

Dell Reference Architecture Guide

Deploying Microsoft® SQL Server™ 2005 Standard Edition SP2 with Microsoft Windows Server® 2003 R2 Enterprise or Standard Edition with SP2 on Dell™ PowerEdge™ Servers and Dell PowerVault™ Storage or Dell/EMC CX3 Family of Storage

Abstract

This white paper provides an architectural overview and configuration guidelines for deploying Microsoft SQL Server 2005 on Dell PowerEdge servers with Dell PowerVault and Dell/EMC CX3 storage. Using the knowledge gained through joint development, testing and support with Microsoft and EMC, the Dell Reference Architecture Guide for SQL Server documents “best practices” that can help speed SQL Server 2005 solution implementation and help simplify operations, improve performance and availability.

December 2007

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Dell Reference Architecture for Microsoft SQL Server 2005 on Windows 2003 Server R2 with SP2

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Introduction

Dell™ PowerEdge™ servers, Dell/EMC CX3 family of storage and Dell PowerVault™ storage systems are ideal choices to deploy highly reliable and sustainable Microsoft® SQL Server™ 2005 databases. This Reference Architecture Guide is intended to help IT professionals design and configure SQL Server 2005 database solutions using Dell servers and storage that apply “best practices” derived from laboratory and real-world experiences. This white paper documents Dell’s recommended approach for implementing a tested and validated solution for SQL Server 2005 SP2 database on Dell PowerEdge 9th and 10th generation servers, Dell PowerVault MD3000 SAS storage system, Dell/EMC CX3 Series storage and Microsoft Windows Server 2003 R2 Enterprise or Standard Edition with SP2.

Dell Solutions for SQL Server 2005

Dell Solutions for SQL Server 2005 are designed to simplify operations, improve utilization and cost-effectively scale as your needs grow over time. In addition to providing price/performance leading server and storage hardware, Dell solutions for SQL Server 2005 include:

- **Dell Configurations for SQL Server 2005** – in-depth testing of SQL Server 2005 configurations for the most in-demand solutions; documentation and tools that help simplify deployment
- **Integrated Solution Management** – standards-based management of Dell Solutions for SQL Server 2005 that lower operational costs through integrated hardware and software deployment, monitoring and update
- **SQL Server Licensing** multiple licensing options that can simplify customer purchase
- **Dell Enterprise Support and Professional Services for SQL Server** – offerings for the planning, deployment and maintenance of Dell Solutions for SQL Server 2005

Dell PowerEdge servers and Dell/EMC or PowerVault storage help to minimize operating costs with price/performance leadership - Dell currently holds the #1 TPC-E price/performance position and six of the top ten TPC-C price/performance leadership positions with SQL Server¹.

For more information concerning Dell Solutions for SQL Server 2005, please visit www.dell.com/sql.

Overview of this White Paper

The balance of this white paper will provide the reader with a detailed view of the Dell Reference Architecture for SQL Server 2005, best practices for configuring the hardware and software components and pointers for obtaining more information.

¹ Source: TPC-E by Price/Performance Version 1 Results as of December 11, 2007.

TPC-C by Price/Performance Version 5 Results as of December 2007. See www.tpc.org for current results
Dell Reference Architecture for Microsoft SQL Server 2005 on Windows 2003 Server R2 with SP2

Architecture Overview

An architectural overview of the Dell Solution for SQL Server 2005 is shown in Figure 1 below. The architecture is made up of the following components:

- Client systems that access data stored within the SQL Server database
- Client-server network made up of network controllers, cables and switches
- Dell PowerEdge servers running Windows Server 2003 and SQL Server 2005
- Server-storage interconnect using Fibre Channel or Serial Attached SCSI (SAS)
- Dell/EMC CX3 Series storage or Dell PowerVault MD3000 storage

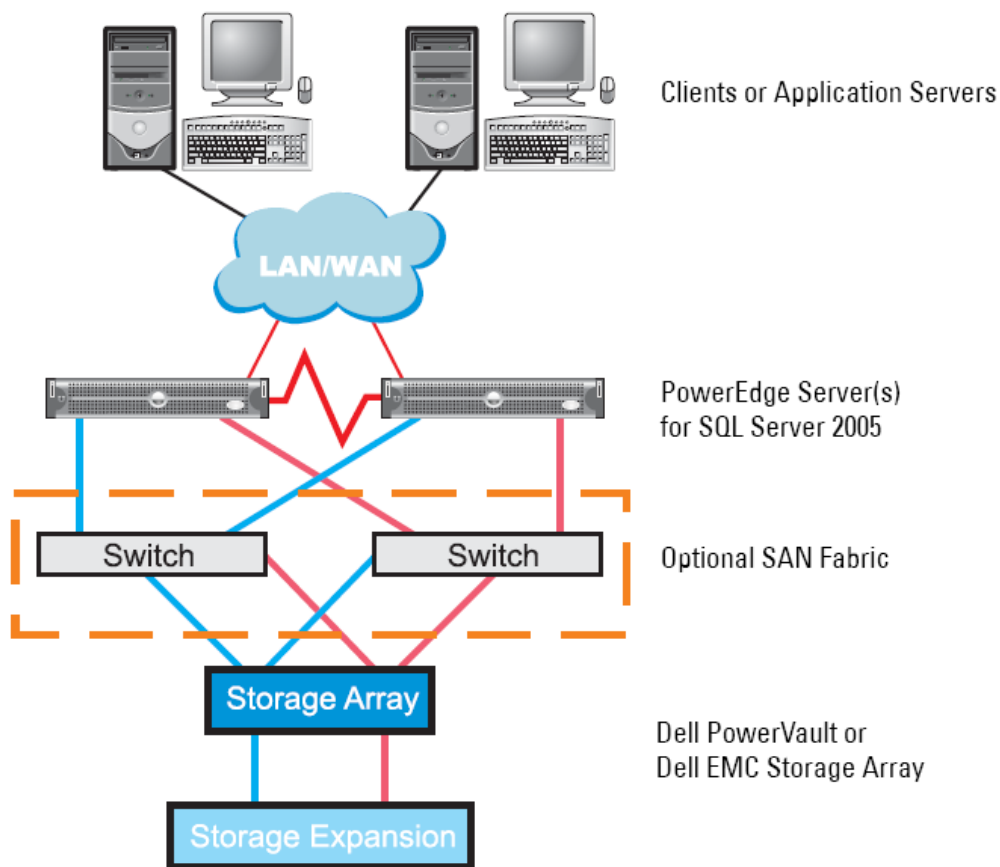


Figure 1 - Architectural Overview of Dell SQL Server 2005 Configuration

Dell PowerEdge servers are designed to deliver the highest performance for critical enterprise applications like database, messaging, web services and infrastructure applications. As proprietary systems are increasingly replaced by industry-standard systems, applications like databases, high performance computing clusters and messaging systems can take advantage of the performance and scalability of the PowerEdge servers. Combined with Dell PowerVault or Dell/EMC CX3 Series storage arrays, customers can easily deploy these PowerEdge servers as building blocks of a scalable enterprise.

The PowerVault MD3000 is a high-performance storage array built for critical applications running on one, two or a pair of clustered PowerEdge servers. Additionally, the storage array can support up to four servers in environments where redundant host connections are not required. The PowerVault MD3000 includes dual active/active RAID controllers with mirrored cache and multi-path I/O management which helps ensure that storage processing continues without disruption. Other high-availability features include hot-pluggable, redundant power supplies, cooling modules and disk drives, active disk scrubbing and non-

disruptive firmware upgrades. MD3000 can be cascaded with up to two MD1000 expansion enclosures to increase the overall capacity supporting up to 45 drives and disk requirement of some applications.

