DELL SOLID STATE DISK (SSD) DRIVES

STORAGE SOLUTIONS FOR SELECT POWEREDGE SERVERS

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Introduction

Dell recently introduced the industry's fastest Enterprise class storage medium, Solid State Disk drives (SSDs) in select Power Edge servers. Solid State, the use of NAND Flash as a storage medium versus traditional rotating disks, is not a new idea. Consumer electronics have made use of NAND Flash at small capacity points for over two decades. In the past, the cost of NAND and the available capacity points had made the technology impractical for use as a mass storage device. Recent increases in capacity capability combined with lowered costs for NAND Flash have allowed architecture designers to create solutions that take advantage of the inherent benefits of NAND Flash over spinning disk as a mass storage medium.

Downfalls of Traditional Hard Drives

Hard disk drives are electro-mechanical devices that incorporate rotating magnetic platters with data laid out within bands (known as tracks) across the surfaces of each platter. The Hard drives incorporate mechanical actuators to move recording heads across the media as it spins to write and read data. The time involved in moving the heads (also known as seeking) plus the time it takes for the data desired to come under the head, known as latency are the bottlenecks in maximum HDD performance capability. Hard Drive manufactures continue to increase the rotational speed of the platters and shorten the seek time as methods of overcoming this mechanical limitation.
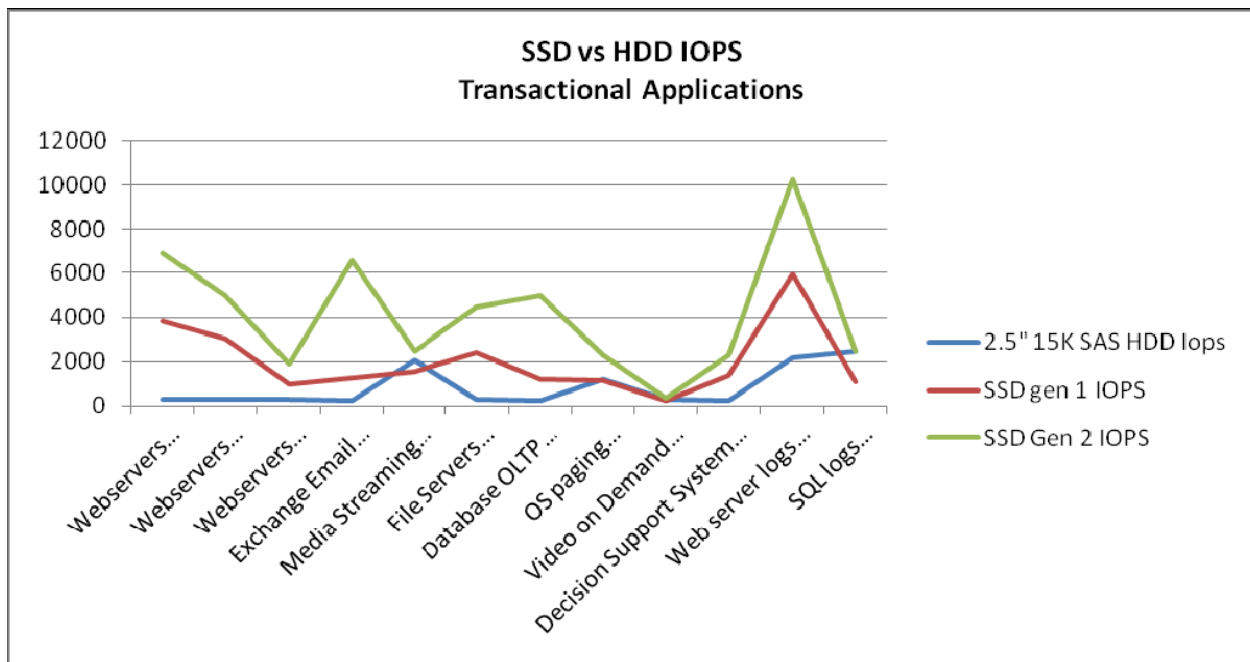
The most relevant example of this today is the Small Form Factor (2.5") 15K RPM SAS HDD's. The rotational speed is nearly 3X that of a typical Notebook Hard Drive (5.4K RPM) while the media platters within the drive itself have been shrunk in diameter to 1.8" versus 2.5" to support the tracking capability at 15K RPM while shortening the distance that the recording head has to seek in order to position itself over the desired data. While these mechanical design tenets have proven effective at gaining maximum performance out of hard disk drives, it has also proven to be an expensive means toward satisfying applications with high IOPS (Input Output Per Second) requirements.

