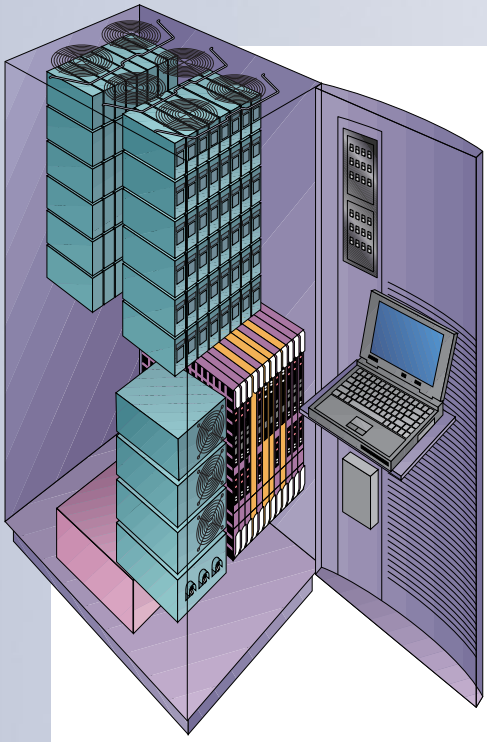
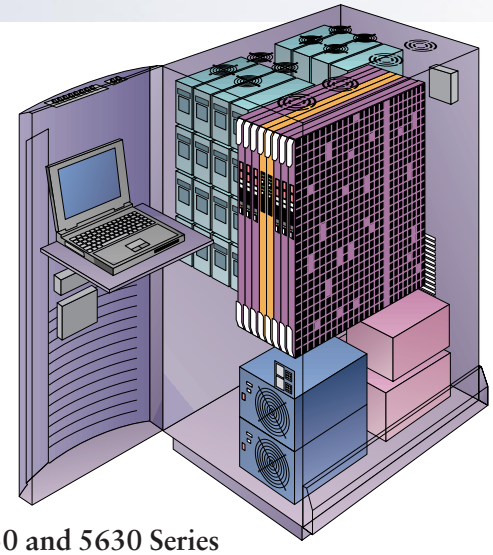
EMC²
The Enterprise Storage Company

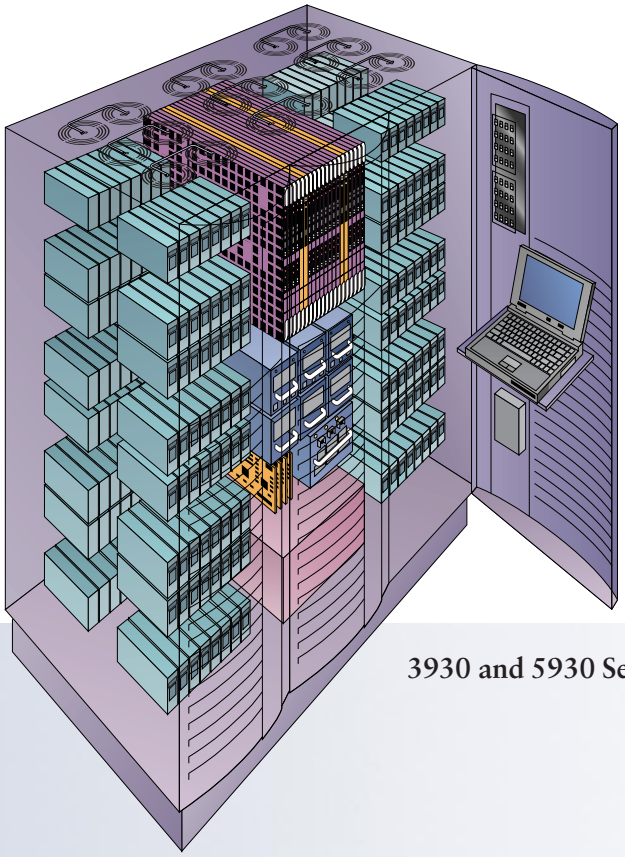
Symmetrix 3000 and 5000 Enterprise Storage Systems Product Description Guide



3830 and 5830 Series



3630 and 5630 Series



3930 and 5930 Series

Symmetrix 3000 and 5000 Enterprise Storage Systems Product Description Guide

Table of Contents

Chapter 1
Introduction

Overview

This technical overview provides information on the Symmetrix® 3000 and 5000 families of EMC Enterprise Storage™ systems, including product descriptions and details on key features and operations. This overview describes EMC's underlying storage system architectural philosophy which is based on the complementary MOSAIC:2000® hardware and ISA software architectures. The objective is to provide IS management and staff with a thorough technical understanding of Symmetrix systems.

There are currently three series in both the Symmetrix 3000 and 5000 families — the Symmetrix 3630, 3830 and 3930, and the Symmetrix 5630, 5830 and 5930. They form scalable families with leadership performance and capabilities in each of their respective capacity classes.

The Value of Symmetrix 3000 and 5000 Enterprise Storage Systems

Performance and Revenue Advantages

Symmetrix 3000 and 5000 systems help EMC customers enhance the performance and revenue of their businesses. These advantages typically can take any combination of three forms.

1 Business Impact 2 Operational Impact 3 Financial Impact

Certain key features and capabilities of Symmetrix Enterprise Storage systems can contribute directly to achieving these impacts.

Business Impact usually provides the greatest customer value and payoff, and is most often a direct result of the industry-leading performance of Symmetrix systems. More transactions can be handled per hour, or less powerful servers can accomplish the task, because Symmetrix offers:

- **higher transaction throughput**
- **improved availability to information**
- **faster data analysis for decision support**

Higher performance can result in:

- **helping customers improve time-to-market of their products and services**
- **reducing development time for new business applications to create sources of new revenue**
- **enabling implementation of global services through improved data processing procedures**

Operational Impact is derived from fast, easy connectivity and integration, continuous data availability, and compatibility with existing technology. EMC customers can deploy their most valuable asset – people – to more productive efforts than having to manage data. Operational impact is typically associated with cost avoidance.

- **Continuous data availability and business continuance keep your business running**
  - Redundant critical components
  - Nondisruptive upgrades and repair of critical components
  - Data protection optimizes performance, availability, and price
  - Continuous data availability during migration from older technology disk systems to new Symmetrix systems

- **Compatibility and ease of implementation**
  - Support for all major multivendor servers: IBM®/PCM mainframes, heterogeneous UNIX® servers, PC LAN and Windows NT® servers, and AS/400® systems
  - Online host-independent mirroring between physically separated Symmetrix systems through Symmetrix Remote Data Facility (SRDF™), enabling business continuity during planned and unplanned outages

Financial Impact is often the most obvious and is frequently associated with both the ability to extend the useful life of technology, and the maintenance and data center environmental savings typically realized with Symmetrix products. EMC's hardware and software architectural approach to storage system implementation permits the seamless integration of new technology and capability as advances are made. Financial impact is typically associated with cost savings.

- **Asset protection**
  - MOSAIC:2000 is a modular hardware framework that allows rapid development and deployment of new storage technology while protecting existing investments.
  - ISA (Intelligent Storage Architecture) is a modular software framework that bridges the gaps between platforms, networks, databases, and applications. ISA also adds value to the storage investment with software such as SRDF, EMC InfoMover™, Symmetrix Data Migration Services (SDMS™), Symmetrix Manager, DataReach™, EMC TimeFinder™, EMC PowerPath™, EMC Data Manager, and the FDR family of backup/restore solutions.

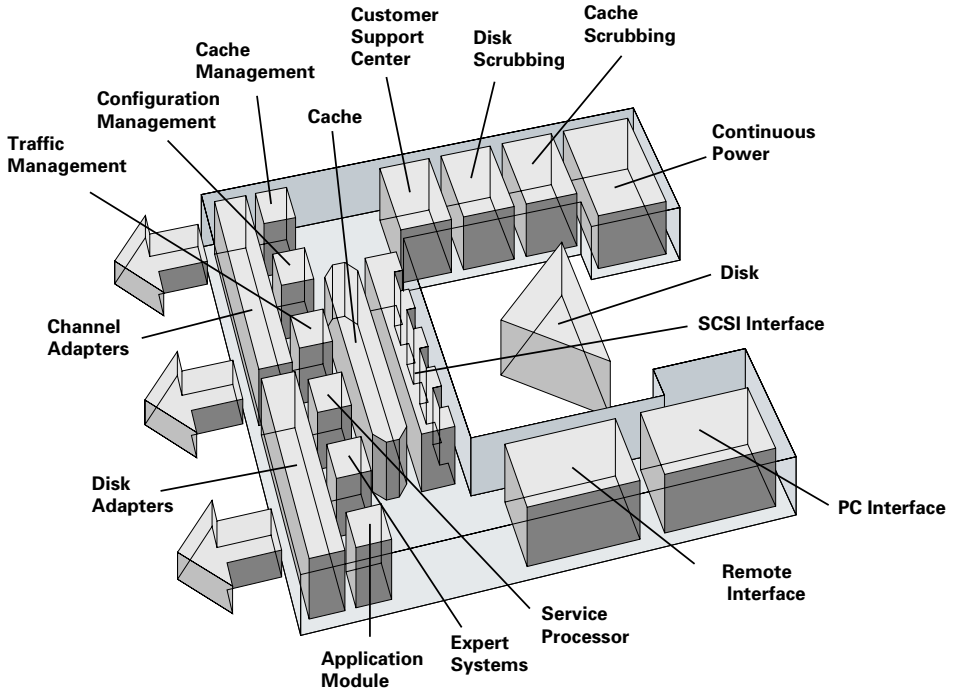
- **Superior economic value**
  - Less floor space
  - Lower power and cooling requirements
  - Lower maintenance costs

EMC's Architectures for Enterprise Storage: MOSAIC:2000 and ISA

EMC Enterprise Storage systems make information protection, information sharing, and information management possible. As a shared central repository for valuable information, EMC Enterprise Storage:

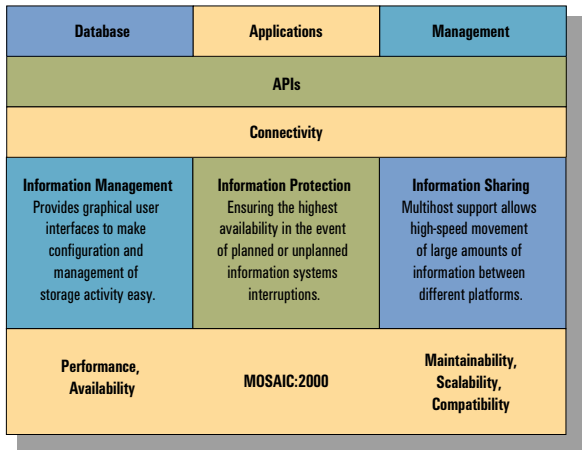
- Connects to disparate computer systems
- Provides common information management, protection and sharing capabilities
- Allows organizations to create a competitive advantage by leveraging large amounts of information

EMC Enterprise Storage systems rely on MOSAIC:2000 and Intelligent Storage Architecture (ISA) — a combination of industry-standard hardware and software. EMC Enterprise Storage architecture ensures optimum performance, availability, scalability and connectivity. Complementary MOSAIC:2000 hardware and ISA software architectures demonstrate the unique storage system philosophy of all EMC storage products and their capability to share information within an organization.



MOSAIC:2000 is the long-standing foundation for Symmetrix. This architecture combines industry-standard hardware with optimized software to provide the highest performance, availability, scalability and connectivity.

Intelligent Storage Architecture (ISA)



ISA provides unique and powerful software that extends the capabilities of Symmetrix in the areas of information protection, information sharing and information management.

Together, MOSAIC:2000 and ISA yield powerful enterprise storage systems that:

- Provide high-level performance, capacity, and reliability
- Store and retrieve data from all major computing platforms, including mainframe and open systems environments
- Enable software-based functionality that ensures business continuance in the event of a disaster
- Deliver rapid and nondisruptive data migration from one system to another
- Share information, regardless of origin

EMC Storage Philosophy

- **Highest performance, scalability, connectivity**
- **Information protection, information sharing and information management**
- **Provide intelligence at the storage system level**
- **Use industry-standard interfaces**

Highest Performance

Symmetrix systems use large cache memory configurations, and EMC proprietary caching algorithms enable the highest probability for "cache hits" when reading data. One hundred percent cache fast writes ensure the highest possible performance when writing data. Fast, 100 percent cache writes enable Symmetrix performance to appear as close to that of solid-state disk as possible while being able to support the largest data capacity per system in the industry.

- *Scalability* – Symmetrix 3000 and 5000 systems enable consolidated storage strategies by providing scalable storage in a common family. System capacities scale from 35GB to multiple terabytes of fully protected storage. Symmetrix offers new ways to manage change and growth in applications, databases, servers, and overall business requirements.

- ***Connectivity*** – Connectivity to host platforms is provided through industry-standard interfaces. The Symmetrix 5000 series supports mainframe connections through ESCON®, parallel or block multiplexor channels. When optional Symmetrix ESP (Enterprise Storage Platform) software is installed, Symmetrix 5000 systems can simultaneously support open UNIX, Windows NT, and AS/400 systems with connectivity to fast-wide-differential (FWD) SCSI, Ultra SCSI, and Fibre Channels.

  Symmetrix 3000 systems support connectivity to open UNIX, Windows NT, and AS/400 systems with connectivity to FWD SCSI, Ultra SCSI, and Fibre Channels. When optional Symmetrix ESP software is added to Symmetrix 3000 systems, they simultaneously support mainframe connections through ESCON and block multiplexor channels.

  This level of Symmetrix connectivity enables simultaneous support of multiple hosts and multiple host types for greater configuration flexibility and the fulfillment of EMC's Enterprise Storage philosophy.

Information Protection

EMC software provides a variety of information protection/business continuance options, including Mirroring the optimum RAID level for both performance and availability.

The following software offerings supplement the EMC Enterprise Storage philosophy.

- **Symmetrix Remote Data Facility (SRDF)** provides fast enterprise-wide data recovery capability in the event of a planned or unplanned data center outage.
- **EMC TimeFinder** supports the online creation of multiple independently addressable business continuance volumes (BCVs) of information allowing other processes such as backup, batch, application development and testing, and database extractions and loads to be performed simultaneously with OLTP and other business operations.
- **Symmetrix Dynamic Address Switching (S/DAS)** offers the capability to dynamically swap DASD addresses in an SRDF environment that participates in a parallel sysplex environment. It also allows dynamic address swapping with **Symmetrix Data Migration Services (SDMS)**.

  EMC's Remote Support network can be used to upgrade Symmetrix operating software (microcode) on an operational Symmetrix system with minimal interruption of service. This unique approach upgrades Symmetrix software and functionality without downtime, combining fast functional enhancements with continuous data availability.

Information Sharing

Symmetrix provides centralized, sharable information storage that supports changing environments and mission-critical applications. This leading-edge technology begins with physical devices shared between heterogeneous operating environments and extends to specialized software that enhances information sharing between disparate platforms.

- **EMC Celerra™ File Server** enables direct attachment to networks for high speed centralized data storage and data sharing without the need for a general purpose server.
- Symmetrix **Enterprise Storage Platform (ESP)** software provides simultaneous mainframe and open systems support for Symmetrix 3000 and 5000 systems.
- **Symmetrix** provides standard simultaneous multiple open systems support.
- **EMC InfoMover** extends information sharing. InfoMover facilitates high-speed bulk file transfer between heterogeneous mainframe, UNIX, and Windows NT host platforms without the need for network resources.
- **DataReach** uses ESP as an enabling technology to provide access to mainframe database information, extract it, and transfer it to UNIX and Windows NT open systems relational databases.

Information Management

Symmetrix systems improve information management by allowing users to consolidate storage capacity for multiple hosts and servers. EMC offers powerful graphical user interface (GUI)-based tools that dramatically simplify and enhance Symmetrix configuration, performance, and status information gathering and management.

- **Symmetrix Manager** offers enhanced GUI-based storage monitoring, configuration, and performance tuning management capabilities for Symmetrix systems supporting open systems and mainframe environments.
- **EMC PowerPath™** optionally offers a combination of simultaneous multiple path access, workload balancing, and path failover capabilities between Symmetrix systems and supported server hosts.
- **EMC Volume Logix** enables storage administrators to efficiently allocate Symmetrix storage in an Enterprise Storage Network environment to hundreds of UNIX or Windows NT servers located on the Fibre Channel hub or switched fabric.
- **EMC Data Manager (EDM™)** supports high performance network-based or directly connected open systems and Windows NT backup needs from one centrally managed site while offering a complete, high-performance database backup solution for the entire enterprise.
- **Fast Dump/Restore (FDR)** family of mainframe-based backup/restore utilities uses Symmetrix with existing mainframe infrastructures to provide a comprehensive suite of fast, nondisruptive information protection solutions for both mainframe and open systems environments.

Enterprise Storage Networks

Symmetrix systems can also serve as the central information repository in an EMC Enterprise Storage Network™ (ESN). An ESN provides an extremely high-speed, Fibre Channel-based network consisting of storage, switches, and hubs that expand EMC Enterprise Storage capabilities beyond the walls of the data center. ESN offers a fault-tolerant, self-healing enterprise wide architecture from which an enterprise can better manage, protect, and share all of its information resources.

System Intelligence

Traditional systems have placed the bulk of storage management decisions and overhead on the operating system and host processor. In this approach, decisions such as what data to cache and when to cache it take cycles away from applications and ultimately impact performance. Symmetrix systems can determine data access patterns in real time and intelligently optimize themselves for performance, independent of the host processor and operating system. Since these capabilities are not tied to specific operating systems or versions of operating systems, they can be exploited and do not require time-consuming and costly software upgrades. These capabilities are used for virtually all major mainframe, UNIX, Windows NT, PC LAN, and AS/400 systems without incurring host processor overhead.

Industry-Standard Interfaces

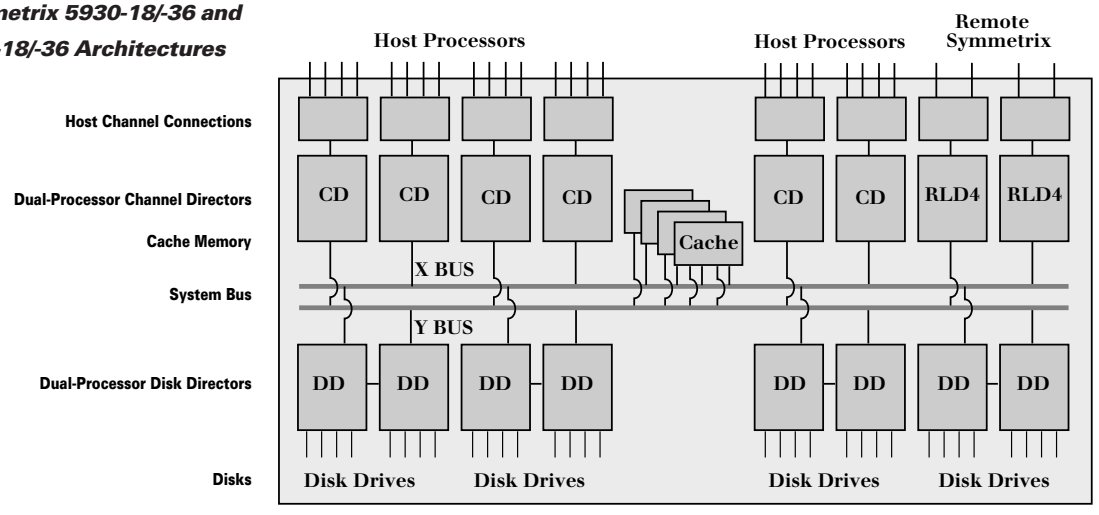
EMC uses open, industry-standard interfaces within Symmetrix systems. New, leading-edge HDAs can be introduced in the fastest possible manner, and popular open host processor interfaces are supported. This enables Symmetrix products to eliminate lagtime between the availability of new industry technology and new EMC deliverable products.