Dell/EMC CX3 Series storage arrays deliver advanced storage capabilities including simple management tools, continuous data availability and integrity, industry-leading price/performance, data mobility, and scalability between multiple storage tiers. The Dell/EMC storage subsystem is offered in various models, ranging from affordable entry-level solutions to high-performance, maximum-capacity configurations for the most demanding requirements. All Dell/EMC CX3 series arrays support advanced software including local replication for backup/restore, remote replication for disaster recovery and data mobility. The Dell/EMC CX3 Series is architected with two storage processors to guard against a single point of failure.

Use Hardware and Software that are Tested and Validated by Dell

Using hardware that is on the Solutions Deliverable List (SDL) can help ensure the successful deployment of your SQL Server 2005 solution by using components that have been tested and validated by Dell. This can help minimize the risk of encountering compatibility problems, and helps provides a solid foundation for your SQL Server database.

Similarly, to help assure the performance and stability of your Dell Solution for SQL Server, it is recommended to install the latest tested and validated software, firmware, and driver versions for HBAs, NICs, storage arrays, and other components as listed in the SDL on www.dell.com/sql.

NOTE: In SQL Server 2005 failover clusters, it is recommended that all nodes be configured with identical hardware, and employ the same software, driver, and firmware revisions.

Hardware Configuration

Storage Configuration

Configure Storage Host Bus Adapters

Depending on the configuration of your Dell Solution for SQL Server 2005, either the Dell PowerVault MD3000 or the Dell/EMC CX3 Series storage arrays may be used. For configurations with the MD3000 it is recommended that at least one dual-port SAS 5/E controller be installed on the PowerEdge server hosting SQL Server 2005 to provide redundant links to the PowerVault MD3000 storage array. Using dual-port SAS 5/E controllers protects against potential data loss or corruption if either a SAS 5/E controller port or MD3000 storage controller fails. Similarly, when using a CX3 storage array, it is recommended that at least two 4Gb Fibre Channel ports are available on the PowerEdge server. This can be accomplished using two single-port Fibre Channel host bus adapters (HBAs), or using a dual-port HBA.

To configure dual storage array controllers for a Power Edge Server hosting SQL Server 2005, follow the procedure described in the appropriate Dell SQL Server 2005 Deployment Guide.

For a list of validated HBAs, consult the Solution Deliverables List on www.dell.com/sql.

Configure SAS Storage Connections

Figure 2 illustrates the interconnection of a PowerEdge server hosting SQL Server 2005 and an MD3000 storage system where the database resides. Using two dual-port SAS 5/E controllers in an Active/Active configuration, commands and data flow over both SAS links between the server and storage system. If either a SAS 5/E controller or an MD3000 storage controller fails, operations continue using the remaining SAS 5/E – MD3000 storage controller pair.

One Server with Two HBAs - Dual Redundant Path

The following image shows a single server attached to an MD3000 with two SAS5/E HBAs installed. Each HBA is cabled to each individual controller.

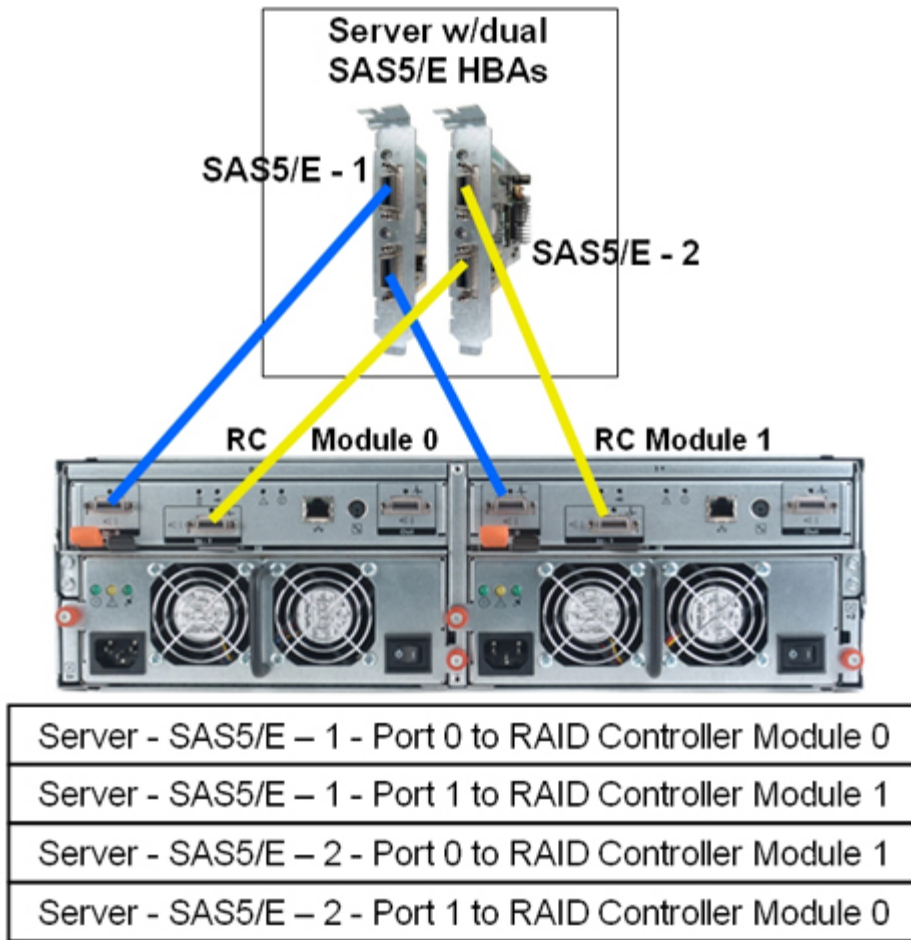


Figure 2 - Cabling a Direct Attached MD3000 Storage Array

Two Servers with Dual HBAs Each - Redundant Path

The following image shows two servers with dual HBAs in each server. Each server has a redundant pathway to the controllers and the virtual disks, and is further protected against the loss of an individual HBA. This configuration is supported for clustering.

