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Smart Array Technology: Basics and Advantages of Battery-Backed Cache

***Abstract:** The purpose of this paper is to communicate the basics and advantages of Compaq's of battery-backed cache for array controllers. This paper also cautions customers of HP's positioning of battery-backed cache as a high availability option.*

Data integrity is critical in today's business environment. A customer's need for RAID centers on data protection to ensure business continuance. Cache on RAID controllers increases the speed of read-write processes but write processes are subject to catastrophic data losses during server or controller failure if the cache is not battery-backed.

If the cache has a power source directly attached, the data in the cache can be maintained for a short period of time, allowing the recovery of that data and the protection of the integrity of business critical information. Battery backing of cache serves this function of an independent, though temporary, power source. Battery-backed cache will normally retain the integrity of the data in the cache for a period of several days, depending on the size of the cache and the capacity of the batteries at the time of the failure.

Because today's business environment demands complete data integrity, Compaq does not allow the use of cache for writing data to storage without the safety of battery backing.



Implementations of battery backing of cache vary based upon the following factors:

- Type of battery used
- Expected lifetimes of batteries
- Simplicity of data recovery in the event of a server or controller failure

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Smart Array Technology: Basics and Advantages of Battery-Backed Cache

Introduction

Power interruptions in the computing environment are not typically frequent but can happen, seemingly at the worst of all possible moments. Power interruptions resulting in loss of data in today's business environment can be more than problematic; they can be devastating to customer satisfaction. Some examples of data which could be lost are:

- Purchase orders in e-commerce environments
- Payments for goods and services
- Transfers of moneys between accounts
- Buy or sell instructions of financial instruments

RAID controllers are commonly used in business critical environments to move data between computing and data storage environments. The movement of data into storage is referred to as a *write* while the movement of data from storage is termed a *read*.

Cache Use

The process of reading and writing data involves the use of *cache*. Cache is a specific amount of memory dedicated to temporary holding of data during the read and write processes. Most RAID controllers offer the storage management professional a range of choices on the use of the cache memory. Management software for the controller can be used to set the use of cache to:

- 100% read use
- 100% write use
- some mix of read and write such as 50%-50% or 75%-25%.

Battery Backing of Cache

Power interruptions, even for brief moments, result in the loss of data which was being written to or read from storage. The loss of data being read does not result in the loss of data because the data, in its entirety, is still complete in the storage environment from which it was being read. Once power has been restored, the same data can be read again in its original form.

However, power interruptions can have terminal effects on data which is in the process of being written and is temporarily residing in cache. This data does not yet exist in the storage environment and has been offloaded from the server. Therefore, loss of power to the cache means any data stored in the cache is lost forever.

If, however, the cache has a power source independent of the external IT environment, the data in the cache can be maintained for a short period of time, allowing the recovery of that data and the protection of the integrity of business critical information. Battery backing of cache serves this function of an independent, though temporary, power source. Battery-backed cache will normally retain the integrity of the data in the cache for a period of several days, depending on the capacity of the batteries at the time of the failure.

Because today's business environment demands complete data integrity, Compaq does not allow the use of cache for writing data to storage without the safety of battery backing.

Compaq Implementations of Battery-Backed Cache

Compaq, with the introduction of the Smart Array 5300 Controller series, has introduced redundant battery backing of cache using tool-free replacement of just the battery packs themselves without having to replace either the Smart Array 5300 Controller series card or the detachable cache board. For the last few years, most batteries used for backing of cache have been permanently attached to either the RAID controller card itself or to a detachable cache board on top of the RAID controller card. Given the lifetime expectation of batteries of 3 years, there has been an assumption the RAID controller card or at least the detachable cache board would be replaced within those 3 years. If the entire RAID controller card or the detachable cache board is not replaced within 3 years, there is increased risk of data loss.

Users of battery-backed cache would be wise to implement a maintenance schedule which identifies batteries requiring replacement. Should replacement of batteries not be possible or desirable, there are two options which users can legitimately use to continue to manage storage without significant risk of losing critical data: 1) turn off the write cache using the configuration software; or 2) replace the RAID controller with a newer, faster, and more powerful RAID controller. If the write cache is turned off, some degradation of write performance might be expected, reducing overall performance of the controller.

If the server is due for replacement by a more powerful, faster server, then redeployment of the server/controller (with the write cache turned off) to a less critical application might help to maximize the return on investment in that server/controller equipment. Should the write cache NOT be turned off, users should be prepared to endure the permanent loss of data should power or server fail and battery capacity is insufficient for maintaining data integrity.

