



New Dynamic RAID Technology From Hewlett-Packard Addresses Issues in Current High Availability Storage Subsystems

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Storage Systems Division

Hewlett-Packard has introduced a new technology that offers the redundancy and high availability found in today's RAID subsystems without the drawbacks of current RAID technology.

Introduction

Users of today's RAID subsystems have to pay a performance and administration price for protecting their data. In on-line transaction processing environments, current RAID subsystems have poor performance and high costs when compared to non fault-tolerant disk subsystems. Today's RAID subsystems are also much more difficult to configure and manage. Administrators are presented with numerous and confusing configuration alternatives ranging from RAID levels to caching options. The difficulty in administration extends beyond the initial installation. Adding capacity or reconfiguring the subsystem to improve performance is a difficult and time consuming process.

Hewlett-Packard has developed HP AutoRAID technology. HP AutoRAID technology offers the redundancy and high availability found in today's RAID subsystems while minimizing the trade-offs of current RAID technology. HP's new technology is much more than a new HP-designed RAID controller. After four years of research, HP's Storage Systems Division has developed the next generation of high availability storage technologies.

HP AutoRAID technology offers high availability storage solutions with the following highlights:

- High performance subsystems that intelligently adapt to the system workload
- Subsystem administration without expertise in RAID technology
- Configurations of non-homogeneous disks -- flexibility for today's and tomorrow's disk capacities
- Add usable capacity, or change performance characteristics in seconds, *not* hours
- Hot spare disks that increase performance yet provides the same function as traditional hot spare disks

HP AutoRAID technology dynamically translates disk block addresses.

HP AutoRAID Technology

The heart of HP AutoRAID technology is a set of new algorithms within the subsystem controller that manage data block addresses. Computer systems store data to a disk drive in groups called blocks. Each block has a unique address on the disk. After a host computer system writes a block of data to the disk at a specific address, it expects to receive that same data back when the block is read from that address. Traditional disk arrays use static, pre-defined algorithms to translate the host block address to a location on the disk. These translation algorithms are part of the fundamental definition of RAID levels, such as RAID 3 or RAID 5.

The new HP technology introduces the ability to intelligently translate, or map, any host block address to any disk drive address with a dynamic algorithm, and to change the translation while the system is operating. This allows the controller to move data stored within the subsystem to any location on any disk drive without affecting the data, or how the host addresses the data.

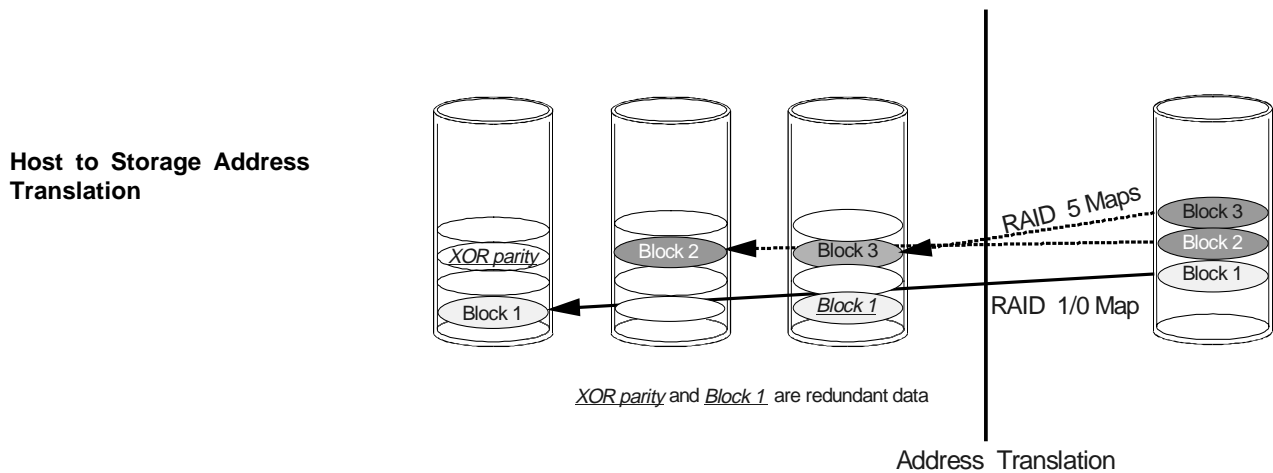


Figure 1

This paper describes some of the features and benefits made possible with this new technology.

Dynamic Data Migration

HP AutoRAID technology removes the requirement for the administrator to understand RAID levels or their effect on subsystem performance.

HP AutoRAID technology takes a new approach to high availability storage that provides two key benefits to the system administrator. First, it eliminates the need for administrators to select or understand RAID levels and their effect on performance and availability. Second, the subsystem continuously optimizes for cost and performance, as if the administrator were spending all of their time tuning the subsystem.

With traditional disk arrays, the performance of the subsystem varies with the configured RAID level and the system workload. As an example, sequential operations may be more efficient in one RAID level versus another RAID level, or random reads may be more efficient than random writes within the same RAID level. HP AutoRAID technology understands these differences and dynamically adapts its algorithms to best meet the demands of the host.