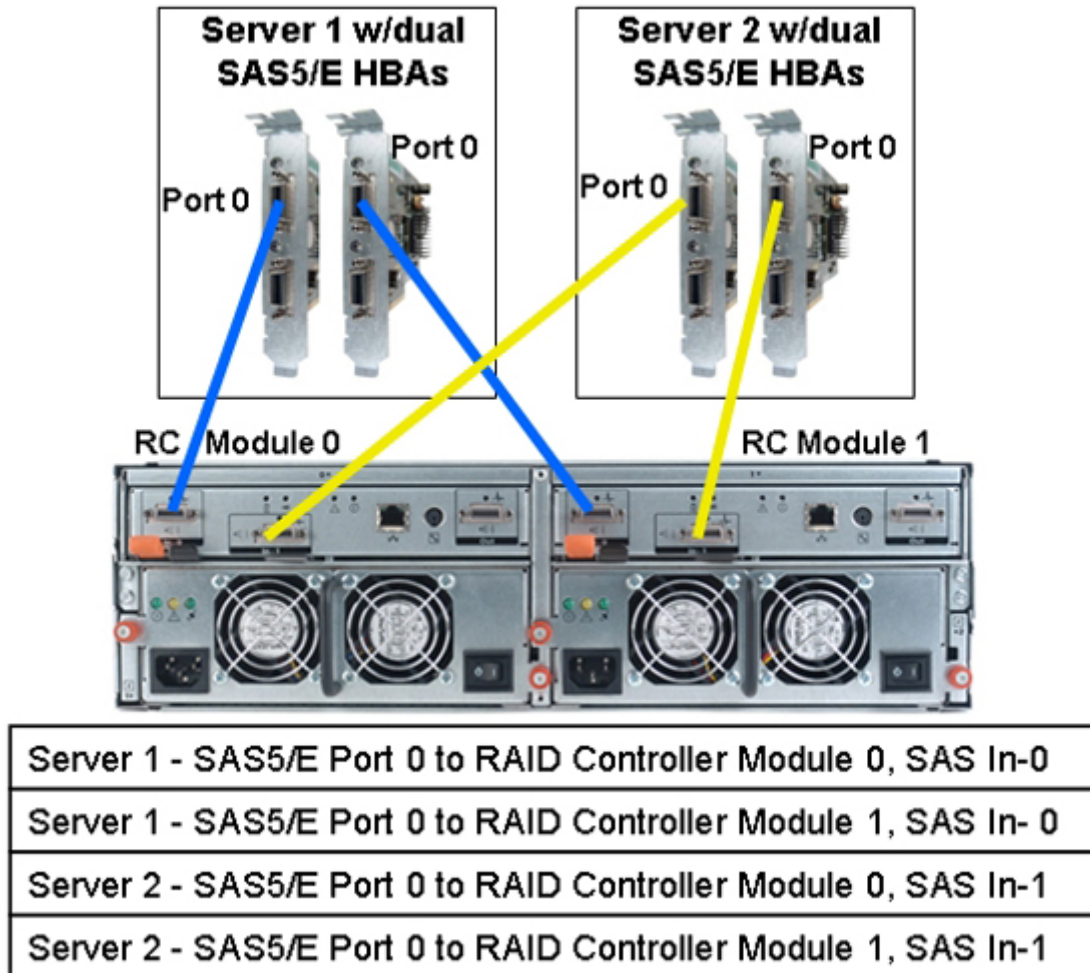


Figure 3 - Cabling two PowerEdge in cluster mode on MD3000 Storage Array

The MD3000 enclosure can be cascaded to as many as two MD1000 enclosures (see Figure 4), provided that the MDSM software, the EMM BIOS and firmware, and the cabling methodology are appropriate. The enclosures must be "cold-add." All enclosures must be powered down for cascading.

WARNING: Adding an MD1000 unit to an MD3000 storage chain is a data-destructive operation for any data on the MD1000s that was created with the MD1000 connected to a PERC5/E. The metadata format (DACstore) of configured drives in the MD3000 differs from the Disk Data Format used on configured drives attached to a PERC5/E. Data cannot be migrated by moving the MD1000 enclosure from a PERC5/E to an MD3000. The data must be backed up, confirmed, and restored to newly formed disk groups and virtual disks on the MD3000. No in-place migration is possible. This operation is not harmful to existing data on the MD3000.

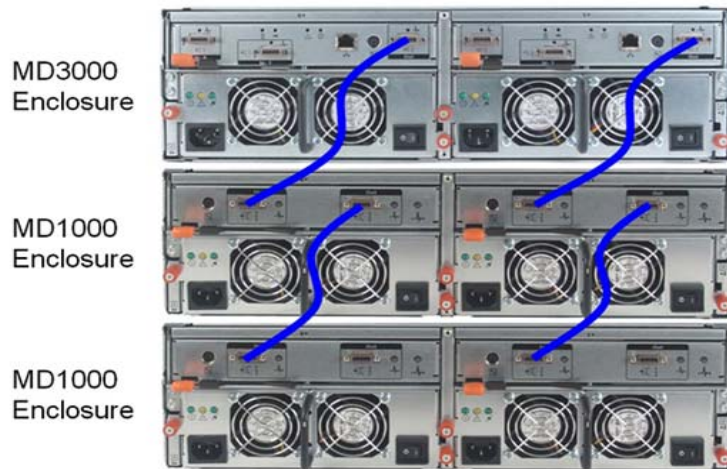


Figure 4 - MD3000 to MD1000 Enclosure Cascading

Configure Fibre Channel Storage Connections

Figure 5 illustrates the interconnection of a PowerEdge server hosting SQL Server 2005 and a CX3 storage system where the database resides. Using two FC HBAs in an Active/Active configuration, commands and data flow over both FC links between the server and storage system. If either a FC HBA or a CX3 storage processor fails, operations continue using the remaining FC HBA port – CX3 storage processor pair.

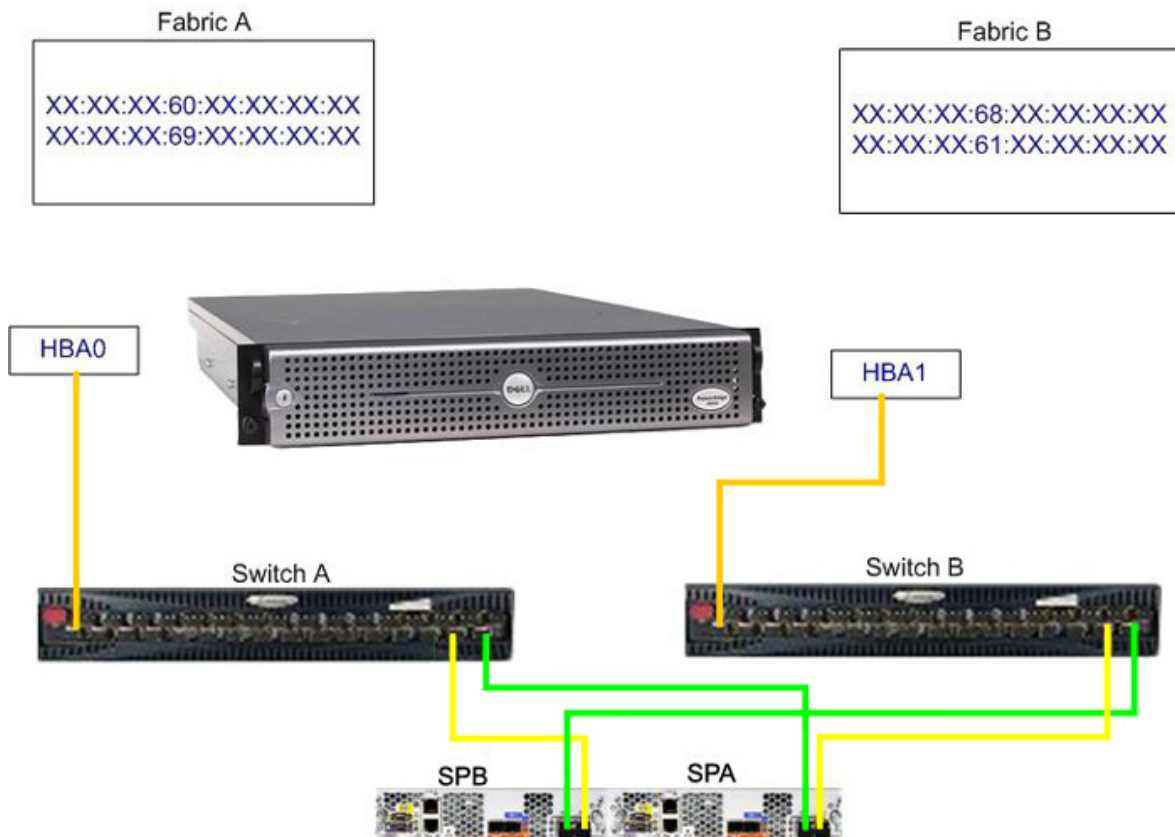


Figure 5 - Cabling a Direct Attached CX3 Storage Array

NOTE: For two node clusters, follow the storage documentation to configure a storage group with multiple hosts and zoning information.

