Storage virtualization and the HP StorageWorks Enterprise Virtual Array

Abstract

This white paper presents an overview of storage virtualization at the controller level of a storage system. Virtualization technology allows companies to respond quickly to ever-changing storage capacity requirements. Virtualization has multiple definitions and many different implementations in a storage area network (SAN). This document describes how HP defines virtualization technology and how it applies to the HP StorageWorks Enterprise Virtual Array (EVA) storage system. It also explores how virtualization of storage provides advantages over conventional storage through performance, management, distributed sparing, Virtually Capacity-Free Snapshot replication, and Virtually Instantaneous Snapclone replication.

This document explains tiered storage and the use of low-cost Fibre Attached Technology Adapted (FATA) drives. It illustrates the cost benefit of FATA drives and introduces the concept of associating the cost of the storage to the value of the data stored on it. Finally, it discusses how the EVA can save a company time, space, and total cost of ownership through the use of virtualization and the advantages it provides to firms doing business in today's climate.

Introduction

IT professionals are always looking for better ways to access and protect data. Organizations are seeking technologies that reduce costs and enhance the management of their rapidly growing storage requirements. Businesses have implemented technologies such as RAID, tape back-ups, and SANs in an attempt to control large amounts of data for business-critical operations. As today's companies face even greater challenges accessing and managing their business-critical information, the need for more effective solutions has become a business necessity.

Virtualization is one of the most exciting and beneficial solutions for storage management. This paper presents an overview of the different layers of virtualization, why this technology has tremendous merit in the area of networked storage, the HP implementations of virtualization, and the significant benefits provided by this approach to data storage.

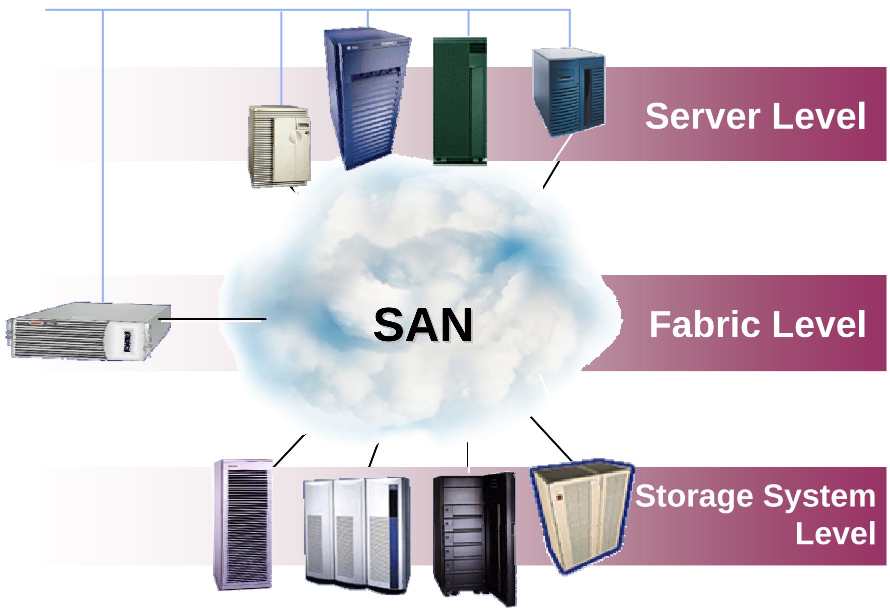
What is storage virtualization?

Storage virtualization is generally defined as: "the transparent abstraction of storage at the block level." In essence, virtualization separates logical data access from physical data access, enabling users to create large storage pools from physical storage. Virtual disks are created from these pools and are allocated to servers on the network as logical storage when needed.

Virtual storage eliminates the physical one-to-one relationship between servers and storage devices. The physical disk devices and distribution of storage capacity become transparent to servers and applications. Storage virtualization provides the added benefit of simplifying storage management.

There are three levels within a networked storage environment in which virtualization can occur: the server level, SAN fabric level, and storage system level. These levels can be used together or independently to maximize the benefits to users. The following section defines these virtualization levels in more detail.

