Abstract

This white paper explains how to configure, deploy, and manage Microsoft SQL Server implementations on EMC® Symmetrix® VMAXe™.

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Executive summary

The EMC® Symmetrix® VMAXe™ platform introduces a new simplified solution for providing scalable storage within medium-size organizations. Built on a trusted and scalable Symmetrix platform, Symmetrix VMAXe extends the benefits of the well-established EMC Enginuity™ operating environment. With support for multiple disk technologies, EMC Virtual Provisioning™ storage allocations and support for Fully Automated Storage Tiering (FAST), Symmetrix VMAXe provides an industry-leading solution for the midsize market.

Administrators are under increasing pressure to effectively deploy storage solutions using Microsoft SQL Server database environments. Invariably administrators are faced with a large number of considerations regarding how to effectively deploy a Microsoft SQL Server database. Symmetrix VMAXe solutions provide a foundation for scalable, robust storage solutions which mitigate the complexity involved in deploying high-performance SQL Server environments.

Using Virtual Provisioning, Symmetrix VMAXe scales performance of storage allocations for Microsoft SQL Server databases. Thin pools use a distribution mechanism to avoid performance bottlenecks that are typical of traditional storage allocation methods.

To further enhance scalability of solutions, FAST can be coupled with Virtual Provisioning in the form of FAST VP. This industry-leading technology dynamically reallocates storage across a number of storage tiers to ensure that workloads gain the performance benefits of higher performing tiers when necessary; it can also relocate storage to more cost-effective storage tiers when application access is not required, or has been reduced due to data set aging.

The Symmetrix VMAXe provides the perfect blend of ease of use and scalability required to deploy Microsoft SQL Server database environments.

Audience

This white paper is intended for Microsoft SQL Server administrators, storage administrators, and storage architects deploying SQL Server-based solutions on Symmetrix VMAXe arrays.
**EMC Symmetrix VMAXe**

EMC Symmetrix VMAXe with EMC Enginuity is a multicontroller, scale-out architecture with consolidation and efficiency for the enterprise with one to four system bays (one to four Symmetrix VMAXe Engines) and up to two storage bays. The system scales from a single engine with no storage bays to four engines with two additional storage bays, as shown in Figure 1.

![Figure 1. Symmetrix VMAXe maximum configuration](image)

**Scalability**

The Symmetrix VMAXe system can be upgraded by adding engines, memory (by adding engines), or disk-array enclosures (DAEs). Each DAE contains 15 physical drives. DAEs are increased in increments of four. Each engine is housed in a system bay, and contains two directors with extensive CPU processing power, physical memory, front-end ports, and back-end ports.

**Availability**

Inherent in Symmetrix VMAXe systems are availability features that ensure uninterrupted access to your mission-critical data and applications. These include:

- A full suite of redundant hardware components
- Redundant internal and external communication paths
- Transparent failover and failback
- Simplified, low count component design, minimizing failure points and providing transparent component maintenance
- Permanent drive sparing
- EMC remote notification and remote support capabilities that provide 24/7 system monitoring and allow EMC support engineers to connect remotely over an
encrypted Internet connection to diagnose and resolve problems. An optional modem is available.

**Host connectivity**

The Symmetrix VMAXe supports connections to open systems hosts over Fibre Channel, Fibre Channel over Ethernet (FCoE), and iSCSI. All host connectivity ports reside on the front-end I/O modules of the engine and access is provided from the rear of the system bay.

Back-end I/O modules provide dual access to each drive. One module connects the drive to one physical path and the other connects the drive to a second physical path.

**Storage management**

A Symmetrix VMAXe can be managed with the following tools:

- **Symmetrix Management Console** — The primary interface for managing Symmetrix arrays.
- **Symmetrix Performance Analyzer** — A graphical analysis tool for monitoring and trending system performance and utilization of the Symmetrix VMAXe system.
- **EMC Ionix™ ControlCenter®** — (formerly EMC ControlCenter) — An intuitive, browser-based family of products that provides management of the overall storage environment, including multivendor storage reporting, monitoring, configuration, and control.
- **Solutions Enabler** — A library of commands that are entered from a command line or from a script.

**Symmetrix Management Console**

Symmetrix Management Console (SMC) is an intuitive, browser-based user interface that configures and manages Symmetrix VMAXe. SMC can be hosted on a Windows, UNIX, or Linux server with access through a Web browser or the Symmetrix service processor.

