Flash Memory & HDD in Computers: Better 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
- Question/Answer Session

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NAND Plus HDD

- NAND is finding its way into PCs
  - Faster boot
  - Faster program launch
  - Longer battery life
- NAND is 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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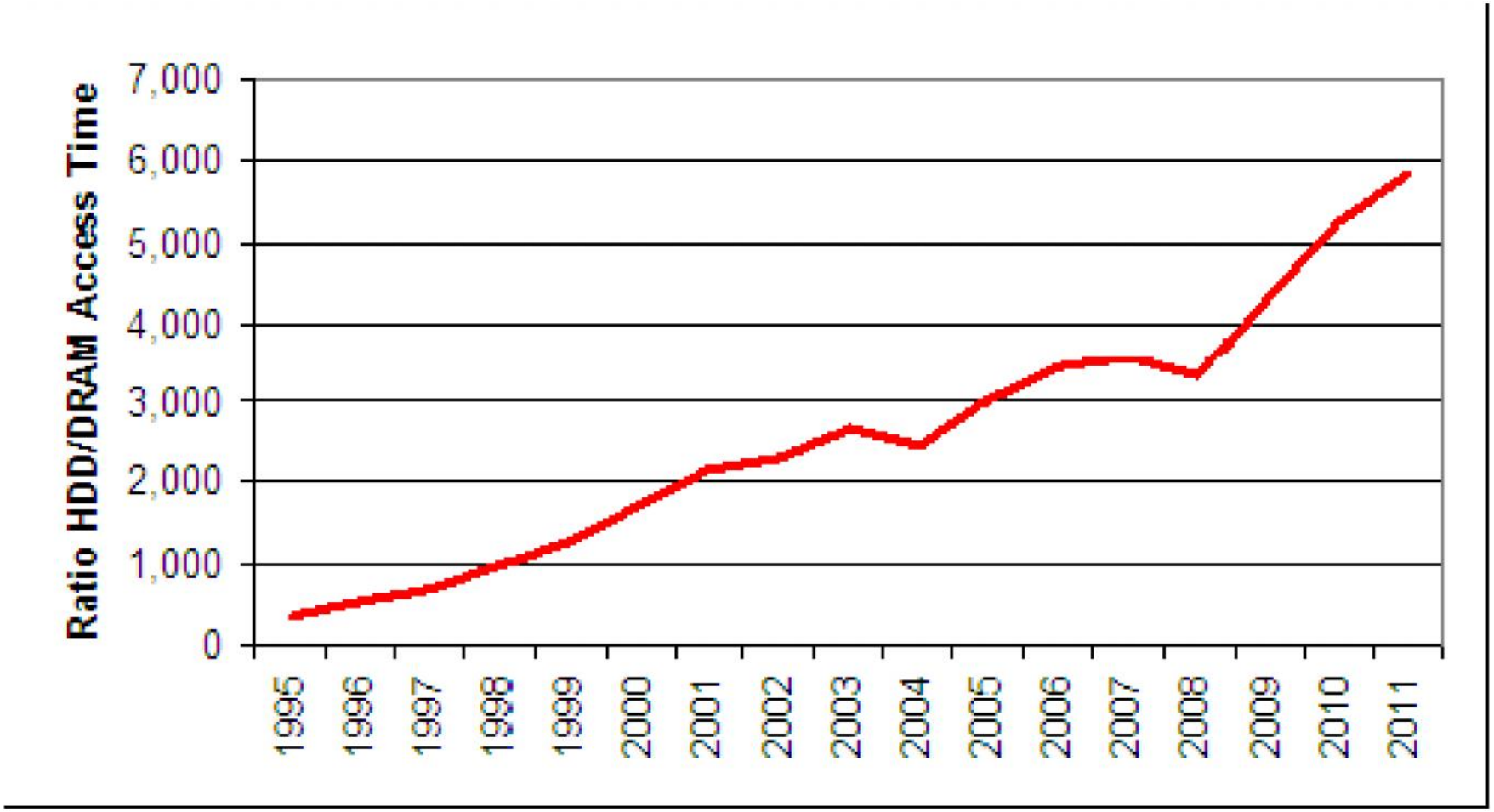
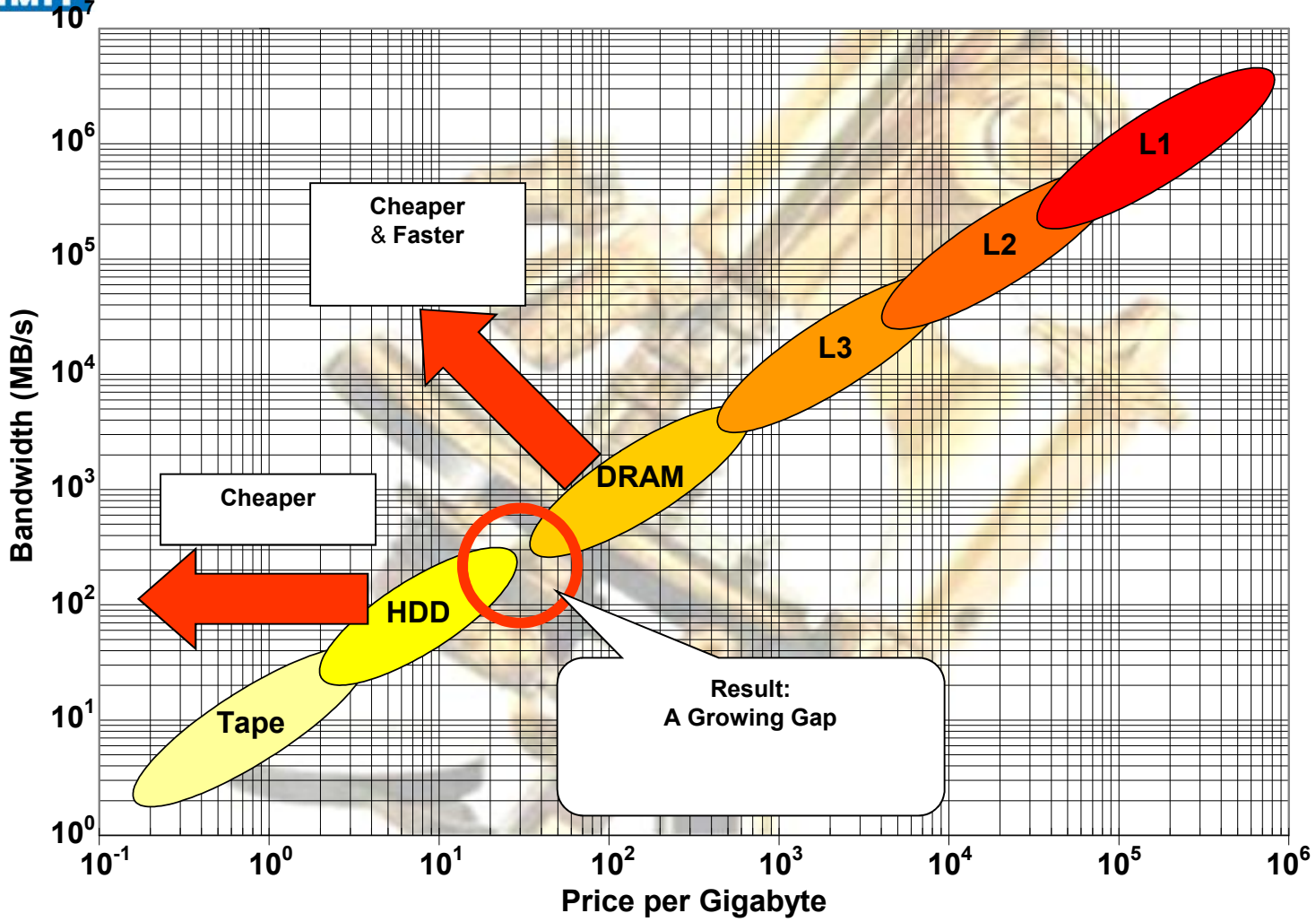
Today's DRAMs
6,000 Times HDDs' Speed