Figure 1. SAN levels



Server level

At the server level, virtualization can be implemented through software residing on the server and is independent of storage devices. With this software, the operating system causes the server to behave as if it is in communication with a device type even though it is actually communicating with a virtual disk. Server-based virtualization can be deployed in homogeneous SAN and non-SAN environments. It has limited interoperability with hardware or software components.

As an example of server-based storage virtualization, HP offers HP OpenView Storage Virtual Replicator for Windows and Logical Volume Manager (LVM) and Veritas VxVM for HP-UX. This product uses virtualization to provide storage pooling in Microsoft® Windows® environments. This is an effective virtualization solution for small and entry-level systems because it is easy to implement and use.

SAN fabric level

The HP vision supports the creation of an open SAN—an infrastructure based on industry standards that delivers the "many-to-many" functionality needed to meet the storage requirements of today's computing environments. This functionality includes scaling, virtualization, automation, simplification, interoperability, and investment protection.

SANs provide the data communication infrastructure needed for the most advanced and most cost-efficient computer mass storage systems. SANs provide unprecedented levels of flexibility in system management and configuration. Servers can be added to and removed from a SAN while their data remains in the SAN. Multiple servers can access the same storage for more consistent and rapid processing. The storage itself can be easily increased, changed, or re-assigned.

SANs minimize total cost of ownership for both large and small storage systems. SAN technology supports the management features and I/O price performance demanded in today’s competitive IT environment and offers the storage component investment protection needed to minimize capital expense.

Storage system level

At the storage system level, virtualization is implemented on storage array controllers, independent of the host. The storage array controllers can create virtual disks, snapshots, and clones in conjunction with management software. This storage virtualization process is centrally managed using a storage management appliance (SMA) or an application server and a Web browser.

Virtualization in the individual storage system controller is the evolutionary next step beyond classic RAID technology. Virtualization at this level is ideal for environments requiring high performance, high data availability, fault tolerance, efficient storage management, data replication, and cluster support.

The HP StorageWorks Enterprise Virtual Array (EVA) is a premier example of the advantages of virtualization at the storage system level. The EVA provides significant benefits in automation and ease of use for customers. How the EVA provides these benefits is described in greater detail in the following sections.

Table 1. Virtualization at various levels of the SAN

Server level	Ideal for small and entry-level storage networking
SAN fabric level	SAN-wide virtualization techniques that increase efficiency in SAN development, management, and service are beneficial to large heterogeneous SAN environments
Storage system level	Storage virtualization for large capacity environments that provides benefits such as Virtually Capacity-Free Snapshot for any Vraid type, allowing allocation of capacity on demand, and does not sacrifice performance or reliability

HP StorageWorks virtualization implementation at the storage system level

HP defines virtualization at the storage system level as the disassociation of capacity from its underlying physical disk restrictions to create large pools of storage available to multivendor hosts. These pools of virtual capacity can be configured as virtual disks and presented to any or all connected hosts. This implementation of virtualization allows for more efficient use of storage capacity, simplified management, and an overall reduction in costs.

The EVA provides tremendous benefits as a result of virtualization. Along with meeting the standard requirements, such as high availability, data protection, and fault tolerance, the EVA also provides many value-added features to help organizations maximize their storage environments. This technology capitalizes on virtualization to provide optimal performance, ease of management, improved capacity utilization, powerful data replication tools, and faster rebuild times, all in a multivendor environment. The following section focuses on the value-added benefits provided by the EVA and how this system truly capitalizes on virtualization technology.

