
# Flash Memory and HDD in Computers: Better Together

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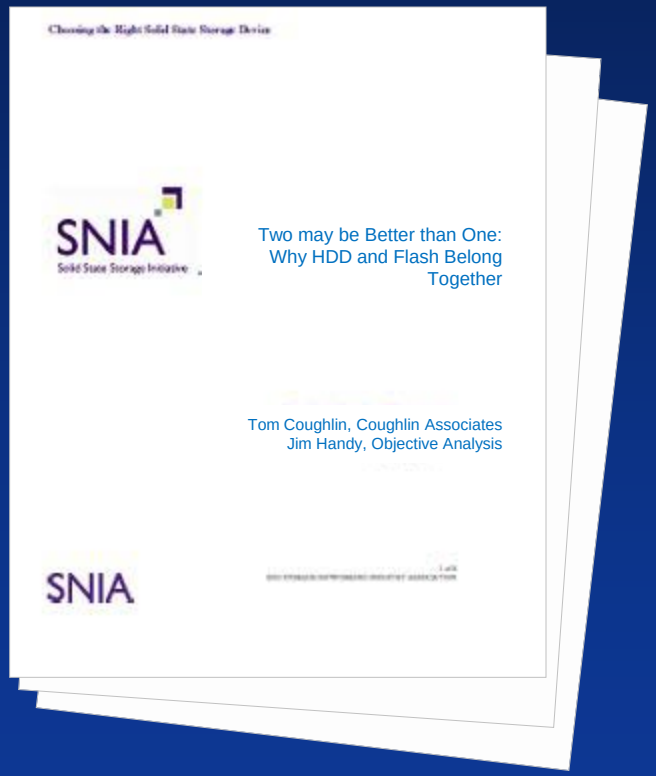
# SNIA White Paper

## Two may be Better than One:
## Why HDD and Flash Belong Together

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# Outline

- What this presentation is about
- Why flash belongs in computers
- Many ways to fit NAND into a PC
  - Hybrid Drives
  - Storage Pairing
  - NAND on the mother board
  - Other ideas
  - Manual vs. automatic data placement
- Outlook for NAND in computing
- Q & A


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# NAND Plus HDD

- NAND is finding its way into PCs
  - Faster boot
  - Faster program launch
  - Longer battery life
- Expensive compared to HDDs
  - SSDs 10-20 times the cost per GB of HDDs
- Ideal solution:
  - Performance advantages of flash memory
  - Low cost of HDDs

