DataSentinel Whitepaper

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BiTMICRO®

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Overview

End users who utilize solid state drives over hard disks demand second-to-none reliability in data security. BiTMICRO Networks, the pioneer in Solid State Drive (SSD) technology, takes data protection a step further by equipping all E-Disk® SSDs with DataSentinel, the first line of defense that effectively minimizes data loss in brownout/unstable power conditions. And together with PowerGuard®, DataSentinel forms a formidable blanket of protection that can perform even in mission-critical applications.

Most computer systems augment their power protection needs via off-device solutions like surge protectors and Uninterruptible Power Supplies (UPSs). These measures inadvertently introduce an additional point of failure to the system because internal batteries in UPSes do not guarantee high levels of reliability, not to mention a limited life span.

DataSentinel comprises sophisticated power management circuitry and firmware code that reduce the probability of data loss and/or corruption. As an in-device solution, it guarantees against data loss by monitoring critical phases in cache and data activity, and preserves the drive's operating environment when a power blackout or surge ensues within the system.

This whitepaper first identifies the behavior of data in solid state drives to better understand the risk areas. It discusses the various features of DataSentinel, possible scenarios for data loss in the event of a power disruption or failure and how DataSentinel acts to avert data loss. This whitepaper also identifies the optional features that set BiTMICRO apart from other SSD competitors.

Behavior of data in a solid state drive

Data Storage Architecture

Most computer systems rely on a complex storage architecture that involves a combination of volatile and non-volatile memory to maximize processing speed and performance.

The need to maintain metadata (tables of pointers to physical memory blocks), data integrity, speed, wear endurance and cost are crucial to determining the appropriate types of memory and the proportion of each type to the other. Figure 1 below shows the delicate balance between the use of volatile and non-volatile memory. It also depicts the trade offs in using both memory types.

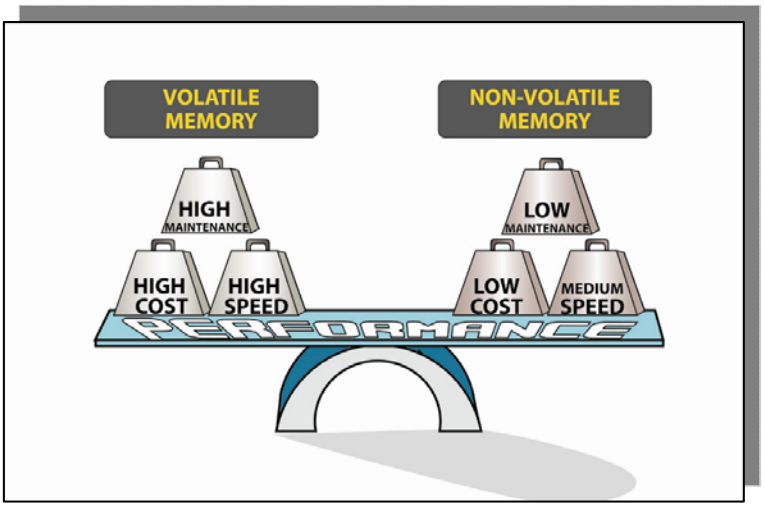


Figure 1: Balancing the use of volatile and non-volatile memory

High-performance SSDs utilize an amount of volatile memory, in the form of RAM and registers that lose data at the instance of power loss. Its speed and flexibility however make up for its vulnerability and generally higher cost per bit when compared to non-volatile memory.

Data storage systems, in the form of hard disks and SSDs, are non-volatile in nature and are able to keep data even when voltage is absent. Complexity is introduced when these data storage systems incorporate volatile memory to speed up data access times and transfer rates. These volatile devices are mostly used for data cache and buffers that work to ensure the promised system speed and reliability. Data is cached so that the information is made readily available to the system. The firmware's data management functions assess which data will be read or modified by the central processing unit and locate them in registers, buffers and caches. Data caching, pre-fetching and the overall memory structure of the device boost system uptime, minimize latency and reduce frequency of access to slower non-volatile memory storage.

As previously mentioned, the drawback to these types of systems is the high probability of data loss under fluctuating power and brownout conditions. Power is a fundamental need but it can also be the biggest threat to the reliability and operation of any system.