Improved performance

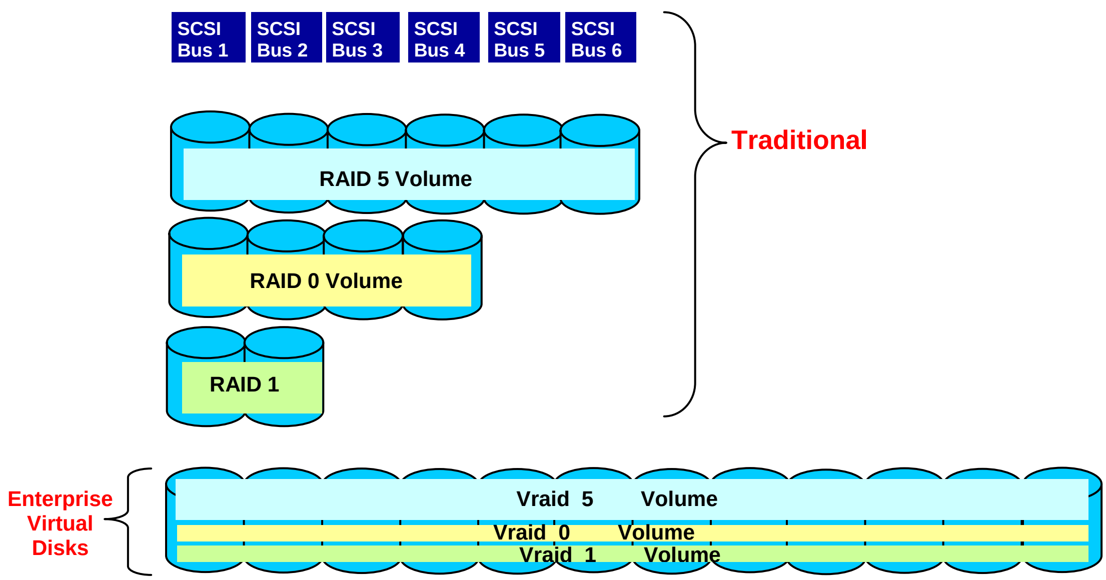
HP believes that performance is one of the most important benefits derived from virtualization at the storage system level. The main reason for this performance improvement is load balancing through the elimination of hot spindles, or hot drives. A "hot spindle" is a drive that is subjected to intense I/O loads because the data it contains is frequently accessed or it is heavily worked as a result of the type of RAID employed. Virtualization allows data to be spread across more spindles (disks), dramatically improving performance. Disks no longer need to be arranged in traditional RAID sets by disk capacity size, disk type (high performance or FATA), and type of RAID protection. Rather, a "virtual" disk draws its capacity from a designated pool of storage. Because of storage pooling virtualization, the

EVA can support multiple virtual disks of varying capacity and RAID types within a single storage pool. In addition, all virtual disks in a pool will spread their capacity across all the physical disks that contribute to that pool.

For example, a traditional RAID 1 (mirrored) configuration for 36 GB of data space requires two 36-GB disks to be assigned as RAID 1 (see Figure 2). When the data, which might be in a high-performance application, is read or written, only two disks are involved, thus limiting performance. With virtualization, this same 36-GB RAID 1 requirement is spread across four, six, eight, or more disks in a pool. Performance can be greatly improved because more spindles are simultaneously involved in larger transfers.

Virtualization allows data to be redistributed across physical disks within a storage pool if an activity occurs that causes a change to the virtual disk data or pool structure. As a result, the EVA utilizes an on-the-fly leveling algorithm to balance performance without interrupting ongoing workloads. This process redistributes the blocks of each virtual disk evenly across as many spindles as the redundancy type (Vraid level) of the virtual disk will allow. This leveling process is activated whenever the EVA detects an opportunity to improve utilization, such as a change in the number of disks in the pool.

Figure 2. Virtual disk flexibility



Management

Simplified storage management is another benefit of virtualization at the storage system level. It enables administrators to handle the attributes of storage rather than the mechanics of storage management. Virtualization enables users to create a single management model for their storage, regardless of RAID type, thus eliminating manual data placement tasks.

