMware HA test results

In this test, we rebooted one of the ESX Servers that was running three WFEs, Index, and Application VMs. All VMs were failed over, and were running on the remaining ESX Server within 6 minutes.

While overall SharePoint farm performance dropped as the VMs failed over, user requests were still serviced by the SharePoint Farm by the remaining VMs on the other ESX Server. When the failed ESX Server returned and as soon as the VMs were migrated back, original SharePoint farm performance was restored.

DRS test results

To prove the value of DRS, we skewed the distribution of VMs across the two ESX Servers and set the DRS configuration to fully automated (3-star recommendation); see [Figure 10](#).



The screenshot shows the vSphere DRS Recommendations interface. The navigation tabs include Getting Started, Summary, Virtual Machines, Hosts, DRS Recommendations (selected), Resource Allocation, Performance, Tasks & Events, and Alarms. The DRS Recommendations table is as follows:

Priority	Recommendation	Reason	Apply
★★★	Migrate TCE-SP-SQL from endeavour-4.sqltce.com to endeavour-3.sqltce.com	Balance average CPU loads	<input checked="" type="checkbox"/>
★★★★	Migrate TCE-WFE-06 from endeavour-4.sqltce.com to endeavour-3.sqltce.com	Balance average CPU loads	<input checked="" type="checkbox"/>

Figure 10. DRS priority recommendations

SharePoint ESX Server 1 was running eight VMs with 64 percent CPU utilization. SharePoint ESX Server 2 was running two VMs with 28 percent utilization.

DRS generated two recommendations in order to improve performance. DRS automatically executed these recommendations and migrated those two VMs (SP-SQL and WFE-06). This resulted in improved overall performance and balanced load. DRS successfully balanced SharePoint ESX Servers 1 and 2 CPU utilization (40% and 42% respectively).

DRS automatic migration times were quick without causing perceived impact to SharePoint performance.

Timing results with DRS

[Table 9](#) lists how long it took the WFE and SQL Servers to fail over using DRS.

Table 9. Timings

DRS automatic failovers using VMotion	Duration
WFE server (4 vCPU, 4 GB memory)	3 mins, 54 secs
SQL Server (4 vCPU, 16 GB memory)	7 mins, 26 secs

Microsoft SQL Server 2008 configuration

Microsoft SQL Server 2008 environments can be consolidated through the use of VMware and Symmetrix V-Max. Consolidated SQL Servers can provide similar performance and throughput as multiple physical hosts in a reduced footprint. This results in greater efficiency in the use of server resources and lower cost in terms of power and cooling. The tested environment provides an example of how SQL Servers could be consolidated.

The Microsoft SQL Server 2008 configuration used in this test included:

- Number of SQL users supported: 75,000
- Number of SQL Server VMs: 2
- SQL Server VM configuration: 4 virtual processors (vCPUs) with 32 GB memory

SQL Server test application

The SQL application used in this test environment is a TPC-E like application. It is composed of a set of transactional operations designed to exercise system functionalities in a manner representative of a complex OLTP application environment. These transactional operations simulate the activity of a brokerage firm that must manage customer accounts, execute customer trade orders, and be responsible for the interactions of customers with financial markets. The workload is centered on the activity of processing brokerage trades. Database properties include:

- Number of tables: 33
- Number of columns: 188
- Data types: UID, CHAR, NUM, DATE, BOOL, LOB
- Primary keys: 33
- Foreign keys: 50
- Check constraints: 22

Design considerations for SQL Server 2008 in a virtualized data center

The TPCE-like application used for this test can be tuned to utilize as much CPU and memory as is available. Four vCPUs and 32 GB of memory were allocated to each virtual SQL Server running on the ESX cluster node. SQL Server has an efficient memory management module that effectively caches recently used data. To maximize performance with the given hardware, 32 GB of memory was allocated.

The practice of storing a database across multiple files in a filegroup (or across multiple filegroups) is commonly used to enhance the performance of user-created databases. This is also a best practice for the system database, TempDB. The general rule of thumb is to provide one separate physical file per processor. This provides each worker thread has a separate physical file, which reduces contention of resource allocation. Each SQL Server has four tempdb files on one physical disk.

The application database is also stored across multiple files. The task of breaking up the database into separate filegroups was achieved by using table partitioning. The larger tables, the broker and the customer tables, in the database were split into 10 equally sized partitions. The partitions were then each placed on their own logical LUN and presented to the ESX Server as RDMS in physical compatibility mode. This gives SQL more available I/O to satisfy queries.

The SQL Servers each used logical disks; see [Table 10](#).

Table 10. VMware HA performance results for SQL Server 2008

Database element	Quantity	Disk size
Broker 1 through Broker 10	10	100 GB
Customer 1 through Customer 10	10	25 GB
Market, miscellaneous, database root partition	1	50 GB
TempDB	1	25 GB
SQL log files	1	100 GB

Local data protection design for SQL Server 2008 using EMC Symmetrix V-Max and Replication Manager

Replication Manager and its SQL 2008 agent were used to make VDI clone replicas of the database. The replicas may be used to validate the integrity of the database by mounting them to a host and performing DBCC integrity checks against them. A common use of replicas in SQL environments is repurposing the data for reporting services.