While it's true that it is technically possible to design a system that does not employ any form of volatile memory caching and buffering, such configurations are often not acceptable for enterprise and military applications because:

(1) the performance degradation outweighs the benefits obtained by securing against data loss;

(2) most storage systems are designed with caches and buffers that complement primary storage components; and

(3) there is always some form of buffering or caching that transpires within the system, if not in the data storage unit itself or in the other areas of the storage system like the RAM and registers.

It is known for a fact that most disk drives utilize some form of buffering so that basic operations can be locally controlled and will not contribute to system delay.

Power Protection Options

Traditionally, end users guard their systems from unstable power by installing UPS with voltage regulation. But how many times have we heard of UPSs that failed at a time when they should be kicking in? So many things could go wrong, and their reliability is compromised because the batteries do not follow the normal charge-discharge cycles, or their rated capacitance is based on ambient temperature of 25° C. Their limitations consequently add more reliability issues instead of sustaining a stable power supply.

Applications that are not cost sensitive usually utilize redundancy in their storage systems to obviate or offset the possible loss of data (due to power loss) in the main storage areas. This setup is not viable for some military systems or embedded applications where space and weight may be constrained and where configuring in redundancy can pose a real challenge.

Optimum Approach

Storage devices must offer outstanding data reliability, and data storage companies must sustain high levels of security and offer technologies that will alleviate these data concerns. DataSentinel presents the best integration of performance and reliability when it comes to securing your precious resource, data.

DataSentinel, a built-in feature that comes with every E-Disk Altima drive, is designed to provide the required protection in any power degradation scenario.

DataSentinel Features

Low Voltage Detection

E-Disk Altima SSDs work optimally when its rated voltage is met by the power supply. When the voltage drops below the allowable input voltage, there is a good chance that the drive may not operate properly, if at all work. For data storage devices, this is crucial. Data may instantly get lost or corrupted if a drive operates under varying levels of power. This inherent problem simply cannot be ignored.

E-Disk Altima SSDs are equipped with input voltage sensors that measure the actual power that is fed to the drive. These voltage sensors are designed so that when voltage drops below some predetermined threshold levels, DataSentinel sets to work to protect your data. DataSentinel employs low voltage detection as its first line of defense. It continuously classifies the state of the drive under one of three possible states and acts accordingly.

Normal State

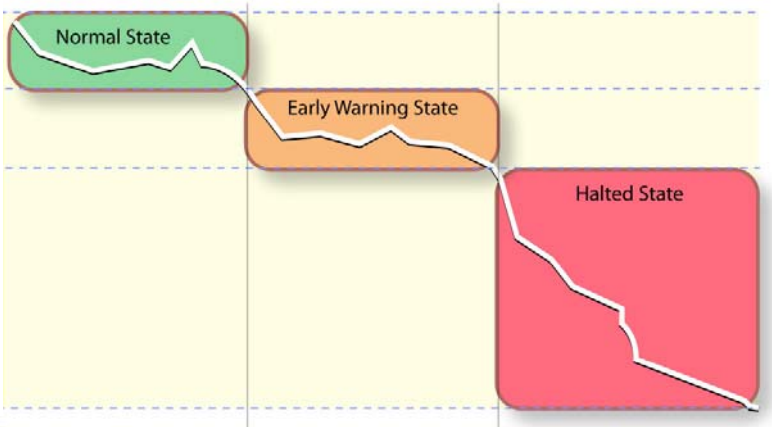
In the Normal State, the drive gets above the allowable voltage requirement. It is in this state that the drive works optimally. DataSentinel at this point can maintain the standard functions needed for normal operation. These features will be discussed in the latter part of this whitepaper.

Early Warning State

In the Early Warning state, the drive is experiencing an input voltage just below its rated input voltage. Upon entering this state, the drive quickly moves data stored in volatile media to more stable and power-independent media. Reads operate normally but data writes are directly saved to non-volatile memory or flash memory instead of staying in the cache. Speed of writes in this drive state deteriorates as writes to main memory are significantly slower when compared to dumping it first on cache.