The SMC user interface additionally incorporates a new dashboard component that presents the most common user processes required for storage provisioning. This new SMC Dashboard interface is illustrated in Figure 2.
Figure 2. Symmetrix Management Console Dashboard view

The Symmetrix Management Console presents a comprehensive implementation of the functionality of Solutions Enabler in a graphical user interface. Administrators can use Symmetrix Management Console to:

- Manage Symmetrix access controls, user accounts, and permission roles
- Install customer-replaceable disk drives
- Discover Symmetrix arrays
- Perform configuration operations (create devices, map and mask devices, set Symmetrix VMAXe attributes, set device attributes, set port flags)
- Manage devices (change device configurations, set device status, reserve devices, duplicate devices, create/dissolve metadevices)
- Perform and monitor replication operations (EMC TimeFinder® for Symmetrix VMAXe, SRDF, Open Replicator)
- Configure and manage FAST VP
- Monitor alerts

**EMC Ionix ControlCenter**

EMC Ionix ControlCenter storage management software provides an end-to-end solution for multivendor storage reporting, monitoring, configuration, and control. EMC Ionix ControlCenter consists of core infrastructure components (providing basic scalability, usability, and information sharing) coupled with a set of EMC Ionix
ControlCenter licensed applications and license packages that ensure the appropriate level of management and control over your environment.

The following EMC Ionix ControlCenter licenses manage the Symmetrix VMAXe:

- SAN Manager™
- EMC Symmetrix Manager
- EMC Symmetrix Optimizer
- Performance Manager
- EMC StorageScope™
- EMC Ionix Storage Configuration Advisor

EMC Ionix ControlCenter also requires Symmetrix Management Console and Solutions Enabler to fully manage Symmetrix arrays.

The *EMC Ionix ControlCenter Planning and Installation Guide, Volume 1* provides detailed information about EMC Ionix ControlCenter.

**Solutions Enabler**

Solutions Enabler is a specialized library consisting of commands that can be invoked on the command line or from within scripts. Solutions Enabler commands can be used to monitor device configuration and status, and to perform control operations on devices and data objects within your managed storage complex.

**Storage design principles of Symmetrix VMAXe**

The fundamental design of the Symmetrix VMAXe environment provides a robust, scalable and simplified storage infrastructure. The storage provisioning methodology for VMAXe centers on the use of Symmetrix Virtual Provisioning. Virtual Provisioning, generally known in the industry as “thin provisioning,” enables organizations to improve ease of use, enhance performance, and increase capacity utilization for applications and workloads.

As part of the deployment of the VMAXe system, all thin data pool devices are pre-created based on the requirements that the customer defines. Since data devices and thin pools are pre-created, the VMAXe system requires only that thin devices be defined and bound to the appropriate thin pool.

VMAXe thin devices are logical devices that can be used in many of the same ways that traditional storage devices have been used. Unlike traditional storage 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 to which the thin device has been bound. Multiple thin devices can be bound to any given thin pool. The thin pool is composed of devices called data devices that provide...
the actual physical storage to support the thin device allocations. These relationships are detailed in Figure 3.

**Figure 3. Relationship of thin devices and thin pools**

When a write is performed to a part of any bound thin device for which physical storage has not yet been allocated, the Symmetrix VMAXe allocates physical storage from the thin pool for that portion of the thin device only. The Symmetrix VMAXe operating environment, Enginuity, satisfies the requirement by providing a block of storage from the thin pool called a thin device extent. This approach reduces the amount of storage that is actually consumed.

As storage allocations from the thin pool are made across all data devices enabled in the thin pool, uniform distribution of extent allocations across all thin data devices results. The resulting application I/O workload against the thin devices causes an even distribution across all these resources. In this way, the scalability of the workload across all bound thin devices is limited only by the configuration of the thin pool.

**RAID sets as building blocks**

The I/O capacity of any given thin pool is based on the specific configuration of that thin pool. Therefore the number of drives used to provide storage for the data devices and the RAID protection scheme used for the data devices are directly related to the performance limits of a given pool.

Data devices for a thin pool can have any of the RAID protection schemes that the Symmetrix VMAXe environment supports. The type of RAID protection scheme selected will have an effect on the I/O capacity of the thin pool, since all write operations will incur some additional I/O operations within the pool. For example, when a random 8 KB write operation, which is typical of an SQL Server random data page write, occurs in a thin pool protected using a RAID 5 scheme, four additional I/O operations are required to calculate and write the new parity information. As a result,
the amount of write I/O and the parity overhead for the write operations must be considered for a given thin pool.