Replication Manager configuration for SQL 2008

- Replication Manager version: 5.2 SP 1
- Replication Manager application sets per SQL Server: 1
- Number of clone disks required: 16 300 GB 10k rpm drives per application set in a RAID 5 configuration

Replication Manager performance summary

Replication Manager leverages EMC TimeFinder/Clone technology to create the SQL database replicas. The first time a set of clone disks is used, a full synchronization of the volumes occurs. This process will take an extended amount of time to complete since all of the data tracks are copied from the source volumes. Subsequent replica synchronizations require only data tracks changed since the last synchronization to be copied to update the replicas to a point in time. The data represented here refers to average metrics of subsequent copies under user load and not the initial synchronization.

- Time to complete the replication task: 19 minutes
- Clone resync rate: 96,274 tracks per minute
- Approximate amount of data per synchronization: 40.7 GB

Validation of the virtualized SQL Server 2008 environment

The following sections validate the efficiency of SQL Server 2008 operations in the virtualized data center.

Typical 24-hour data center run—SQL Server 2008 test summary

SQL Server, EMC Storage, and VMware performance data was logged for analysis during a 24-hour test run. During the early phases of the test run, CPU utilization was very high, eventually leveling off to a stabilized usage levels. A stabilized environment for the SQL Servers represents a period after recently accessed data has been cached and users are running in a normalized manner.

Table 11 summarizes average values across an extended time period.

Table 11. 24-hour test run analysis

	TCE-SQL-1	TCE-SQL-2	ESX Server
CPU utilization	78.55 %	82.42 %	21.07 %
Memory utilization	58.99 %	54.15 %	63.06 %
Network (kbps)	1860.36	1095.27	4984.46

Each VM was near the 80 percent CPU utilization mark so that some processing power accommodated usage peaks, or provided the ability to perform VDI backups of the database. While the VMs were at a comfortable maximum, the ESX Server still had plenty of processor capacity. More of the ESX Server capacity could not be utilized because ESX Server 3.5 supports a maximum of four vCPUs per VM.

Ample memory remained at the VM level as well as at the ESX Server level. SQL Server effectively cached the data it needed to maintain growth capacity. The ESX Server had memory capacity to support more VMs on this node.

Network traffic to the node and the individual servers was stable and did not stress the network interfaces.

VMware HA and VMotion performance testing with SQL Server 2008

This testing focused on testing HA features in VMware as they applied to a virtualized SQL environment. Testing included:

- VMotion through VM migration—The ability to move a VM across servers while users are active.
- VMware HA—Providing protection in a server loss scenario.

VMotion was used to migrate the virtual SQL Servers from one ESX node in the cluster to another node. The storage used by the VM is entirely on the Symmetrix V-Max array and had been masked to both the source and target servers. Under a full user load, VMotion took 17 minutes to migrate the running SQL Server, its storage, and active memory (31.5 GB) to the other node.

VMware HA was also tested in this environment. The virtual SQL Server was placed under load and the ESX Server node was rebooted. The cluster became aware of the failure and proceeded to fail the VMs to other cluster nodes. The SQL Server was back up and ready in 4 minutes.

Storage tiering enabled by Virtual LUN migration

Virtual LUN technology enables transparent, nondisruptive data mobility among storage tiers within the same array and between RAID protection schemes. Migrations can be performed while users are actively accessing the data on the disk volumes. Data availability and protection remain a constant as the data is moved to new physical disks. When the migration is complete, the new volumes maintain the same identity as the previous volumes and local replication through Replication Manager is not affected by the change.

Virtual LUN technology offers two types of data movement: migration to reconfigured space and migration to configured space. In each case, the migration provides users the ability to move data between high-performance drives and high-capacity drives, or to populate newly added drives.

In this test, a SQL Server was placed under a load and the database drives were migrated from RAID 1 devices to unconfigured space. The end result was a change in physical drives with the database LUNs changing RAID type to RAID 5.

- Total amount of data migrated: 1.3 TB
- Time to migrate: 2 hours 10 minutes
- Migration rate: 10.18 GB/min.

User load remained active throughout the migration.

References

Additional information is provided in the following EMC documents, accessible from the Resource Library on <http://www.emc.com>:

- *EMC Symmetrix V-Max and Microsoft Exchange Server—Applied Technology* white paper
- *EMC Symmetrix V-Max and Microsoft SQL Server—Applied Technology* white paper
- *EMC Symmetrix V-Max and VMware Virtual Infrastructure—Applied Technology* white paper
- *An Overview of Groups in EMC Symmetrix and Solutions Enabler Environments—A Detailed Review* white paper
- *Secure and Consolidated 16,000 Exchange Users Solution on a VMware/EMC Environment—Applied Technology* white paper

See the following VMware technical documents for further reference:

- *Performance Tuning Best Practices for ESX Server 3*
- *VMware Certified Compatibility Guides*

Conclusion

With the increased demand for infrastructure consolidation requirements to meet today's budgetary constraints, clients require as much integration as possible across multiple products. Storage management and server virtualization are no exception. The EMC Symmetrix V-Max consolidation solution and the VMware server virtualization capability for Microsoft applications truly provide compelling consolidation advantages, bringing down the total cost of the server resources and accelerating storage management.