Solid State Drives Meet These Challenges

SSD's have no mechanical moving parts. There is no mechanical seek time or latency to overcome. Because of this, SSD's can transfer data out as quickly as the data can be read off of the NAND Flash. While access to data is still not instant, SSD's provide performance improvements up to forty to fifty times (40X-50X) faster than enterprise class 15K RPM hard drives in customer applications that have high random I/O (input/output) requirements. For IOPS (Input Output Per Second) intensive applications, total IOPS demands can be met with a much lower number of SSD's than hard drives. This provides a total cost of ownership advantage for SSD's over hard drives. Customer applications with the most random data requirements will see the greatest benefit from SSD's over hard disk drives. Customers with highly sequential data will see very little performance benefit with SSD's over hard disk drives.

SSD's mechanical nature of no moving parts also allows SSD's to manage failure modes differently. A single head-crash on a hard disk drive is an immediate and total failure mode. SSD's can have multiple cells degrade and fail over time prior to an end-user impacting failure.

In addition to improved performance over hard drives, enterprise class SSD's have higher reliability ratings. Enterprise class SSD's are rated at 2 million hours MTBF (mean time between failure) versus enterprise class 10K & 15K RPM SAS hard drives at 1.6 million hours MTBF.

SSD vs HDD IOPS
Transactional Applications

Legend:
- 2.5" 15K SAS HDD Iops
- SSD gen 1 IOPS
- SSD Gen 2 IOPS

Categories (x-axis): Webservers..., Webservers..., Webservers..., Exchange Email..., Media Streaming..., FileServers..., Database OLTP..., QS paging..., Video on Demand..., Decision Support System..., Web server logs..., SQL logs...

Performance versus Capacity

The primary factor that affects Solid State Drive performance is the ratio of writes versus reads for customer applications. Write performance is dependent upon how often time is spent writing to the flash memory versus rewriting the flash memory. Re-writes take longer because they require the additional, slower step of first erasing the portion of flash memory that needs to be updated with new data. If no rewriting of flash memory is required for the write operation, then the data is written with much greater speed.

Dell enterprise class solid state drives incorporate the practice of over provisioning to mitigate the issue of poor re-write performance. Over provisioning provides flash capacity beyond the user addressable area in order to overcome the downfalls of SSD write performance. Over provisioning allows for the direct writing of data into the over provisioned or "hidden" blocks of space in the foreground operations . In the background , a cleanup routine of moving the data from the "hidden" area into the user are occurs.
This cleanup process of freeing up and erasing blocks occurs in the background and is managed to ensure that most writes to the drive do not require the slower erase step prior to writing to the sector. Having more "hidden" capacity in "free" blocks available to the SSD allows for significantly higher write performance.

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Typical Enterprise Performance Comparisons