Chapter 2
Symmetrix 3000 and 5000 Enterprise Storage Product Description

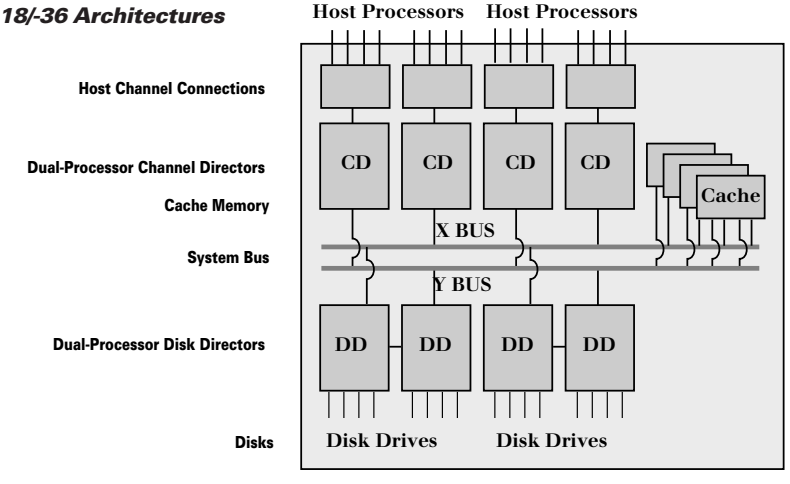
Symmetrix Enterprise Storage Family Configurations

Symmetrix systems support a mix of Channel Directors that include combinations of ESCON channels, parallel channels (Symmetrix 5000 only), Fibre Channel, Ultra SCSI and FWD SCSI channels, and Remote Link Adapters (used with SRDF and SDMS). Channel Directors are always installed in pairs to allow for redundancy and continuous availability in the event of repair or replacement to any single Channel Director.

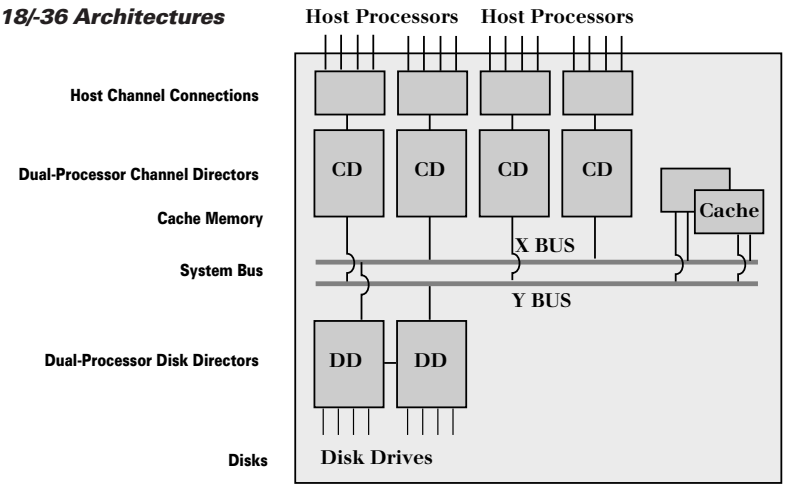
Symmetrix 5930-18/-36 and 3930-18/-36 Architectures



Symmetrix 5830-18/-36 and 3830-18/-36 Architectures

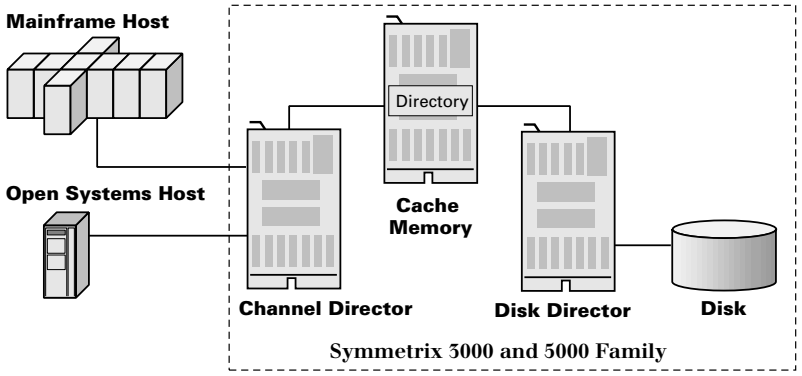


Symmetrix 5630-18/-36 and 3630-18/-36 Architectures



Basic Operation

Basic operations in the Symmetrix 3000 and 5000 family systems include Channel Directors, cache memory, Disk Directors, disks and the flow of data among these components, as illustrated in the following diagram.



Host Integration

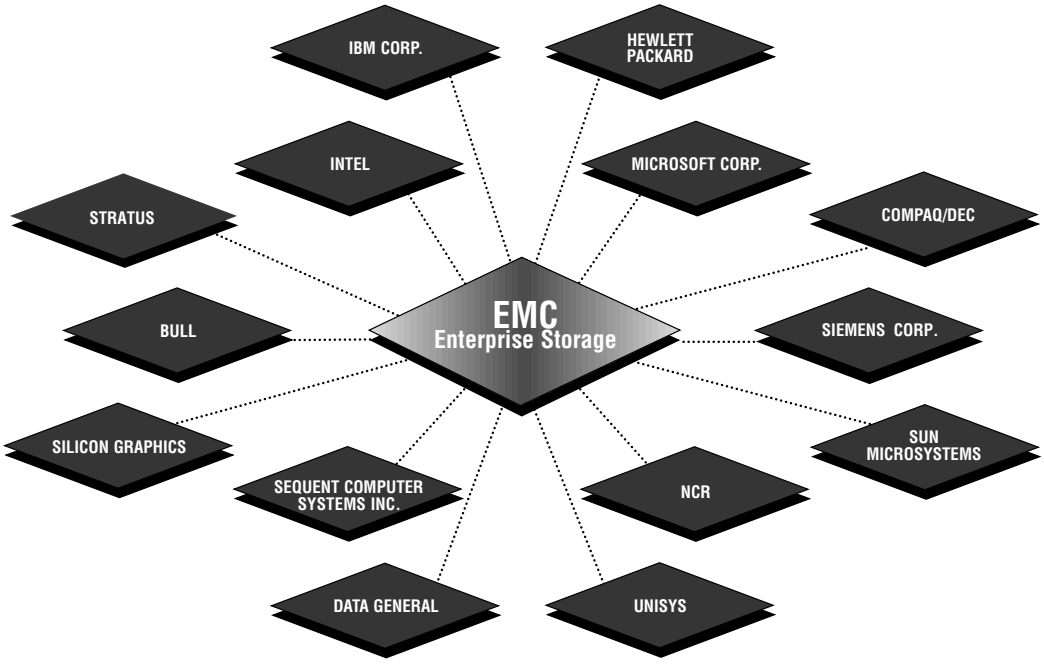
Symmetrix systems can be integrated easily and quickly with existing host processors, including all major enterprise servers and mainframes.

Multihost Support

Open systems connect to Symmetrix systems through fast-wide-differential (FWD) SCSI, Ultra SCSI, and Fibre Channel interfaces. The following list and illustration cover vendors of servers currently supported by Symmetrix systems. Support for additional system environments and additional system connections will continually be added, based upon customer demand and industry direction.

Bull®
Compaq®/DEC®
Data General®
Hewlett Packard®
IBM®
Intel®-Based Servers
NCR®
Sequent®
Siemens®
Silicon Graphics®
Stratus®
Sun Microsystems®
Unisys®

For a more detailed list of specific server models and supported operating system versions and interface technologies, contact your EMC representative or check EMC's web site at: *www.EMC.com/products/enterprise_storage_systems/open_sys_matrix.htm*.



Mainframe Operating System Support

In IBM®/PCM mainframe environments, all Symmetrix 5000 and 3000 with ESP systems are operating-system independent. The caching algorithms are self-managed and Symmetrix 5000 systems do not depend on host cache commands to receive the benefits of read and write caching. This means that the Symmetrix 5000 system will provide high performance and high functionality for I/O processing, not only to the latest ESA versions of mainframe operating systems but also to nontraditional mainframe operating systems and noncurrent versions of MVS, VM, and VSE. Virtually every System/370 and System/390® operating system can be supported, including:

MVS/ESA™	MVS/XA™	MVS/SP™	ACP/TPF™
VM/ESA™	VM/XA™	VM/SP™	VM/HPO™
VSE/ESA™	VSE/SP™	MVT/VSE™	AIX/ESA™

In addition, Symmetrix systems support other mainframe operating systems, including:

UTS®	OS/1100®	GCOS7™	GCOS8™	PICK™

Host Cluster Matrix

Configuring hosts in clusters achieves high availability and high performance. Cluster nodes share access to Symmetrix systems via fast-wide SCSI, Ultra SCSI, and Fibre Channel interfaces. Support for additional system environments and additional system connections will continually be added, based upon customer demand and industry direction. Symmetrix currently supports cluster hosts from the following vendors:

Bull
Compaq/DEC
Hewlett Packard
IBM
Intel-Based Servers
Sequent
Siemens
Sun Microsystems

For more detailed information on Symmetrix support for clustered environments, contact your EMC representative or check EMC's web site at:
www.EMC.com/products/enterprise_storage_systems/cluster_host_matrix.htm.

