Technology Paper

Solid-State Storage

Frequently Asked Questions

What is solid-state storage?

Solid-state storage (SSS) is a method of data storage accomplished by using integrated circuit devices to store data rather than moving magnetic or optical media. SSS is typically non-volatile and may take various forms, such as a solid-state drive, solid-state card or solid-state module. In addition, SSS includes PATA (legacy), SATA, SAS, Fibre Channel or PCIe interface options.

What is a solid-state drive?

Solid-state drives (SSDs) used in the enterprise are data storage devices that use non-moving flash memory technology rather than rotating magnetic discs or optical media. SSDs are compatible with traditional hard drive interfaces, such as SATA or SAS, and have a familiar hard drive form factor, such as 3.5-, 2.5- or 1.8-inch.

What is the difference between a USB flash drive and a solid-state drive?

Both USB flash drives and SSDs use NAND flash memory. However, it is the quality of NAND used — as well as the controller and interface involved — that separates a simple USB flash drive from an enterprise-class storage device, such as those found in blade servers and external storage systems.

What is flash memory?

Flash memory is non-volatile, rewritable memory. Unlike DRAM, it requires erasing blocks of data before they can be written to, resulting in a lower write performance than read performance. Flash memory supports only a finite number of writes, and the number varies according to the technology used.

Flash memory is available as NAND or NOR. SSD products use NAND flash because it is more durable, less expensive, its cells are denser, and write/erase operations are faster compared to NOR flash. NOR flash memory is designed to store the binary code of programs and has high performance in read operations.

What is NAND?

NAND is a technological description for the gate structure used to create a form of flash computer memory that can be erased and reprogrammed electrically. It is non-volatile, meaning no power is needed to keep the information stored in the chip. As of 2010, most SSD storage is made from NAND-based flash.

What is the difference between SLC and MLC NAND technology?

NAND flash uses either single-level cell (SLC) or multi-level cell (MLC) flash technology. SLC NAND stores one bit per cell and has high endurance (approximately 50,000 writes per cell). MLC NAND uses two bits per cell — delivering higher capacity — but wears out faster than SLC NAND (approximately one tenth of the endurance of SLC flash). Newer 3-bit-per-cell (approximately 1,000 supported writes) and 4-bit-per-cell (a few hundred supported writes) NAND flash are targeted for applications with a very limited number of writes.

What is DRAM?

To most end users, DRAM is memory; hard drives and NAND/SSDs are storage.

Dynamic random access memory (DRAM) is a type of random access memory that stores each bit of data in a separate capacitor within an integrated circuit. Since real capacitors leak charge, the information eventually fades unless the capacitor charge is refreshed periodically. Because of this refresh requirement, it is a dynamic memory as opposed to SRAM and other static memory.

The advantage of DRAM is its structural simplicity: only one transistor and a capacitor are required per bit, compared to four transistors in SRAM. This allows DRAM to reach very high density. Unlike flash memory, it is volatile memory since it loses its data when the power supply is removed.

How are SSDs different from hard drives?

Today's SSDs are different from hard drives when it comes to data storage. SSDs are sophisticated storage devices that use non-moving memory chips, mostly non-volatile NAND flash, instead of the rotating magnetic discs found in hard drives. Hard drives can take the data directly from the host and write it to the rotating media. By contrast, SSDs cannot write a single bit of information without first erasing and then rewriting very large blocks of data at one time (also referred to as P/E).

Because SSDs and hard drives have different strengths in terms of efficiency, they complement each other and can co-exist. SSDs deliver ultra-fast random data access (inputs-outputs per second, or IOPS, performance), low power consumption, small size and high physical resilience (due to no moving parts) — but they cost more. Hard drives provide fast sequential data access with high capacity, endurance and reliability at a much lower price.

Seagate provides both SSD and hard drive storage solutions in our enterprise portfolio.

What is wear levelling?

Wear levelling is the process used by an SSD controller to maximise the life of flash memory. This technique levels the wear across all blocks by distributing data writes across the flash memory devices.

What are the challenges facing SSD?

There are three primary concerns impacting SSD adoption in the enterprise: endurance and reliability, a lack of industry standards and high cost.

Endurance/Reliability Concerns

SSDs wear out over time. NAND flash memory can only be written a certain number of times to each block (or cell). SLC memory generally sustains 50,000 program/erase (P/E) cycles, while MLC memory is generally ten times less at 5,000 cycles. Once a block (or cell) is written to its limit, the block starts to forget what is stored and data corruption can occur. Seagate is actively developing techniques such as wear-levelling algorithms to address endurance and reliability concerns.

Lack of Standards

SSDs store data differently than hard drives do; therefore the time-tested and field-proven industry standards used by hard drives do not apply equally when working with NAND flash technology. Seagate is actively leading SSS industry standards development through organisations such as JEDEC and SNIA to advance SSD adoption in the enterprise.

High Cost

To date, the cost of SLC memory is roughly three times higher than that of MLC memory due to two factors. Firstly, MLC NAND stores two bits of data per cell and can provide twice the storage per square millimetre of silicon (the main cost of memory). Secondly, the volume of MLC is roughly 90 per cent of all NAND flash, further increasing the economies of scale in its production[1].

Today, manufacturing facilities (fabs) are focused primarily on building MLC memory. Significant investment is needed to recalibrate or build fabs that are designed to meet the quality, consistency and support levels required in the enterprise. Fabs are expensive and sophisticated operations; a 2010 estimate puts the cost of building a new fab in the billions (US dollars)[2].

[1] "Solid-State Drives: Enabling MLC Technology in the Enterprise", Report No. FI-NFL-SSD-1109, www.forward-insights.com/report14.html, November 2009.
[2] "Semiconductor fabrication plant", Wikipedia, en.wikipedia.org/wiki/Semiconductor_fabrication_plant, March 2010.

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Sources

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How does SSS impact enterprise architectures?

Solid-state storage technology requires fundamental changes to IT enterprise architectures in order to optimise performance. This impacts both the physical hardware stack (hard drives, host bus adaptors, interfaces, integration points) and the software infrastructure (operating systems, applications). While the hardware changes are beginning to hit the market now, software changes will take longer.

Additional work is needed to define and implement these architectural changes. Data lifecycle, access and usage patterns must be understood, and data storage and processing hierarchies must be re-evaluated. In addition, system throughput and latency accumulation must be recalibrated and automatic data tiering, migration and placement solutions must be developed.

What is the enterprise market opportunity for SSD, and will it overtake hard drives?

Solid-state storage is an emerging segment of the the traditional enterprise storage market. Seagate expects SSDs to be a small but very important segment of the overall enterprise storage market, which could increase over time as the technology and standards mature.

Seagate provides both SSD and hard drive storage solutions in our enterprise portfolio and will adjust the product balance to accommodate market demand as needed.

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