Configure Disks for SQL Server 2005

The physical disks in the MD3000 or Dell/EMC CX3 storage array provide the physical storage capacity for the SQL Server database. Before data can be stored, the physical storage capacity must be configured on the storage array. Depending on the storage array in the solution, different terms may be used to refer to similar groupings of physical disks into volumes that are presented by the storage array to the Windows Server operating systems, and by the OS to SQL Server 2005. Throughout this paper, the terms in Table 1 may be used interchangeably. A disk group (MD3000) or RAID Group (CX3) is a set of physical disks that are logically grouped and assigned a particular RAID level. Each group of physical disks provides the overall capacity needed to create one or more virtual disks (MD3000) or LUNs (CX3), which are logical entities that the server uses to store data.

Logical Entity	MD3000 Terminology	Dell/EMC Terminology
Set of physical disks that contains one or more logical disks of the same RAID level	Disk Group	RAID Group
Logical disk or RAID volume that is presented to the operating system	Virtual Disk	LUN
Set of one or more hosts and one or more logical disks that are accessible by the host(s)	Host Group	Storage Group

Table 1 - Storage Logical Entities and Terminology

SQL Server 2005 uses three specific storage areas: TempDB, Transaction Log File, and Data files for user defined databases. TempDB is a system database which is automatically created during the installation of SQL Server 2005. TempDB is a shared working area for all databases on the server, for various activities, including temporary tables, sorting, processing subqueries, building aggregates to support GROUP BY or ORDER BY clauses, queries using DISTINCT, cursors, and hash joins. In addition to TempDB, SQL Server 2005 also maintains a Transaction Log File for each database. The Transaction Log File stores the details of all the modifications made to a SQL Server database and the details of the transactions that performed each modification. This information is critical for maintaining database consistency and for aiding database recovery. In SQL Server 2005, data for user defined databases are stored in a separate data storage area. This data file contains user defined database objects such as tables, indexes, and stored procedures. All databases have one data file and one or more transaction log files. Data is physically stored in the data file.

It is a best practice to separate the TempDB and Transaction Log files onto their own virtual disks on separate disk groups. The separation of TempDB and log files can enable better I/O performance by ensuring that these files do not share the same physical disks. Figure 3 illustrates a sample disk group and virtual disk configuration which separates TempDB, transaction logs, and data on distinct physical disks.

When designing the storage layout, various considerations need to be evaluated depending on the business requirements for the database system. These considerations include the following:

- Cost
- Performance
- Reliability/Availability
- Manageability
- Scalability and capacity management
- Type of Workload: OLTP vs. OLAP

The following figure is an example storage layout on a MD3000 storage array for TempDB, Transaction Logs, and Data optimized for Data Warehousing. The maximum configuration can be expanded to include up to two MD1000 storage enclosures for a total of 45 spindles.

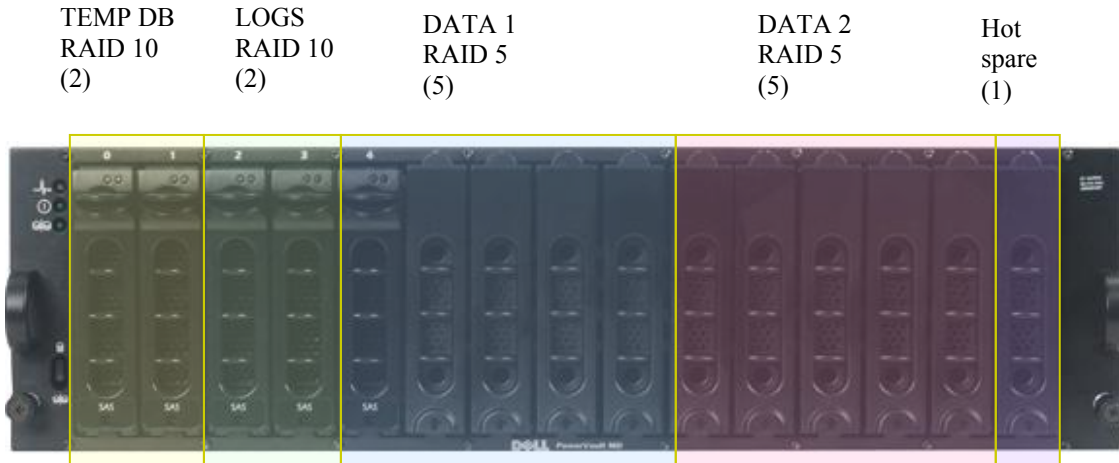


Figure 6 - Data Warehousing on MD3000 storage

The recommended number of virtual disks for data should equal the number of physical CPU sockets².

Table 2 illustrates recommended virtual disk configuration and sizes for single-socket host servers.
 Table 3 illustrates recommended virtual disk configuration and sizes for dual-socket host servers.

Virtual Disks	Minimum Size	Disk Group RAID	Used for
Data1	Database size	10, or 5 for read-only	data
TempDB	Depending on required TempDB size	10, or 0	TempDB
Logs	10% of database size	10, or 1	logs

Table 2 - Single-Socket Server - Storage Configuration

Virtual Disks	Minimum Size	Disk Group RAID	Used for
Data1	Database size /2	10, or 5 for read-only	data
Data2	Database size /2	10, or 5 for read-only	data
TempDB	Depending on required TempDB size	10, or 0	TempDB
Logs	10% of database size	10, or 1	logs

Table 3 - Dual-Socket Server - Storage Configuration

RAID 10 is considered the optimal choice for SQL Server 2005 virtual disk implementation because it offers greater performance and fault tolerance by combining the best attributes of mirroring and striping³. When possible, the disk groups on which the transaction logs, TempDB and data virtual disks reside should be configured with RAID 10.

Because additional drives are required to implement RAID 10, it may not be the preferred choice for certain databases. In these cases, RAID 0 can be used as an alternative for the disk group of the TempDB virtual disk. However, if RAID 0 is used, system availability will be impacted if a TempDB disk is lost. For the disk group of the transaction log virtual disk, RAID 1 is an alternate recommendation as RAID 1 provides protection from drive hardware failure. For the disk group of the virtual disks for the data files, RAID 5 provides a cost effective alternative especially for predominantly read-only workloads such as a data warehouse database. However, RAID 5 is not suitable for heavy write workloads, such as in an OLTP

² “Storage Top 10 best Practices”, Microsoft TechNet, October 17, 2006;
<http://www.microsoft.com/technet/prodtechnol/sql/bestpractice/storage-top-10.mspx>

³ “Physical Database Storage Design”, Kathy Lu, Lewis Bruck, Microsoft TechNet, February 12, 2007.
<http://www.microsoft.com/technet/prodtechnol/sql/2005/physdbstor.mspx>

database, as RAID 5 can have significantly lower write performance due to the reading and writing of parity blocks in addition to the reading and writing of database data.

Each virtual disk created in storage will be mapped to one partition at the OS level. For details on operating system partitions, please refer to the “Configuring File System” section below.

Network Configuration

Configure NIC Teaming

To help guard against network access failures, PowerEdge servers running SQL Server 2005 can be configured to provide redundant links to the client network. Using NIC teaming software, two NIC interfaces of the PowerEdge server can be bonded together to operate under a single IP address. The NIC teaming software provides load balancing and failover functionality, balancing the workload and routing network traffic between the two NIC interfaces. If a failure occurs, affecting one of the NIC interfaces – examples include switch port failure, cable disconnection, or failure of the NIC itself -- network traffic is routed to the remaining operable NIC interface. Failover occurs transparently to the SQL Server 2005 database with no network communication interruption or changes to the server IP address.

NOTE: In a SQL Server 2005 failover cluster, NIC teaming can only be used on the public network.

Configure Cluster Network

Use Static IP Addresses

All cluster networks should be configured using static IP addressing. This reduces the chance that SQL Server 2005 resources will become unavailable due to failures of DHCP servers or other network infrastructure components. Each node should use a static IP address for its public and private network interfaces. The cluster management and SQL server instance IP addresses should also be statically assigned.

