Advancements in SSD Technology

By Gaitz Soponski and Gregory Mullin
Agenda

- Introduction to SSD Technology
- Comparison with other storage mediums (Advantages/Disadvantages)
- History and Improvements
- Modern Uses
- Future of SSD Technology
Introduction

- Solid State Drives are data storage devices with no moving mechanical components
- Usually use NAND flash memory
- Almost instant start up time (no spinning disks)
- Components of an SSD are the controller (electronics), memory, and interface
Other storage mediums

<table>
<thead>
<tr>
<th></th>
<th>Optical Disk (CD)</th>
<th>Magnetic Tape</th>
<th>DVD &amp; Blu-ray</th>
<th>Flash drive</th>
<th>Hard Drive</th>
<th>Solid State Drive</th>
<th>SD card (SDXC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit density (GBit/in²)</td>
<td>0.9</td>
<td>1.23</td>
<td>2.2 (12.5 for Blu-ray)</td>
<td>950</td>
<td>1.5 TBit/in² (1,536 GBit/in²)</td>
<td>2.8 TBit/in² (2,867 GBit/in²)</td>
<td>3.36 TBit/in² (3,441 GBit/in²)</td>
</tr>
<tr>
<td>Maximum size</td>
<td>700 MiB</td>
<td>6.0 TB</td>
<td>4.7 GB (128 for Blu-ray)</td>
<td>2TB</td>
<td>12TB</td>
<td>60TB</td>
<td>512GB</td>
</tr>
</tbody>
</table>
SSDs vs HDDs

- SSDs are typically faster, and have low startup time
- SSDs have no mechanical parts and can be more durable
- SSDs have much faster access time (.1ms vs 2.9ms)
- HDDs are cheaper per gigabyte
Comparison of Speeds

Boot-time Comparison
Maingear Tower PC
Hard Disk Drive vs. Solid-state Drive

With Seagate Barracuda 2TB, 7200 RPM HDD
82.5

With Samsung 840 EVO 250GB SSD
23.2

Seagate HDD vs. OWC SSD

- Sequential Write (4K): 199 MB/s vs. 503 MB/s
- Sequential Write (256K): 120 MB/s vs. 484 MB/s
- Sequential Read (4K): 86 MB/s vs. 183 MB/s
- Sequential Read (256K): 68 MB/s vs. 495 MB/s
- Random Write (4K): 1 MB/s vs. 340 MB/s
- Random Write (256K): 121 MB/s vs. 403 MB/s
- Random Read (4K): 1 MB/s vs. 439 MB/s
- Random Read (256K): 49 MB/s vs. 439 MB/s
Comparison of Sales

- HDDs have consistently outsold SSDs
- Recently SSD sales are rising
Origin of SSDs: Precursors

- 1950s: Magnetic Core Memory and Charged Capacitor Read-Only Storage (Used by IBM)
- Non-volatile memory
- Pre-transistor technology
- Vacuum-tube era
Origin of SSDs: First SSD on the Market

- 1976: Dataram produces the first SSD, called BULK CORE
- 19 inch long rack mount, 2 megabytes of storage
History of SSDs: Late 1970s

- In 1978 StorageTek develops the STC 4305 for use with IBM mainframe.
- Device was 7 times faster than IBM’s 2305 HDD.
- $400,000 for 45MB of storage (1.5 million today).
- Contained within a cabinet, represented an increase in SSD capacity.
History of SSDs: 1980s

- SemiDisk Systems, SanDisk, and EMC entered the market
- SSD accelerators for Intel processors
- SSDs being used mostly for RAM
- EMC developed SSDs for the mini-computer market
- 20 times faster than available hard drives
- Intel begins implementing NOR flash technology
History of SSDs: 1980s

- “Interstellar Drive” by PION in 1983
- 256KB of storage for $1095 (with inflation: $2678)
- Plugged into Apple II expansion slot
History of SSDs: The 1990s

- Flash based SSDs become popular
- Was found useful for military applications that required durability
- SunDisk/SanDisk manufactures a 20MB 2.5 inch SSD for IBM in 1991
- Price was $1788, adjusted for inflation
- In 1996 ATTO Technology’s SiliconDisk II achieves a throughput of 80 MB/s and 22,000 IOPS
History of SSDs: The 2000s

- Flash memory becomes more widespread due to digital cameras
- In 2003 Transcend develops flash SSDs to compete with hard drives
- 16MB to 512MB, prices significantly cheaper ($50)
- By 2006 SSDs had become extremely popular for use in laptops
- 41 Manufacturers are now involved in SSD production
- By 2009 SSD speed begins approaching limits of SATA connection
History of SSDs: 2010 - Current Year

- PCIe SSDs start to become popular in 2013
- 2.0 Gbit/s vs 1.5 Gbit/s with SATA
- In 2014 Samsung 2.5” SAS SSDs achieve a speed of 12Gbps
- AFA (All Flash Array) vs Hybrid approach
- In 2016 Seagate unveils 60TB SSD with 12 Gbps SAS interface
Price per MB over time

- 1977: MM-S100 - 8KB $650
- 1978: STC 4305 - 45MB, $400,000
- 1982: S-100 form factor - 512KB, $1,995
- 1991: First Flash-based SSD - 20MB, $1,000
- 2001: S35PC - 14GB, $42,000
3D NAND

- The most important SSD innovation of the last decade
- 3D NAND technology in use by Micron and Intel
- Process involves stacking memory cells vertically to increase density
- Three times increase in storage space

Intel: Ultimate SU800 - up to 1TB for $280

Micron: 1100 SATA SSD - 2TB for $570
Future of SSDs

- 3D NAND expected to become mainstream, greatly increasing SSD storage capacity
- ReRAM - Resistance based memory that some anticipate will replace NAND flash
Conclusion

- Approaching Cost of Hard drives
- Significantly better performance
- More durable than Hard drives
- High information density
- 100 Million times cheaper now compared to 1976
References

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