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

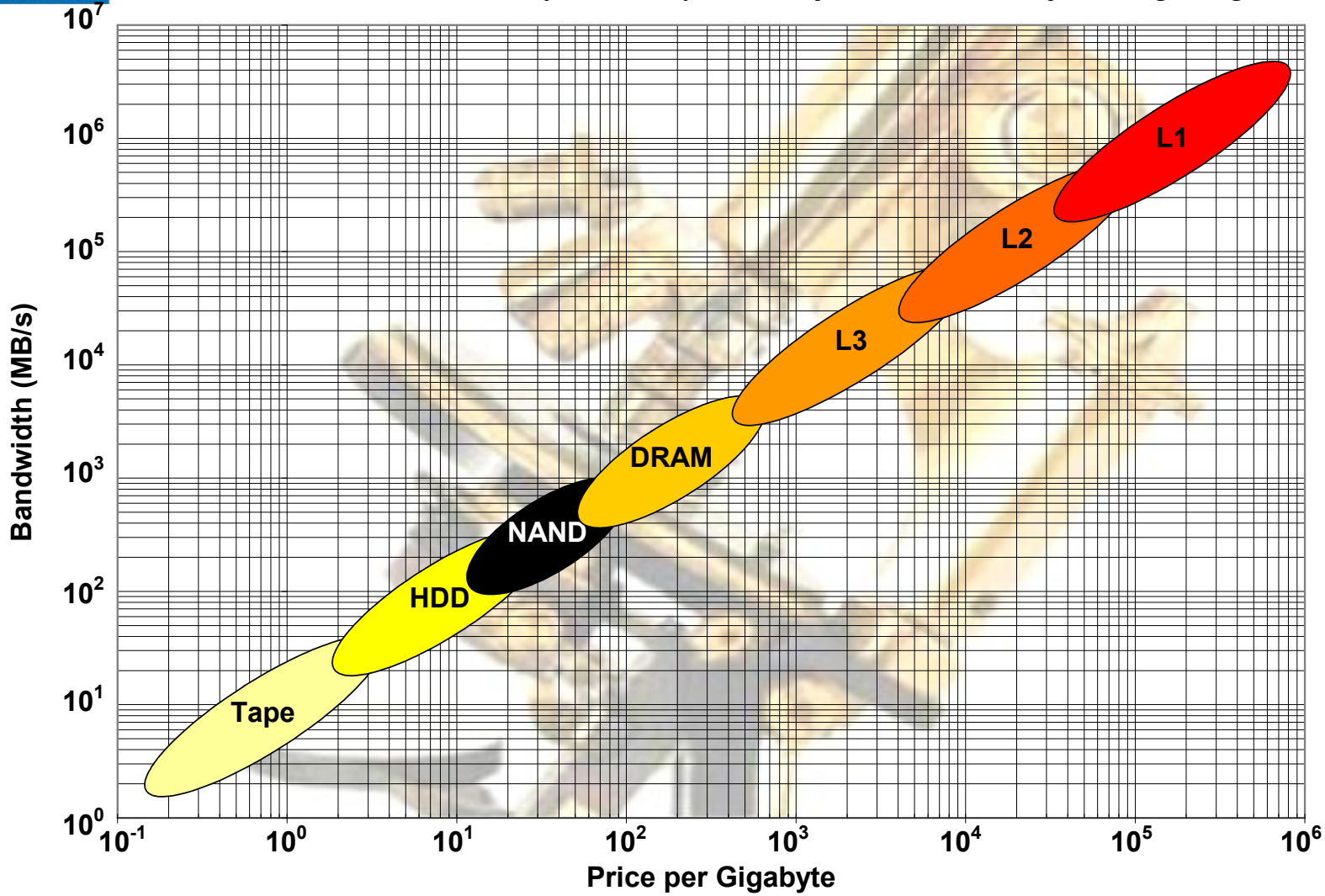
A Gap in the Storage Hierarchy

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



NAND Fills the Gap

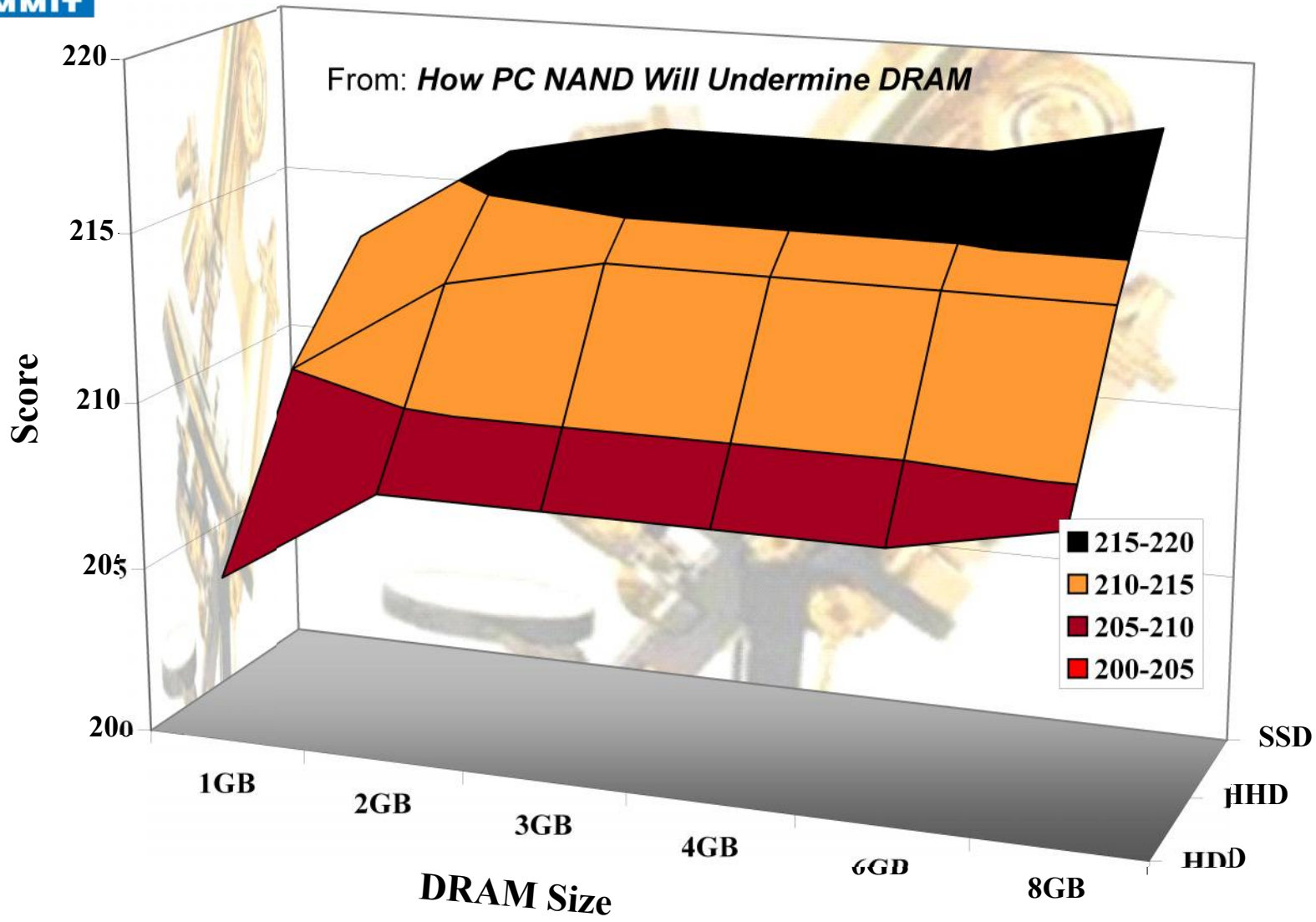
From Objective Analysis: ***Are Hybrid Drives Finally Coming of Age?***