# What PC Users Want

- HDD-like price
- HDD-like capacity
- SSD-like speed


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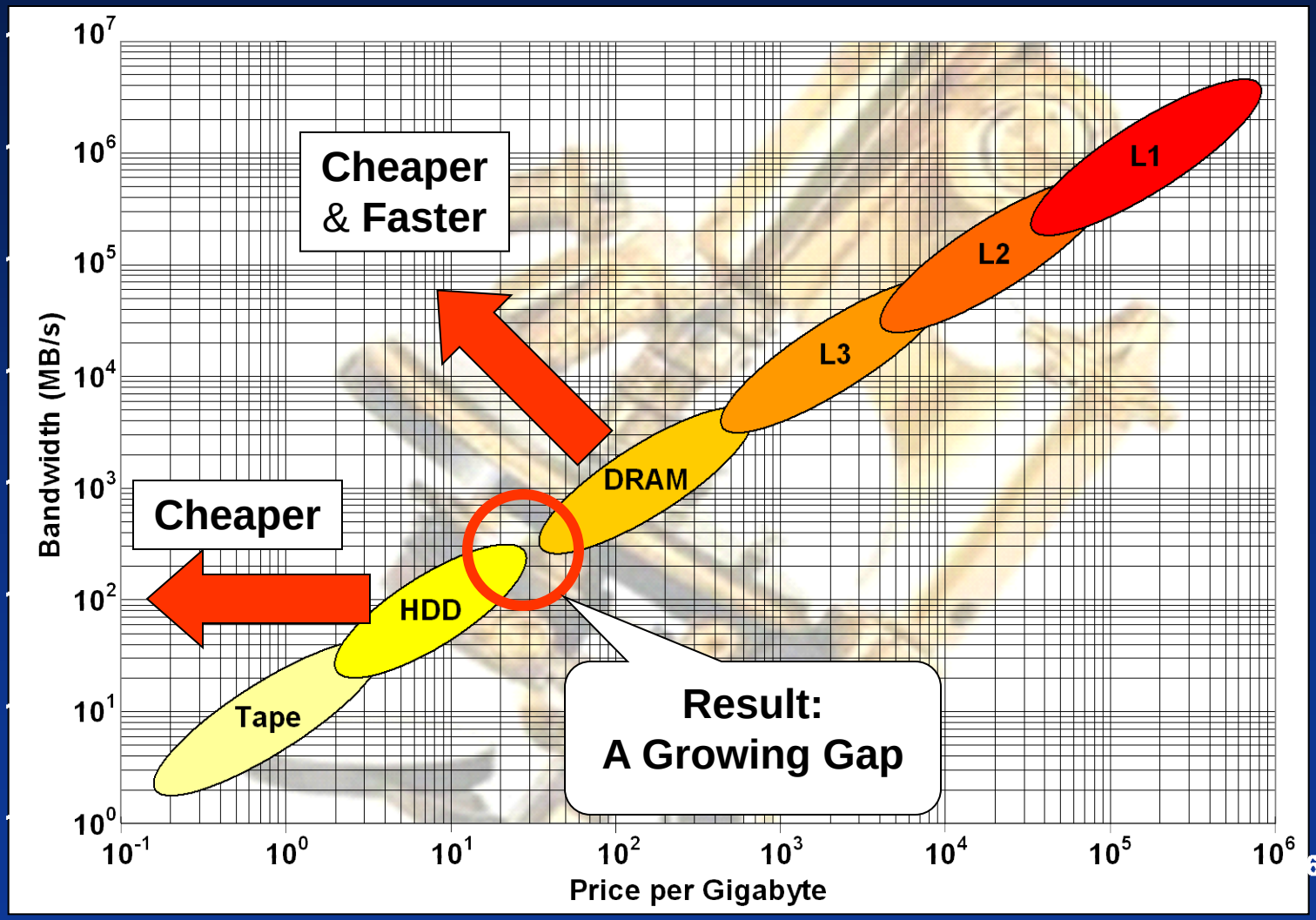
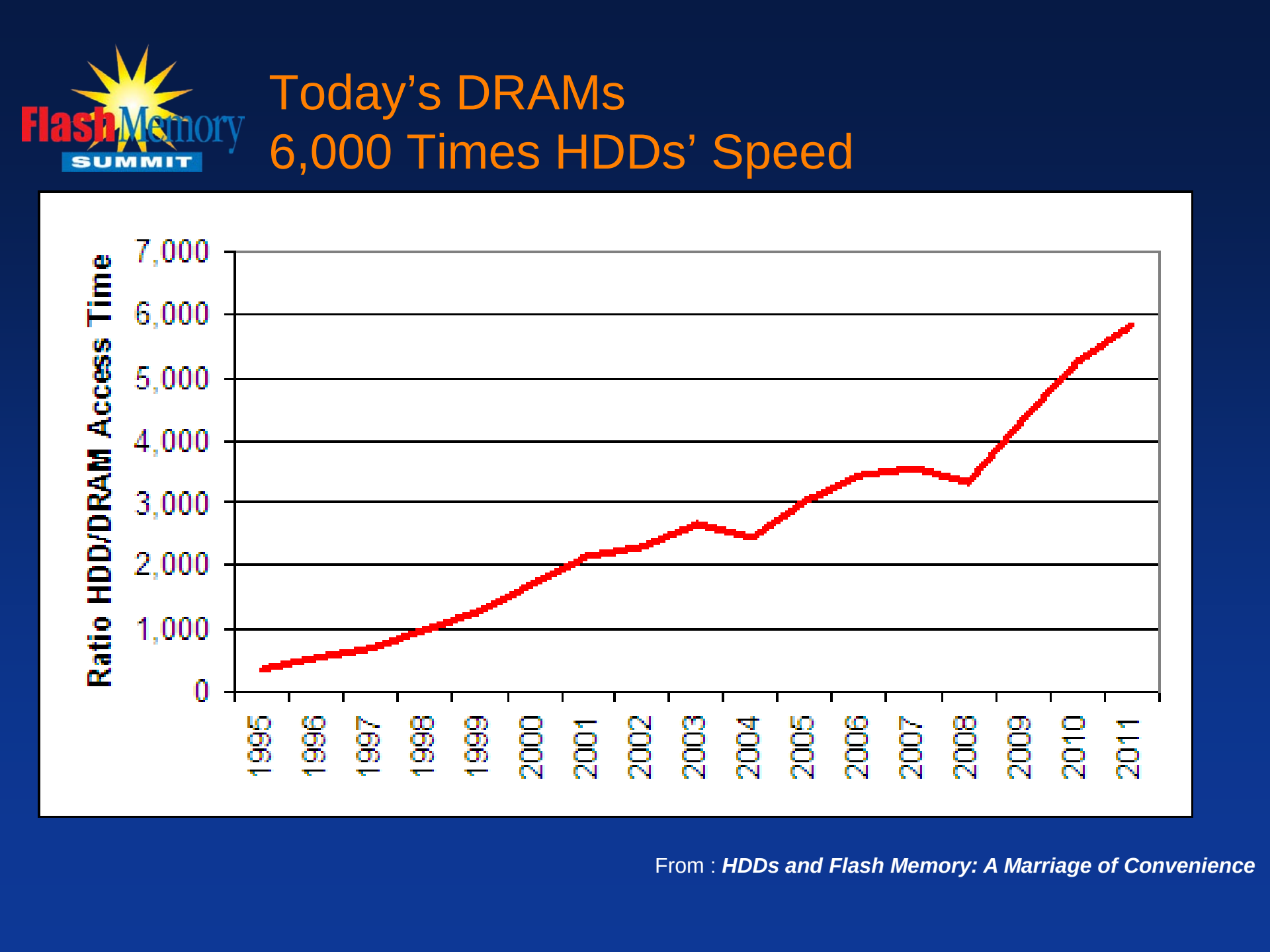
# A Gap in the Storage Hierarchy