By using a single RAID set as the basis for configuring capacity allocations, you can define how many drives of a given configuration are required to service a given workload. Conversely, you can calculate how much I/O capacity a given thin pool can service. For example, consider a single RAID 5 disk set defined in a 3+1 configuration based on 15k rpm 450 GB drives. Fibre Channel drives of this type (15k rpm) can provide 180 random I/O operations per second for random read workloads of 8 KB in size. The performance metric is based both on the size of the I/O (8 KB), the nature of the operation (read compared to write) and an acceptable performance level (latency for the operation). Thus a single 3+1 RAID 5 set of drives (4 drives in total) can provide 4 x 180 I/Os, or 720 I/Os per second of read workload. By using this basic block of storage, you can calculate how many blocks of storage are required for a given read workload.

In a tested configuration, a thin pool of 88 x 450 GB 15k rpm drives was configured with a RAID protection of RAID 5 3+1. Using the methodology previously described, you can calculate the upper limit of the performance of such a pool. For the 88 drives at the 180 I/O per second value, the expected performance limit would be around 88 x 180 I/O per second, or around 15,800 I/O per second, for the pool with a reasonable response time, that would be defined as a read latency of below 20 msec.

It is also important to consider the workload that write operations for a given thin pool generate. As mentioned, a RAID 5 implementation implies additional I/O operations for all write operations. The chart in Figure 4 shows a plot of the I/O capabilities of a given pool with different read/write ratios implemented.

![Figure 4. Performance profile for a given RAID 5 pool](image-url)
The I/O capacity of any give pool (the actual disk I/O rates) will remain constant; however, the actual write I/O operations have a four-fold impact on back-end I/Os for a RAID 5 configuration. In the example configuration in Figure 4, at 100% write I/O, the host write I/O operations approach 3,960, as shown by the secondary axis.

For any given read / write ratio, the actual host-generated read and write operations can be calculated. For example, at a ratio of 80 percent read to 20 percent write, a configuration of 88 x 450 GB 15k rpm drives in a RAID 5 configuration can support 12,672 read operations and 792 write operations. A similar calculation can be done for host-based workloads to ensure that a given thin pool can satisfy the anticipated workload. For co-located workloads, administrators should ensure that a given pool can satisfy the cumulative workload.

**FAST VP – Extending beyond single pool limits**

Many customer workloads change dynamically during the course of an application’s lifecycle, and often throughout the course of a business day. Active data sets (that amount of data actively used) also changes over time, where more recent data is often more heavily accessed than historical data. Sizing in the form previously described, while providing a way to accurately size given pools, can become overly burdensome. Symmetrix VMAXe configurations can be augmented by using Fully Automated Storage Tiering (FAST) functionality, which allows the system to dynamically provide for changing workloads.

By combining the functionality of FAST with the use of Virtual Provisioning, the Symmetrix VMAXe FAST VP solution eliminates the performance limitations of a single pool. Using dynamic relocation, FAST VP allows administrators to define a policy-based approach for optimizing storage allocations based on application access patterns. In such implementations, the workload is no longer associated to a single pool, but rather is dynamically distributed across a number of thin pools. In implementations where Flash drives are associated with a FAST VP policy, heavily accessed components of the allocated storage will be moved into this higher performing tier.

The combination of different storage tiers and the dynamic placement capabilities of FAST VP with Symmetrix VMAXe provide highly scalable solutions for even the most demanding Microsoft SQL Server database installations.

Further information regarding the implementation of FAST VP with Microsoft SQL Server can be found in the white paper *Storage Tiering for Microsoft SQL Server and EMC Symmetrix VMAX with Enginuity 5875*.

**Storage provisioning for Symmetrix VMAXe**

Throughout this white paper, Symmetrix Management Console will be used to demonstrate the mechanisms available to simplify all aspects of a VMAXe deployment. By using a wizard for major provisioning, you can quickly and effectively deploy solutions.
Storage provisioning for SQL Server databases

The provisioning of storage for an SQL Server database in a Symmetrix VMAXe is significantly simplified. The provisioning model for Symmetrix VMAXe uses thin pools to support devices that are virtually provisioned. In such environments, the design of the database layout is much simplified. To adequately service the I/O load of the SQL Server database, storage and database administrators need to ensure only that the I/O capacity of the thin pool supporting the database is sufficient.