Use a Dedicated Network or VLAN for the Cluster Heartbeat

The cluster public and private networks must be configured to use distinct IP subnets. Further, it is recommended that the cluster heartbeat network be physically isolated from other networks. In a two-node cluster, a simple cable between the two machines can be used for heartbeat network. The gigabit Ethernet adapters in Dell PowerEdge servers generally do not require the use of a crossover cable when they are directly connected in this manner. Alternately, a dedicated switch or VLAN can be configured for the node-to-node communications within the cluster.

Use Gigabit Ethernet Switches with VLAN Capabilities

To facilitate segmentation of network traffic, and to provide quality of service (QoS) for SQL Servers, it is recommended that GbE (1 Gb/s Ethernet) switches with Virtual LAN (VLAN) capabilities are used. Managed and web-managed Dell PowerConnect™ switches typically offer this functionality.

Use CAT6 Cables for GbE Connectivity

To achieve optimal network performance and reliability, it is recommended to use category 6 twisted pair (CAT6) cables which have demonstrated superior results for 1000 Mb connectivity than CAT5E cables.

Set Network Speed and Duplexing

Although automatic detection of network adapter and link properties (such as link speed and duplex) is useful during the initial configuration of your Dell Solution for SQL Server, these automatic settings introduce the possibility of negotiating a connection with diminished network performance. Therefore, it is recommended that production SQL servers be manually configured to connect at 1 Gb/s with full duplex communication. This configuration can generally be configured in the NIC driver properties, and may also be configured on managed or web-managed GbE switches.

Software Configuration

Operating System Configuration

Set the NTFS File System Allocation Unit Size

All SQL Server volumes, including those used for Data, Logs and TempDB, should be formatted using the NTFS file system, and it is recommended that the allocation unit size for these volumes be set to 64 KB.⁴

For additional recommendations regarding SQL data files and volumes, refer to *Configuring the File System* in this document.

Enable Disk Partition Alignment

Performance of the operating system and applications is affected by the placement of metadata on the LUN, which causes disk partitions to be misaligned. The *fdisk* utility and Windows Disk Manager place a Master Boot Record (MBR) on every device.

The MBR specifies 63 hidden sectors on the device. This causes subsequent data structures to become misaligned with respect to the track boundary. If a single I/O operation crosses a track boundary, it can consume added resources or cause additional work by the storage array leading to performance degradation.

Note: Dell recommends a host based utility such as *diskpar* or *diskpart* to align the partitions.

There are two methods to align the disk partitions:

- 1) Random Access - Set the starting offset to the Stripe Element Size.
For example:
Dell PowerVault MD3000 – the default Stripe Element Size is 128KB (256 blocks)
Dell/EMC CX3 storage – the default Stripe Element Size is 64KB (128 blocks)
- 2) Sequential Access high bandwidth - Set the starting offset to the LUN stripe size or RAID stripe size. For example, using DELL/EMC CX3 default stripe element size.

RAID type and size	RAID Stripe Size with 64KB Element Size
5-disk RAID 5	256 KB
6-disk RAID 6	256 KB
6-disk RAID 5	320 KB
9-disk RAID 5	512 KB
10-disk RAID 6	512 KB
8-disk RAID 1/0	256 KB
16-disk RAID 1/0	512 KB

Table 4 - RAID Stripe Size

For more information see “EMC CLARiiON Fibre Channel Storage Fundamentals – Technology Concepts and Business Considerations” -

http://www.emc.com/techlib/pdf/H1049.1_emc_clariion_fibre_chnl_wp_ldv.pdf

⁴ Predeployment I/O Best Practices <http://www.microsoft.com/technet/prodtechnol/sql/bestpractice/pdplioibp.mspx>

The following illustrates a misaligned disk partition where the second 64 KB I/O has spread to the first and the second MD3000 tracks.

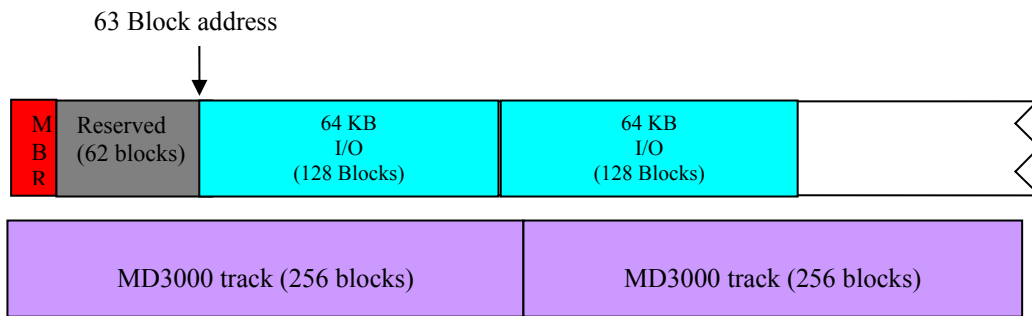


Figure 7 – Dell PowerVault MD3000 - Misaligned Disk Partition

The following illustrates a misaligned disk partition on a DELL/EMC storage array where the first 64 KB I/O has spread to the second CX3 tracks.

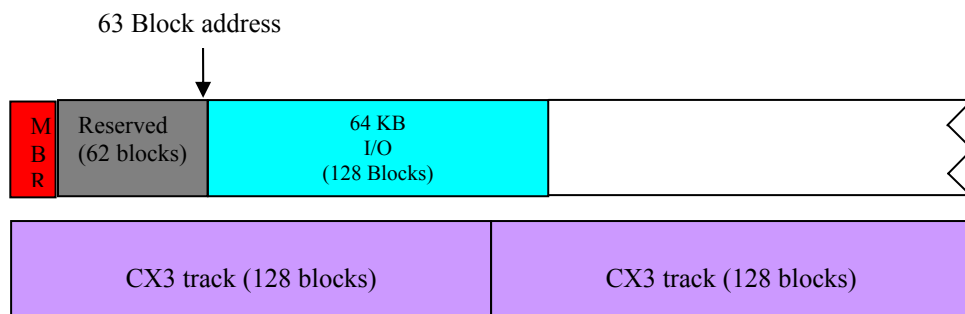


Figure 8 – Dell/EMC CX3 - Misaligned Disk Partition

In Windows Server 2003 SP1 or later, the *diskpart* utility is available for aligning partitions. *Diskpart* allows the creation of a primary partition at any desired block address rather than the default block address 63. This enables partitions to be aligned to minimize performance loss due to track boundary crossing.

The following illustrates an aligned disk partition where the partition starts at block address 256 or 128 KB for Dell PowerVault MD3000, instead of the default partition location of block address 63.

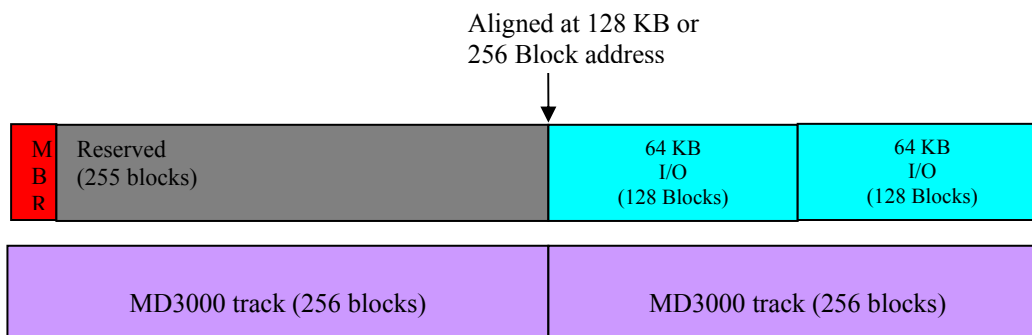


Figure 9 – Dell PowerVault MD3000 - Aligned Disk Partition

The following illustrates an aligned disk partition where the partition starts at block address 128 or 64 KB for Dell/EMC CX3.