Device Support and Emulation

Symmetrix 5000 and 3000 systems with ESP appear to mainframe operating systems as a 3990-6, 3990-3 or 3990-2. The physical storage devices can appear to the mainframe operating system as a mix of multiple 3380 and 3390 devices. All models of the 3380 or 3390 volumes can be emulated up to the physical volume sizes installed. A single Symmetrix system can simultaneously support both 3380 and 3390 device emulations.

The Symmetrix responds to cache commands from the host processor and will respond as 3990-3 or 3990-6, but will not always perform the command in exactly the same manner as 3990-3 or 3990-6. Some host access methods are designed to turn off cache during sequential processing. This is necessary with conventional cached controllers as their caching algorithms create cache pollution when processing sequential I/O. The sequential prefetch capability of Symmetrix allows for efficient sequential operation without having to actually turn off Symmetrix cache. This allows the Symmetrix to provide the high performance of an integrated cached environment 100 percent of the time, while the host operating system perceives that cache has been turned off.

The Symmetrix emulation of the IBM 3990-3 or 3990-6 allows it to be compatible with IBM's Systems Managed Storage (SMS) and other data management systems. Symmetrix knows how data is being accessed and will manage its own caching and prefetch processes accordingly. EMC

cache management algorithms select which channel commands to process and which to ignore for greater efficiency and performance.

On open systems hosts, Symmetrix logical disk volumes appear to the host as physical disk devices at SCSI target ID/logical unit number addresses. All host logical volume manager software can be used with Symmetrix disk volumes.

When using a FWD SCSI connection to an open system processor, the Symmetrix system appears as industry-standard SCSI disk devices behind a FWD SCSI interface and data is stored in Fixed Block Architecture (FBA) format.

Host Channel Connection

All Symmetrix systems provide exceptional channel connectivity through combinations of Channel Directors. These include ESCON channels, parallel channels (5000 systems only), FWD SCSI and Ultra SCSI channels, Fibre Channels, and Remote Link Adapters (used with SRDF and SDMS). Channel Directors are installed in pairs, providing redundancy and continuous availability in the event of repair or replacement to any one Channel Director.

Channel Directors

Symmetrix systems support mainframe, UNIX, Windows NT, and AS/400 connections through Channel Directors. They connect directly to host processors through physical path types or Physical Channel Attachments.

The Symmetrix 3000 and Symmetrix 5000 family systems with ESP support open UNIX systems, Windows NT systems, and AS/400 connectivity through Symmetrix FWD SCSI, Ultra SCSI, and Fibre Channel Channel Directors. Each Channel Director is a single board with four host connections (two for Fibre Channel) and, depending on the Symmetrix, from two to eight Channel Directors.

The Symmetrix 5000 and Symmetrix 3000 family systems with ESP support mainframe connectivity through serial Channel Directors for ESCON connections and parallel Channel Directors (Symmetrix 5000 systems only) for block multiplexor connections. Each channel connection supports four channel connections. For configuration flexibility, these directors can be installed simultaneously and, depending on the Symmetrix, from two to eight Channel Directors are supported.

When Symmetrix ESP software is installed on a Symmetrix 5000 or 3000 system, simultaneous connections for mainframes, UNIX, Windows NT, and AS/400 systems are provided. This specialized software enables combinations of serial Channel Directors, parallel Channel Directors, FWD SCSI Channel Directors, Ultra SCSI Channel Directors, and Fibre Channel Directors on the same Symmetrix system.

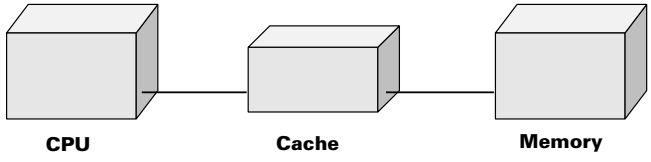
Internal Data Flow

Data Flow

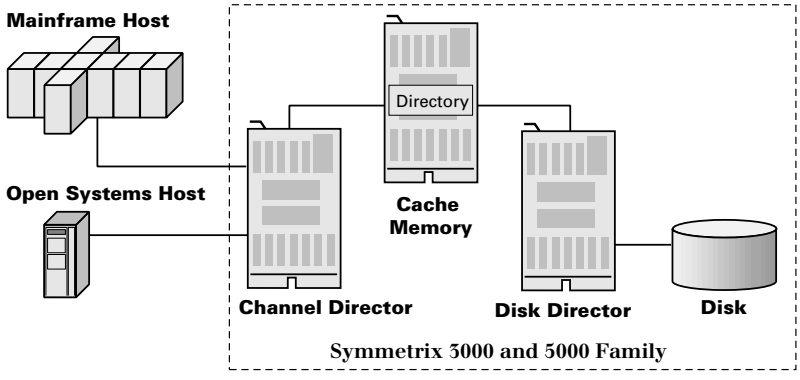
Intelligent cache configurations allow Symmetrix systems to transfer data at electronic memory speeds which are much faster than physical disk speeds. Symmetrix products are based on the principle that the working set of data at any given time is relatively small when compared to the total system storage capacity. When this working set of data is in cache, there is a significant improvement in I/O performance. The performance improvement achieved is dependent on both:

- *Locality of Reference* – If a given piece of data is used, there is a high probability that a nearby piece of data will be used shortly thereafter,
- *Data Reuse* – If a given piece of data is used, there is a high probability that it will be reused shortly thereafter.

This cache principle has been in use for years on host processor systems (CPU and storage devices). The figure below illustrates this type of host cache use. The cache used in this manner is often a high-speed, high-cost storage unit used as an intermediary between the CPU and main storage.



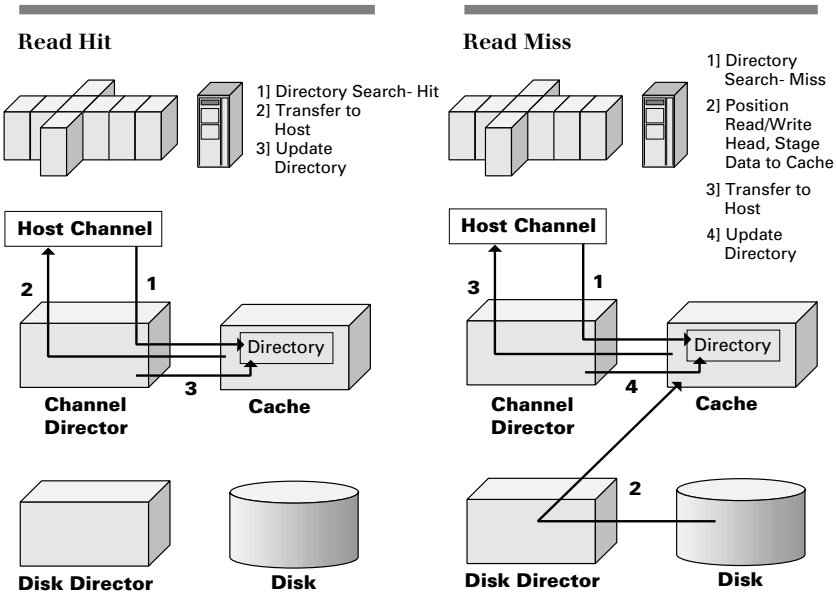
Symmetrix uses the same cache principle as host systems, but with enhanced caching techniques. The following diagram illustrates cache use in Symmetrix.



In the Symmetrix system, the Directors perform the following functions:

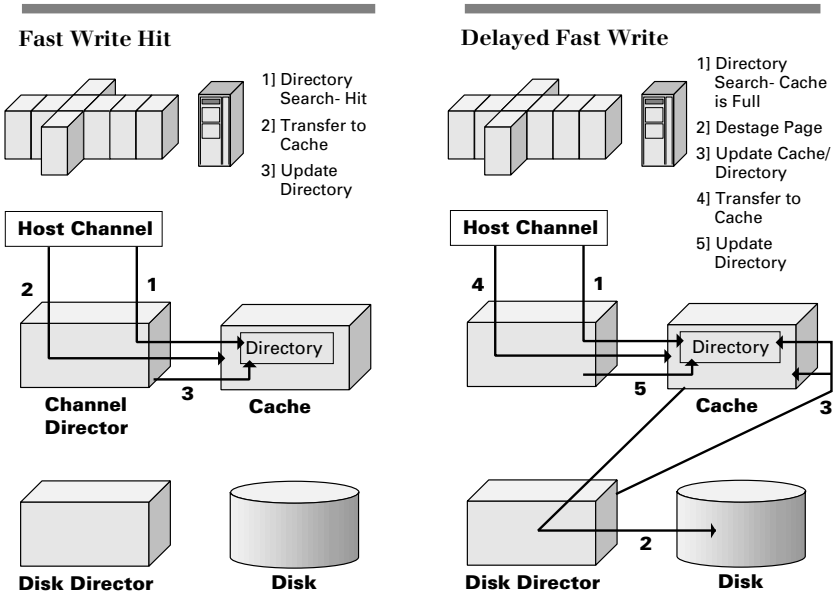
- Each Channel Director handles I/O requests from the host. It accesses the directory in cache to determine if the request can be satisfied within the cache. The directory contains information on each cache page and blocks within each page.
- Each Channel Director manages cache using an Age Link Chain table and Least Recently Used (LRU) algorithm. An Age Link Chain table maintains the references to the Most Recently Used (MRU) to Least Recently Used page locations. The LRU algorithms use the information in this table to ensure that only pages of data that have been used recently are kept in cache.
- A prefetch algorithm dynamically detects sequential data access patterns to the disk devices. The directors improve the hit ratio of these accesses by promoting blocks from the disk devices to cache slots before that data has been requested. The prefetch algorithm can stage two to 12 tracks to cache depending on access patterns learned.
- The Disk Director manages access to the disk drives. It performs a background operation that destages "written-to" blocks to disk.