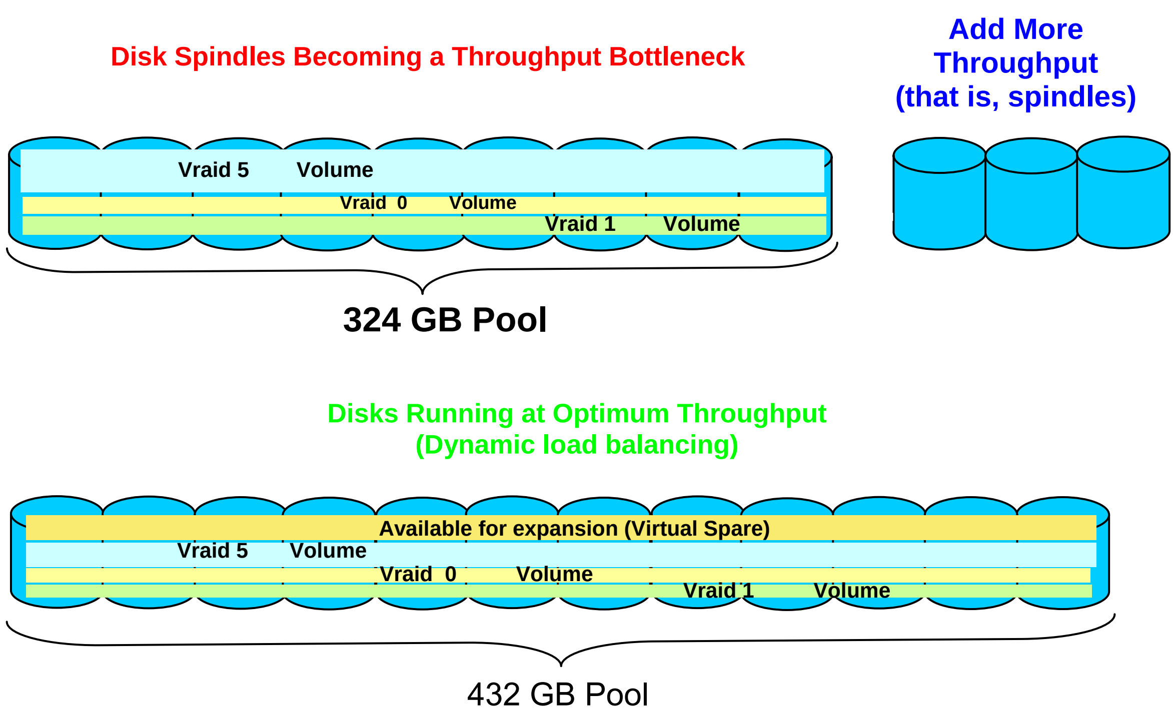
This significantly reduces the complexity of storage deployment, enables administrators to manage storage assets as a consolidated pool, and shifts capacity management from the individual unit to the pool level. All of these functions simplify storage management, improve capacity utilization and minimize training requirements

Through the use of HP OpenView Storage Operations Manager or HP StorageWorks Command View EVA on an SMA or application server, administrators can manage EVAs on the SAN. This centralized management point and Web browser capability from other servers enables an administrator to manage significantly more storage capacity than in previous architectures. The ease of use, high disk utilization, and compact footprint of the EVA provides an ideal solution for IT consolidation.

Dynamic expansion

The ability to expand virtual disk capacity dynamically—without application downtime—greatly improves efficiency at the system level. Virtualization enables administrators using the EVA to monitor the capacity usage of a volume or the storage pool and dynamically allocate additional capacity to either as needed. This functionality eliminates "stranded capacity" seen in other architectures. Stranded capacity is often seen as capacity that is pre-allocated to a volume to account for the growth of the volume over time. The ease of volume expansion with the EVA eliminates this traditional requirement, providing significantly better capacity utilization over traditional architectures.

Figure 3. Dynamic expansion



For example, consider a 50-GB virtual RAID 5 (Vraid 5) set. As user files increase in size, capacity approaches the 50-GB limit of the volume. At this point, an administrator can add capacity to the existing pool, and the new capacity will be brought online dynamically (see Figure 3). This process can be performed automatically or manually as directed by the storage administrator. When capacity allocation occurs, the virtual disk will expand and the existing data will be releveled across all of the spindles in the volume as a background task—all with zero downtime.

This ability for the user to increase the virtual disk size (subject to available free capacity in the pool) results in outstanding gains in capacity usage and consolidation. This feature of virtualization allows storage use to be more efficient by eliminating stranded capacity and redistributing data as the pool grows.