EMC Symmetrix Virtual Provisioning can support user workloads for heavily used SQL Server environments. An even distribution of I/O across all resources within a given thin pool ensures that workloads are implicitly balanced. Therefore, with an understanding of the I/O capability of a given thin pool, administrators only need to ensure that the cumulative workload of the given thin devices bound to the pool do not exceed the upper performance limit of the pool.

Administrators should continue to ensure that typical SQL Server guidance for data files is adhered to. For example, while it is entirely possible to provision a single LUN to support all data files for a given database, EMC recommends creating multiple LUNs and utilizing SQL Server file groups. Providing multiple LUNs allows other factors, such as queues, which are based on the number of LUNs, to be scaled at the operating system layer. Utilizing file groups and separating data files can also enhance SQL Server availability, which can maintain availability of discreet files or file groups within the database, in the event that individual components become unavailable.

Provisioning storage for data files

As described in the section Storage design principles of Symmetrix VMAXe, storage allocations from a single thin pool derive their I/O capacity from the pool. Co-locating multiple LUNs within a single pool provides a simplified storage management approach. Since workloads tend to be balanced across all physical resources within the thin pool, bottlenecks based on skewed workloads to a limited set of spindles are avoided.

Understanding the threshold limits of the thin pool ensure that systems can meet the I/O demands. It also ensure that administrators can appropriately plan for incremental upgrades where necessary to extend the performance characteristics of a given thin pool. EMC Symmetrix Performance Analyzer (SPA) provides a graphical interface for visualizing performance characteristics of all aspects of the Symmetrix VMAXe platform. The implementation and use of SPA are beyond the scope of this white paper. Additional information is available in EMC Symmetrix Management Console and EMC Symmetrix Performance Analyzer Installation Guide.

Provisioning storage for log files

Storage allocations used for SQL Server transaction log files are based on a different style of I/O activity. Typically the I/O generated to a transaction log is a sequential write stream, with occasional read entries when user transactions abort. Sizing I/O
capacity for a LUN that serves as storage for a transaction log is therefore different from that required for a data file.

Overall performance of a highly active SQL Server database servicing an Online Transaction Processing (OLTP) workload can be adversely affected by long latencies to the transaction log. This results from the Write Ahead Logging (WAL) feature of SQL Server. WAL ensures that SQL Server returns to a transactionally consistent state even after a server or system outage. The WAL feature persists all updates and inserts to the transaction log before committing them to the data files. The combination of the current state of the data files and the transaction log allows SQL Server to recover in the event of a failure. This functionality requires that a commit for a transaction must be persisted to the log file before the transaction returns a status to the user process. Longer latencies for the log writes will reduce user process performance.

Symmetrix VMAXe provides support for transaction log write operations from global memory. All write operations are acknowledged as complete when they are saved to cache. All cache is protected by both battery backup and a cache vault. Write operations received by the Symmetrix VMAXe environment are persisted to disk, and provide full support for SQL Server WAL requirements.

Since the cache acknowledges all write operations, Symmetrix VMAXe depends less on the physical storage required to service the write stream. In fact, Symmetrix VMAXe may coalesce multiple discrete write operations into a smaller number of larger write operations, which improves the efficiency of transaction log writes while reducing the I/O demand within a thin pool. Write operation workloads are therefore smaller for a thin pool, and as long as the performance threshold for the thin pool has not been reached, sizing for the transaction log volumes is generally easily met.

In the tested environment, the transaction log LUN came from the same thin pool that was used to service the storage requirements for the SQL Server data files for the database.

**SMC simplified storage provisioning**

Several basic steps are required during a storage provisioning operation. These steps involve the definition of the storage objects (LUNs) that are presented to a selected Windows Server host. In the case of a Symmetrix VMAXe storage allocation, these LUNs will be thin devices, which must be bound to a thin pool. Therefore the provisioning operation must bind the selected storage devices to an available thin pool.

In this example, storage devices are presented to hosts based on a Fibre Channel connectivity model. Such a model uses a target / initiator pairing to allow for storage devices to be presented to a host. The initiators, in this case, are the World Wide Node Names (WWNNs) of the host bus adapters (HBAs) located in the server. It is assumed, in this example, that a Fibre Channel switch is used and that the appropriate zoning information has been preconfigured.

The following example demonstrates the provisioning of a set of five LUNs to a given Windows Server host. The five LUNs contain an SQL Server 2008 R2 database. This
configuration is composed of four data file locations and a single transaction log location. All four thin LUNs are bound to a single thin pool containing 88 x 450 GB 15k rpm drives using a RAID 5 (3+1) protection scheme. In this example, the thin pool was already constructed, as is expected for customer deployments.