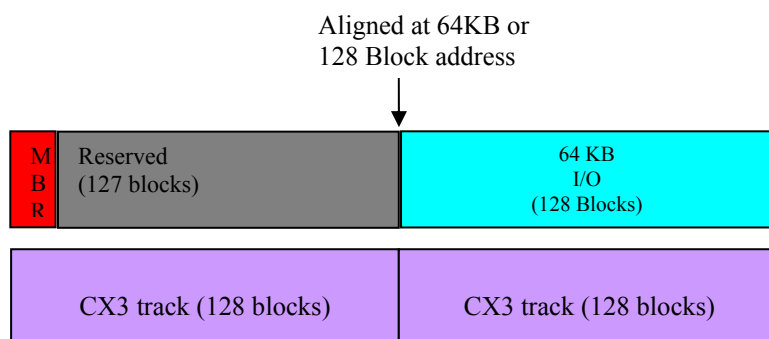


Figure 10 – Dell/EMC CX3 - Aligned Disk Partition

Follow the procedure described in the appropriate Dell SQL Server 2005 Deployment Guide to align the primary partition for Windows Server 2003 basic disks on the storage arrays.

For more information on aligning partitions, see the article “Using *diskpart* and *diskpart* to Align Partitions on Windows Basic and Dynamic Disks”, EMC PowerLink, September, 2005 - https://powerlink.emc.com/nsepn/webapps/btg548664833igtcuup4826/km/live1/en_US/Offering_Technical/White_Paper/H1445_Using_Diskpart_Align_Partition_ldv.pdf.

Configure the File System

In SQL Server 2005, each database consists of a data file and one or more transaction log files. As mentioned in the Section *Configure Disks for SQL Server 2005* above, the recommended number of virtual disks for data should equal the number of physical CPU sockets, and each virtual disk created in the storage system is mapped to an operating system file partition. To achieve optimal performance that scales with heavy workloads, Microsoft recommends that the number of data files configured for a SQL Server 2005 database equal the total number of CPU cores installed on the server⁵. Therefore, within each of the partitions used for data, the recommended number of data files should equal the number of cores per CPU socket. However there is a cost associated with having multiple files in a filegroup. If these files share spindles then this can lead to contention when they are accessed simultaneously. Therefore a decision to balance the decreased contention of multiple files against the increased I/O load has to be made. The recommendation is to break data files into a number of files equal to half the number of cores.

For example, a Quad-Core, single-socket system should have four data files for each data volume as illustrated in Figure 11 and Table 5.

⁵ Lu and Bruck, op. cit.

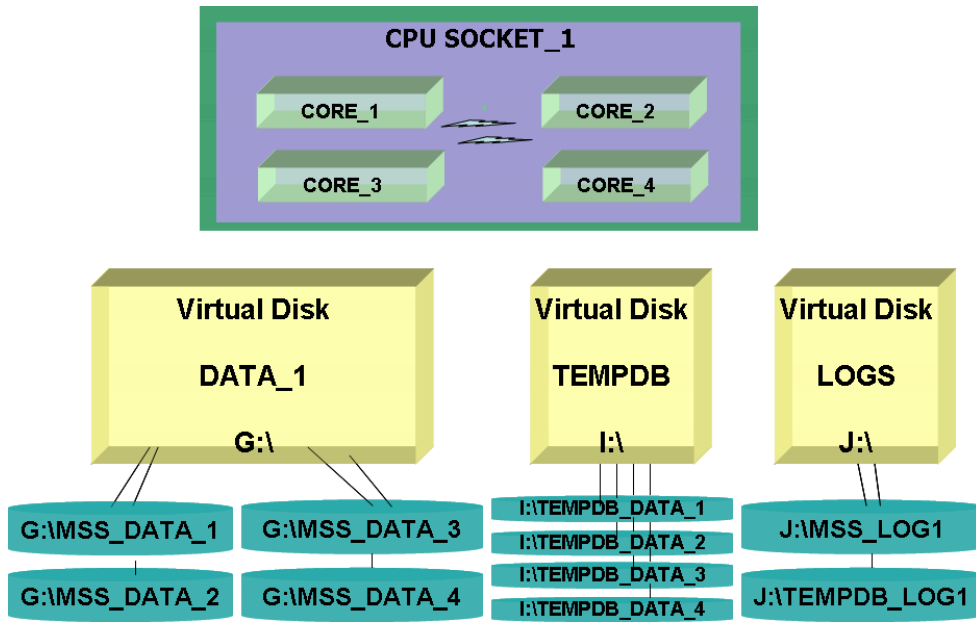


Figure 11 – File System Layout for a Quad-core Single-socket PowerEdge server

Drive Letter	Folder Name	Format	Used for
G:	MSS_DATA_1, MSS_DATA_2, MSS_DATA_3, MSS_DATA_4	NTFS 64 KB	data
I:	TEMPDB_DATA_1, TEMPDB_DATA_2, TEMPDB_DATA_3, TEMPDB_DATA_4	NTFS 64 KB	TempDB
J:	MSS_LOG1, TEMPDB_LOG1	NTFS 64 KB	Logs

Table 5 - Quad-core Single-socket Server - Storage Configuration

The following table illustrates a sample file system configuration for a quad-core, dual-socket host server; details on configuring the TempDB files are covered below.

Drive Letter	Folder Name	Format	Used for
G:	MSS_DATA_1, MSS_DATA_2, MSS_DATA_3, MSS_DATA_4	NTFS 64 KB	Data
H:	MSS_DATA_5, MSS_DATA_6, MSS_DATA_7, MSS_DATA_8	NTFS 64 KB	Data
I:	TEMPDB_DATA_1, TEMPDB_DATA_2, TEMPDB_DATA_3, TEMPDB_DATA_4, TEMPDB_DATA_5, TEMPDB_DATA_6, TEMPDB_DATA_7, TEMPDB_DATA_8	NTFS 64 KB	TempDB
J:	MSS_LOG1, TEMPDB_LOG1	NTFS 64 KB	Logs

Table 6 - Quad-core Dual-socket Server - Storage Configuration

The number of TempDB data files should equal the number of CPU cores. Refer to section “Configuring TempDB files” below for more details.

Check Total Memory Allocation

When you allocate memory for multiple instances of SQL Server (clustered or non-clustered), make sure that the summed value of the maximum server memory settings for all the instances of SQL Server, plus any other cluster resource and local application requirements, is less than the physical RAM available.

Enable SQL Server to Access All Server RAM

If your server has SQL Server 2005 Standard or Enterprise Edition, the amount of RAM it can access depends on the OS Edition your server is running, along with how much physical RAM is available in the server. For SQL Server 2005 Standard Edition under Windows 2003 Server Standard Edition, the maximum amount of RAM available is 4 GB; Windows 2003 Enterprise Edition offers up to 64 GB.

The Advanced Windowing Extensions (AWE) API allows applications that are written to use the AWE API to run under Windows 2003 Enterprise Server and access more than 4GB of RAM. SQL Server 2005 Standard Edition is AWE-enabled and can take advantage of RAM in a server over 4GB. For more information on Physical Address Extensions (PAE) and AWE refer to Appendix B.

Optimize the Server for Network Applications

By default, the “Maximize data throughput for file sharing” option is selected in the Windows Server 2003 Network Connection configuration. This option may limit the memory available for SQL Server 2005 operations because this option gives priority to applications which perform buffered I/O operations by caching their I/O pages in the system cache. For a PowerEdge server hosting SQL Server 2005, it is a best practice to select the “Maximize data throughput for network application” option in the Network Connection section of the Windows Server Control Panel. Follow the procedure described in the appropriate Dell SQL Server 2005 Deployment Guide optimize network performance for SQL Server.