From Objective Analysis: ***Are Hybrid Drives Finally Coming of Age?***

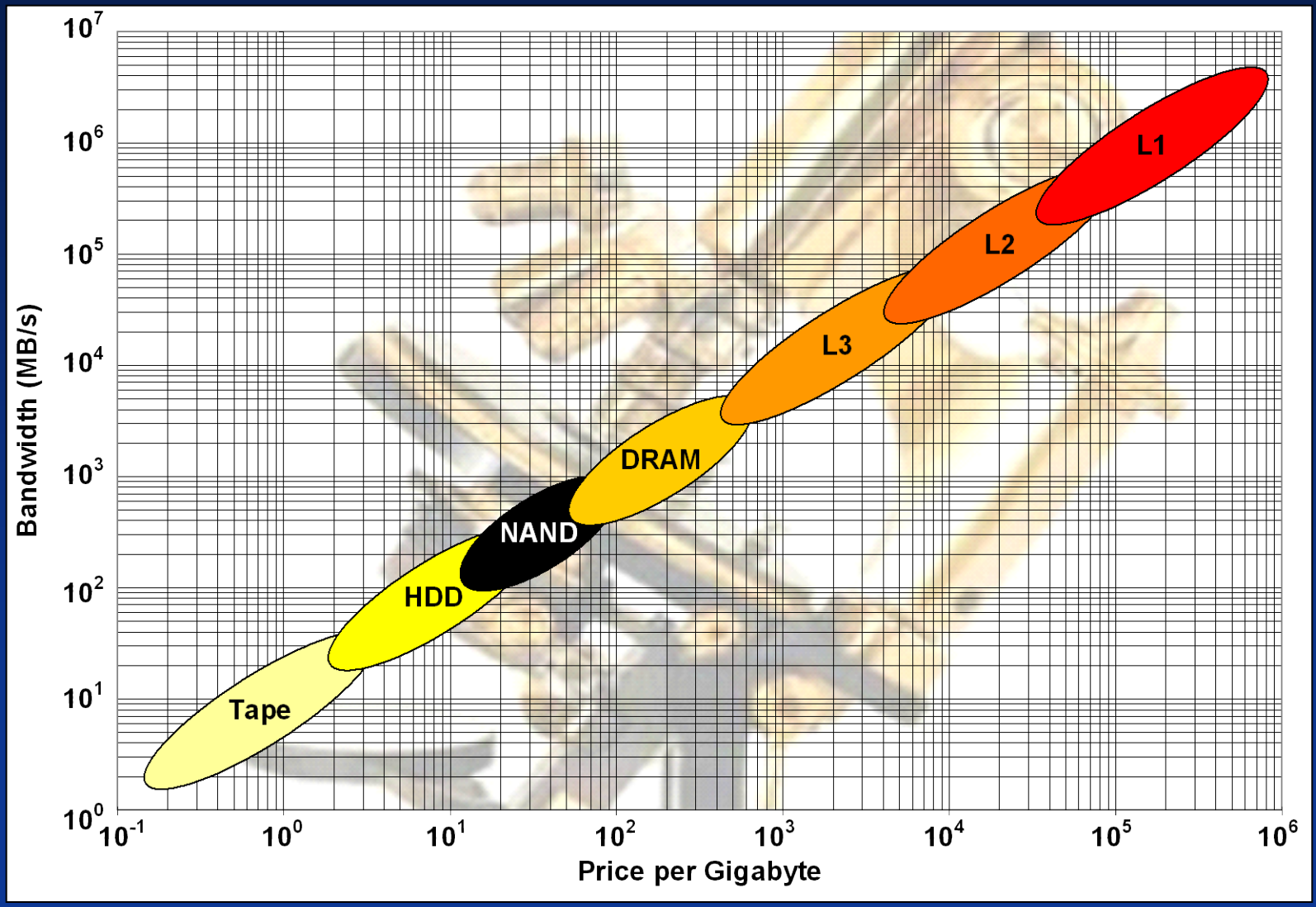



# Today's DRAMs 6,000 Times HDDs' Speed




From : ***HDDs and Flash Memory: A Marriage of Convenience***

# NAND Fills the Gap

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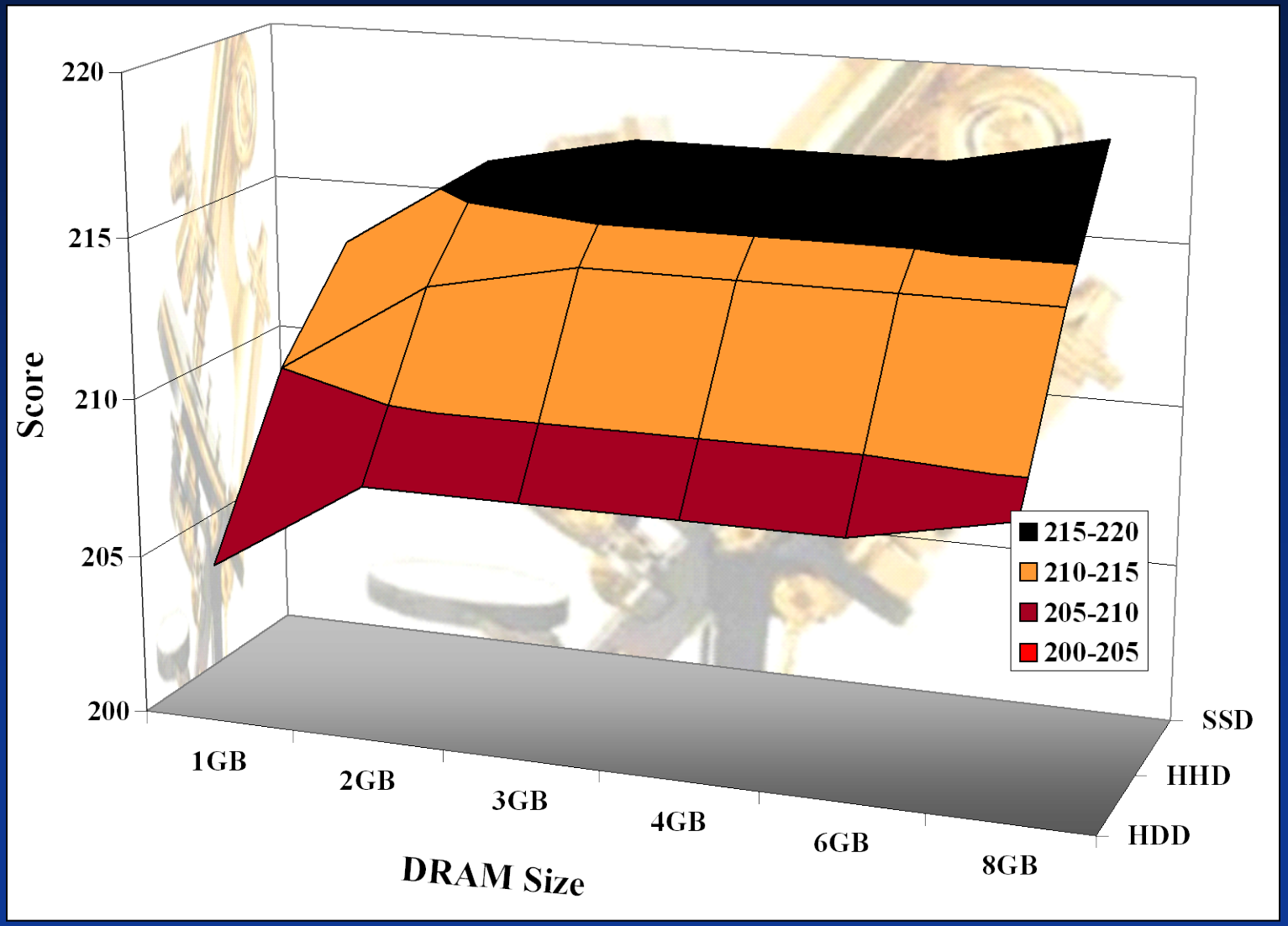
# Why Flash Fits

