VERITAS Volume Management Technologies for Windows

The Next Generation of Disk Management for Windows Platforms

Windows 2000 and Windows Server 2003
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INTRODUCTION

One constant in today’s dynamic computing environment is the continual need for more storage. Users expect databases, mission-critical applications and other resources to be available 24 hours a day, seven days a week and expect fast access to data on demand.

Most storage administration tasks are labor- and expertise-intensive. Windows administrators track storage, add new storage, and do their best to monitor and correct performance problems as necessary. Many storage-configuration tasks require taking the system offline and restarting the server, which interrupts system and data availability. As the amount of storage being managed grows, these tasks become more complex. Even in the Windows environment, which emphasizes ease of use, disk storage tasks can be time-consuming. Storage management adds considerably to the ongoing total cost of ownership of systems.

In building its Windows operating system (Windows 2000/Windows Server 2003), Microsoft selected VERITAS Software to develop storage management software, including the Disk Management system. VERITAS Software is the leading provider of enterprise storage management software for Windows, and its products support high-performance, highly available storage configurations for most enterprise computing platforms today.

Together, VERITAS and Microsoft developed a disk- and volume-management framework for the Windows platform. On Windows 2000 and Windows Server 2003, the result of this collaboration is Windows Disk Management and the Logical Disk Manager (LDM) program, which provides logical volume management for Windows.

Logical volume management removes physical limitations of storage, enabling administrators to build higher-performance, more available storage configurations from existing disk storage and simplifying disk administration tasks for reduced cost of ownership.

Building on the framework established in Windows, VERITAS has developed a family of Windows-specific volume-management software, which provides advanced volume management capabilities for Windows systems:

- VERITAS Volume Manager™ for Windows provides support for Windows 2000
- VERITAS Storage Foundation™ for Windows provides support for Windows Server 2003

This paper provides an overview of these products and their capabilities for administrators familiar with the Windows platform. It includes:

- An introduction to logical volume management in Windows systems
- A discussion of software RAID and hardware RAID, with strategies for using the two together
- An overview of the VERITAS volume-management products for Windows

LOGICAL VOLUME MANAGEMENT ON THE WINDOWS PLATFORM

Traditionally, disk space is allocated on the basis of the physical boundaries and capacity of the disk drive. This simple paradigm has worked well for many years, but as demands on storage increase, it introduces limitations. For example:

- The size of the physical disk can limit the size of a file system or database table space.
- A problem with the disk (slow performance or I/O errors) can affect the availability of critical data or application performance.

Logical volume management removes these physical limitations by allowing administrators to select and combine disk space from more than one physical disk into a logical volume, or virtual disk. A logical volume is a disk partition managed in the host software that can be composed of physical storage on multiple devices. Logical
volumes can have greater capacity, availability and performance than a single drive. Logical volume management is analogous in many ways to virtual memory management. Just as virtual memory creates virtual, contiguous blocks of memory from whatever memory or storage is available, logical volume management creates virtual volumes from available disk storage. These virtual volumes look like single, contiguous storage volumes to the application and user, but may be spread over multiple physical storage devices.

Using logical volume management, system administrators can create volumes that have greater capacity, higher performance and higher reliability than the physical devices themselves, all using existing storage. Administrators can balance performance and availability needs and configure storage on the basis of actual usage patterns.

The dynamic disk and volume support in Windows (which we refer to as Logical Disk Manager or LDM in this paper) provides basic logical volume-management capabilities. VERITAS volume management products offer advanced volume management capabilities, including many more configuration options, online performance monitoring and tuning, and domain-wide storage management for Windows 2000 and Windows Server 2003 servers.

Logical volume management provides many benefits in the Windows environment. This section provides an introduction to some of these capabilities.

**WINDOWS DYNAMIC VOLUMES**

The Windows Disk Management (DM) facility supports basic disk (using the traditional disk partition table used by DOS and earlier versions of Windows) and a new dynamic disk format. Dynamic disks use the new logical volume-management support to create software-managed disk partitions, called dynamic volumes. Logical Disk Manager (LDM) replaces the software RAID mechanisms provided by previous releases of Windows - offering software RAID capabilities combined with online management and configuration of local and remote disk storage.

Windows 2000 and Windows Server 2003 have five types of dynamic volumes: simple, spanned, mirrored, striped and RAID 5. These formats are described in more detail below.

**Simple**
The simple dynamic volume is similar to a traditional disk partition, with a logical volume residing on a single physical disk. You can have multiple simple volumes on a single disk, and these volumes can use different file system formats (such as FAT or NTFS). When you need to add space to a simple volume, you can use LDM’s online configuration capabilities to extend the volume online, without a system restart.