To facilitate the storage provisioning aspects, Symmetrix Management Console is used. From the SMC Dashboard, the administrator selects the “Add New Host” wizard, which provides the necessary steps for adding a new host to a Symmetrix VMAXe system.

**Defining a host**

In a storage provisioning model, the host busses (initiators) used to access storage devices define the host. In a Fibre Channel environment, these are the WWNNs associated with the initiators. Typically a storage administrator knows the WWNNs associated with a given host, and can use a number of tools to identify what the WWNNs are for a server. Microsoft Windows, for example, provides a Storage Explorer tool in the Administrator Tools. In Figure 5 the WWNNs of the tested configuration are displayed.

![Windows Storage Explorer showing initiator WWNNs](image)

**Figure 5. Windows Storage Explorer showing initiator WWNNs**

Multiple initiators usually provide access to a given storage array. Using multiple initiators with multipathing software, such as EMC PowerPath®, provides both a scalable storage connectivity solution as well as a highly available connectivity solution that protects against single path failures. Also using multiple physical switches protects against single switch failure scenarios.

All zoning operations must be completed to ensure that host initiators can access the necessary storage arrays; therefore, appropriate zoning must exist in the customer environment. Since all switch fabric implementations differ, the zoning configuration is beyond the scope of this white paper.

In the tested configuration, zoning was created using two of the initiators from the host. In Figure 6, two of the initiators that were previously zoned to the Symmetrix VMAXe array are selected.
Figure 6. Selection of host initiators

**Specification of VMAXe front-end ports**

After specifying the WWNNs to define the host, the Storage Provisioning Wizard will subsequently present a list of front-end ports. In a configuration where the zoning was already created, the wizard will present a list of ports where the WWNNs were detected. In Figure 7 the list shows four front-end ports from the Symmetrix VMAXe that were previously zoned to two WWNNs previously indicated.

For both scalability and high-availability reasons, EMC recommends that multiple paths be presented to a given host. In the example configuration, paths from two directors (DIR 1 and DIR 2) are shown. On DIR 1, processors 1E and 1F, and on DIR 2, processors 2E and 2F are shown. Subsequently, any outage of a single director or single processor will not result in connectivity loss. Additionally, this style of configuration ensures a scalable implementation using multiple processor resources.

In general terms, a best practice approach for connectivity is to allocate at least one front-end processor from each engine configured within the Symmetrix VMAXe system. From each director, at least one processor should be allocated. Typically a configuration with at least four discrete front-end processors scales well and avoids the bottleneck resulting from allocating too few processors.
Defining storage objects

After selecting front-end ports, the Storage Provisioning Wizard prompts for the storage allocations for the defined host. As shown in Figure 8 the number of new thin devices can be defined, as well as the size for the new storage allocations. In the event that the storage allocation is larger than a single volume defined within the Symmetrix VMAXe configuration, the wizard automatically uses the Auto Meta functionality.

The list of available pools is also displayed within the wizard, and a single selection must be made for this initial allocation. The selection of the target pool should be based on the desired thin pool used for new allocations for the thin devices. Most commonly, the target pool is an associated Fibre Channel pool, but the selection is at the discretion of the administrator.

The storage allocation model allows you to specify the number of LUNs to be created and a single LUN size for all LUNs. Since the created LUNs will be thin devices, they will consume only physical storage allocations from the selected thin pool because host allocations occur against the partitions created at the host level. Therefore, over-provisioning of thin devices will not adversely affect thin pool usage or performance.

Administrators can limit the actual usable space at the operating system level, by creating NTFS volumes that constitute only a portion of the LUNs. In this way, administrators can protect against unexpected allocations against thin devices.
Figure 8. Definition of size and count of host accessible LUNs

Subsequent storage allocations for the host can be executed as separate operations, thus allowing for the creation of differently sized thin devices, and for specifying different bound pools. Also the new storage devices can be associated with a FAST VP policy by selecting the “Put under FAST control” checkbox, and a pre-existing FAST policy. In this example, no policies existed, and all thin devices were allocated against the single SQLFibre thin pool.

Summary of storage provisioning

At the completion of the storage provisioning wizard, a summary of the actions to be executed is shown for verification. Figure 9 contains a sample of this summary. The summary provides information on the various Auto-provisioning groups that will be created, including a default Initiator Group, Port Group, Storage Group, and Masking View. Symmetrix Management Console provides the ability to subsequently alter any of these groups, and thereby alter the devices presented to the specified host.
Figure 9. Storage provisioning summary

When the “Finish” option on the summary screen is selected, SMC creates devices as necessary, assigns these devices to the thin pool specified, and presents the storage devices as LUNs to the host represented by the HBA initiators.