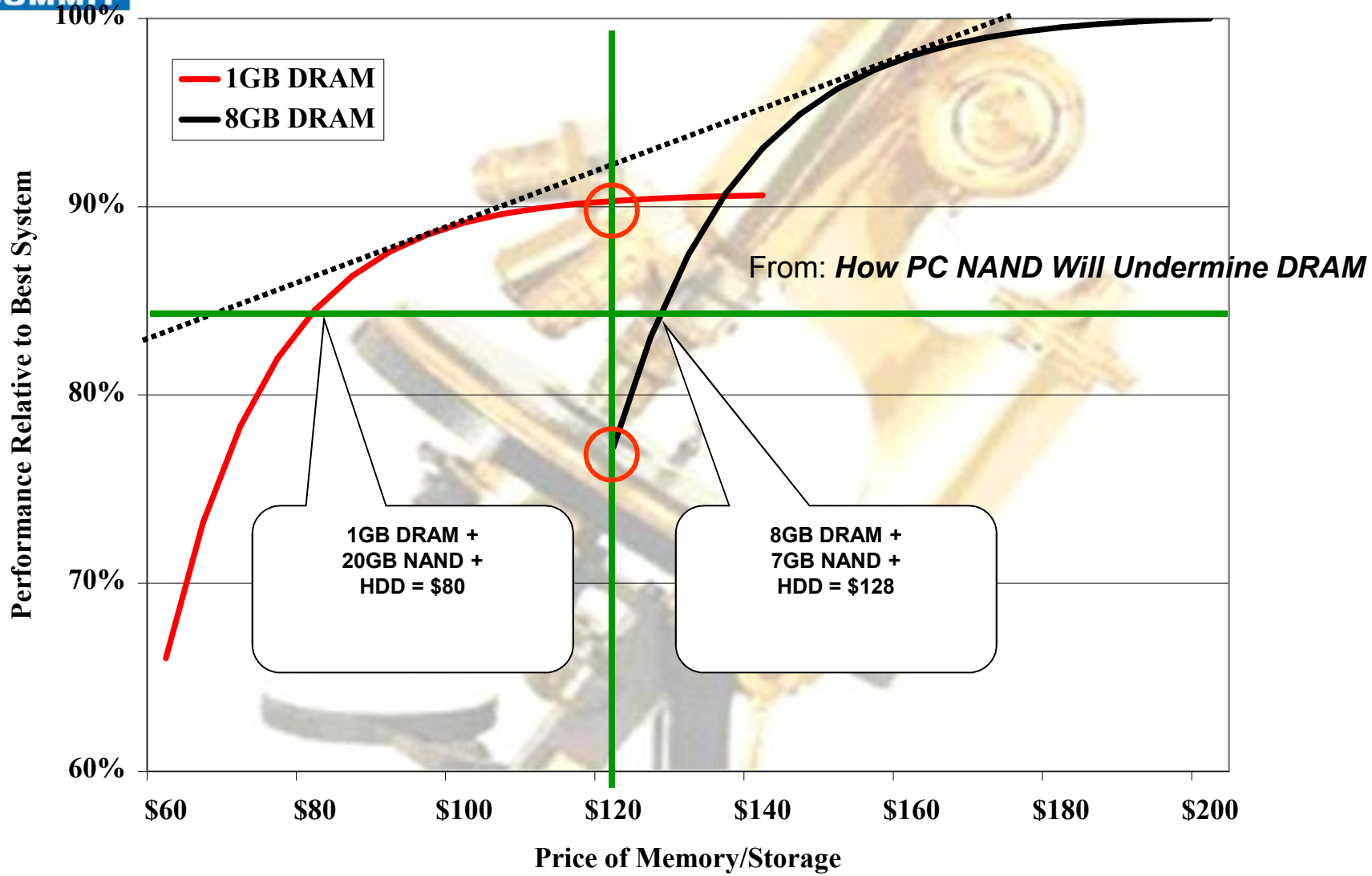
Why Flash Fits

- 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

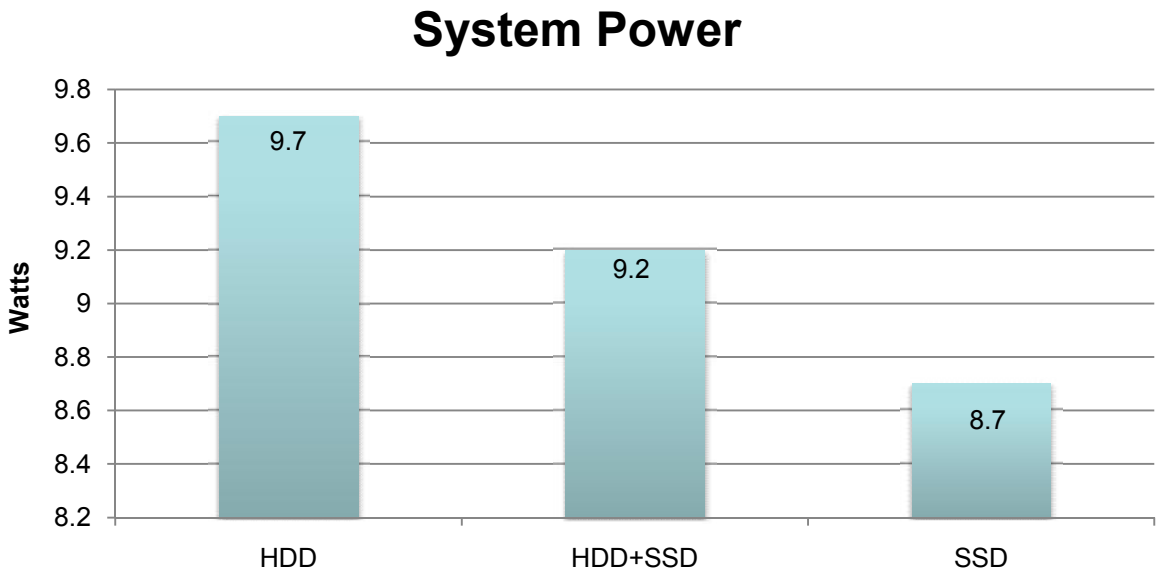