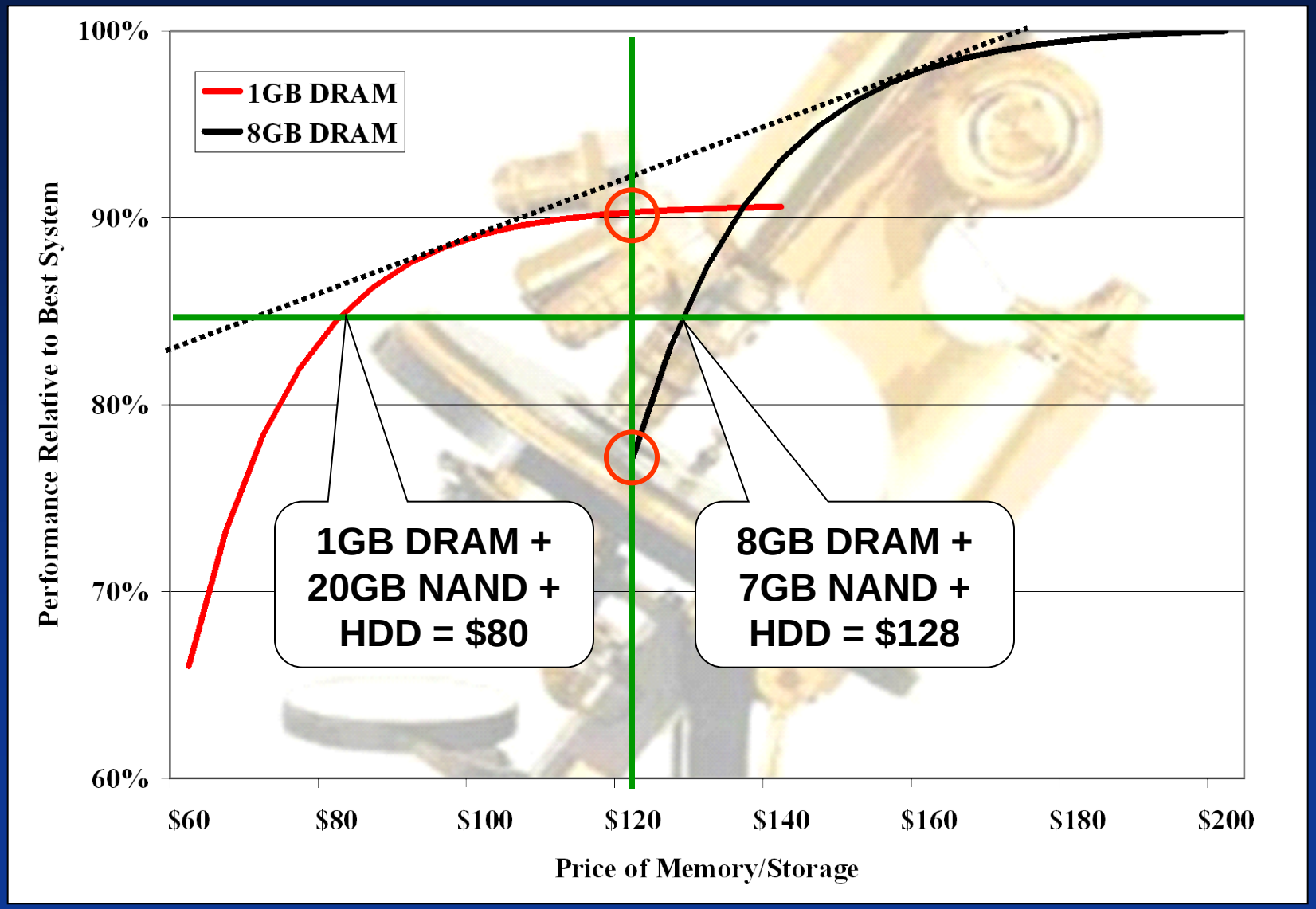
- Speed:
  - Faster than HDDs
  - Slower than DRAM
- Price ($/GB):
  - Less expensive than DRAM
  - More expensive than HDD
- Bonus: It’s nonvolatile
- Good cache or buffer for fast access of frequently used content
- Flash memory expands storage tiering options in computers