**Spanned**
A logical volume can span multiple physical disks. This means that the size of a file system or database table space is no longer restricted by the physical size of a single disk partition.

A spanned volume concatenates space allocated on multiple physical drives. By using the free space on one or more available disks, administrators can make more efficient use of storage they already have. A spanned volume is susceptible to the failure of any of the physical devices composing the volume. Mirroring (below) alleviates this problem.

**Mirrored**
Mirroring critical data to multiple physical devices is an excellent way to protect data from disk device failures. If one disk fails, the mirrored copy remains available to service read and write operations. Administrators can provide even better redundancy by mirroring devices on separate disk controllers.
LDM provides flexible mirroring; mirrored devices do not have to be of the same size or type, so you can use devices already in-house to mirror critical data. Using LDM, you can split a mirrored volume while it is online and available.

Although mirroring is used primarily to improve data availability, it has other uses as well:

- Administrators can put frequently requested data on a mirrored volume — even if it is a small part of the overall data. By providing multiple copies of the data, mirroring can reduce contention and improve performance on read requests. With VERITAS volume management “Preferred Mirror” support, you can create a mirror on storage with fast access characteristics to offload access requests from a single physical device.

- You can perform backups without locking data by using mirrored copies. For example, you can detach a mirror from a volume and use it to produce an internally consistent backup. Another method is to add a new mirror to a volume, then detach it and perform the backup when the mirror is fully synchronized. This method can be used with volumes that are not normally mirrored.

**Striped**
A striped volume interleaves writes to multiple devices. Striping can improve overall I/O performance to the volume by reducing the time spent waiting for disk head movements.

LDM can create volumes with up to 32 stripes; VERITAS volume management products can support larger numbers of stripe devices. The devices do not have to be of the same size or speed. Each physical device can contribute different amounts of storage to the dynamic volume. This lets administrators optimize the hardware already in-house.

**RAID 5 (Striping with Distributed Parity)**
A striped volume is susceptible to the failure of any of the physical devices in the striped set. For this reason, striping is often combined with mirroring (supported with VERITAS volume management products). Another approach is striping with parity — this combines the enhanced performance of striping with the increased availability provided by parity checking. LDM provides the RAID 5 specification for striping with distributed parity. (See the discussion below on hardware and software RAID for more information about RAID levels and the differences between software and hardware RAID.)

Again, the LDM RAID 5 volume is very flexible — administrators can add volumes to existing striped sets and use differing numbers of striped volumes.

The logical volume support is completely transparent to both users and applications.

**ONLINE MANAGEMENT OF LOGICAL VOLUMES**

VERITAS volume management products and LDM simplify basic disk administration tasks, such as adding or removing storage or moving data. The products use a Microsoft Management Console (MMC) snap-in interface and offer wizards to guide disk management operations.

A single GUI console can support multiple disk management servers within the MMC framework, and a single MMC framework supports multiple GUI connections to separate servers.
Disk- and volume-configuration information is stored on the disk itself, not in the registry or other system-specific locations. This means that it is easier to move disks between systems and to change disk configuration without system reboots.

Administrators can perform disk storage administration tasks while the data is online and available and without restarting the server. Examples of these tasks include:

- Expanding simple or spanned volumes online, without shutting down the server
- Repairing (resyncing) mirrored or RAID volumes in case of a disk failure
- Removing mirrors from mirrored volumes or breaking a mirrored volume into two volumes
- Creating new volumes and reactivating offline volumes, without restarting the server

VERITAS volume management products provide a domain-wide view of Windows-attached storage, so administrators can configure and manage local and remote disk storage from a centralized interface. It also supports online expansion and reconfiguration of mirrored, striped and RAID 5 devices.

Together, these features reduce the planned downtime frequently used for disk administration purposes and simplify overall disk administration tasks.

**SOFTWARE RAID AND HARDWARE RAID**

VERITAS volume management products and LDM provide host-based RAID configurations — often referred to as software RAID. These same storage combinations are also available on dedicated hardware devices (controller-
based or hardware RAID). These two approaches to RAID may be used separately or in combination, depending on your storage needs and system characteristics.

This section provides some background on hardware and software RAID, the advantages and limitations of both, and how to integrate the two for optimal performance and availability.

**RAID LEVELS**

The general purpose for RAID devices (and RAID support at the host level) is to improve disk storage availability or performance. This is achieved through some combination of disk mirroring or parity (for protection against failure) with striping (for optimal performance). The exact definitions of the various RAID levels are beyond the scope of this paper, but the following table provides a brief reference:

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<td>RAID 1</td>
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<td>RAID 1+0</td>
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<td>RAID 2 through RAID 5</td>
<td>Striping with parity checking</td>
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RAID 2 through RAID 5 use different approaches to combining striping with parity checking, which protects against device failure without requiring full redundancy of the data (and double the disk space). RAID 2 is not implemented commercially. RAID 3 distributes bytes across multiple disks; this does not perform well with applications that read and write small blocks. RAID 4 stores all parity on information on a single disk in the array; RAID 5 rotates parity information across all drives in the set.