Speed/Price Advantage



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

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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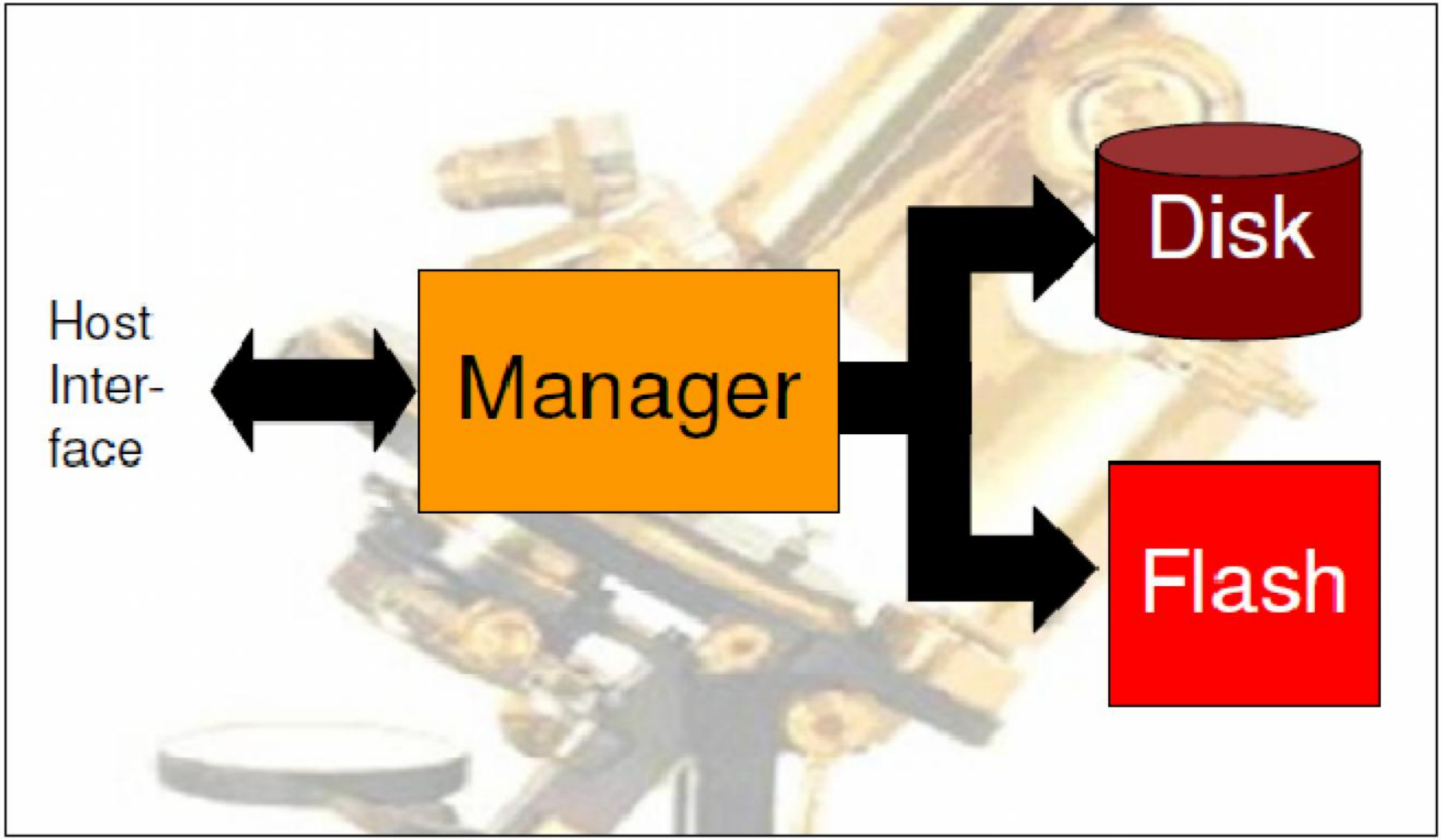
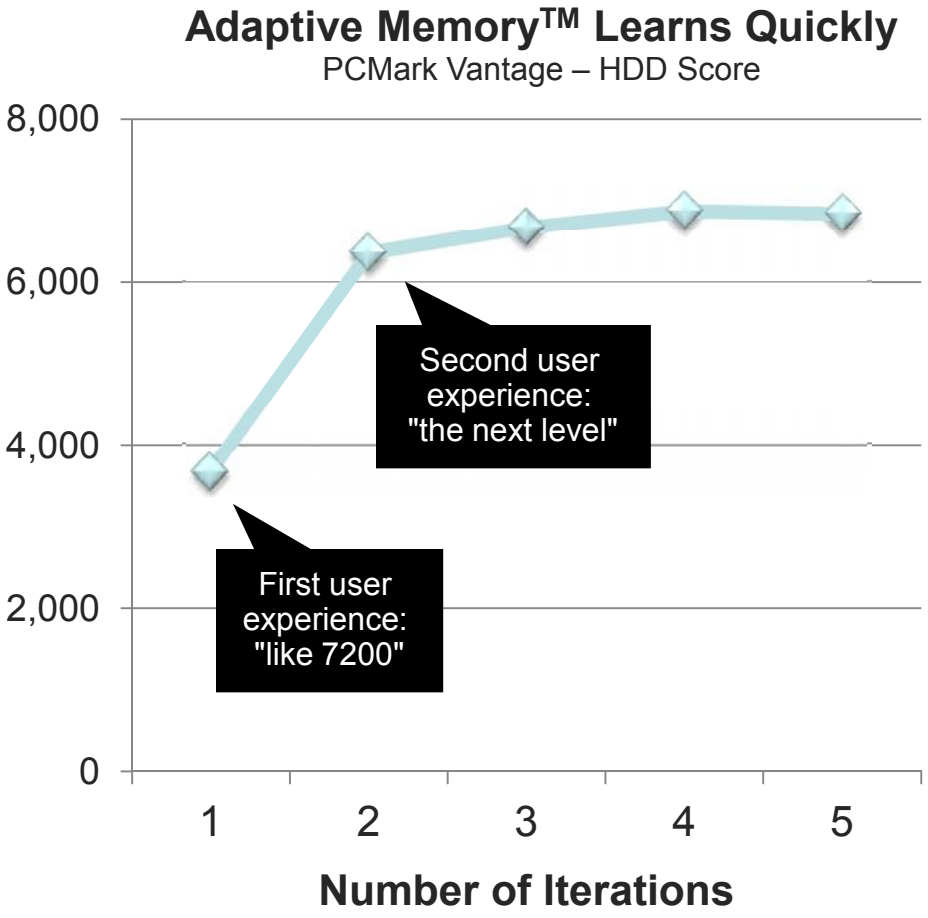
The Hybrid HDD