HP AutoRAID adapts to host system workload to optimize performance.

The block address translation facility is the key to HP AutoRAID technology. The subsystem controller can convert data stored in one RAID level to another RAID level without disrupting the host view of the data. The dynamic data migration strategy is to keep the active data in RAID 1/0, which offers the best overall performance, and the less active data in RAID 5, which is lower in cost. Typically active data is only a small portion of total data during a given time period. Thus the majority of data is stored in RAID 5. This strategy provides the performance of RAID 1/0 with the better cost of RAID 5.

Adaptive Hierarchical RAID

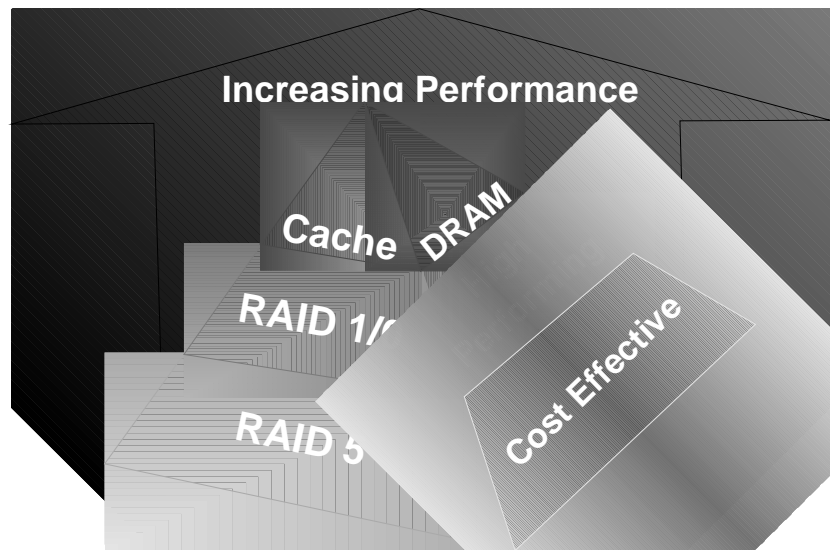


Figure 2

Log Structured RAID 5

Log Structured RAID 5 improves traditional RAID 5 random write performance.

HP AutoRAID technology introduces log structured RAID 5 algorithms to minicomputer and PC systems. Currently available on some very expensive high-end mainframe computer storage subsystems, log structured increases RAID 5's performance. With traditional RAID 5, which is block striping, sequentially addressed host blocks are written to different disks within the disk array. An XOR (exclusive OR) of all the data within a stripe is sent to another disk to provide redundant information. Traditional RAID 5 is very inefficient in maintaining the XOR data in a random write workload. RAID 5 requires a read modify write, which is four separate disk IOs, to complete one random write. Log structured RAID 5 is also block striped, with the exception that each block is not required to be from a sequential address. Thus when HP AutoRAID technology is migrating data from RAID 1/0 to RAID 5, the data can be gathered from many random addresses to be written in one complete stripe. These large writes get RAID 3 performance, which delivers the best RAID level for large transfers.

Mixed Disks and On-line Expansion

Disks of different capacities can be easily managed in a single array.

Another feature of HP AutoRAID technology is the ability to *easily* mix and match disks of different capacity or performance. Although some traditional disk arrays have a similar feature, their configuration process is complex and time consuming. With HP's technology the process is simple and fast. Like traditional disk arrays, one of the configuration tasks of the administrator is to create virtual disks from the physical storage space available. The array controller then presents the virtual disks to the host computer system as if they were real physical disks. A traditional disk array requires the administrator to understand the characteristics of each of the physical disk drives to manually group the drives or sections of the drives together to build a virtual disk. With HP AutoRAID technology, the administrator is simply informed of the total space available on all the disk drives. The administrator then specifies how much of this available space is to be used by each virtual disk. The subsystem mapping policies then group the disks together to guarantee the largest usable capacity and the best performance while assuring that the data is protected by RAID technology.

Configuration of the disk array is accomplished in seconds.

Reconfiguration is also simplified. HP AutoRAID technology dynamically selects the appropriate RAID level so reconfiguration of an array to change RAID levels is no longer needed. There are still other reasons to reconfigure a subsystem. The most typical reconfiguration is to add more storage space to a subsystem. With existing RAID technology there are two options to perform this task. The administrator could add

enough disks to create a completely new redundancy group (a redundancy group is a fault-tolerant set of disks containing both data and XOR information). Or the administrator could backup all the data to another device, add the new disks, reconfigure the entire subsystem, and finally restore the data. If few disks are being added to the subsystem, the first method is not very cost effective because it requires the full capacity of one of the largest new disks to be used for redundancy information, not for user data. The second method is very time consuming and requires the subsystem to be taken off-line.

HP AutoRAID technology greatly simplifies the addition of capacity. To add more storage capacity to a subsystem, the administrator simply installs the disk drives and builds another virtual disk. As with the initial configuration process, the administrator is informed of the total available capacity including the new disks. This process is done on-line and takes seconds to complete.