Windows storage management operations

After the storage provisioning steps are complete within SMC, host-based steps must be completed, including the creation of and formatting of NTFS partitions on the thin devices. These operations proceed in the same manner as with traditional storage devices. When formatting the NTFS volume, a Quick Format operation must be selected. This type of format ensures that a full allocation of the thin device does not occur.

The newly created storage LUNs from the tested environment are shown in Figure 10, where Windows Disk Management on the server has been launched. From the Windows Disk Management interface, Windows NTFS partitions can be created. The definition of the partition can allocate the full LUN space, or in cases where an administrator wants to limit the accessible space, a portion of the available LUN can be defined as an NTFS volume. With Windows Disk Management to the administrator can extend a partition and thereby allocate additional space from the LUN. In this way, administrators can limit allocations, and still can dynamically expand the available space as necessary.
Configuration Best Practices for Microsoft SQL Server and EMC Symmetrix VMAXe

Figure 10. Windows Disk Management view of provisioned storage

Typical best practice recommendations for formatting storage allocations of locations used as storage for SQL Server data files and transactions log should be applied. These recommendations include the previously mentioned Quick Format option, as well as the selection of an Allocation unit size of 64 K as shown in Figure 11.

Figure 11. Typical settings for formatting an NTFS volume for SQL on a thin device

Once the creation of Windows NTFS volumes is complete, the SQL Server database environment can be created on the provisioned storage devices. This is the same process used with any traditional storage configuration.

Microsoft SQL Server administrators should ensure that SQL Server Instant File Initialization is enabled for the environment in order to limit the storage allocations.
made when a new database is defined on the provisioned storage. Information regarding the Instant File Initialization functionality is provided in the Microsoft SQL Server Books On Line product documentation.

**Deploying FAST VP**

Symmetrix VMAXe storage arrays provide support for Fully Automated Storage Tiering for Virtual Pools (FAST VP). This technological advancement allows a Symmetrix VMAXe array to dynamically adjust storage allocations across a predefined set of storage tiers. Typically these tiers will relate to differing storage technologies with differing performance characteristics. It is common, for example, for customers to identify a high performance tier that may be located on Flash drives, a traditional performance tier based on Fibre Channel drives and a third tier that can be composed of more cost-effective, but lower performing SATA devices.

The ability to optimize the type of storage used, based on its utilization by the application layer, is a central value proposition of FAST VP. Identifying allocations at the sub-LUN level improve the efficiency of the overall solution, and allow for fine-grained movements in a timelier manner. As a result, Symmetrix VMAXe FAST VP provides the basis for efficient, dynamic, adaptable storage provisioning solutions for Microsoft SQL Server.

Allowing the storage array to dynamically adjust storage allocations further enhances the simplified storage allocation methodology. Rather than calculate performance levels of individual LUNs or even thin pools, administrators now need to monitor only the overall performance of the storage array, while allowing the system to dynamically migrate allocations between the tiers defined within the policies.

Symmetrix VMAXe supports the implementation of multiple storage tiers, as required. Further, administrators can define multiple FAST VP policies to provide for differing business or application needs. As a result, the Symmetrix VMAXe solution can be configured to optimize storage configurations across multiple policies, each with multiple associated storage allocations, in parallel.

**Conclusion**

The Symmetrix VMAXe platform provides customers with a highly scalable storage solution based on a principle of simplified storage management. Combining best-of-class technology with industry-leading software in an easy-to-deploy and manage configuration enhances the customer’s ability to deploy enterprise-class solutions within their infrastructure.

With a broad range of storage technology and host connectivity, Symmetrix VMAXe provides the perfect blend of scale and performance. Dynamic configuration capabilities of FAST VP allow the system to dynamically configure storage allocations based on the application performance requirements.
**References**

The following documents can be found on [EMC.com](http://EMC.com) or Powerlink®:

**White Papers**

- *Implementing Virtual Provisioning on EMC Symmetrix with Microsoft SQL Server*
- *Storage Tiering for Microsoft SQL Server and EMC Symmetrix VMAX with Enginuity 5875*

**TechBooks**

- *Microsoft SQL Server on EMC Symmetrix Storage Systems*

**Product and Installation Guides**

- *EMC Symmetrix Management Console and EMC Symmetrix Performance Analyzer Installation Guide*