# A Tale of 300 Benchmarks




From: ***How PC NAND Will Undermine DRAM***

# Speed/Price Advantage

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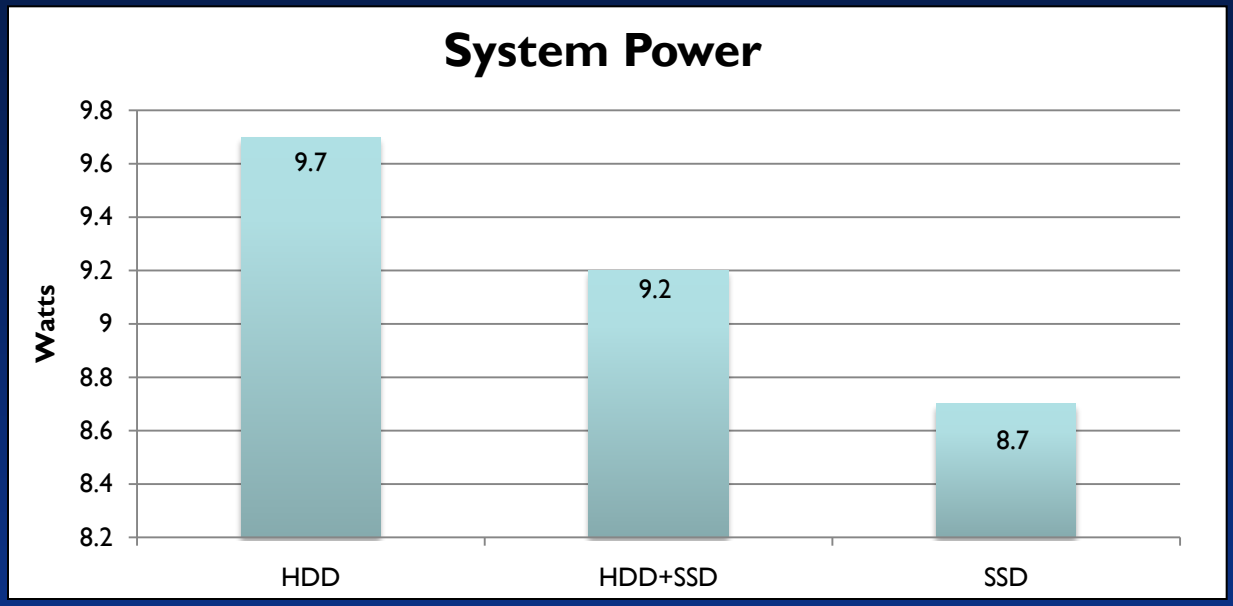
# Even Partial SSD Saves Power




- SSD-based system consumes lowest energy
- Two-drive system comes next
  - Most common files loaded onto SSD
  - All else on HDD
  - HDD spun-down ~97% of time
- HDD alone consumes most power
  - Results from Intel, MobileMark* 2007 workload, Intel® 80GB SSD vs. 5,400rpm HDD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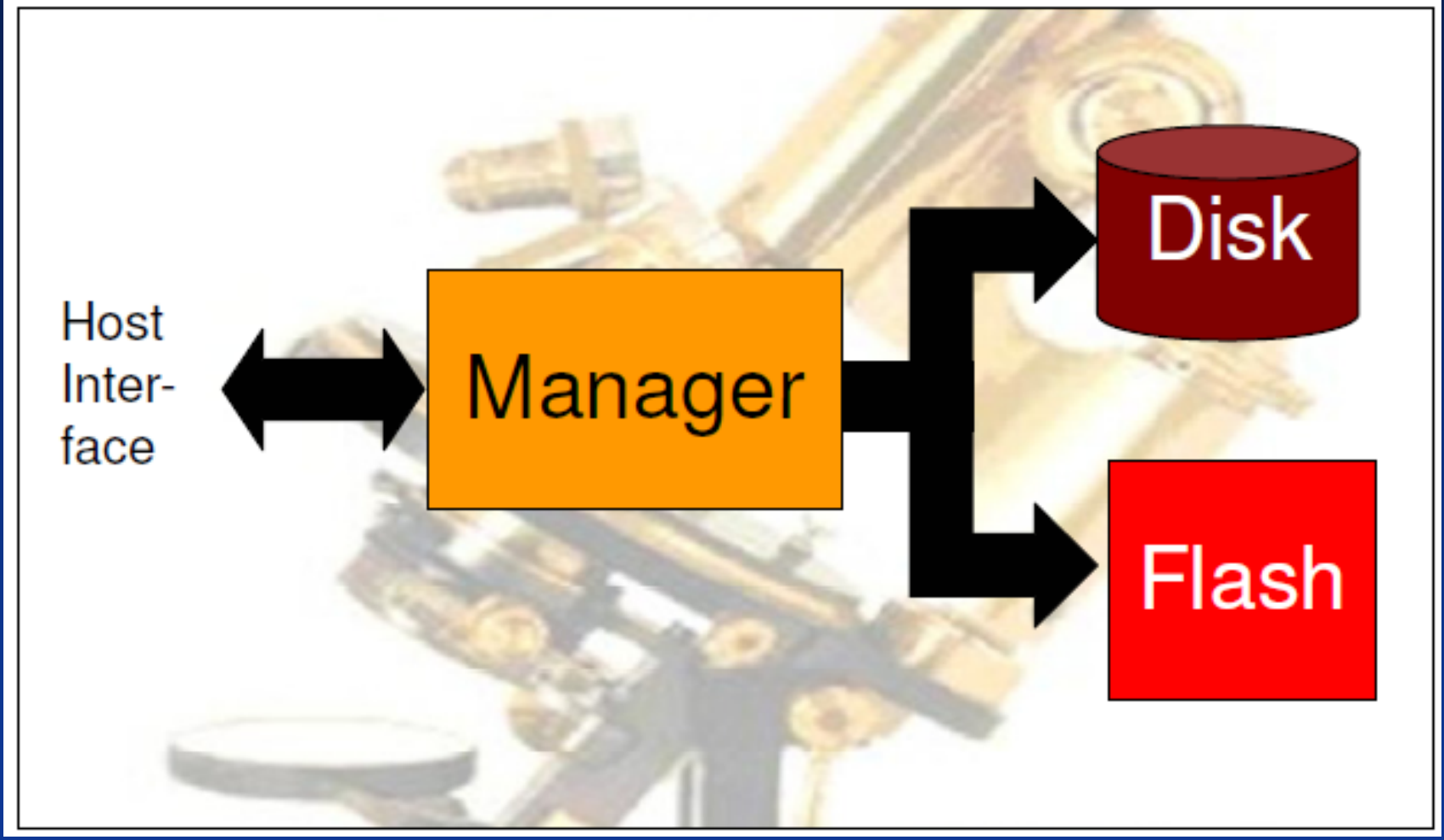
# The Hybrid HDD