Four basic types of operations occur in a Symmetrix system: Read Hit, Read Miss, Fast Write, and Delayed Fast Write operations. The following diagrams illustrate these operations.



A *Read Hit* occurs on a read operation when all data necessary to satisfy the host I/O request is in cache. The Channel Director transfers the requested data from cache to the host and updates the cache directory.

A *Read Miss* occurs when all data necessary to satisfy the host I/O request is not in cache. The Disk Director stages the block(s) containing the data from disk. The Disk Director places the block(s) in a cache page. Simultaneously, the Channel Director reconnects to the host and sends the requested data.

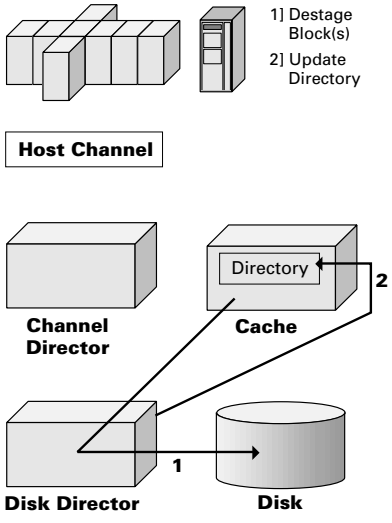


A ***Fast Write*** occurs when the percentage of modified data in cache is less than the Fast Write threshold. On a host write command, the Channel Director places the incoming block(s) in cache.

A ***Delayed Fast Write*** occurs only when the Fast Write threshold has been exceeded (that is, the percentage of cache containing modified data is higher than the Fast Write threshold). The Least Recently Used data is destaged to disk. When sufficient cache space is available, the Channel Director processes the host I/O request as a Fast Write. With sufficient cache present, this type of cache operation will rarely occur.

A background operation also occurs in Symmetrix systems. This background operation destages "written-to" blocks to disk. This allows any written-to or changed data to be maintained in two locations: cache for high performance in the occurrence of reuse of that data, and on disk to maintain the highest levels of data integrity. All pending writes are assured of arrival to the intended disk even in the event of power failure. The following diagram illustrates this destaging operation.

Destaging Operation



Cache Memory

One of the most crucial components of a Symmetrix system is the cache memory. All read or write operations transfer data to or from cache. Any transfers between the host processor, Channel Directors, and cache are achieved at electronic speeds that are a quantum leap faster than transfers involving disk. Optimization around the movement of data between disk and cache results in the highest performance possible. There are two cache buses, x and y; each has a 360MB per second bandwidth for a total processing bandwidth of 720MB per second.

Performance Features

Performance remains a significant differentiation between Symmetrix systems and all alternative disk offerings. The features that will be discussed all impact performance and contribute to increasing transaction volumes, improving online response time, and reducing the time needed to execute batch runs.

Electronic Data Transfer

Symmetrix greatly exceeds the throughput and response time performance of conventional disk storage because the majority of data is transferred at electronic memory speeds, not at the dramatically slower speeds of physical disk devices. The Symmetrix system's intelligent use of up to 16GB of cache contributes greatly to this performance advantage.

Advanced Caching Algorithms

Simply having these robust cache configurations is not enough. One of the fundamental differences between Symmetrix products and all other DASD is the advanced caching algorithms that allow intelligent usage of the installed cache for high performance. These algorithms search quickly and efficiently to determine whether the requested data is in cache. They also understand how the application is accessing the data and tune themselves accordingly in real time. The cache management algorithms respond to channel requests to manage the cache via host processor software when appropriate and perform the management functions independently when the host processor does not make requests. This is a complex series of tasks and requires the advanced cache management algorithms of Symmetrix to accomplish them effectively.

With the large amounts of cache offered on Symmetrix systems, the typical installation will attain a read hit ratio (requested data is in cache) of 90 percent to 95 percent. In some alternative cached environments, read performance may be acceptable due to the opportunity of a read hit, but write performance is inferior unless there are DASD Fast Writes (DFW). Even with DFW, these alternative products often have a very limited resource, Nonvolatile Storage (NVS), for this function. In the event of a power outage, NVS is only nonvolatile for the cache and only for a limited period of time. The Symmetrix systems, however, always provide 100 percent system nonvolatility, allowing all writes to be "fast writes." Channel End/Device End is presented to the host channel when the data is written to cache and verified.

Efficient Cache Searching

One of the problems of traditional controllers with large cache configurations is the lack of an ability to search the cache in an efficient manner. Increasing cache configurations means that the search time increases proportionally. This search time is added to every I/O request, read hit, write hit, read miss, or write miss. This is a considerable penalty for every I/O request, especially in performance-critical applications. The controller may actually disconnect from the channel during this process and must then reconnect if there is a cache hit.

The Symmetrix systems perform the cache search via advanced proprietary algorithms. It only requires 20 microseconds to determine if a record is in cache. This advanced algorithm allows the 20 microsecond search time to remain constant regardless of cache configuration. With a 20 microsecond cache search, there is no reason to disconnect from the channel during the search. In fact, it takes longer to disconnect and reconnect than it does to perform the cache search. In normal operation, the only time that a Symmetrix system will disconnect from the channel is in the case of a read miss.

Sequential Prefetch

Symmetrix systems continually monitor I/O activity and look for access patterns. When the second sequential I/O to a track occurs, the sequential prefetch process is invoked and the next track of data is read into cache. The intent of this process is to avoid a read miss. Once the first track is completely read by the host processor, the third track is read and reuses the same cache location as the first.

This process of using the track slots in a round-robin fashion prevents cache pollution caused by conventional sequential caching algorithms. Should a read miss occur, the Symmetrix system will increase the number of track slots from two to five. If a read miss still occurs, the Symmetrix prefetch routines will increase the slots to eight. The maximum number of track slots that will be allocated for a sequential operation is 12. Should I/O activity reduce, the number of track slots will be reduced accordingly. When the host processor returns to a random I/O pattern, the Symmetrix system will discontinue the sequential prefetch process.

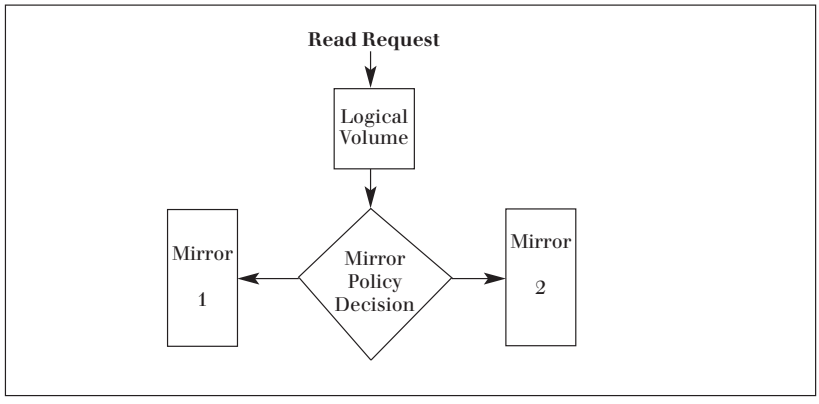
PermaCache Option

Symmetrix allows you to permanently assign mission-critical data requiring extremely high performance to cache. A variable number of contiguous cylinders on the disk devices can be reserved for PermaCache backup.

PermaCache is best used for infrequently accessed data that needs instantaneous response since this data normally may not be in cache at the time it is requested. The large cache and intelligent caching algorithms strive to keep frequently accessed data in cache, making its assignment to PermaCache unnecessary. PermaCache requires additional cache memory to be available above the base cache required for any particular configuration.

Dynamic Mirror Service Policy

Symmetrix Dynamic Mirror Service Policy (DMSP) is an enhancement to Symmetrix which provides the algorithms for processing read operations for mirrored (RAID 1) volumes. As shown, DMSP determines which mirrored volume will service each read request. Using only a static mirror service policy results in a single mirror always being used and no performance advantage when using mirrored volumes over non-mirrored volumes.



The DMSP feature takes advantage of static mirror service policies, but addresses their limitations by making periodic adjustments. Over time, data access pattern information is collected and results in a decision about the best policy to use for each volume. Volumes with higher access rates get more preferential treatment than volumes with lower access rates. The result is improved overall system performance and reduction or elimination of arduous studies of access patterns and manual configuration changes.

Disk Drives

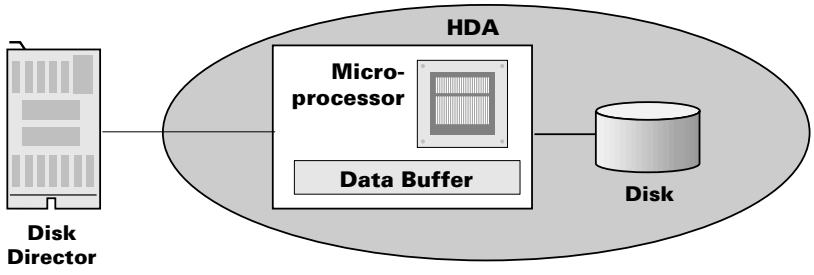
EMC uses advanced technology disk drives and disk controllers to enhance Symmetrix capabilities. Microprocessors embedded in the controllers of each drive enable capabilities such as advanced RAID protection to be offloaded from CPUs, disk directors and controllers. This further enhances the performance of Symmetrix systems and also serves to make them more easily compatible with a wide array of hardware and software platforms.

Symmetrix 3630/5630, 3830/5830, and 3930/5930 systems support mixed configurations of up to 32, 96, and 256 (respectively) 18GB and 36GB disks drives. This breadth of scalable capacity and configuration choices allows Symmetrix systems to adapt to virtually any enterprise storage requirement.

Disk Directors

The Disk Directors manage the interface to the physical disk, and are responsible for data movement between the HDAs and cache. HDAs are connected to Disk Directors through industry-standard SCSI interfaces with two microprocessors per Disk Director. This connection allows rapid introduction of the latest disk drive technology into Symmetrix systems.