Deploy SQL Server in an Active Directory Domain

The primary recommended method for security and account management in SQL Server is through Active Directory domain user accounts, using integrated security. This allows for greater security, at multiple levels, and makes user management easier.

SQL Server 2005 should not be installed on a domain controller, except in certain unusual circumstances. The added overhead of serving as an Active Directory controller is likely to have a negative impact on the performance of SQL Server.

NOTE: Cluster nodes running SQL Server 2005 must belong to an Active Directory domain. It is recommended that these nodes be configured as member servers, and not as domain controllers.

Cluster SQL Servers for High Availability

Failover clustering in Microsoft SQL Server 2005 provides high-availability support for an entire SQL Server instance. For example, you can configure a SQL Server instance on one node of a failover cluster to fail over to any other node in the cluster during a hardware failure, operating system failure, or a planned upgrade.

A failover cluster is a combination of one or more nodes (servers) with two or more shared disks, known as a resource group. The combination of a resource group, along with its network name, and an internet protocol (IP) address that makes up the clustered application or server, is referred to as a *failover cluster* or a *failover cluster instance*. A SQL Server failover cluster appears on the network as if it were a single computer, but has functionality that provides failover from one node to another if the current node becomes unavailable.

A cluster is a collection of servers known as nodes that together provide a single, highly available system for hosting applications such as Microsoft SQL Server 2005. Microsoft Windows Server 2003 Enterprise Edition 32-bit R2 and Microsoft SQL Server 2005 Standard Edition provide support for clusters with two nodes.

Microsoft failover clusters provide a highly-available environment that can help protect against Microsoft SQL Server 2005 server unavailability that may otherwise arise due to failures of hardware, operating systems, device drivers, or applications. If one of the nodes in a cluster is unavailable as a result of a failure, the service fails over to another node, which begins providing service in place of the failed node.

Reboot the Passive Cluster Node When Altering Storage

In case of disk configuration changes, the passive node of a cluster may not detect these changes until it is rebooted. If the passive node has not detected these changes, then it may not be able to bring disk resources online and a cluster failover may not succeed. Therefore, it is recommended that the passive node be rebooted after any changes to the LUNs being presented to the cluster nodes.

Use Failover-Aware Applications

When a Microsoft SQL Server failover occurs, using MSCS clustering, all database connections are lost and any “in-flight” transactions are rolled back. To minimize data loss, it is recommended that all applications be failover-aware and have reconnect/retry logic. Thus, in case of a failover, the application will attempt to reconnect, and once it successfully reconnects, it will retry the transaction that was previously rolled back.

Configure Non-Critical Services

To prevent the failure of specific services from causing the SQL Server group to fail over, configure those services using Cluster Administrator in Windows, as follows:

Clear the **Affect the Group** check box on the **Advanced** tab of the **Full Text Properties** dialog box.

However, if SQL Server causes a failover, the full-text search service restarts.⁶

If installing Integration Services, Notification Services, or Workstation Components, Microsoft Distributed Transaction Coordinator (MSDTC) should be installed and network DTC access should be enabled. To help ensure availability between multiple clustered applications, it is highly recommended that the MSDTC have its own resource group. If MSDTC cannot be configured to have its own resource group, the recommended alternate choice is to use the Cluster group and Quorum drive.

Security Best Practices

In a SQL Server 2005 failover cluster, different service accounts have distinct privileges and management roles. The following best practices help provide separation of duties between these roles:

- The cluster service and SQL Server service domain accounts need to be a member of the Local Administrators group of each node, but they should not be a member of the Domain Administrators group.
- Use the same cluster service and SQL Server service accounts for all clusters in the same domain.
- The cluster service and SQL Server service accounts should only be used for their own specific purposes.
- By default, all local administrators of cluster nodes can use Cluster Administrator. This privilege includes the ability to take resource offline including SQL Server.
- Do not use local accounts on clustered nodes. Always use domain accounts for clusters. This is because during a failover, local account information is not failed over.
- If the BUILTIN/Administrators account is removed ensure that the account that the Cluster Service is running under can log into SQL Server for the IsAlive check. If it cannot, the IsAlive check fails.

SQL Server 2005 Configuration

Separate Physical Spindles for Database Data Files, Log Files and TempDB

It is highly recommended that the database data files and log files and TempDB do not share the same physical spindles. This helps in preventing the loss of data in case of multiple drives failure, and in improving the performance. Refer to *Configure the File System* in this document for more information.

Enable SQL Server to Keep Pages in Memory

Based on the current state of the server, Microsoft SQL Server dynamically allocates and deallocates memory in an attempt to prevent memory pressure and swapping. However, if a process suddenly attempts to grab a substantial amount of memory, SQL Server may not be able to react quickly enough and the OS may swap some of SQL Server's memory to disk. Unfortunately, there is a good probability that the memory that was swapped to disk contains part of what SQL Server will soon be de-allocating to decrease its memory use in response to the newly created memory pressure.

It is recommended that SQL Server be enabled to prevent its memory from being swapped. This is known as "Locking pages in RAM." To perform this, the account that the Microsoft SQL Server service is running under must be given the "Lock pages in memory" user right.

Enable Windows Instant File Initialization

By default, when a new data file is created or a data file is expanded as a result of AUTO GROW, the pages on the file are initialized by writing zeros before the file can be used. The file zeroing process can be time consuming and can lead to application timeout, especially during the AUTO GROW activity. One of the major improvements of SQL Server 2005 is the instant file initialization feature. This feature skips the file zeroing process when a data file is created or a file size is increased. Instead, the pages on the data file get overwritten with new data when pages are actually allocated. Microsoft's in-house testing for creating and growing files shows a significant performance improvement when the instant data file initialization is used⁷.

To enable instant file initialization, you must run the SQL Server 2005 service account under a Windows account and assign the Windows SE_MANAGE_VOLUME_NAME permission to that Windows account. Follow the procedure described in the appropriate Dell SQL Server2005 Deployment Guide to Configure a Windows Account to enable Instant File Initialization.

Set the Database File Sizes and Autogrow Increments

Microsoft SQL Server 2005 supports the ability to automatically grow both data and log files as they fill. However, this should not be misconstrued as a method of database sizing. It is a best practice to set the file sizes appropriately and grow them manually at times of minimal system use, on a planned basis. Autogrowth should only be used as a safety net to prevent the files from becoming full and making the database read-only, when unpredicted substantial growth occurs. When a database's files are expanded there is an impact on performance. This impact is minimized but not nullified through fast file initialization.

Additionally, the file autogrowth increments should be set such that the time it takes for the growth to occur is short enough to minimize its impact on performance, but large enough to prevent many small allocations that invite file fragmentation. An adequate increase in file size that prevents fragmentation usually impacts the performance of the database. Hence, it is recommended that the files are manually grown during periods of lowered activity on the database.

Log files have an additional issue, as there are virtual log files within a physical log file, and a virtual log file cannot span file growth increments. Thus, if the log file were set to grow at 1 MB increments, then the virtual log file would not be able to exceed 1 MB either. This will have an impact on the performance as discussed above due to the impact of file expansion. This limit may also make certain transactions impossible to complete.

⁷ Lu and Bruck, op. cit.

For all files, because of the impact to performance, it is recommended that an absolute growth increment (in MB or GB) be used instead of a percentage growth. This way the file growth will be predictable as file sizes change. It is also recommended that Auto Shrink should never be enabled. A file should not be shrunk, unless necessary, and only through a controlled manual action.

Plan Database Filegroups Based on Workload

SQL Server provides many options for the data architect to lay out database tables and other structures on disk. The primary structure to control this behavior is a filegroup. Database structures are assigned to filegroups, which contain files on disk where that data can be stored. The placement of these data files is critical to the I/O performance of your database. The recommendations for the best ways to set up filegroups vary based on the database workload. Refer to *Configure Disks for SQL Server 2005* in this document for details.