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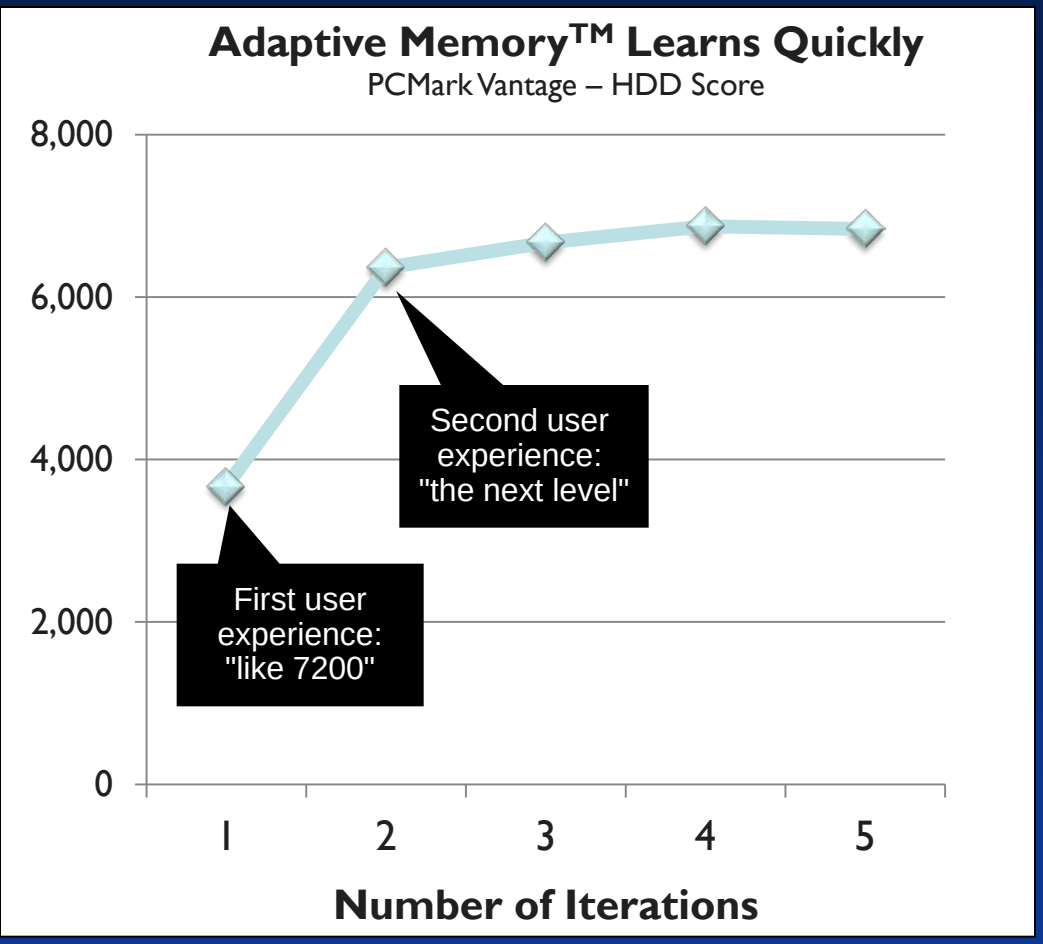
# Example Hybrid HDD
## Seagate Momentus XT

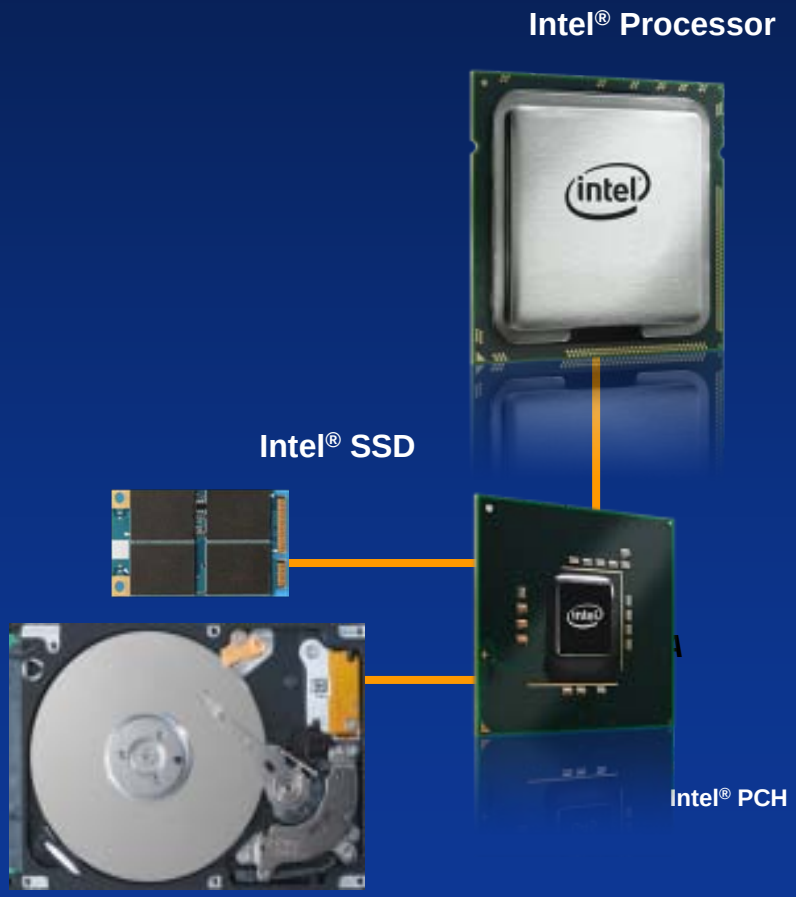



From Seagate Momentus XT Introduction Presentation, 2010

- Self-managed, independent of the OS
  - "Adaptive Memory™"
  - Algorithms monitor data access transactions
  - Qualified data is placed in the SSD
  - Maintains frequently used data
- Dynamically improves based on usage
- Customizes performance to the user
- Highest performance with least NAND