Distributed sparing

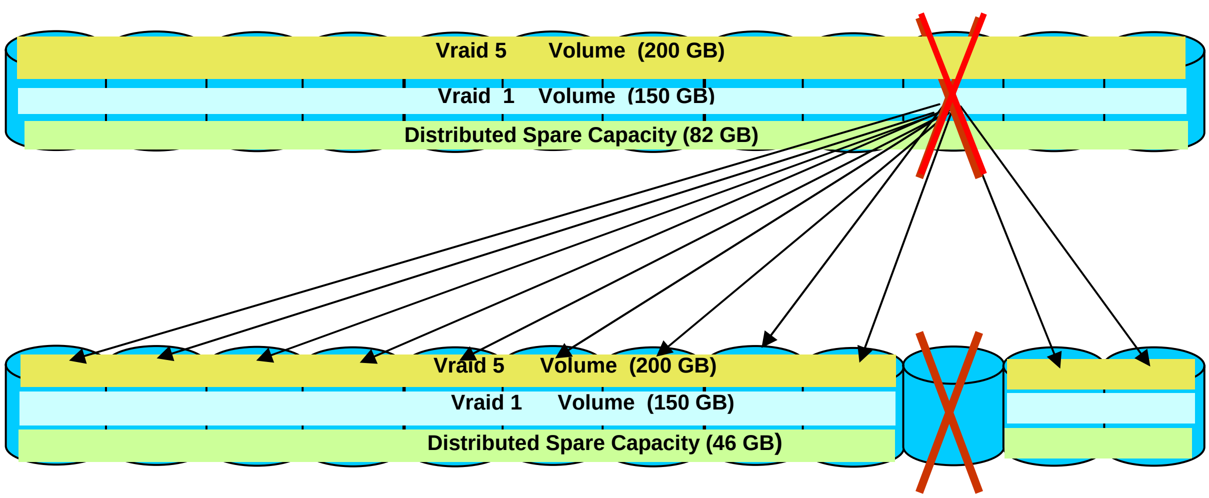
Distributed, or virtual, sparing of disk capacity provides faster rebuild times in the EVA, which is a benefit because it reduces the possible vulnerability of data to an additional failed drive. In traditional architectures, storage administrators must set aside a physical drive as a dedicated "hot" spare in case of a drive failure. Because of its virtualizing architecture, the EVA distributes spare capacity in the same manner as a dedicated spare, across multiple spindles. This functionality allows data to be stored on each spindle, further balancing the I/O load across additional disks. EVA distributed sparing eliminates the risk that the spare disk has failed. The administrator can also dynamically modify the reserved space based on availability or space requirements and add more protection as needed.

The most obvious benefit for carrying spare capacity in this manner is faster rebuild times in the case of a drive failure. Because the data is striped across multiple spindles, the EVA can rebuild data faster because more spindles are accessing data (see Figure 4).

Management software can be used to hold back enough pool space to spare an optimal number of drives per pool, depending on the application. This spare space is used to restore redundancy to virtual disks that have segments mapped to a disk drive that fails. If a drive fails, the EVA initiates a background process that rebuilds Vraid 1 or Vraid 5 data into the spare space of the pool. If a Vraid 0 virtual disk has blocks on a drive that has warned of imminent failure, the data from that drive is copied directly to spare space. However, when the drive actually fails, the Vraid 0 data will be unrecoverable.

Distributed sparing works with an algorithm similar to load leveling, except the goal is to empty the failed or failing drive, rather than level its usage with other drives.

Figure 4. Distributed sparing capability



Data replication tools

The EVA controller provides three types of local data replication tools: traditional snapshot, Virtually Capacity-Free Snapshot (Vsnaps), and Virtually Instantaneous Snapclone. These data migration and replication tools have been refined in the EVA to provide tremendous flexibility and data protection.

Traditional snapshot

A traditional snapshot using EVA virtualization requires the dedication of similar capacity as in a non-virtualized array. In a snapshot, a set amount of capacity equal to the original volume is reserved for the snapshot. Data is not written into that reserved space until necessary. As the data changes in the original virtual disk, the data in the snapshot volume is updated with the original data. Even though the snapshot volume might not utilize all the reserved capacity, it must be set aside in reserve.