Disks



Symmetrix systems use industry-standard SCSI HDAs for physical disks. The use of industry-standard HDAs allows EMC to keep pace with customer needs as technology advances in the area of increased capacities and improved performance. Each HDA is configured with its own controller consisting of control logic, a microprocessor, and a device-level buffer. The device-level buffer is designed to eliminate Rotational Position Sensing (RPS) misses. An RPS miss occurs when the head or current rotational position of the disk media is such that the transfer is possible when requested, but the controller and its path to an HDA are not available. An RPS miss typically causes a time delay for transfer of at least one additional rotation of the disk. Through the use of the device-level buffer, data is easily moved between the Disk Director or the drive media and the buffer. This enables an electronic transfer between the buffer on the HDA and the Disk Director, thereby avoiding the possibility of an RPS miss. It can also be segmented, using the SCSI-2 command set. This allows Symmetrix control logic to issue a read command to the device, detach, then issue a data write to a different segment of the device-level buffer. The onboard microprocessor will manage the read or write, and will notify the Symmetrix system when the read is complete.

Every HDA contains its own microprocessor which has the capability of self-management. This gives Symmetrix the ability to perform parallel tasks, such as diagnosis and simultaneous transfers, and further enhances performance.

Hyper-Volume Extension

Symmetrix enhances disk system functionality by supporting up to 32 logical volumes on one physical device. Up to a maximum of 4,096 logical volumes are supported on a Symmetrix system.

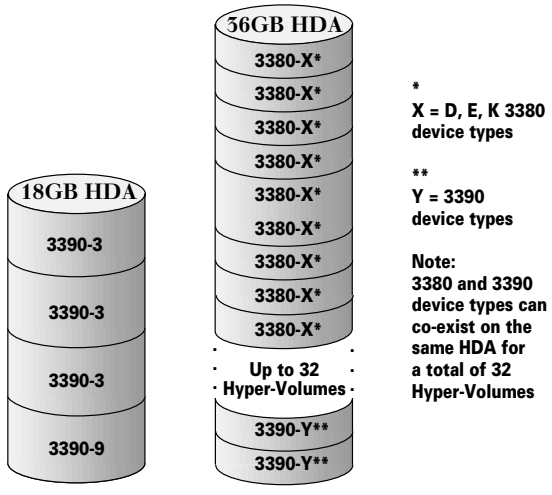
For mainframe customers, there are two separate uses of Hyper-Volume Extension (HVE).

- *Extended Cylinder Addressing for higher performance* – Beyond the capacity on the drive required for IBM device emulation, there can be an additional small logical volume for data sets that require very high performance (Multi-Image Manager files, JES Checkpoint, RACF Control files, etc.). Since this small logical volume is separate from other volumes, Unit Control Block (UCB) busy conditions due to contention are eliminated.
- *Split-Volume Capability for greater flexibility* – Up to 32 separate logical volumes can be configured on a single physical drive. For example, a single EMC 18GB drive could support up to six logical 3390-3s, or up to 18 logical 3390-1s, or nine logical 3390-2s or two logical 3390-9s. A single 36GB drive could support 12 logical 3390-3s, or up to 32 logical 3390-1s, or 18 logical 3390-2s, or four logical 3390-9s. This flexibility provides for the consolidation of many physical DASD devices into far fewer physical high capacity, high performance disks. HVE enables the replacement of older storage devices without requiring application or data format changes.

Support is provided for native IBM 3390 and 3380 track emulation with all 3390 and 3380 disk volumes being supported. No modifications are required to the operating system, application, or program product software to take advantage of HVE.

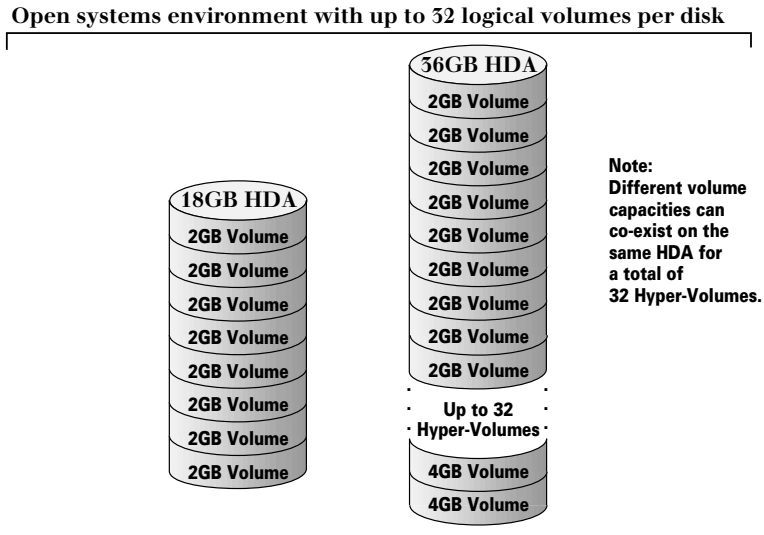
The following illustration represents some examples of possible Hyper-Volume Extension logical configurations of EMC 18GB and 36GB drives in mainframe environments.

Mainframe environments with up to 32 logical volumes per disk



Open systems customers can also take advantage of Hyper-Volume Extension to support multiple logical disk volumes on individual disks. This capability is particularly useful for some 32-bit implementations of UNIX that allow only 2GB file systems per single logical disk. For example, up to eight 2GB logical disk volumes can be defined for a single EMC 18GB HDA.

The following illustration represents examples of possible Hyper-Volume Extension logical configurations of EMC 18GB and 36GB drives in open systems environments.



Meta Volume Addressing

Symmetrix also enhances disk system functionality in Windows NT and open systems environments through the capability of meta volume addressing. Symmetrix allows the concatenation of contiguous logical devices, up to a maximum of 512GB per meta device. This overcomes the addressing limitations imposed in Windows NT environments.

Symmetrix Data Protection

EMC has chosen to enhance the basic RAID level definitions in each of the two implementations of data protection that are offered for Symmetrix. Unique customer value can be derived from the ability to have Symmetrix products support disk arrays that can be protected with:

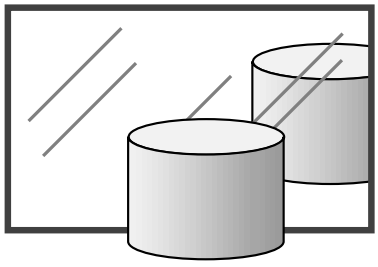
- ***Mirroring (RAID 1)*** – for mission-critical data with highest performance and highest availability.
- ***Symmetrix Remote Data Facility (SRDF)*** – an enhanced version of mirroring for multiple storage system data protection and availability that can include multiple sites.

This capability allows optimization for the best relationships of availability, performance, and cost for individual data sets. These options are configurable at the physical volume level so that different levels of protection can be applied to different data sets within the same Symmetrix system. This unique flexibility allows the customer to maintain the lowest possible costs in relation to the necessary levels of performance and data availability.

The EMC Symmetrix implementations of data protection are able to exploit Symmetrix functionality that differentiates the EMC offerings from typical RAID offerings as follows.

Mirroring (RAID 1)

The implementation of RAID 1 Mirroring on Symmetrix systems includes performance enhancements beyond the high availability capabilities normally associated with RAID 1.



Write Operations with Mirroring

A write operation to any mirrored volume is executed identically to a nonmirrored write. The Channel Director presents Channel End/Device End to the host after data is written and verified in cache. The Disk Directors then destage the data to each drive of the mirrored pair of drives asynchronously. As such, Mirroring on Symmetrix exploits the 100 percent fast write capability, and the application does not see additional time associated with having to physically perform two disk write I/Os (one to each drive of the mirrored pair) as is normally associated with RAID 1.

Read Operations with Mirroring

The Symmetrix performance algorithms for read operations in mirrored pairs offer three service policies to best balance the use of the Symmetrix architecture. Interleave Service Policy shares the read operations of the mirrored pair by reading tracks from both HDAs in a flip flop method, a number of tracks from M1, and a number of tracks from M2. Interleave is designed to achieve maximum throughput. Split Service Policy differs from Interleave because read operations are assigned to either the M1 or the M2, but not both. In the case of multiple hyper-volumes in the mirrored pair, certain logical volumes are read exclusively from M1 and certain logical volumes are read exclusively from M2. Split is designed to minimize head movement Dynamic Mirrored Service Policy (DMSP) utilizes both Interleave and Split for maximum throughput and minimal head movement. DMSP adjusts each logical volume dynamically based on access patterns detected.

Mirroring Error Recovery

In the unlikely event that one disk in the mirrored pair fails, the Symmetrix automatically uses the other disk drive of the mirrored pair without interruption of data availability. The Symmetrix system notifies the host operating system of the error via the message to operator protocol and to the EMC Customer Support Center via an Auto-Call action. The EMC Customer Support Center Product Support Engineer (PSE) then begins the diagnostic process and, if necessary, dispatches a Customer Engineer (CE) to the customer site. Once the suspect HDA is nondisruptively replaced, the Symmetrix system re-establishes the mirrored pair and automatically resynchronizes the data with the new disk. During the data resynchronization process, the Symmetrix system gives priority to host I/O requests over the copy I/O to minimize the impact on performance.