Finally, unless the user has implemented Compaq's line of Smart Array controllers, replacement of the RAID controller can be an extraordinarily expensive and tedious process involving total backup and restore of all data, application, OS, and storage configuration information.

HP's Usage of Battery Backed Cache

Customers should use caution when faced with competitors' positioning of battery-backed cache as a high availability option. In the event of a Netfinity server failure, utilizing HP's NetRAID cache data, customers must find another identical HP server with an embedded RAID controller. This situation leaves customers with two options:

1. Have a costly "spare server" on hand
2. Be willing to shut down service to an existing server, for the purpose of moving data cache, drives, and network to an existing network, thus shutting down the existing server network in the process.

Neither option is optimal!

Although HP's battery-backed cache may increase some performance parameters, it is not a guarantee of performance. With server board or RAID controller failure, critical data is left in the controller cache and supported by batteries for a limited number of hours.

Data Recovery from Compaq Battery-Backed Cache during Server Failure

Compaq, on the other hand, maintains the integrity of the data in the cache during server or controller failure. To maintain this integrity, upon failure, the battery-backed cache module should be removed as soon as possible and placed into a compatible environment for data recovery. The storage array must be moved to the new environment, as well.

Users of battery-backed cache must have a data recovery plan which defines the specific actions necessary to recover the cached data. If the battery-backed cache has a specific interface, memory structure, and data formatting parameters, it must be placed into equipment having the exact parameters in order to recover the data without corruption.

This is a special concern to battery-backed caches implemented with RAID controllers embedded in server boards. Since the RAID controller is embedded in the server board, another server or server board of the same model must be available for this operation. With Compaq PCI RAID controllers, a server board failure requires only that the PCI card, with the battery-backed cache attached, be moved to an available PCI slot on another server.

Battery Types, Characteristics, and Life Management

Implementations of battery backing of cache vary by type of battery used, expected lifetimes of batteries, and simplicity of data recovery in the event of a server or controller failure. Compaq recommends replacement of batteries for battery backing of cache after three years of use. Beyond three years, remaining capacity of battery packs cannot be expected to be sufficient to provide data integrity protection in the event of a loss of power.

RAID controller vendors use a variety of battery types for backing of cache. Some of the parameters which impact battery life and performance are:

- Time (the age of the battery)
- Memory (which dramatically shrinks capacity unless periodic full discharges are effected)
- Deep discharge cycles supported prior to capacity shrinkage
- Capacity shrinkage due to dendrites caused by continuous trickle charging
- Accuracy of remaining capacity measurement
- Disposal methods required by regulation

Nickel Cadmium (Ni-Cd) batteries are common in the battery backing of cache. However, NiCad batteries have memory, limitations on deep discharge cycles, do not offer an accurate basis for measuring remaining capacity, and are subject to disposal regulations.

Lithium Manganese Dioxide ($\text{MnO}_2\text{-Li}$) batteries have been used by Compaq for several years. Li-Mn batteries do not have memory and require no special disposal procedures, advantages Ni-Cd batteries do not have. However, Li-Mn batteries support only 60-100 deep discharge cycles, form dendrites over time, and do not offer an easily measurable parameter which accurately defines the actual capacity which remains.

Nickel Metal Hydride (Ni-MH) batteries have been recently introduced by Compaq on the Smart Array 5300 Controller series. Ni-MH batteries have the same advantages as Li-Mn but support

<1,000 deep discharge cycles and offer a measurable parameter which quite accurately defines the actual capacity remaining. In addition, Compaq developed and patented technology included with the Smart Array 5300 Controller series eliminates the forming of capacity reducing dendrites.

Summary

Data integrity is critical in today's business environment. The user's need for RAID centers on data protection to ensure business continuance. Cache on RAID controllers increases the speed of read-write processes but write processes are subject to catastrophic data losses during server or controller failure if the cache is not battery-backed.

Battery backing of cache is only as good as the remaining capacity of the batteries. Users of battery-backed cache on RAID controllers must be aware of the battery life factors which can lead to data loss even with the protection of battery-backed cache. A maintenance program should include battery replacement every three years unless other specific actions are taken.

Since data lives longer than servers, hard disk drives, or even RAID controllers, upgrading equipment while maintaining data integrity can be a significant business cost if data compatibility and data migration are not supported by the hardware vendor. Customers should use caution as to which hardware vendor they choose for battery-backed caching to ensure their choice is a safe and cost-wise one.

Compaq has addressed the needs of today's business environment by providing a line of Smart Array controllers, which provide exceptional data protection while minimizing the long-term costs of that protection. For more information on Compaq's products and solutions, see <http://www.compaq.com/smartarray>