Virtually Capacity-Free Snapshot

In a Virtually Capacity-Free Snapshot, the storage system does not reserve capacity for the snapshot volume in advance. Rather, space in the snapshot volume is used only as the data of the original virtual disk is changed. This is called demand allocation. The snapshot volume is a new virtual disk that initially shares the original virtual disk map entries. As the original virtual disk is written, free space is consumed as necessary to preserve the original contents of the snapshot.

Both traditional snapshot and Vsnaps use unshared segments as data is written. The difference is that standard snapshots pre-allocate all space needed to do those unsharing operations, while Vsnaps allocate space only as needed at the time the unsharing is to be performed. Because the original and snapshot virtual disks share storage for similar segments of blocks, this form of snapshot is called virtually capacity-free. Other than this difference, the two types of snapshots are the same. It is important to note that a Virtually Capacity-Free Snapshot can be created from any level of redundancy (Vraid 0,1, or 5) using the EVA. In addition, the EVA offers Cross-Vraid Snapshots, in which the Vraid level can be changed when snapping within the same disk group. This capability allows for more efficient disk utilization because redundant data can be changed from Vraid 1 to Vraid 5.

Virtually Instantaneous Snapclone

Virtually Instantaneous Snapclone is an improved type of data cloning similar to a traditional clone because duplicate space is reserved. A complete copy of the original virtual disk is made as quickly as data transfer rates permit, resulting in two identical independent copies of the data in the shortest time possible.

There is an important difference between Virtually Instantaneous Snapclone and the traditional clone. With traditional controllers, the clone copy is not available until the copy is complete. With Virtually Instantaneous Snapclone, the snapclone data can be accessed almost immediately. As the Virtually Instantaneous Snapclone is being created, the controller can access the original virtual disk for the data and keep track of what data has changed since the instant the Virtually Instantaneous Snapclone was taken. The benefit of a Virtually Instantaneous Snapclone is that users get a point-in-time clone of a virtual disk essentially immediately.

Cross-Vraid Snapclones are another option for improving disk utilization. The EVA can change the Vraid level when creating snapclones across virtual disk groups, which would provide the customer significant cost savings when creating redundant copies of data. Not only could customers change the Vraid level of the snapclone, but they could also snapclone from standard high-performance Fibre Channel drives to less costly FATA drives.

In general, Virtually Instantaneous Snapclone is the optimum tool for long-term preservation of a copy or a series of copies of a disk, while capacity-free Vsnaps or traditional snapshots are better for creating short-lived, frozen images for applications such as backup.

Highlights of virtualization at the controller level with the EVA include:

- High performance through load leveling
- Efficient, automated storage management
- Better utilization of capacity and assets
- A dynamic storage environment

- More effective utilization of storage space with Virtually Capacity-Free Snapshots
- Immediate access with Virtually Instantaneous Snapclone
- Highly effective storage deployment environment

EVA remote replication with HP StorageWorks Continuous Access EVA

HP StorageWorks Continuous Access EVA provides a storage-based SAN application that brings the power of EVA virtualization to the arena of remote replication. Continuous Access EVA is enhanced to perform remote replication and deliver high data availability and performance on Fibre Channel-based campus, metropolitan, or continental SANs.

Continuous Access EVA features the highest level of storage data-protection capabilities to meet business continuity implementation goals with:

- Fast application recovery with minimal or no transaction loss
- Application recovery to a metropolitan, regional, or continental site
- Disaster-tolerant solutions to ensure business continuance and company survival
- Essential component of every business continuity planning and implementation
- Creation of disaster-tolerant copies of critical business data
- No single-point-of-failure solution to increase the availability of your customers' data
- Easy-to-use graphical user interface for managing data replication between arrays

Virtualization and tiered storage

The EVA enables the user to identify different types of data that require different levels of accessibility and throughput. Virtualization enables easily managed, tiered storage solutions that comply with long-term data retention requirements and can be accessed instantaneously.

The EVA provides additional efficiencies for the customer's existing storage infrastructure and provides for the implementation of different classes of storage based on the data availability requirement of the customer's environment. Through the use of the FATA disk drive, the EVA provides users a low-cost storage solution for the intermediate storage case in which the customer's data might need to be migrated quickly between low-cost and high-performance devices. The EVA brings the same virtualization features to the management of the FATA disks at no additional cost.