The chart below show the superior performance of the Dell 25 GB SSD compared with a representative industry standard 32 GB SSD. The Dell SSD has the same native capacity as the industry standard SSD at 32GB, but has a user capacity availability of roughly 78% (25GB) in order to over provision the flash for write performance as noted above. The test data shown below is a comparison of a Dell Enterprise SSD versus an industry standard enterprise class SSD. For this test, the industry standard enterprise SSD under test is the same base model as the over provisioned Dell SSD. The test configuration is six SSD drives in a RAID 5 environment, running typical enterprise workloads at a RAID queuing depth of 16. In these comparison charts a performance improvement of 0% means that the Dell Enterprise SSD per-forms the same as the industry standard enterprise SSD. A performance improvement of 100% signifies that the Dell SSD is performing at a 100% improvement over the industry standard drive.
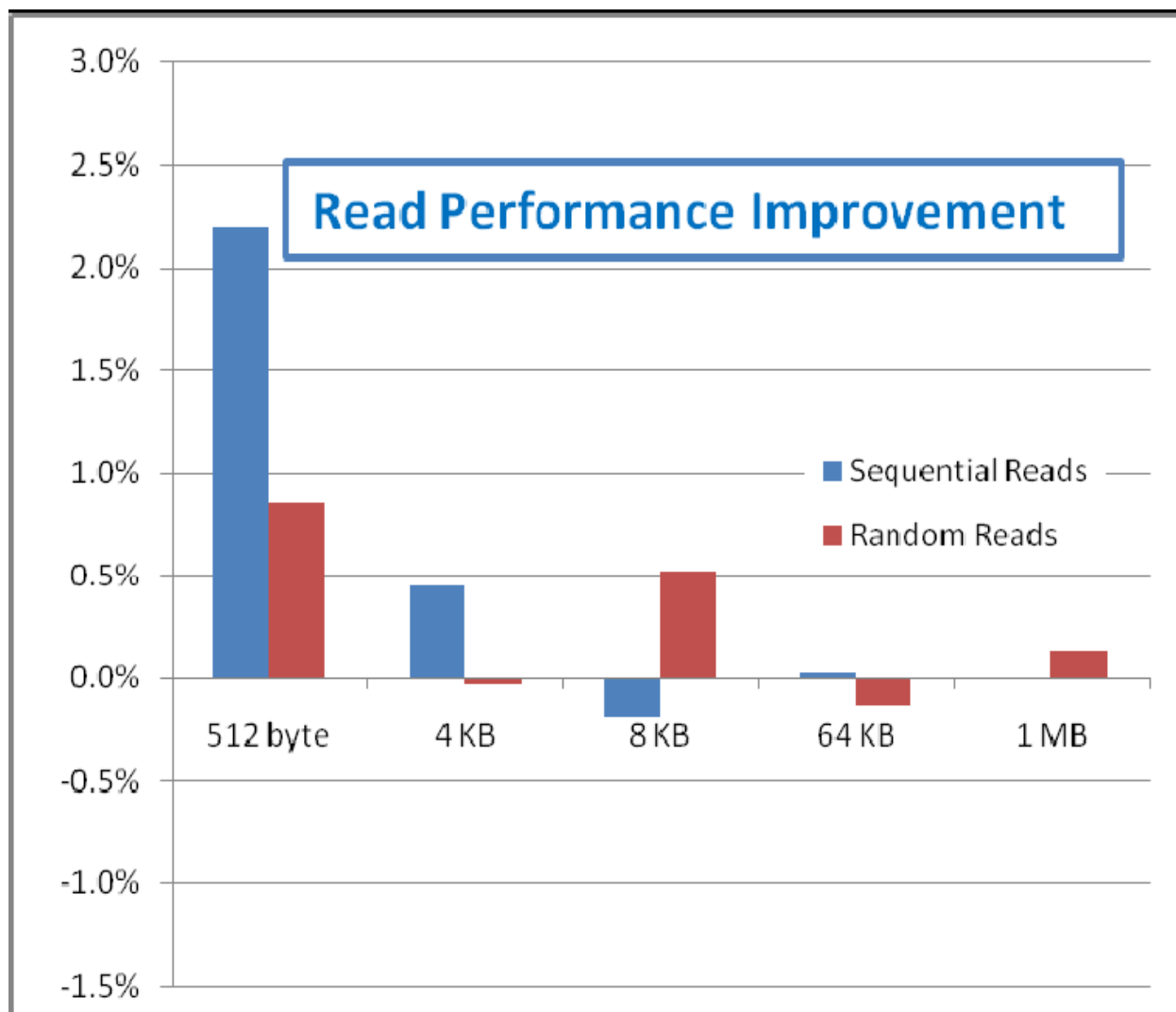
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Typical Enterprise Performance Comparisons
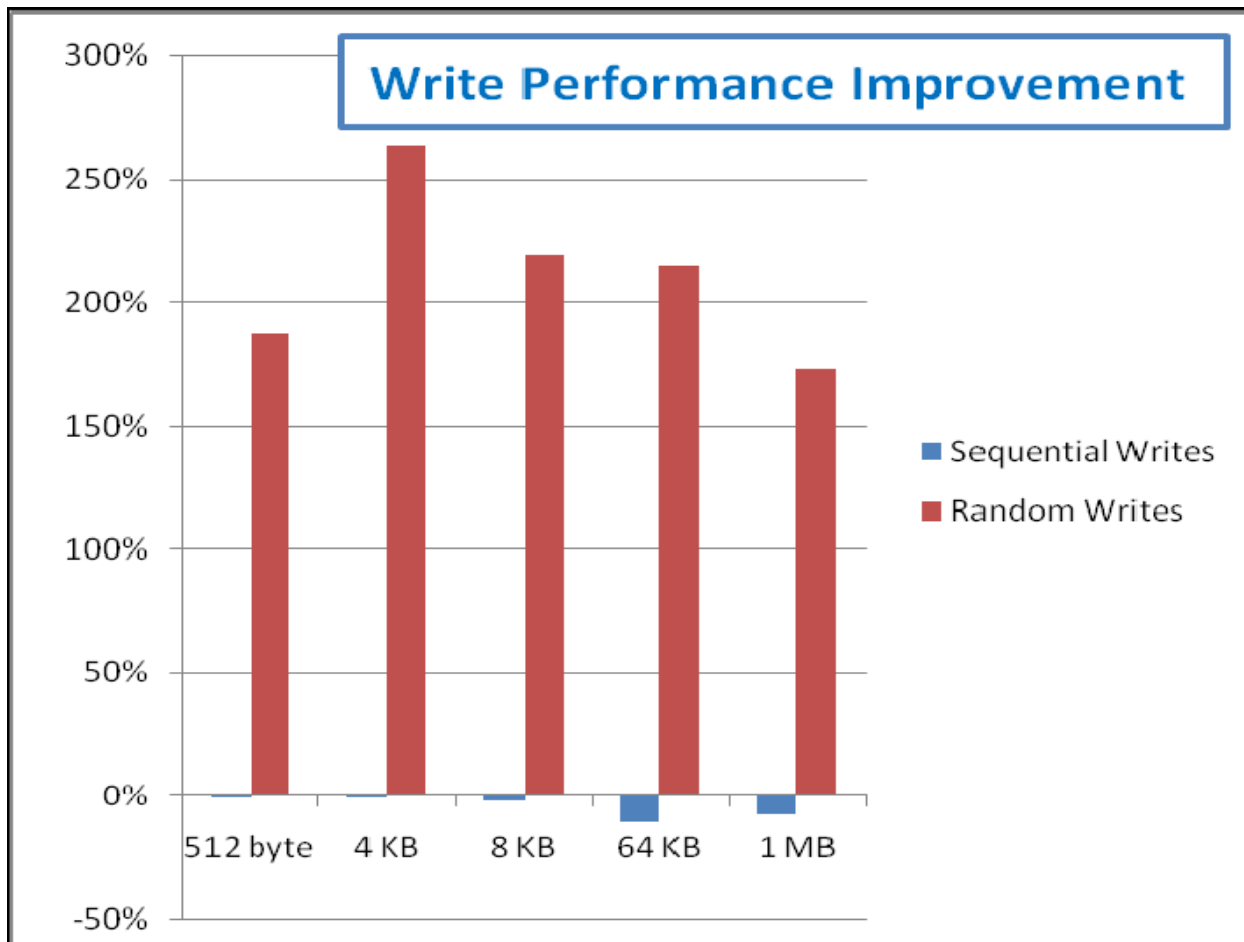
MLC versus SLC Flash within Solid State Drives: Today there are two choices for the type of NAND flash utilized within flash based Solid State Drives; SLC and MLC. SLC, or Single-Level-Cell, allows for the storage of one bit of information per NAND memory cell. MLC, or Multi-Level-Cell allow for the storage of more than one bit of information per memory cell.