RAID levels 3, 4 and 5 are available on controller-based (hardware RAID) devices. Windows LDM supports RAID levels 0, 1 and 5. VERITAS volume management products support RAID 0, 1 and 5 as well as mirrored stripes.

Which RAID organization to select depends on data access patterns and availability requirements. Each has its advantages and drawbacks.

**CONTROLLER-BASED OR HARDWARE RAID**

RAID devices that you purchase from a storage vendor have the RAID logic contained in the disk controller’s software. The RAID level is pre-configured, as are other settings such as stripe size. These hardware RAID devices are a fast and easy way to implement striping and redundancy techniques.

Hardware RAID has several advantages compared with a host-based RAID implementation:

- It is fast and easy to deploy — you simply buy and install the RAID device.
- It uses fewer CPU cycles and less bus bandwidth than host-based implementations. Even if data is mirrored, the host writes the data only once to the RAID controller, whereas host-based mirroring requires more I/O. And parity computation occurs in the RAID device, not on the host. For systems that are constrained by CPU cycles or bus bandwidth, hardware-based RAID will have less of a performance impact than software RAID.

However, hardware RAID tends to be less flexible than software RAID — the amount of disk storage and stripe size are pre-configured and may be difficult to change.
SOFTWARE RAID

VERITAS volume management products and LDM both implement host-based or software RAID. In software RAID, the mirroring, striping and parity computation occurs on the host system.

Software RAID is extremely flexible:

- You can build RAID objects from partitions of existing disk devices or mirror across different RAID devices.
- You can tune the RAID implementation on the basis of actual usage patterns. For example, you can add devices to a striped set or change the stripe size.
- You can improve availability by mirroring across disk controllers or host bus adapters.

Software RAID does compete for bus bandwidth and CPU resources with other programs on the host computer; this can cause problems on constrained systems. However, it is easier to add resources to most host systems than to dedicated RAID controllers.

COMBINING HARDWARE AND SOFTWARE RAID

Happily, these options are not mutually exclusive. In fact, using hardware and software RAID implementations together offers many benefits. For example, you may build simple mirrored or striped sets with existing disks for some logical volumes and use hardware RAID for others.

The VERITAS volume management products and LDM can also use RAID devices as an available device for mirroring and striping — for example:

- Mirroring data between RAID devices that are not fully redundant
- Distributing parity (with RAID 5) across multiple arrays
- Striping data across arrays for applications with high bandwidth requirements (such as a video server or image processing)

THE VERITAS VOLUME MANAGEMENT FAMILY FOR WINDOWS

Through its close development relationship with Microsoft, VERITAS Software has created a family of logical volume management products for the Windows platforms.

The Windows 2000 and Windows Server 2003 platforms provide basic logical volume management in its Logical Disk Manager component, developed cooperatively by Microsoft and VERITAS. Windows 2000 users can easily upgrade to advanced volume management features with VERITAS Volume Manager for Windows and Windows Server 2003 users can easily upgrade to advanced volume management features with VERITAS Storage Foundation for Windows.
This section describes the features of these products in more detail.

**LOGICAL DISK MANAGER ON WINDOWS**

The Logical Disk Manager provided in Windows 2000 and Windows Server 2003 provide basic volume-management capabilities. These include:

- **Dynamic volumes** — flexible, virtual volumes can be simple, spanned, striped, mirrored or RAID 5 (striping with distributed parity).
- **Online storage management** — the ability to monitor storage, add new storage, un-mirror devices and otherwise manage storage while systems and data are online and available includes the ability to extend a simple or spanned volume without restarting the system, while the data is online.

With LDM, administrators can create storage configurations that bypass the physical limitations (in size, performance and availability) of existing storage devices. For example, administrators improve data availability by mirroring critical data and by performing storage operations such as expanding volumes while data remains online. And for high-performance situations, administrators can use striping or RAID 5 to improve overall throughput.

This native support also makes storage administration tasks simpler to perform. A graphical user interface makes it easy to get a complete view of both the logical and physical storage layout and to perform storage administration tasks with the aid of graphical interfaces and wizards.