The ability to use disk drives in this way helps an organization create a more adaptive enterprise. Moreover, the lower cost of the technology in the same footprint and the ability to expand the use of an existing device enhances the investment in the EVA and its value-added software and increases operational efficiency.

Additional information on the FATA disk drive can be found in the white paper, "HP StorageWorks Enterprise Virtual Array (EVA) Storage Solutions: High-Performance and Low-Cost Disk Drives," at http://h18006.www1.hp.com/storage/arraywhitepapers.html.

The business value of virtualization

Companies continue to face challenges associated with storing data in today's business environment.

Today's business challenges include:

- Limited to no economic visibility
- Lower IT costs increasingly important
- Brutally competitive in many industries
- Internal headcount constraints

- Holding to major strategic projects
- Looking for creative new approaches

The common problems that IT professionals face every day include: the costs associated with the purchase of additional storage, physical space and environmental costs, operational time to bring storage into service, administration cost for storage allocation, people with the skill to manage storage, and more demand for data integration all within a multivendor environment. All of these problems can be summarized in the root issues of time, cost (resources), and space (capacity).

With virtualization, these common problems are reduced. Time, cost, and space are all better utilized to provide real value to the business.

Time

With the architecture of the EVA, virtualization at the controller level offers great performance advantages. Using EVA features such as automatic load balancing when new capacity is added to the storage pool can yield significant performance improvements, which means administrators no longer need to micromanage data placement, data replication, and performance tuning.

This technology offers truly scalable capacity, configuration flexibility, and more consistent user service levels. All of these benefits enable IT administrators to minimize the time required to maintain and manage their storage, while maximizing the power and availability of their storage environment.

Cost

Virtualization can reduce total cost of ownership and lower the effective price per megabyte through management cost savings and better utilization of assets. The EVA, with its virtualizing architecture, utilizes a common management point for each unit on the SAN. As a result of this centralized management, storage administrators can manage more storage.

Storage pools can easily be managed with features such as dynamic expansion, simplified storage allocation, and load leveling to better utilize resources. These features enable the same number of administrators to manage significantly more storage, which is a real cost savings in today's climate of limited resources.

Cost savings are also critical as storage requirements continue to grow. Because of virtualization features, such as dynamic expansion and Virtually Capacity-Free Snapshot, a business must only purchase the capacity that is needed today. It is no longer necessary to buy two or three times the amount of storage actually needed to make provisions for future growth. The key benefits of the EVA allow a business to buy storage when it is needed and not tie up precious capital.

Space

Through the benefits of virtualization, the EVA enables users to maximize the value of their storage. They can take advantage of new flexibility, capacity management, and capacity savings through tools such as Virtually Capacity-Free Snapshot, Virtually Instantaneous Snapclone, and Cross-Vraid Snapshots and Snapclones. The versatility and cost effectiveness of the EVA is reemphasized through the introduction of FATA disk drives without restrictions into the current hardware and software configuration, which enables customers to optimize resources and assets.

Virtually Capacity-Free Snapshot, for example, enables administrators to replicate a point-in-time copy of data with only minimal use of capacity, which means that a storage manager has essentially twice the capacity in which to replicate data for backups, data mining, and other capacity-intensive activities. Because the controllers in the EVA use minimal capacity for data replication—while allowing any level of redundancy to be replicated—the result is a much lower "effective" cost per megabyte because the user can access more storage for the money.

Because of the Fibre Channel virtualization architecture of the EVA, the amount of capacity behind the controller is significant. The EVA can support up to 240 drives behind one pair of controllers and 168 drives in one cabinet. The result is denser storage configurations in the same footprint of a standard 42U cabinet.

The elimination of stranded and over-allocated capacity through virtualization is another important benefit. Traditionally, as data is moved and changed over time, segments of unused or "stranded" capacity can result. This condition leads to wasted capacity and resources. In addition, because of the difficulty in expanding raidsets in traditional storage, the raidsets would typically be created with significantly more capacity than needed at the time to prepare for future expansion. However, the EVA can move this stranded or over-allocated capacity into an available storage pool. As a result of this functionality, the user can once again use more of their storage capacity.