# Dual-Drive PCs

- What is a Dual Drive?
  - Small SSD plus HDD
    - SSD for performance
    - HDD for capacity
- Software manually organized
  - SSD contains the operating system and some applications
  - HDD contains other applications and personal data




Shahed Ameer, Intel, IDF 2010

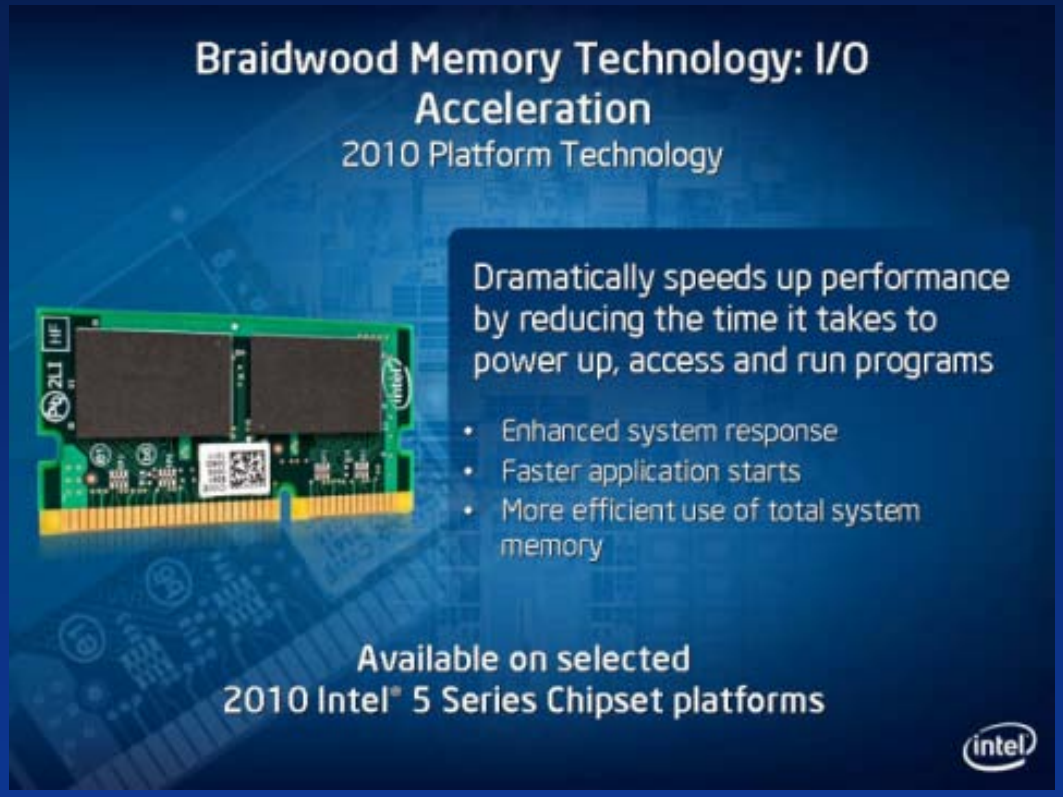

# Flash Capacity Required

| | Dual-Drive | | Single-Drive |
|---|---|---|---|
| | C: SSD | D: HDD | C: SSD |
| Microsoft Windows* 7 64-bit (Ultimate) | 13.5 | | 13.5 |
| Page file | 4GB (4GB DRAM) | | 4GB (4GB DRAM) |
| Hiberfile | 3.2GB (4GB DRAM) | | 3.2GB (4GB DRAM) |
| Updates | 1.5 – 6 | | 1.5 - 6 |
| Drivers | 0.2 | | 0.2 |
| Office* 2007 | 0.9 | 0.9 | 1.8 |
| Adobe Photoshop* | 1.3 | 1.0 | 2.3 |
| iTunes* | 0.8 | | 0.8 |
| Total Disk Space used | 25.4–29.9 GB | 1.9 GB | 27.3-31.8 GB |

***40GB is the minimum size for dual drive software and DRAM scalability***

**Shahed Ameer, Intel, IDF 2010**

# Flash on the Motherboard




## Past Failed Attempts

- Intel TurboMemory
- Intel Braidwood
  - NAND on the motherboard
  - Managed by chipset & firmware
  - SSD speeds with HDD capacities
  - Low-priced option

**This approach will resurface!**

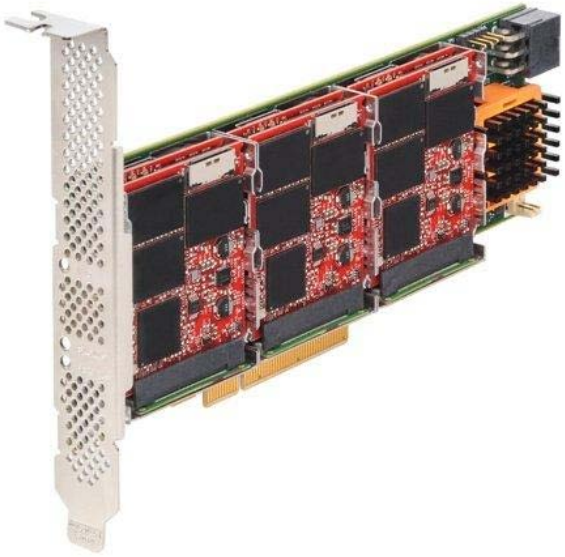
**The fundamental concept is very sound**

