Seagate Nytro® NVMe SSDs: More Than Speeds and Feeds for Business-Critical Needs

Technical Brief

Overview

Non-Volatile Memory Express (NVMe) accelerates SSD performance beyond the limits of legacy bus architectures like SATA and SAS. This new protocol uses the PCIe interface and delivers optimizations to lift business-class storage performance to new heights. However, SMBs and large organizations demand more than fast speeds, which is why the Seagate Nytro XF1440 (2.5-inch), Nytro XM1440 (M.2) and Nytro XP7102 (HHHL) enterprise-grade SSDs integrate several features critical to protecting data integrity and extending drive reliability.

Error Detection and Correction

Seagate Nytro SSDs include several data protection methods already common throughout the NAND world, including cyclic redundancy check (CRC) code for data passing between the host and storage device as well as error-correcting code (ECC) applied to data written to and read from NAND. Seagate NVMe SSDs take protection much further, however, with three key technologies:

Low-density parity-check (LDPC) code

Nytro SSDs feature LDPC as their first line of defense against media error correction. This methodology is particularly suited to moving data through noisy channels with no integrity loss. Also found in 10Gbit Ethernet, high-performance Wi-Fi technologies and hard drives, Seagate implements LDPC alongside user data within each NAND memory page. The LDPC technology featured in Nytro SSDs combines hard and soft decision decoding to achieve significantly better error correction than SSDs using conventional BCH codes. Applied to SSDs, LDPC can help to extend NAND's longevity and deliver enterprise-class endurance by reducing the potential for corrupted data as NAND reaches its end of life.

End-to-End Data Protection

The Nytro SSD's controller hardware appends an embedded logical block address (LBA), a CRC and an ECC field to each block of host data. The controller checks these fields prior to data being returned to the host after it has been processed through the SSD and stored on the NAND. This provides protection against silent data corruption across all memory in the data path. Additionally, end-to-end data protection allows the controller and firmware to safeguard user data without assistance from the host system, which in turn frees up host processing cycles.

RAISE: RAID-like NAND Protection

Seagate's engineers applied the data protection processes of conventional RAID to the die of NAND devices, creating an implementation called a Redundant Array of Independent Silicon Elements (RAISE™). The Seagate RAISE technology protects against rare errors that conventional ECC protection might miss. In a 32-die implementation, for example, the user data on any given die is evenly spread across the other 31 die, ensuring that no data exists uniquely at any given location. In exchange for this redundant protection—which improves the drive's Uncorrectable Bit Error Rate (UBER) by a factor of almost one quadrillion — RAISE carries a capacity cost of only about three percent. Out of every 32 die, 31 are user-accessible (97% of total NAND storage). The result is a remarkably small capacity sacrifice in exchange for a tremendous leap in data defense.

Typically, RAISE rescues data at the individual stripe level: pages and blocks. This process occurs automatically in under 100ms, resulting in no perceptible application impact. In fact, individual pages typically recover in under 10ms. In the rare case of a die failure, the drive will enter a read-only mode. That condition is temporary, however, and any required data should be extracted or backed up before further data loss occurs. RAISE lets Seagate Nytro SSDs enjoy RAID-like data defense without the cost or power demands of adding more die or channels.

Power Loss Data Protection

During a normal system shutdown, the host issues a command to the SSD, prompting it to save any in-flight data or data resident in buffers to non-volatile NAND. However, during a sudden, unexpected power loss, the shutdown process never initiates, and any unsaved data will most likely be lost.

Fortunately, Seagate Nytro SSDs feature a special circuit that monitors the drive's voltage levels. If power drops below a given threshold, stored power in integrated capacitors immediately supplies the energy necessary to allow in-flight writes to complete and for buffer data to copy to NAND. Essentially, these capacitors—a key feature only found on Seagate's enterprise-grade SSDs — serve as an onboard uninterruptible power supply with enough power reserve to copy the drive's entire buffer space and permit all NAND writes to complete. Once power returns to the system, the SSD returns to normal operation and recharges the capacitors for the next unexpected power failure.

Nytro SSDs also incorporate logical protection and recovery. They maintain a log of writes, erases and other critical changes to its internal file system that track the location of user data and the state of the NAND. The log is written redundantly to NAND memory as part of normal operation. Moreover, every write of user data has identifying metadata embedded within it so that after an unexpected power loss, the firmware can use a combination of the data contained in the log and the embedded metadata to recover every write acknowledged by the drive up to the instant of power loss. This process is very rapid even after a rude power loss, as the log prevents the drive from needing to scan the entire media for valid data: relatively few reads are needed for the firmware to recover the state of the drive. Instant recovery is accomplished in less than 10 seconds.

Self-Encryption Capability

Part of protecting data means protecting it from falling into the wrong hands. To address this threat, Seagate provides Self-Encrypting Drive (SED) options across its Nytro family, both in 2.5-inch and M.2 form factors. Specifically, Seagate supports the Trusted Computing Group's Enterprise Security Subsystem Class (SSC) for storage devices. The Enterprise SSC provides an industry standard set of functions to protect user data against loss, theft or intrusion through the use of authentication and encryption keys. Seagate also supports Instant Secure Erase (ISE), letting users and/or administrators perform cryptographically complete drive wiping in seconds.

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Enterprise eMLC NAND

SSD reliability corresponds closely to NAND endurance, or how quickly NAND cells wear out. While single-level cell (SLC) NAND remains the SSD media option with the highest speed and longevity, it dramatically trails multi-level cell (MLC) media in total cost/capacity/performance value. The trick lies in getting MLC NAND to deliver the endurance characteristics enterprises require.

The enterprise-grade eMLC NAND deployed on Seagate Nytro SSDs accomplishes this higher reliability through a combination of improved NAND density and superior cell and error recovery techniques. While specifics will vary according to exact workload parameters, Micron eMLC will generally support three times the drive writes per day (DWPD) of conventional MLC.

Conclusion

The data integrity and reliability features of Seagate Nytro SSDs stand second to none in the enterprise storage world. This, combined with performance and the results of five decades of Seagate enterprise storage design and firmware refinement, make Nytro the most competitive SSDs on the market. Visit seagate.com/nytro to learn more about this product line and how it can help elevate the long-term value of your enterprise storage.

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