Better Computers with Tiered Storage

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Outline

• Background for new caching and tiering in computers
• Dual drive storage in computers—new caching and performance approaches
• Hybrid drive approaches
• Conclusions
AVERAGE $/GB FOR HDDS AND FLASH MEMORY.

Average Retail Prices of Storage

- DRAM
- Flash
- Desktop
- Mobile
- Enterprise
- 1"

Price/GB, Dollars

Year


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Historical Symbiotic Relationship Between Flash and HDDS in Consumer Apps

- Almost all consumer flash applications require HDDs
  - Music and video players
  - Cameras
- Consumer flash applications have created greater demand for HDDs
  - Downloads
  - Uploading photos and videos
  - Backup of Consumer Content

Symbiotic Combination of Flash Memory and HDDs in Computers

- HDDs suffer from a latency issue, storage capacity has grown much faster than data access speeds (GB/IOPS) have declined.
- However flash memory is much more expensive ($/GB) than HDDs.
- Can the two be combined together to give better performance at lower cost than a pure SSD?
SSD and HDD Steady State IOPS

Calypso SSD Blind Survey 2010*
Steady State RND 4KB IOPS** - 65:35 R/W Mix

* Calypso RTP 2.0 / CTS 6.5
** SNIA PTS Compliant

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Using Flash for Faster System Performance

• Flash most used in consumer applications and USB sticks
• Flash is less expensive than DRAM but a bit slower—a new cache layer?
• Is it better to use some flash or more DRAM for caching?
Hetzler’s Chasm (Cache) Analysis

Two Chasms: DRAM - SATA, SATA - Tape

S. Hetzler, IBM, Diskcon 2008
Dual Drive and Hybrid HDD Approaches

• Dual Drive/Storage Tiering
  – Marvell HyperHDD
  – Hitachi-LG HyDrive
  – Intel dual drive
  – Other companies potential dual storage products

• Hybrid solid state HDD
  – Seagate Momentus XT
Capacity Scaling - Dual Drive

- What is Dual Drive?
  - Intel® Solid-State Drive (SSD) combined with a Hard Disk Drive (HDD)
  - Intel® SSD for performance
  - HDD for capacity

- Software Configuration
  - SSD: Operating System and key applications
  - HDD: General applications and user personal data

Shahed Ameer, Intel, IDF 2010
How much SSD space do you need?

- Application-common files, Updates, and Page & Hibernate files grow boot-drive capacity

<table>
<thead>
<tr>
<th></th>
<th>Dual-Drive</th>
<th>Single-Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C: SSD</td>
<td>D: HDD</td>
</tr>
<tr>
<td>Microsoft Windows* 7 64-bit (Ultimate)</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>Page file</td>
<td>4GB (4GB DRAM)</td>
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<tr>
<td>Hiberfile</td>
<td>3.2GB (4GB DRAM)</td>
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<tr>
<td>Updates</td>
<td>1.5 – 6</td>
<td></td>
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<tr>
<td>Drivers</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Office* 2007</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Adobe Photoshop*</td>
<td>1.3</td>
<td>1.0</td>
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<tr>
<td>iTunes*</td>
<td>0.8</td>
<td></td>
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<tr>
<td>Total Disk Space used</td>
<td>25.4–29.9 GB</td>
<td>1.9 GB</td>
</tr>
</tbody>
</table>

40GB is the min size for dual drive s/w and DRAM scalability

Shahed Ameer, Intel, IDF 2010

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Implementing Dual Drives

- Dual Drive software solutions coming to market
  - Spans the drives to provide one drive letter
  - Dynamically allocates data to the SSD based on usage models to maintain performance

- Configure Libraries in Windows* OS
  - Move user data folders to HDD (Documents, Music, Pictures, Videos)
  - Once configured, seamless for end-users even with multiple drive letters
  - Maintains many performance benefits of SSDs
    - Faster boot times
    - Faster application launches
    - Fast access to OS and Common Files
  - No need for third party software or special drivers

Shahed Ameer, Intel, IDF 2010
Dual Drive Power scaling

- Power needed to complete a workload = Power efficiency
- Higher performance allows workload to complete faster
- Allowing platform to enter low power states faster

Shahed Ameer, Intel, IDF 2010

- In dual drive configuration, HDD spin down increased to ~97% of system run time
- SSD only configuration provides additional power savings

System power claim as measured by MobileMark® 2007 workload with Intel® 80GB SSD and 5400rpm HDD

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Other Possible Dual Storage/Storage Tiering Products for Computers

- Marvell HyperDrive (Software)
- SanDisk iSSD
  - BGA SATA SSD, very small form factor
  - Targeted at tablet and other mobile applications
- Other SSDs from Samsung, many others
- PCIe products (esp. for desktops and workstations)
Hybrid Flash Memory/HDD
(Seagate’s Momentus XT)

Adaptive Memory™ Learns Quickly
PCMark Vantage – HDD Score

1 2 3 4 5
Number of Iterations

8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0

• Adaptive Memory™
  – Algorithms monitor data access transactions
  – Qualified data is placed in the SSD
  – Maintains frequently used data vs. not used data

• Dynamically improves response time and application load times based on usage

• Customizes system performance to the user

• Maximizes the performance and minimizes the amount required

First user experience: "like 7200"
Second user experience: "the next level"

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Solid State Hybrid Competing Technologies

- Flash Cache Module & Dual-drive: SSD + HDD
  - Software Required: $$ / $$$

- Solid State Drive
  - No Software Required: $$$$$

- Seagate Solid State Hybrid w/Adaptive Memory™
  - No Software Required: $$

Seagate Momentus XT Introduction Presentation, 2010

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System-Level Benchmarks

SYSmark 2007 Preview

- Provide better model of end-user activity
- Scoring is highly sensitive to specific PC hardware, OS, and device drivers
  - Data presented in the chart was taken on Dell E6400 notebook, running MS Vista, with Intel graphics hardware.
- A handful of percentage points between SYSmark scores is noticeable to an end user
- Performance Comparison
  - The gain from 5400-to-7200 is similar to 7200-to-SSD
  - SSH brings a similar system performance score as SSD
- System-Level Benchmarks show SSH delivers the next tier of storage performance

Seagate Momentus XT Introduction Presentation, 2010
Hitachi-LG HyDrive
(Another Hybrid Drive)

• Combines an optical disk with flash memory drive for dual storage laptops
• Released in August 2010
• Future plans are to slim the HyDrive down and possibly shove it within a netbook, set-top box or tablet

Photo from EnGadget at Computex 2010
Conclusions

• There are latency issues with HDDs that could benefit from caching or potential dual storage approaches
  – But should this be more DRAM or flash memory?
  – Flash memory is establishing new levels in the storage/memory hierarchy
• Intel and other are promoting products that would combine some flash memory and hard disk drives to give a better user experience
• Seagate has launched a new generation of “hybrid” HDDs using flash with the HDD for adaptive memory caching
• A new generation of computers and mobile devices (e.g. tablets) will likely use dual storage or hybrid storage for better user experiences
Thanks