Introduction

Recent advances in Flash memory design and production processes have made Flash the hottest new storage technology. Now, new Flash-based solid-state drives, or SSDs, are poised to bring enhanced driver experiences to notebooks, servers, and enthusiast computers. This paper reviews the SSD architecture and its Flash memory chip, examines the benefits of Flash-based SSDs, and lists the potential users of this technology.

Architecture

Solid State Drives (SSDs) are completely interchangeable with industry standard hard disk drives. SSDs conform to the same physical dimensions as hard drives, so they can fit in the standard drive bays and enclosures used by millions of computers. And SSDs use the same Serial ATA (SATA) or IDE interface as hard drives, making them functionally identical. This 100% physical and electrical compatibility and interchangeability with hard drives makes it very easy to design SSDs into systems and storage appliances.

In short, an SSD is a storage device that is based on semiconductors rather than rotating magnetic platters. Most SSDs, including Super Talent's offerings, are based on NAND Flash chips because they are fast, highly reliable, widely available and are non-volatile, meaning they save data even without a power source.

Flash vs. DRAM

SSDs based on DRAM components are lower cost than their NAND Flash based siblings. But DRAM is volatile storage, meaning it will lose all data if the power supply is removed. In a power outage, all the data stored on a DRAM based SSD would be permanently lost. Some DRAM based SSDs get around this limitation by including built-in rechargeable batteries. The obvious disadvantages of this solution are that batteries are heavy, have a limited life, and result in a unit that is far less reliable than an SSD based on non-volatile NAND Flash components.

Flash Cost

Currently, the main disadvantage of Flash-based drives is the more cost per gigabyte than hard drives. However, Flash memory is decreasing in price around 20%-30% per year. Currently, NAND flash is sold around $8/GB and SSD is sold around $17/GB. Thus, as the price of the NAND flash chip decreases, the price of the SSD will decrease.

Flash Reliability

Flash endurance has increased due to a few techniques that have been implemented gradually in the past few years.

The write/erase mechanism in Flash causes the Silicon to wear down over time. The procedure to program Flash can be done one word (byte) at a time and the procedure to erase is done on a per-block-basis. The degradation of the semiconductor material causes Flash to have a limit of 100,000-300,000 write/erase cycles. When a block reaches this threshold, the device can become unreliable and failure can occur.

Since it only takes one block to cause the entire Flash device to fail, wear leveling is incorporated to ensure that write/erase mechanisms are evenly distributed over all blocks. The technique does not allow one block to reach this limit sooner than other blocks. For example, if block A is written to 10x times and other blocks are written to “x” times, the algorithm will stop writing to block A and will write to other blocks. Thus, this will increase the endurance of the Flash device.

Benefits

Table 1 graphically shows that Flash-based SSDs have more desired characteristics for data memory storage when evaluated against conventional rotating hard drives.

	SSD	HDD
Industry Standard Dimensions	✔	✔
Industry Standard Interface	✔	✔
Rugged / No Moving Parts	✔	
Ultra Low Power Consumption	✔	
Silent Operation	✔	
Fast Access Time	✔	
Fast Enter/Exit Hibernate	✔	
Fast Sustained Read/Write Speed	✔	✔
Light Weight	✔	
Low Cost per GB		✔
Very High Capacity		✔

Table 1: Comparative Analysis of SSD and HDD

Low Power Consumption

A major disadvantage of hard drives is the amount of power they consume. Most of the power in a hard drive is used by the motor that has to spin the disk. Faster performance in a hard drive requires faster rotational speeds of the disk, up to 10,000 rpm's for high performance hard drives. The SSD offers an enormous advantage over hard drives in power efficiency. Thanks to the lack of motors and to the efficiency of flash IC's, SSDs consume a fraction of the power a conventional hard drive demands. When idle, SSDs use about 95% less power than hard drives; and when active, 50 to 85% less power. Lower power consumption means less heat produced inside the chassis that needs to be expelled, which results in cooler components and a lighter need for chassis ventilation. And more important, in mobile computing less power means longer battery life. Furthermore, each SSD can save up to 21.9 Kilowatt-Hours of power per year compared to a hard drive, making SSDs the ultimate choice for eco-friendly computing.

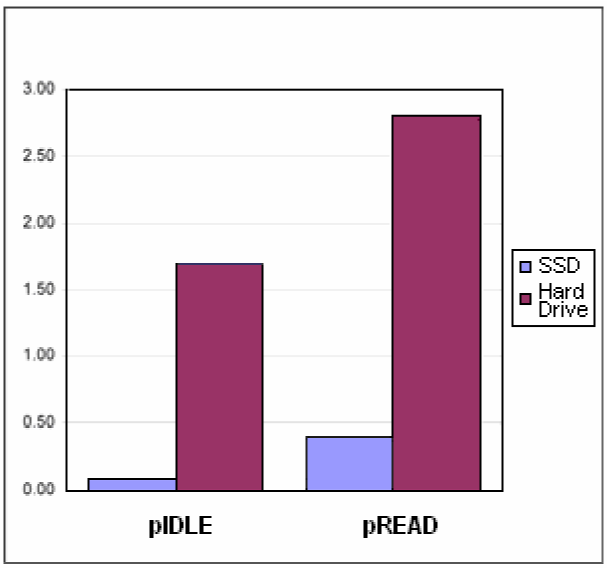

Figure 1: Typical Power Consumption in Watts

Fast Performance

Hard drives and Flash technology have very different performance characteristics. With access times in the 10-20ms range, hard drives are very slow to locate data. Flash has the advantage of lightning fast access time of 1ms or less. Therefore, SSDs are far superior to hard drives for small random reads and writes.

Hard drives are relatively fast for burst transfers of large sequential blocks of data. But the fastest SSD drives support even faster sustained read and write speeds than the fastest hard drives. High speed SSDs are the best choice for maximum throughput.

Another considerable advantage Flash has over hard drives is that they do not suffer from delay waking from sleep mode because with no moving parts, they have no need to spin down like a conventional hard drive.

	SSD	HDD
Typical Access Time	0.5ms	11ms
Sustained Read	80+ MB/sec	70 MB/sec

Table 2: Side-by-side Performance Comparison

Rugged & Reliable

Conventional hard drives use a spinning magnetic disk and a moving magnetic head to read and write data to or from the disk. This architecture requires many moving parts inside the drive including a motor to rotate the disk, the spinning disk itself, a motor to move the head across the disk, and the magnetic read/write head. Moving parts are far more vulnerable to failure than solid state components. Hard drives are a common point of failure in desktop computers. And the hard drive as a point of failure is a far more serious concern in portable computers that are subject to much more shock and vibration than a stationary desktop. Drop a laptop computer off a table and the hard drive will be one of the first things to break (we don't recommend trying this experiment at home). When a hard drive crashes, not only does the system stop working, but the data stored on the hard drive may be completely wiped out as well. Hard drives are generally not a reliable way to store important data.

Solid State Drives store data on memory IC's that are soldered onto a printed circuit board; they have no moving parts. Consequently, SSDs deliver a level of reliability in data storage that hard drives can not approach. This reliability advantage makes SSDs the preferred storage option where reliable data storage is critical. In any application that is exposed to shock or vibration the reliability offered by SSDs is vitally important.

SSDs typically support wider temperature ranges than hard drives. Industrial grade SSDs support even more extreme temperature ranges of -40°C - 85°C.

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