Configure TempDB Files

When the SQL Server 2005 database is initially created, the TempDB files are placed on server internal drives. Follow the procedure described in Appendix A, to move the TempDB files to external disk drives dedicated for TempDB files.

By default, a single TempDB data file is created during installation of SQL Server 2005. Adding additional TempDB data files can help avoid latch contention on allocation pages and help solve I/O performance issues. The recommended number of TempDB data files should match the number of CPU cores of the server. To better utilize the allocation mechanism, all TempDB data files should be equal in size. But, there is a cost associated with having multiple files in a filegroup. SQL Server stripes data across all files in a filegroup and there is a likelihood that all files may be accessed simultaneously. If these files are located on LUNs that share same physical disks (on same RAID group), this will induce head movement which in turn increases latency and decreases throughput. Therefore a decision to balance the decreased contention of multiple files against the increased I/O load has to be made. The recommendation is to separate tempdb into a number of files equal to half the number of cores. For more information, please refer to the following Microsoft KB article: “Microsoft SQL Server I/O subsystem requirements for the tempdb database” - <http://support.microsoft.com/kb/917047/en-us>

By default, the AUTO GROW option is set to “on” for TempDB files. However, expanding TempDB too frequently can lead to performance degradation. To avoid this issue, it is recommended to pre-allocate the TempDB space with a size large enough to accommodate the expected workload and set the file growth increment large enough to minimize TempDB expansions. In addition, Microsoft recommends setting the TempDB files FILEGROWTH increment to 10%⁸.

Disable Hyperthreading on Microsoft SQL Server 2005 Servers

Theoretically, Hyperthreading enables faster enterprise-server response times and provides additional CPU processing power to handle larger workloads. However, testing has shown that hyperthreading can have a negative impact on many Microsoft SQL Server 2005-based processor loads. It is recommended to disable Hyperthreading at the hardware (BIOS setting) level, not through the application of processor affinity or other software means.

For more information, refer to <http://blogs.msdn.com/slavao/archive/2005/11/12/492119.aspx>.

Set Processor and Memory Parameters in a SQL Server to Defaults

Default settings for processor and memory parameters on a SQL Server run at a standard priority which allow the use of all the processors in the system and also make available as much RAM as needed by SQL Server. These settings can be changed depending on the tuning required to achieve desired performance.

⁸ “Working with TempDB in SQL Server 2005”, Wei Xiao, Matt Hink, Mirek, Sunil Agarwal, Microsoft TechNet, June 26, 2006, <http://www.microsoft.com/technet/prodtechnol/sql/2005/workingwithtempdb.msp>
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Conclusion

Dell Solutions for SQL Server 2005 are designed to simplify operations, improve utilization and cost-effectively scale as your needs grow over time. This reference configuration white paper provides a blueprint for setting up a standalone SQL Server 2005 SP2 database on Dell PowerEdge servers and Dell PowerVault or Dell/EMC storage arrays.

The best practices described here are intended to help achieve optimal performance of SQL Server 2005. To learn more about deploying SQL Server 2005 on PowerEdge server and PowerVault and Dell/EMC storage, please visit www.dell.com/sql or contact your Dell representative for up to date information on Dell servers, storage and services for SQL Server 2005 solutions.

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APPENDIX A: Moving tempdb Files to External Disks

1. Click Start and select Programs → Microsoft SQL Server 2005 and then click SQL Server Management Studio.
2. In the Connect to Server window:
 - a. Select Database Engine from the Server type drop-down menu.
 - b. Select the name of the server from the Server name drop-down menu.
 - c. Select Windows Authentication from the Authentication drop-down menu.
 - d. Click Connect to connect to the database.
3. In the Microsoft SQL Server Management Studio, click on the New Query in the tool bar.
4. In the new query window (right-hand side of the panel), type the following:

```
USE Master
GO
ALTER DATABASE tempdb
MODIFY FILE (NAME=tempdev, FILENAME='<Drive
letter>:\TEMPDB_DATA_1\tempdb.mdf');
GO
ALTER DATABASE tempdb
MODIFY FILE (name=templog, FILENAME='<Drive letter>:\TEMPDB_LOG1\templog.ldf');
where <Drive letter> indicates the drive letters assigned to the external disks which were allocated
for the temp database and log files .
```
5. Click Execute in the tool bar.
6. To add new files to tempdb, type the following in a new query window:

```
USE Master
GO
ALTER DATABASE tempdb
ADD FILE (NAME=TEMPDEV1, FILENAME='<location of the new temp file>', SIZE =
<initial size of the file>, FILEGROWTH=10%);
```

NOTE: To add additional files, repeat the previous entries starting with ADD FILE.
7. Click Execute in the tool bar.

APPENDIX B: Enable Large Memory Support

On 32-bit Microsoft Windows® operating systems, SQL Server 2005 provides large-memory support using Address Windowing Extensions (AWE). AWE is a set of extensions to the Windows management functions that allows applications to acquire physical memory directly and map views of physical memory to their virtual address spaces, enabling physical memory usage beyond 4 GB and up to 64 GB. Each Windows process has its own virtual address space, the size of which depends on the architecture (32-bit or 64-bit). A 32-bit process can map only up to 4 GB; only 2 GB of this space (3 GB with the /3GB boot option) is made available to the application, and the rest is reserved for the OS. However, SQL Server can directly acquire up to 64 GB of physical memory or the maximum supported by the OS as nonpaged memory using AWE. AWE support was included with SQL Server 2000 on 32-bit platforms, but SQL Server 2005 enhances the AWE support by dynamically allocating and managing AWE-mapped memory to balance overall system memory needs when deployed on Windows Server 2003. The following should be taken into account when enabling AWE with SQL Server 2005:

- A maximum of 64 GB of physical memory is supported through AWE.
- Physical Address Extension (PAE) support for accessing physical memory greater than 4 GB is provided only on Windows 2000 Advanced Server and Datacenter Server and on Windows Server 2003 Enterprise Edition (32-bit) and Datacenter Edition (32-bit).
- Only database pages can reside in the physical memory allocated through AWE. Memory allocated through AWE cannot be used for supporting additional database users, threads, databases, queries, and other objects that permanently reside in the virtual address space.
- SQL Server 2005 Analysis Services cannot take advantage of AWE-mapped memory.

AWE requires the database engine to run under a Windows account with “Lock pages in memory” permission. Administrators can further control memory allocation using the min server memory and max server memory options, which enforce upper and lower limits on SQL Server memory utilization.

On Windows Server 2003, AWE memory is allocated dynamically and returned to the system as required to balance the overall system needs. The max server memory option must be set to guarantee additional memory for other system applications or SQL Server instances. In failover clustering scenarios, all server nodes must have adequate physical memory to handle the memory requirements of all SQL Server instances for both before and after failover load conditions. AWE is not necessary on 64-bit versions of SQL Server 2005 because virtual address space is not limited to 4 GB. However, the Windows account under which the database engine is running should still have “Lock pages in memory” permission. This setting enables SQL Server to hold on to the allocated memory and prevents the OS from paging the allocated memory, which can help provide performance improvements. The dynamic memory management mechanism releases locked memory appropriately if a system-wide resource shortage occurs.⁹

For additional information refer to the following:

<http://msdn2.microsoft.com/en-us/library/ms175581.aspx>

http://www.sql-server-performance.com/articles/per/awe_memory_sql2000_p1.aspx

⁹ Advanced Configuration Options in Microsoft SQL Server 2005

<http://www.dell.com/downloads/global/power/ps3q06-20060270-Sankaran.pdf>