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# Are Flash Solid-State Disk Drives Ready for the Enterprise?

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Solid-state disks (SSDs) were originally designed in the 1980s for use as cache in real-time performance hungry applications, as well as mass storage in industrial and military systems, where immunity against shock, vibration, and extreme temperatures was required. Throughout the 1980s and 1990s, SSDs remained a relatively expensive niche product – a high-cost technology only justified for mission-critical applications such as those found in the avionics and defense industries, with few and far-in-between deployments in the IT arena.

That was then. Today we are witnessing tremendous improvements in processing technology due to increasingly complex and demanding applications. Considering the steady declines in the cost of memory, demand for SSDs in all applications has significantly increased, with most of the upward movement and new demand emerging in the enterprise market.

The two main types of SSDs are DRAM-SSDs and Flash SSDs. In the past two decades, IT managers would primarily refer to DRAM-SSDs when discussing ways to improve I/O and access time performance in various applications. However, aside from the fast sustained read/write and low latency characteristics everyone enjoyed, DRAM-SSDs also had major inherent weaknesses: these storage devices are volatile and will lose all their data unless an alternative power source is provided within 10 milliseconds. Moreover, they consume huge amounts of power and generate excessive heat due to an expensive back-up support system comprised of hard disk drives (HDDs) and batteries.

Industry analysts have been relentlessly searching for solutions to enhance the capability of SSDs to provide higher I/Os per second (IOPS) at lower latencies, while eliminating volatility and addressing power consumption/heat dissipation concerns.

On the other side of the spectrum are Flash SSDs. These storage devices are non-volatile and can retain data for up to 10 years without system power. At the heart of Flash SSDs are Flash memory chips, which consume a fraction of the power DRAM memory draws. This also amounts to less heat being generated.

What does one obtain? The holy grail of solid-state storage: no moving parts. “OK. Then why didn’t the IT world rush in and replace their DRAM system caches and SSDs with Flash SSDs?” might be a self-evident question. The fact of the matter is that, until recently, both memory types have been more expensive than what a wide array of applications could justify, while a single DRAM chip has been and still is faster

than one discrete Flash chip. How does it all add up?

## Core Applications

The SSD industry continues to evolve. Today, with high-end Flash SSD technology improving several folds, these products now offer performance comparable to that of DRAM-SSDs, while their inherent non-volatility allows them to be more compact, have higher capacities, consume considerably less power, and generate less heat than DRAM-SSDs. Most Flash SSDs now have the same 2.5-inch and 3.5-inch HDD form factors, allowing them to become literally drop-in, “plug-and-play” replacements for HDDs and be system and controller agnostic.

In terms of applications, Flash SSDs offer significantly shorter access time to stored information — similar to DRAM-SSDs — and are considerably faster than other conventional storage. The main benefits are much faster I/O operations and higher data transfer rates, primarily in random access environments. Some of the fastest performing Flash SSDs may be used to improve the transfer performance of Direct Attached Storage (DAS), Network Attached Storage (NAS) and Storage Area Network (SAN) architectures by acting as cache disk, complementing or even replacing installed HDDs.

In examining the applicability of Flash SSDs for any architecture, it is helpful to review ways that SSDs are currently being used in a number of large industries.

## ISP/ASP/E-commerce Applications

ISP, ASP, E-commerce, and networking applications typically employ the SAN or NAS architecture and generally require storage solutions to handle a significant number of transactions per second. Flash SSD significantly improves user response time when used as a read/write cache, storing “hot files” such as database indexes, journals and logs. A Flash SSD front end to SAN or NAS terabyte installation can handle the performance these applications typically require. Rather than buying additional servers to improve IOPS, an SSD is all that is needed; a storage solution with the smallest total cost of ownership.

## Financial and OLTP Applications

Financial and on-line transaction processing (OLTP) applications not only have the requirements as mentioned above but also incur significant costs due to system downtime. Again, these applications typically employ the SAN or NAS architecture. SSD is used as a read/write cache to significantly improve user response time, in addition to RAID

(Continued on page 15)

(Continued from page 14)  
 Article: Flash Solid-State Disk Drives...

systems as well as being a storage component of the RAID system. In database apps, transaction volumes are continuously growing although the files transported are rather small (2KB of data or text). Flash SSD meets all the criteria imposed by these applications and can very well be an integral part of any such storage solution.

**Price/Performance Trends**

Realizing the huge potential of Flash memory due to the growing prevalence of portable electronic devices such as PDAs, mobile phones, and digital cameras, fabs have ramped up production capacities as well as increased memory densities. As a result, price per MByte of Flash SSD is expected to fall by an average of 80.86 percent annually within a 5-year period starting 2004, according to market research firm Web-Feet Research (see Figures A and B).

As we move towards 2009, the price gap between HDDs and F-SSDs narrow significantly (a difference of about \$0.05 per MByte in 2007), while F-SSDs increase in performance over HDDs (at 100x-150x over in terms of sustained transfers and IOPS). Web-Feet Research also predicts a reduction in the F-SSD/HDD cost ratio by approximately four times, from 433:1 (\$0.078 vs. \$0.0018 per MByte) in 2003 to 107:1 (\$0.096 vs. \$0.0009 per MByte) in 2006. Flash-based SSDs will also maintain their cost-per-MByte advantage over DRAM-based SSDs.