Conclusion

While virtualization is being addressed at all levels of the SAN, the most powerful application of this technology today is at the storage system level. With the HP StorageWorks Enterprise Virtual Array, organizations can take advantage of the many benefits of virtualization with a solution designed specifically for open systems.

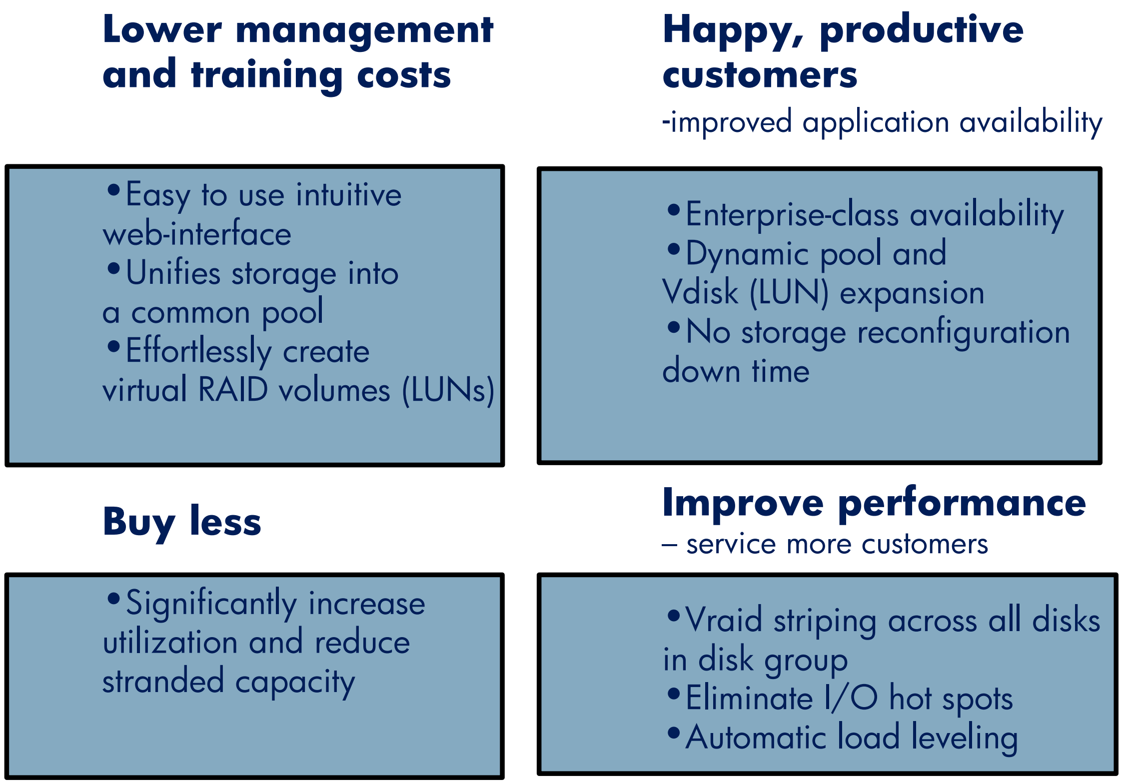
Virtualization at the storage system level with the EVA offers many advantages. The common problems of storage environments are all curtailed. Cost, space, and management resources are all better utilized in a virtualized environment, providing real value to business.

The EVA provides time savings though automatic performance tuning as well as a high controller throughput. As a result, administrators no longer need to micromanage data placement and performance tuning. The result is less storage downtime.

Through centralized management, virtualization helps reduce costs. The same number of storage administrators can manage more storage, while company assets, such as disk space, are better utilized.

IT professionals benefit from the flexibility and capacity savings through support for virtual disk mirrors, Virtually Capacity-Free Snapshot, and Virtually Instantaneous Snapclone. These tools deliver optimized capacity and greater flexibility to storage administrators.

Figure 5. The value of virtualization



As an ideal storage system for SAN environments, the HP StorageWorks Enterprise Virtual Array offers true value in today's demanding storage environments. IT managers who want to save money, space, and time will find the EVA the right solution to meet their business-critical storage needs.

5982-8671EN, 09/2004

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