**VERITAS VOLUME MANAGEMENT**

VERITAS volume management products provide basic and advanced volume-management capabilities and complete dynamic volume support to Windows Server 2003 and Windows 2000 systems. Advanced volume management features include the following:

- **Domain-wide storage configuration** — Administrators can see and manage storage available in the Windows domain from a central interface.
- **Larger striped and RAID 5 volumes** — Administrators can create striped or RAID 5 dynamic volumes with more than 32 columns.
- **Mirrored stripe volumes** — Mirroring the stripe volume combines the performance of RAID with the full redundancy of mirroring for a high-performance, highly available storage solution.
- **Online growth for mirrored, striped and RAID 5 volumes** — Administrators can extend striped or mirrored volumes (including RAID 5 volumes) online, without restarting the system or making the data unavailable.
- **Preferred mirror** — This feature provides improved performance for data with a heavy read-request load. Creating a local mirror for read operations improves read performance. For example, the preferred
device for most data access could be mirrored on a high-performance local device while update requests access a remote disk (on another controller).

- **Online monitoring and tuning** — Administrators can identify storage bottlenecks online and move data to correct or prevent performance problems before they become serious.

I/O activity is tracked at a system, volume, logical disk, physical disk or disk-region level. Average I/O activity is calculated per subdisk; a subdisk with 90 percent or more of average is flagged as a potential “hot spot.” The administrator can then relocate a high I/O activity subdisk region to another, low-activity region to alleviate I/O bottlenecks. By supporting optimization based on actual usage patterns, VERITAS volume management products eliminates much of the guesswork and expertise required for optimal disk configuration.

- **Private diskgroup protection** — VERITAS volume management products supports Storage Area Network and shared storage configurations. For example, multiple Windows servers can share a disk farm by segmenting the storage on the disk farm. Each server accesses its’ own diskgroup only.

- **Proactive monitoring and notification** — VERITAS volume management products support proactive storage-event notification, which improves performance and reduces downtime. Features such as Capacity Monitoring warns when any dynamic volume has reached nearly full capacity; SNMP Alerts allows alerts to be sent to a centralized management console; e-mail and pager notifications are sent to storage administrators in the event of storage-related problems; and Event Log alerts allow storage administrators to review storage changes and events.

- **Hot Relocation; Hot Spare and Undo Hot Relocation** — This feature allows proactive storage management when I/O errors occur on disks. It allows the designation of one or more empty dynamic disks as hot spare disks. Data may be moved off failing drives or bad disk blocks and restored to the original configuration after the failed device is replaced.

- **Dynamic multipathing (DMP)** — This feature enables multiple paths to be established between the storage and the server it is attached to. And in the event of failure of a path, an available path will automatically take over the I/O, providing virtually uninterrupted access to the data by users. Dynamic multipathing can be used to increase performance by spreading I/O between multiple paths.

- **Clustering support** — VERITAS volume management products supports VERITAS Cluster Server™ and Microsoft Cluster Server (MSCS) in a Windows environment.

- **Snapshots** — VERITAS FlashSnap enables administrators to create point-in-time snapshots with minimal impact to applications and users. The snapshots can be accessed from the same server or easily imported to another host. On-disk snapshots provide administrators with the ability to quickly recover from data corruption issues. Off-host snapshots allow users to perform resource intensive processes such as testing, decision support and backups without affecting production servers and data.

VERITAS gives administrators the tools to create high-performance, highly available storage configurations on the basis of their actual usage patterns.

- **Better availability** — Administrators can spot potential problems, such as disk errors, before devices fail. Mirroring, mirrored stripes and RAID 5 configurations protect data with high availability requirements. And because all storage management tasks can occur while storage is online and available, planned downtime for storage administration is not needed.

- **Better performance** — The VERITAS volume management I/O statistics and graphical user interface give administrators the tools they need to identify I/O bottlenecks and correct them immediately while systems remain online. Striping and RAID 5 implementations create logical volumes with performance
that can exceed the characteristics of the individual device. Administrators can use mirroring techniques to provide improved read performance for heavily accessed data and to create point-in-time snapshots for administrative actions like analysis or backups without affecting production performance.

UPGRADES AND COMPATIBILITY

When you are currently using Windows 2000 or upgrading to Windows Server 2003, you automatically get the logical disk management support. To take advantage of his support with existing storage, you need to upgrade your simple disks to dynamic disks.

If you are running Windows 2000 and need the advanced storage-management capabilities of VERITAS volume management products, you can upgrade to Volume Manager for Windows.

If you are running Windows Server 2003 and need the advanced storage-management capabilities of VERITAS volume management products, VERITAS Storage Foundation for Windows.
SUMMARY

Together, VERITAS Software and Microsoft have created powerful volume-management capabilities for the Windows platform. You can take advantage of these capabilities today with VERITAS volume management products or upgrade the native support in Windows using VERITAS Volume Manager for Windows and VERITAS Storage Foundation for Windows. These products give Windows administrators the flexibility to create and manage high-performance storage configurations in a dynamic, around-the-clock computing environment.