# PC Caching Software is Now Here!

- NVELO DataPlex
- Marvell HyperDuo
- LSI CacheCade
- Intel Smart Response
- STEC EnhanceIO
- More coming…

**Caching is very popular in the enterprise**

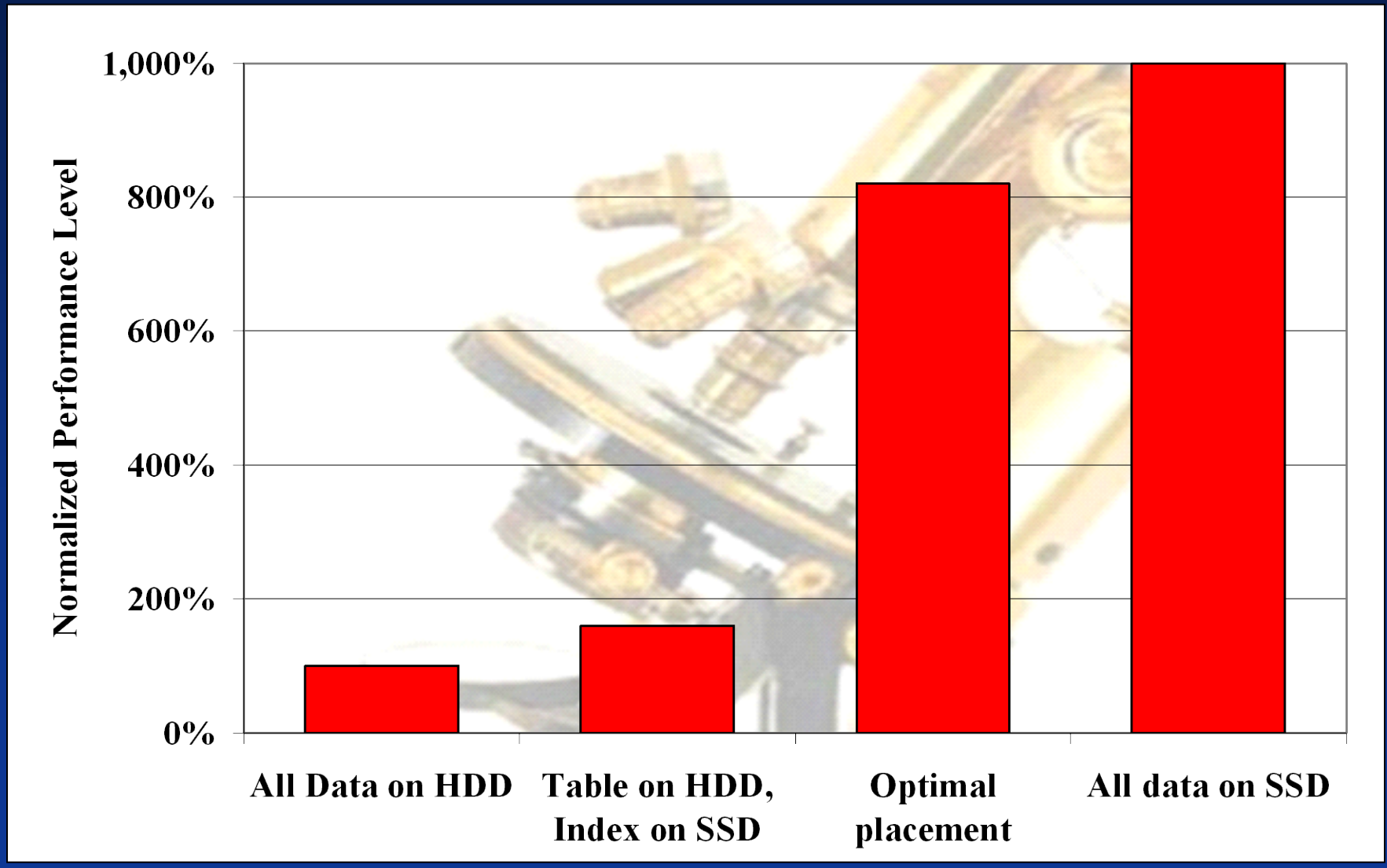





# Flash Capacity Data Points

- Seagate Momentus XT Hybrid HDD
  - 4GB
  - Automatic data placement
- NVELO recommendation
  - 16GB
  - Automatic data placement
- Intel
  - Manual data placement (from earlier slide) 40GB
  - Automatic data placement (Smart Response Technology) 20GB

# Manual vs. Automatic Data Placement




Source: IBM Corp. Used with Permission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# NAND Fits in Computers

- NAND is a layer between HDD and DRAM
  - It does not replace HDD
- It is necessary for speed
  - A key component in the memory/storage hierarchy
- All computers will have NAND soon
  - Hybrid HDDs
  - Boot drives
  - NAND on the motherboard
  - Other places?
- Result: Strong NAND growth in Data Processing


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# Thank You!

Thomas Coughlin
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Tom Coughlin, President, Coughlin Associates is a highly-respected storage analyst and consultant with over 30 years in the data storage industry in engineering and management at high profile companies.

Jim Handy
Objective Analysis

Jim Handy is a widely recognized semiconductor analyst, has over 30 years in the electronics industry. His background includes marketing and design positions at market-leading suppliers.


# Source Material

- ***HDDs and Flash Memory:  A Marriage of Convenience***, Coughlin Associates and Objective Analysis, 2011 (www.tomcoughlin.com/techpapers)
- ***Are Hybrid Drives Finally coming of Age?***, Objective Analysis, 2010 (Objective-Analysis.com)
- ***Two may be Better than One: Why HDD and Flash Belong Together***, Tom Coughlin and Jim Handy, SNIA SSSI White Paper, 2010 (www.SNIA.org)
- ***How PC NAND Will Undermine DRAM***, Objective Analysis, 2011 (Objective-Analysis.com)