

How Firmware Makes an Optimized Drive Soar

Technology Paper

For Enterprise Hard Drives, Firmware Is Often the Key to Optimal Performance

Imagine if your body's *firmware* didn't function properly. If that were the case, your *hardware*—muscles, bones, organs and other physiological systems—may not function properly. To extend this metaphor, imagine if software represented the knowledge of how to read, cook or play a game, meaning that software represents those sets of instructions designed to execute high-level cognitive tasks that typically involve interfacing with the outside world. Firmware, by contrast, is baked-in software that controls the low-level operation of hardware—automatically—like the body's breathing, immune responses, assimilation of sensory input, and so on. In short, if your body's firmware doesn't operate properly, you're in big trouble!

Similarly, this is true for hard drives (HDD). While much of the discussion about HDD quality and application-based optimization revolves around component selection, interfaces and other features (refer to [Optimized Hard Drives: Storage Tuned for Top ROI](#)), only a few people understand the critical role of firmware in tuning drives for specific uses and reliability levels.

Choose the Right Drive

Every HDD is designed for a specific use case. For example, the Seagate® Surveillance HDD targets single-purpose business systems working around the clock, with workloads almost exclusively typified by sequential streaming writes. Engineers code the drive firmware to efficiently handle this type of traffic, resulting in higher performance and lower power consumption.

In contrast to surveillance and similar types of specialized hard drives, desktop HDDs expect to encounter a much more *bursty* sort of workload. On average, desktop HDDs occasionally need to move small numbers of large files (as opposed to, say, tiny financial transactions or short, frequent data logging), and their active work cycles tend to be inconsistent. This sort of workload is clearly shown in the graphic below (Figure 1).

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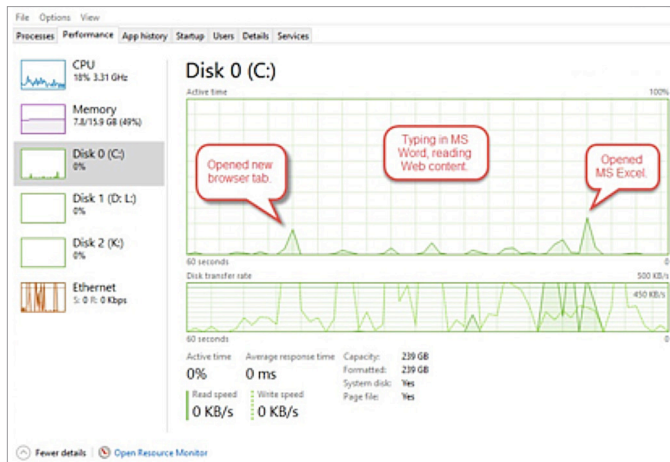


Figure 1. Windows Task Manager showing typically sporadic, lightweight data accesses (desktop)

On the other side of the HDD spectrum, nearline use assumes always-on work conditions that require low latency data access and high I/O operations per second (IOPS). Caching architecture becomes more important for performance and high-sustained I/O levels. Moreover, nearline drives generally handle large block transfers under Linux-centric applications, and nearline firmware usually gets tailored for these variables accordingly. In fact, nearline firmware can even be tweaked to help mitigate the *hot spots* that build up under heavy use by restricting the amount of writes occurring in a particular media area.

“More than anything else with nearline, we care about reliability,” says Abhay Kataria, Seagate principal engineer and manager for firmware development in nearline drive products. “The drives have a five-year service life. We provide workload assurances of up to 550 terabytes per year—ten times that of a desktop drive! So the components written into the firmware manage drive use in that specific high workload, helping to ensure that we have reliability through any mitigation schemes needed. We adapt and learn and then manage some of our algorithms so that we react to environmental changes.”

The range of customers and their respective demands and priorities is vast. However, three critical-to-quality (CTQ) factors consistently emerge from Seagate’s clients: high performance, low power, and the best possible drive management. Firmware tackles all three, and often the interplay between firmware and these characteristics dovetails with specific applications. For example, the power profiles best suited to archiving will be radically different from those for high-volume transaction processing. Performance and power both influence—and are influenced—by specific firmware optimizations.

Firmware-driven drive management can include such aspects as read-after-write (RAW) processes. Hard drives must contend with the possibility of silent data corruption during the writing

process, and so a read generally follows a write. And while the error checking process trades some performance for reliability, the firmware can help introduce controls, which allow the host to dig deeply into the error recovery steps, thereby extending or shortening them. Shortening could prove beneficial in situations when, for instance, data has been replicated to a RAID that could offer the same bits in less time.

“If the customer wants the drive to be the one doing most of its data recovery schemes,” says Kataria, “we also have a parity recovery scheme built into our drive design that provides above and beyond multi-sector error recovery capability to the host.”

The Firmware Difference

The beauty of firmware is that it is flexible. Without it, all instructions would have to be hardcoded into the drive’s processors. During the drive development process, for example, if a software defect is discovered in how the drive responds to SAS protocol code, it’s one thing to remedy the code but another to implement it. Firmware allows engineers to update low-level code without having to incur the time and expense of rolling out new system-on-a-chip (SoC) hardware. Seagate has its own SoC and respective drivers, but modifying firmware remains a far easier route to drive improvement than by modifying hardware.

Firmware tweaking often occurs throughout the 18 months or so of quality assurance and testing within Seagate’s normal product design process. As discussed in [Reliability: Understanding the Critical Factor Behind Disk Storage](#), a new drive design undergoes many months of development in ever-growing waves of fine-tuning. Several drive samples, for instance, might fail under a given set of environmental conditions when handling a certain type of workload. In some cases, the issue can be fixed through firmware changes, and would be confirmed in a subsequent round of testing.

This process continues even after a particular HDD enters mass production. In fact, during this early production phase, there are often opportunities to enhance drive functionality or performance weeks or even months into production. If Seagate can implement these changes in firmware and then validate the changes with follow-up testing, then an optional patch can be offered to customers for download and installation via admin tools. In short, firmware opens the door for great hard drives to continue getting even better over time.

Note that most desktop drives cannot have their firmware upgraded after manufacture—yet another key factor separating the desktop and nearline categories.

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Conclusion

“To me, it’s a myth that you can use a desktop drive in a dense, multi-drive data center chassis,” says Kataria. “You can, but it doesn’t provide the same longevity that you’re looking for or that overall lower TCO that you’re desiring.”

Much of the desire to place desktop drives into enterprise environments springs from a combination of lower desktop model pricing and desktop drives exhibiting similar performance when compared to their enterprise counterparts... at least long enough to finish a 3-minute benchmarking test.

However, this is not realistic. Like pushing a compact commuter car to 150 MPH for a short distance, the car can likely reach this performance peak, but it’s not going to maintain that level for very long. It’s simply not built for that task. Similarly, an enterprise-class drive is going to provide an entirely different TCO proposition. Not only will it reach those top speeds, but it will sustain them reliably and likely provide an advantage due to firmware-based optimizations geared toward specific enterprise workloads. Add in the reinforced construction, upgraded components, superior error correction, and extra manageability of an enterprise drive, and the value above and beyond desktop alternatives becomes obvious.

On a single-drive basis, the difference that firmware makes in this TCO evaluation is incremental, but that increment scaled across the total number of drives in a data center can transform that data center’s bottom line. Firmware is what gives enterprise drives their edge across performance, reliability and manageability. Drive manufacturers that place more time and resources into ongoing firmware refinement will ultimately deliver the greatest opportunity for businesses wanting to protect their data and seize a competitive edge.

To learn more about how firmware-optimized enterprise drives can help your organization, visit www.seagate.com/bestdrive.

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