The key to this capability is the HP AutoRAID mapping technology. Each disk is viewed as blocks of storage, not whole disks. As new disks are added, their blocks are added to the pool of available storage. Through the map, the storage controller can use each block independently to best meet performance, cost and availability goals.

Tuning for Performance

Additional disks can be used to improve the subsystem performance.

Unique to this storage technology is the ability to automatically and immediately use new disks to increase subsystem performance. When a new disk is installed, HP AutoRAID will redistribute the data evenly across all of the disks in the subsystem. This process, called balancing, is done in the background between host operations. With the data distributed evenly across all the disks in the subsystem there are more opportunities for concurrent (simultaneous) operations. In transaction processing environments, the more concurrent operations, the better the performance.

Active Hot Spare

Active Hot Spare improves subsystem performance without sacrificing redundancy protection.

Another innovation for HP technology is active hot spare. Active Hot Spare provides the same function as a hot spare disk drive in traditional disk arrays. That is, when a disk fails, the controller can immediately start the rebuild process without operator intervention. The rebuild process will reconstruct the missing data and restore the redundancy of the subsystem. In traditional disk arrays, the hot spare disk remains inactive until a failure, because it contains the reserved space for the rebuilt to use for the new reconstructed data. While some current disk arrays

allow the creation of temporary capacity on the hot spare disk, this data will be lost when a disk failure occurs. With HP AutoRAID technology, the hot spare is used to improve the performance of the subsystem.

Comparing traditional hot spare and HP AutoRAID technologies Active Hot Spare

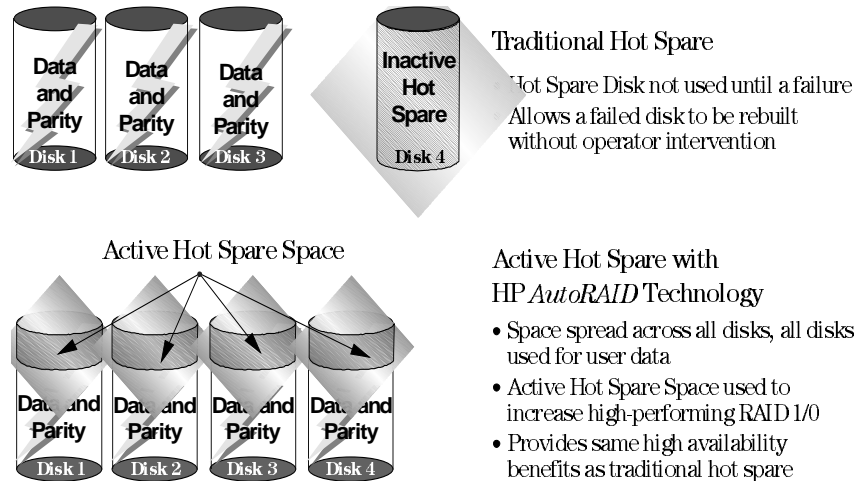


Figure 3

The innovation is done by balancing the user data across all the disks in the subsystem, *including* the hot spare (data balanced across more disks provides better performance), and by reserving a portion of space on each disk for the reconstructed rebuild data. When a disk failure occurs, the rebuild process will reconstruct the missing data and store it in the reserved space each of the disks.

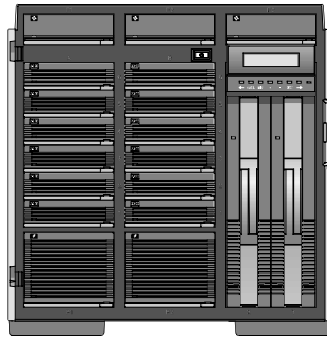
The HP Disk Array with AutoRAID

The first product implementation of this technology for HP 9000 Servers and Workstations is called the HP Disk Array with *AutoRAID*. The enclosure supports up to twelve low-profile disk modules. The HP AutoRAID array features dual-active controllers, redundant cooling fans and optional redundant power supplies. All components are front-accessible and replaceable on-line by customers.

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The HP Disk Array with AutoRAID is now available for HP 9000 Server and Workstation customers.



- ▶ Up to 12 2Gbytes low-profile disk modules, up to 20Gbytes useable capacity per enclosure.
- ▶ Redundant controllers, fans, and optional redundant power supply.
- ★ *Self-configuring eliminates RAID level selection --installs in minutes.*
- ★ *Add capacity and improve performance online without reconfiguration or reload.*
- ★ *Ease of use will lower cost of storage management.*
- ★ *Dynamically adapts to provide best price/performance possible.*
- ★ *Only HP AutoRAID offers this benefit*

To ensure interoperability between the HP Disk Array with *AutoRAID* and HP 9000 Servers and Workstations, extensive testing has been completed in single-host and multi-initiator configurations, many involving complex high availability configurations. Customers can be assured that they are purchasing a solution that is well integrated with the complete system's environment.

Conclusion

Hewlett-Packard Company delivers the next generation of disk array technology. HP AutoRAID redefines the features offered by high availability storage subsystems. This technology promises products that are high performance, low cost and easier to use than any existing disk array technology.

“HP sets a new standard for high availability storage”