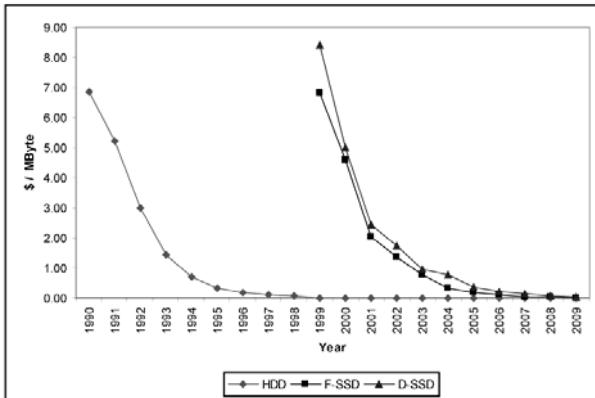


Figure A: 2.5-inch and 3.5-inch Flash-SSD, \$ / MByte  
 Source: Web-Feet Research

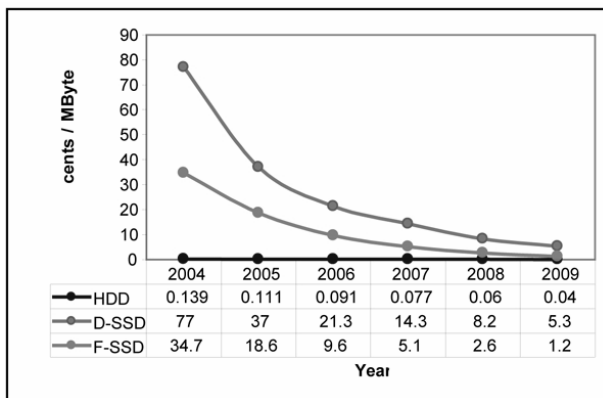


Figure B: HDD and SSD Storage Price Trend (2004-2009), cents / MByte  
 Source: Web-Feet Research

A good example of a Flash SSD is a 3.5-inch E-Disk Fibre Channel and Ultra320 SCSI series from BiTMICRO Net-

works with sustained R/W rates of up to 68 MBytes/sec and up to 10,500 random IOPS. In comparison, the fastest 3.5-inch mechanical HDD spinning at 15,000 RPM can only deliver up to 600 random IOPS. Figure C reveals that within a 20-year period, BiTMICRO's 3.5-inch Flash SSDs are expected to post more than 20x improvement in sustained random R/W rates, peaking at 1.6 GBytes/sec by 2008. Meanwhile, random IOPS is projected to peak at 240,000 (for a 3.5-inch E-Disk 10 Gbits/sec Fibre Channel) by 2008.

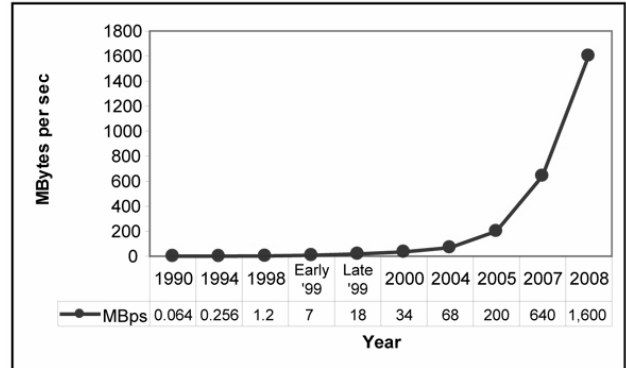


Figure C: 3.5-inch Flash-SSD Sustained Random Read/Write Rates Trend

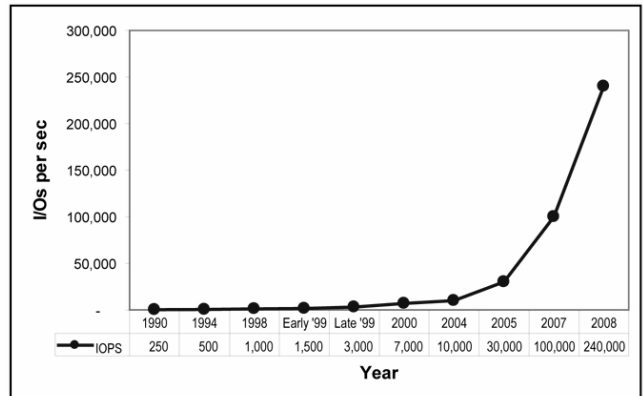


Figure D: 3.5-inch Flash-SSD Random IOPS Trend

**Conclusion**

Increasing reliability and performance requirements in military, industrial and enterprise applications are pushing data storage standards to unprecedented levels. High bandwidth, mobility, and "zero downtime" are becoming common IT must haves. As HDDs reach performance limitations, Flash SSDs are expected to play a critical role in meeting industry demand for fast, reliable yet economical data storage due to their impressive line up of inherent and built-in characteristics, as well as the continuous down spiraling cost of Flash memory.

Thanks to lower costs and much higher performance, solid-state Flash drives will become the next disruptive technology in the IT landscape, sweeping enterprise storage off its feet by providing faster access to information at a lower overall cost of ownership.