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

Example Hybrid HDD
Seagate Momentus XT

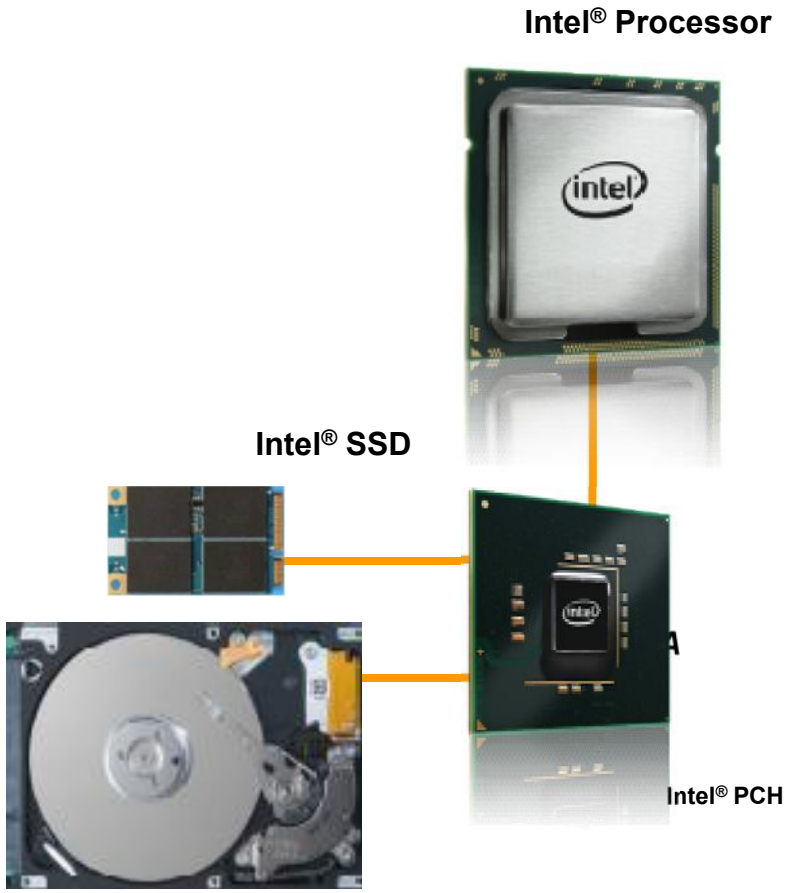


From Seagate Momentus XT Introduction Presentation, 2010

- 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



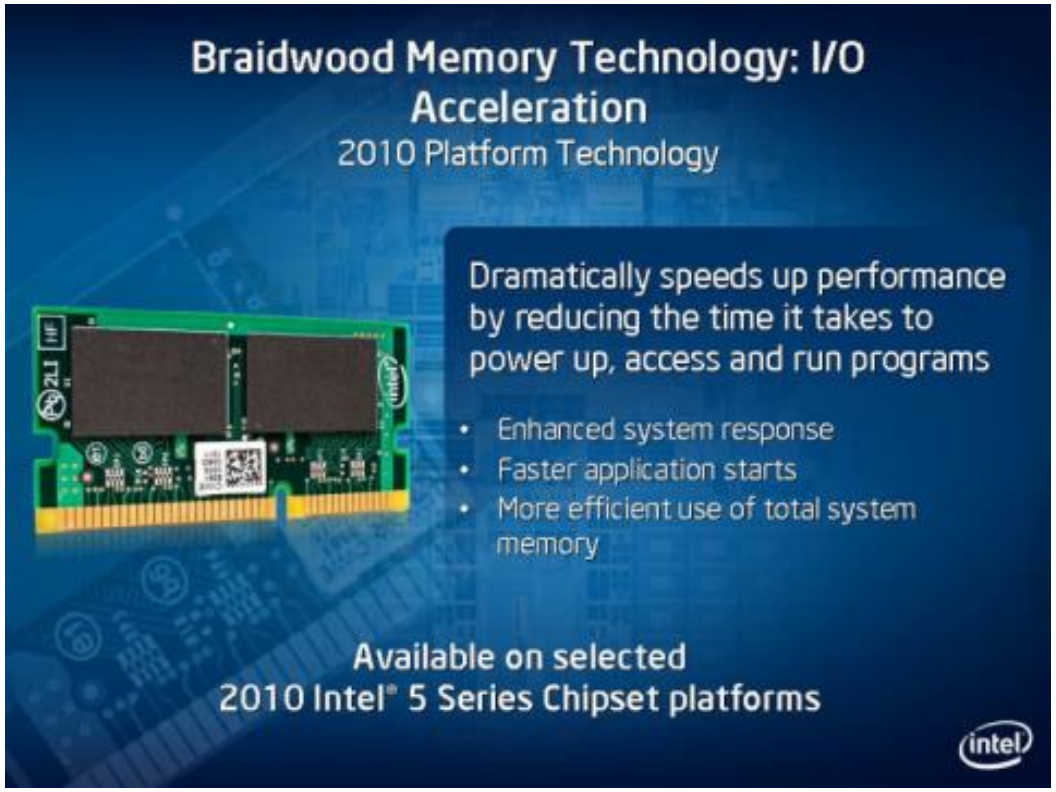
Shahed Ameer, Intel, IDF 2010

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

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 good

Other Paired Storage Products