MLC NAND flash is much cheaper to purchase than SLC and has the capability for much higher total capacities within the same footprint (assuming the same nanometer technology). There are some key differences that have led Dell to release our first and second generations of SSD's with SLC based NAND flash. SLC NAND flash has much higher write cycle durability at 100K writes per cell versus MLC at 5K-10K writes per cell.

Dell's Enterprise class SSD's are designed to endure a 24x7 enterprise environment which includes the potential for continuous writes. For today's SSD's, Dell chose SLC to meet the requirements of the demanding enterprise environment. Wear leveling technology is incorporated in Dell Enterprise class SSD's to further meet the demands of the enterprise by ensuring that writes are distributed across the SSD in a manner that allows for maximum lifetime. MLC based NAND flash does hold a lot of promise for future solutions and is being investigated for its potential within the enterprise.

Conclusion

Dell's Enterprise Solid State Drive technology was developed with Enterprise performance and reliability as top design requirements. Dell Enterprise SSD's over provision on flash capacity so that both read and write intensive applications benefit from SSD's. Within the enterprise, SSD's are best suited for applications that are highly random in their data requirements. SSD's are not well suited for highly sequential environments. Incorporating Dell Enterprise SSD's into targeted customer enterprise environments can save on total deployment costs by allowing hard disk drive substitution at an advantaged ratio.