Mirroring Advantages

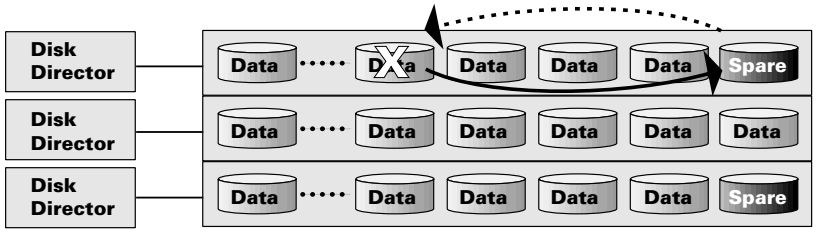
In summary, Mirroring provides:

- Improved performance over traditional RAID 1 by supporting 100 percent fast write, and two simultaneous internal data transfer paths.
- Protection of mission-critical data from any single point of failure.
- Continuous business operation by switching to the alternate HDA of a mirrored pair without interruption to data availability should loss of access occur to one of the HDAs in the mirrored pair.
- Assurance that the second copy is identical to the first copy.
- Automatic resynchronization of the mirrored pair after repair of the suspect volume.
- Transparency to the host processor and operating system.

It is possible to provide even greater protection for data that is already protected by mirroring by defining spare disks for disks protected by mirroring. In the event of the error threshold having been exceeded for a volume that is already protected by mirroring, instead of starting the dynamic sparing process of copying from the failing disk to the spare disk, data will be copied from the "good" disk to the spare disk. This will provide additional protection for the remaining active disk of the mirrored pair in case the failing disk cannot be immediately replaced.

Dynamic Sparing

Symmetrix family systems can provide Dynamic Sparing, an additional level of protection for volumes that use the mission-critical redundancy of RAID 1 Mirroring. A small pool of spare volumes is committed to this option, typically in groups of spares equal to the number of data volumes in the RAID 1 group. This user-selectable option is capable of providing dynamic reallocation of data to a standby spare, thus maintaining data protection in the event of an HDA failure.



Synchronization and HDA Replacement

Once all HDAs in the RAID group are synchronized, the spares become the active volumes, the failing HDA is taken offline, and notification is made of the occurrence. Notification is made to the host via sense information and to the EMC Customer Support Center via an Auto-Call event. The local Customer Engineer is notified and will then report onsite to perform a nondisruptive replacement of the reported failing HDA. Once the physical replacement is complete, microcode is notified and the new HDA is synchronized with the Dynamic Spares in use during this process. Because data volumes are fully protected, the HDA replacement and resynchronization can be deferred to a time convenient to the customer. When the synchronization is complete, the HDA in the original location becomes the operational HDA, leaving the spares standing by and ready should another HDA fail at some time in the future. Throughout this process, continuous data availability is provided to users and applications without any disruption.

Dynamic Sparing Operation

The entire Dynamic Sparing process requires no intervention from customer personnel as it is completely implemented in Symmetrix microcode. All that is required from an operational perspective is to select the Dynamic Sparing option during initial Symmetrix system configuration and to reserve the necessary spare HDAs. Priority is given to host I/O requests during resynchronization, so high performance can be maintained even during asynchronous data resynchronization. Since errors are usually detected well in advance of an actual disk failure, dynamic sparing has proven itself to be very effective at being able to copy a full drive to a spare drive prior to data becoming unavailable on the failing drive.

Symmetrix Backup Restore Facility (SBRF)

Symmetrix 5000 systems have the ability to perform high-speed backup and restoration of data while applications remain online and accessible with the Symmetrix Backup Restore Facility (SBRF). SBRF is compatible with IBM's Concurrent Copy, but provides a much higher performance environment.

Service and Maintenance

Goals and Philosophy

The goal for Symmetrix products is to be able to address all possible aspects of systems operation that contribute to providing continuous data availability to allow continuous business operation. The philosophy of EMC is to design in maximum reliability and then to implement the design with the most reliable components available. Once the design and component selection are complete, the reliability focus continues with Design Verification Testing (DVT), Highly Accelerated Life Testing (HALT), and Ongoing Reliability Testing (ORT) to assure customers of an inherently highly reliable product at all times. EMC also employs extensive leading-edge Environmental Stress Screening (ESS) techniques to weed out early life component failures well before the Symmetrix system is delivered to the customer site. Beyond the redundant hardware components and basic microcode operations of Symmetrix, EMC provides significant data protection and RAID offerings that provide continuous data availability in the event of disk failures or even the total loss of a data center.

Building upon this foundation of highly reliable components, the architecture of the Symmetrix focuses on redundancy so that data availability is assured even in the unlikely case of a component failure. In addition to redundant data paths, redundant components exist within all the major functional units, providing backup should a component failure occur.

The concept of continuous data availability is extended further to one of business continuance with capabilities offered by Symmetrix Remote Data Facility (SRDF), EMC TimeFinder, Symmetrix Data Migration Services (SDMS), and the FDR family of backup/ restore software products. These EMC-unique offerings provide continuous data availability and continuation of business operations in situations where alternative DASD would typically require multiple hours or days of application downtime.

Nonvolatile Power System

The entire Symmetrix system is made nonvolatile via an onboard battery backup system. The battery backup system provides the means for destaging any fast write data that might be in cache should an AC power failure occur. In addition to providing nonvolatility to the Symmetrix system, the batteries are fully capable of powering not only all electronic components, but also all HDAs during this time. This means that the disks are always powered down in an orderly manner, eliminating emergency power off situations and extending their useful life considerably.

The Symmetrix system battery will keep the entire system powered long enough to destage all write tracks currently in cache. Symmetrix will continue to accept host I/Os for a period of three minutes. If external power is not restored after three minutes, Symmetrix will return a Device Not Ready condition for all devices to all connected hosts. Symmetrix will then destage all write tracks currently awaiting destage and then perform an orderly shutdown. An orderly shutdown is a condition where the heads on the HDAs are properly retracted and the drives are spun down and powered off. Should AC power be restored prior to the Symmetrix being powered down, the Symmetrix becomes immediately operational without requiring a system restart.

The power system provides similar redundancy if a power supply fails. There is sufficient capacity in the remaining power supplies to maintain full operation until a nondisruptive repair can be made to the failed component. Additional redundancy is provided in the system backplane with two duplicate busses providing redundant data paths should a catastrophic type of failure occur in this component. Two fully redundant AC power lines are provided and if one power source is lost, the other will provide continuous operation.

Self-Maintenance and Continuous Data Availability

Symmetrix has full state-of-the-art self-monitoring, self-diagnosing, and, where possible, self-repairing algorithms. The objective of this philosophy is the avoidance of user-observable errors. Symmetrix will actively identify internal temporary errors that could potentially lead to any type of user-observable hard failure and attempt to correct them prior to data being unavailable to a user or an application. This error avoidance is accomplished through a process of error detection, error logging, and notification.

During idle time, the disks are read ("disk scrubbing"), looking for any type of error. Upon sensing a correctable error, the error is corrected and then rewritten. The block of data is read again to verify that it was a permanent correction. If it is correctable, the pertinent information is logged and scrubbing continues. If the error is not permanently corrected, the process is repeated until it is either corrected or the error recovery routines determine that a skip defect must be executed. If the skip defect must be executed, it is done via Symmetrix microcode. When the skip defect is complete, notification is made and the scrubbing process continues. Should a sufficient number of skip defects occur on a track that would make an alternate track assignment necessary, that too is accomplished through Symmetrix microcode and is transparent to the user.

"Cache scrubbing" is accomplished in a manner similar to disk scrubbing. During idle time, cache is checked for any single bit errors. Should a single bit error be encountered, it is corrected and the line of cache is rewritten and then read to determine if it was permanently corrected. If the single bit was permanently corrected, a counter is incremented, the error is logged, and processing continues. If the error was not permanently corrected the first time, the correction process continues until either the correction is permanent or microcode determines the single bit error is not correctable. Should it be determined that the single bit error is permanent, that section of cache is taken offline. This process of "fencing off" allows EMC to take the section of cache out of service prior to the customer seeing a temporary error.

Nondisruptive Component Repair

All Field Replaceable Units (FRU) of Symmetrix systems are capable of nondisruptive repair, including microcode and hardware. Intermediate versions of microcode are capable of being loaded without disruption to data availability for users and applications. Major hardware FRUs consist of the following:

- Channel Directors
- Disk Directors
- Head and Disk Assemblies (HDAs)
- Cache Memory Cards
- Power Supplies
- Battery System
- Fan Subsystems

Nondisruptive Microcode Upgrades

Microcode upgrades, performed by the EMC Product Support Engineers (PSEs) at the EMC Customer Support Center, provide enhancements to performance algorithms, error recovery and reporting techniques, diagnostics, and microcode fixes.

Nondisruptive microcode upgrades are available for Symmetrix systems. Symmetrix takes advantage of its multiprocessing and redundant architecture to allow for hot loadability of similar microcode platforms.

During a nondisruptive microcode upgrade, the PSE downloads the new microcode to the service processor. The new microcode loads into the EEPROM areas within the Channel and Disk Directors, and remains idle until requested for hot load into control storage. The Symmetrix system does not require manual intervention on the customer's part to perform this function. All Channel and Disk Directors remain in an online state to the host processor, thus maintaining application access. Symmetrix will load executable code as selected "windows of opportunity" within each director channel resource until all have been loaded. Once the executable code has been loaded, internal processing is synchronized and the new code becomes operational. This capability can be utilized to upgrade or to back down from a release level or interim update.

Data Integrity

Checking mechanisms are necessary throughout the data path within the storage subsystem to ensure that your information is the correct data every time. EMC's Symmetrix subsystem is the only storage system that guarantees that your data is both available and accurate.

Symmetrix offers a unique end-to-end integrated data verification technique consisting of codes and embedded ID on 4K clusters of data. Data integrity is verified from the host channel interface to cache to disk and back again, with the same data verification codes that are generated once at the entry point.

Additional Symmetrix Features

Multi-System Imaging

Symmetrix supports multiple System/390 environments through use of its 3990-3 or 3990-6 emulation modes and Hyper-Volume Extension feature. For control unit definitions of more than 64 device addresses, it is necessary to define multiple system IDs (SSIDs) with each SSID having a maximum of 64 devices. Symmetrix systems support up to 16 SSIDs with up to 64 devices per SSID up to a maximum of 1,024 logical devices per Symmetrix 5000 system. With IBM and PCM equivalents, up to eight-path connectivity may exist to any single device within the Symmetrix configuration.