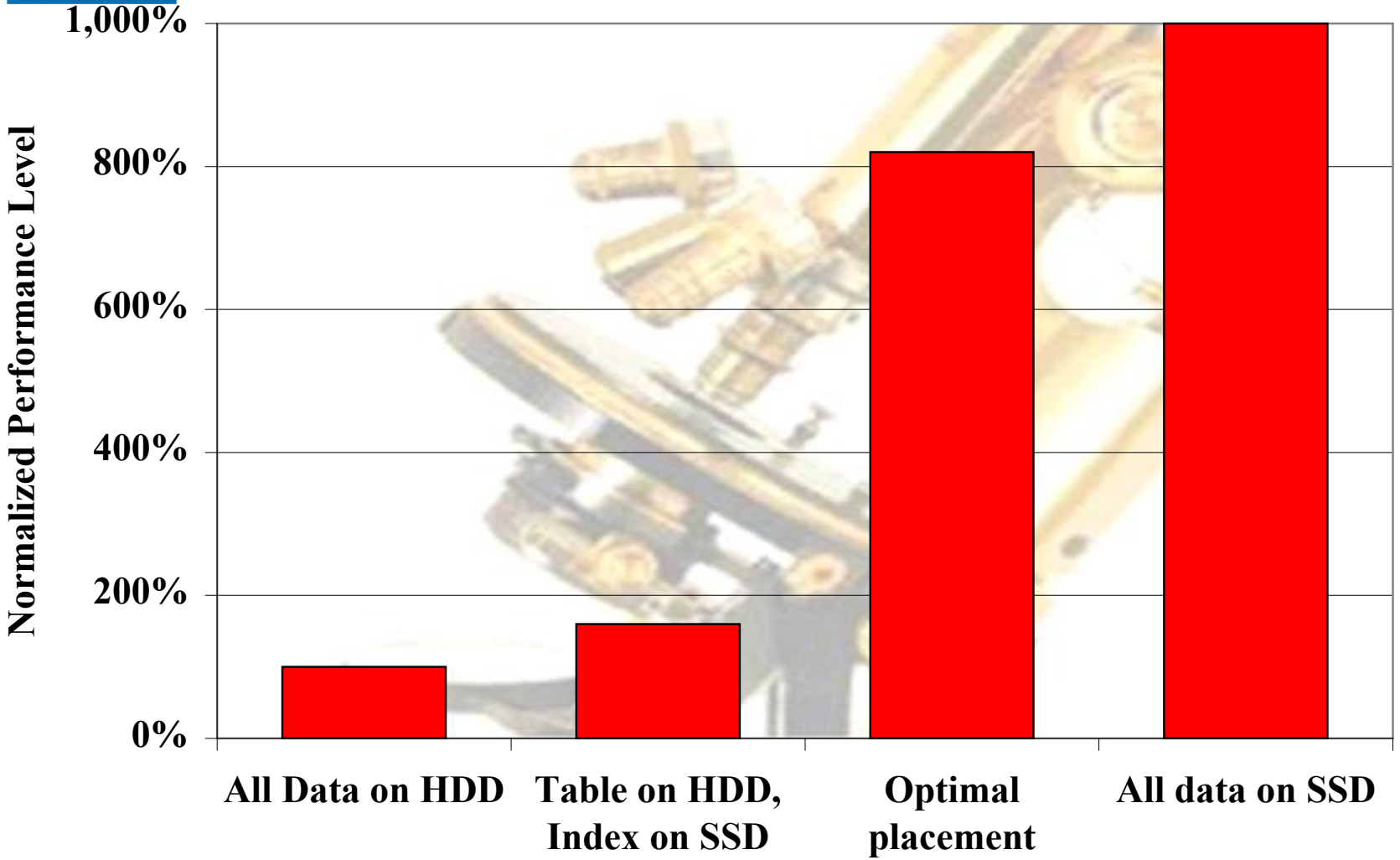
- Marvell HyperDrive
- LSI CacheCade
- Intel Smart Response
- Other SSDs from Samsung, many others
- PCIe products

Caching is very popular in enterprise applications

Flash Capacity Data Points

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

Manual vs. Automated 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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Source Material

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