Halted State

If the input voltage further decays to less than the allowable input voltage, the drive is placed in the Halted State. All read and write operations are disabled and the drive's sole task is to flush the data to a more secure area of memory. In theory, it may still be possible to operate the drive under such conditions but there will be a risk of more damage to the data if the drive is allowed to do so at such low voltages.



DRIVE ACTIVITY	Normal State	Early Warning State	Halted State
Cache	Normal operation	The remaining data in the cache is flushed to the flash memory blocks	The remaining data in the cache is flushed to the flash memory blocks
Flash Memory	Normal operation	Writes the data flushed from the cache.	Writes the data flushed from the cache.

Table 1: E-Disk Altima SSD power states and corresponding DataSentinel functions

Redundant Pre-Write / Logging

The basic concept behind caching is to speed up the access of data by keeping copies of the most frequently used data in a faster but smaller memory location. As the system accesses and updates the data in the cache, it does not immediately update its contents in the flash memory. Instead, it implements its updates in batches or when the cache is full and it would need to make room for more relevant data.

A complication arises because the memory type typically used for data cache is volatile by nature. Once power is lost and the contents of the cache have not been updated to the main memory, any updates or new data will clearly be lost.

Redundant Pre-Write solves this by pre-writing translation table modifications to a scratchpad that utilizes non-volatile memory. In this function, a copy of the translation table is secured in the scratchpad while the dirty cache is being flushed.

Concurrent Multiple Write

Data is at its most vulnerable when data modifications are finally updated to the main memory. It is in this stage where data corruption may occur. Unlike other storage types such as HDDs where writes are limited to the number of spindles or heads, E-Disk Altima SSDs are equipped with Concurrent Multiple Write. BiTMICRO Networks' FlashBus Technology is the proprietary

feature that makes this possible. Concurrent Multiple Write reduces the window of vulnerability, or window of time that the flash device spends in the write phase. This feature also translates to faster write times, as data can be quickly accessed and modified using multiple data lines than can fetch data simultaneously.

Power disruption scenarios and how DataSentinel acts to avert data loss

Unstable voltage situations

Fluctuating voltage is just as damaging as a sudden power outage. Unstable voltage levels are symptomatic of an impending drive failure. The E-Disk Altima SSD implements proactive measures to mitigate and ready itself for a possible power loss.

When Low Voltage Detection recognizes the unstable voltage. All writes to the cache are halted when the actual voltage falls below 90% of the listed voltage requirement. The cache instead dumps its contents to flash memory.

Sudden power loss situations

Even though the drive cannot fully guarantee the availability of the data in a sudden power loss scenario, DataSentinel's features mitigate this situation by minimizing the "window of vulnerability".

The Concurrent Multiple Write feature achieves this objective by writing multiple data blocks at a time instead of in a serial fashion. Aside from an increase in performance (faster IOPS), larger chunks of data are securely saved in main memory in a shorter span of time.

At the user's option, the data cache may altogether be disabled. When the user sets the drive to Cache-on-Write Disable Mode, data integrity is guaranteed because it is written directly to flash memory before sending a positive acknowledgment to the host.

Optional Data Protection Features

PowerGuard

BiTMICRO Networks offers a PowerGuard option, a hardware-based solution unique to E-Disk and E-Disk Altima drives that enhances the data protection capabilities of E-Disk SSDs. When paired with DataSentinel, PowerGuard acts as a standby voltage source by supplying the needed power to sustain and complete the flushing out of dirty cache in an actual brownout or power degradation scenario.

For more information on how you can purchase an E-Disk Altima drive with the optional PowerGuard, contact any of our BiTMICRO Sales Representatives.

Conclusion

SSDs cannot just rely on the integrity of its components to safeguard against drive faults, including data loss. DataSentinel was specifically developed in our SSD products to complement any storage application's redundancy measures. It provides the highest level of data protection without the need for sacrificing performance and user control. DataSentinel focuses on minimizing the risks of data corruption by controlling cache and buffer operations to secure data in non-volatile memory. DataSentinel makes E-Disk Altima SSDs more resilient to power failures and disruptions thereby diminishing the risk of data loss.