Sequential Data Striping

Symmetrix family systems are fully compatible with IBM's Sequential Data Striping function for 3990 Model 3 and 3990-6 with Extended Platform in the ESCON environment. Sequential Data Striping automatically distributes accesses to balance the workload across disks. It also provides fast execution on large I/O-bound sequential processing requests by allowing I/O operations to be managed in parallel across as many as 16 devices. The Symmetrix system handles the smaller blocks of data provided by Sequential Data Striping by performing up to 16 concurrent I/Os over multiple paths.

Sequential Data Striping is available only with DFSMS/MVS (Data Facility Storage Management Subsystem) with storage management active. Symmetrix must be emulating 3990 Model 3 or Model 6 and running the appropriate level of microcode. It must be attached via ESCON channels and have SMS-managed volumes.

Host Data Compression

Host Data Compression compatibility is provided on Symmetrix 5000 systems via implementation of Sequential Data Striping support. The MVS instruction-driven data compression function is supported on high-end air-cooled and water-cooled IBM ES/9000 model 511/711 processors.

Multi-Path Lock Facility/ Concurrent Access

Symmetrix systems support the Multi-Path Lock Facility/Concurrent Access (MPLF/CA) for use with the ultra-high performance Airline Control Program (ACP) and Transaction Processing Facility (TPF) host operating system environments. MPLF/CA allows multiple concurrent I/O requests to the same logical device from multiple TPF mainframes. The Symmetrix system maintains the names and status of logical locks currently in use and responds to requests to obtain or release a lock. This allows multiple hosts to share DASD through multiple paths in an active OLTP environment while maintaining data integrity. MPLF/CA is an enhancement and replacement for the Extended Limited Lock Facility (ELLF) and Limited Lock Facility (LLF).

Partitioned Data Set Search (PDS) Assist

Symmetrix systems support IBM's Partitioned Data Set (PDS) Search Assist feature for 3990 Model 3 or Model 6 with Extended Platform in both ESCON and parallel channel environments. PDS Assist improves performance on large, heavily-used partitioned data sets by modifying the directory search process.

Chapter 3
EMC Enterprise Storage Networks (ESN)

Overview

EMC Enterprise Storage Networks (ESNs) are dedicated networks that connect multiple enterprise storage systems to all types of servers and their associated operating systems and applications. With a fast, reliable infrastructure for the common management, protection, and sharing of data across the enterprise, they relieve network bottlenecks and offer considerable cost savings. In this way, they enable cost-effective, high-capacity, heterogeneous information consolidation.

ESNs use Fibre Channel technology to provide EMC Symmetrix storage systems with connectivity, distance accommodation, and throughput rates that are significantly superior to those provided by traditional point-to-point connectivity. Fibre Channel is a highly reliable message transport protocol that provides the fastest, most scalable performance available today for connecting multivendor host servers and storage systems, either centrally located or dispersed throughout the enterprise. With an EMC ESN, organizations can consolidate hundreds of servers into a virtual data center spanning the entire enterprise. EMC's advanced software functionality for information sharing, protection, and management enables central monitoring and control of this virtual data center.

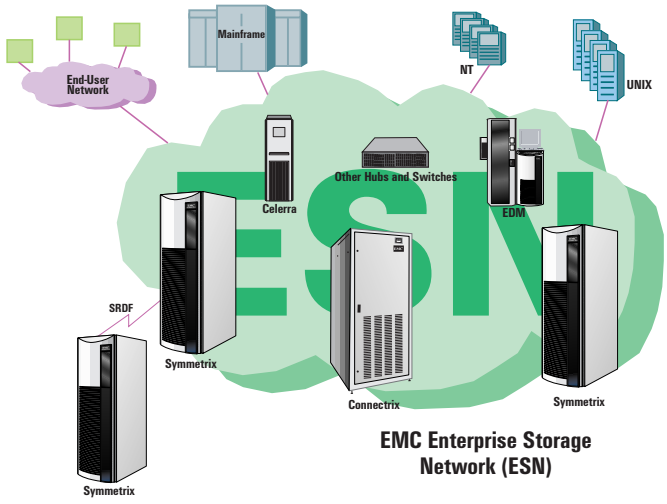
ESNs offer several major benefits:

Distance — ESNs enable customers to physically attach heterogeneous UNIX and Windows NT servers and EMC Symmetrix Enterprise Storage systems across great distances. Current implementations of SCSI impose a distance limitation of just 25 meters between servers and storage systems.

Consolidation — ESN connectivity enables organizations to consolidate data among widely dispersed servers and storage systems, while supporting the ever-increasing amounts and types of corporate data. Servers that were once outside the immediate vicinity of the data center now can leverage ESN technology to take advantage of the advanced information sharing, protection and management benefits of centralized EMC Enterprise Storage resources.

Enterprise Connectivity — Consolidation of multiple server types with multiple connectivity options requires maximum flexibility from the storage system. The ability of a single Fibre Channel-based enterprise storage platform to simultaneously handle not only mainframe parallel and serial channel connections, but also major open systems servers with FWD SCSI, Ultra SCSI, and Fibre Channel, enables a plethora of connections among mainframe hosts and open systems.

Channel Throughput — Until now, storage connectivity has been restricted to point-to-point, relatively slow connection schemes. By extending channel bandwidth, ESN enables customers to exploit the performance and functionality of EMC Enterprise Storage systems for key applications such as OLTP, data warehousing and Internet commerce.



The EMC Enterprise Storage Network™ architecture enhances the ability to consolidate, share, protect, and manage vital information from across the entire enterprise and gain maximum business value from it.

Chapter 4
EMC Enterprise Storage Solutions

Information Protection - EMC provides software solutions that maintain continuous data availability. The standard features of Symmetrix software solutions facilitate continuous data availability in the event of any major system component failure or power outage, and provide the ability to repair or replace the failed component without any interruption in operation. EMC Enterprise Storage software solutions continually perform self-diagnosis to identify and correct potential problems prior to any disruption of data availability. These software products include:

- Symmetrix Remote Data Facility (SRDF)
- EMC TimeFinder
- Symmetrix Data Migration Services (SDMS)

Information Sharing - EMC offers centralized, sharable information storage for supporting changing environments and mission-critical applications. This leading-edge technology begins with physical devices shared between heterogeneous operating environments and extends to specialized software that enhances sharing information between disparate platforms. These software solutions include:

- Symmetrix Enterprise Storage Platform (ESP)
- EMC InfoMover
- DataReach

Information Management - EMC consolidates storage capacity for multiple hosts and servers and improves information management. The Symmetrix Manager family of products further enhances this efficient, consolidated storage approach. These optional software solutions provide powerful GUI-based tools that simplify Symmetrix configuration, performance, and status information gathering and management. These software solutions include:

- Symmetrix Manager
- EMC PowerPath
- EMC Volume Logix
- EMC Data Manager (EDM)
- FDR Family of Backup/Restore Solutions

For more information about EMC Enterprise Storage solutions, contact your EMC sales representative.

Chapter 5
Services and Support

Professional Services

EMC Professional Services consultants provide a full range of services to enable you to extract maximum value from your information. These services assist you in applying EMC Enterprise Storage concepts and capabilities to your business issues. The EMC approach enables you to put information at the center of your IT infrastructure so you can take control of your information and utilize it to your full advantage.

Professional Services help you leverage EMC Enterprise Storage solutions, expertise, and resources to achieve success faster, more cost effectively and with less risk. They enable you to:

- Understand your current IT environment and take charge of it
- Create a more responsive, efficient, and flexible IT infrastructure with information at its center
- Share, protect, and manage critical information across the enterprise
- Deploy robust new enterprise solutions faster.

EMC Professional Services personnel utilize EMC Storage Logic™, a framework of EMC-specific and storage industry best practices that addresses all phases of an enterprise solution. Use of this framework ensures consistency and quality of deliverables and facilitates effective management of project budgets, schedules, and specifications.

To help you build an IT infrastructure that takes full advantage of all your critical information, EMC Professional Services provides both strategic enterprise consulting services and practical enterprise software implementation services. Consulting services help you assess your current infrastructure in light of your requirements and sort through various options. Implementation services help you integrate a specific hardware and software solution into your unique environment.

Enterprise Business Continuity

Enterprise Business Continuity services protect and enhance your ability to generate revenue. They help you build an enterprise business continuity infrastructure that not only eliminates unacceptable downtime (planned and unplanned) but also creates new ways to capitalize on business opportunities to generate increased revenue and customer services.

Enterprise Business Continuity services help you map and build your infrastructure to satisfy a range of business continuity requirements from high availability to mission-critical availability to continuous availability to disaster recovery. Assessment, planning and design, and software implementation assistance is available.

Use of EMC Professional Services personnel for implementation enables you to quickly realize the advanced functionality of EMC software, while your in-house IT staff continues with other revenue-generating activities. A range of SRDF software implementation services are available, from basic software installation to complex integration projects that encompass the complete project lifecycle. Regardless of the level of complexity, EMC Professional Services personnel can address your unique technical, staffing, or timing requirements.

In addition to software implementation services for such key business continuity products as EDM, SRDF, and TimeFinder, implementation services are also available to help you expand your information sharing, management, and protection capabilities by adding other EMC software products to your infrastructure.

EMC Customer Support

The EMC Customer Support Center, headquartered in the United States, directly supports EMC hardware and software products. The following numbers offer technical support:

U.S.:	(800) 782-4362 (SVC-4EMC)
Canada:	(800) 543-4782 (543-4SVC)
Worldwide:	(508) 497-7901 (or contact the nearest EMC office)

EMC²
The Enterprise Storage Company

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