



Flash Memory & HDD in Computers: Better Together

Jim Handy, Objective Analysis

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The logo for Flash Memory Summit features a stylized yellow sunburst with multiple rays. Below the sunburst, the word "Flash" is written in red, "Memory" in black, and "SUMMIT" in white on a blue rectangular background.

Flash Memory Summit 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

An advertisement for a Lenovo laptop. The ad features the Lenovo logo in blue, the text "AMD ATHLON II PROCESSOR" in black, and a list of specifications: "15.6" Display", "3GB RAM, 160GB HD", "Windows 7 Home Premium", and "Limit 1". The price "\$349⁹⁹" is displayed in large black font. A black laptop is shown on the right with a green and blue screen displaying "15.6\"/>

lenovo

AMD ATHLON II PROCESSOR

- 15.6" Display
- 3GB RAM, 160GB HD
- Windows 7 Home Premium
- Limit 1

\$349⁹⁹

#6249880

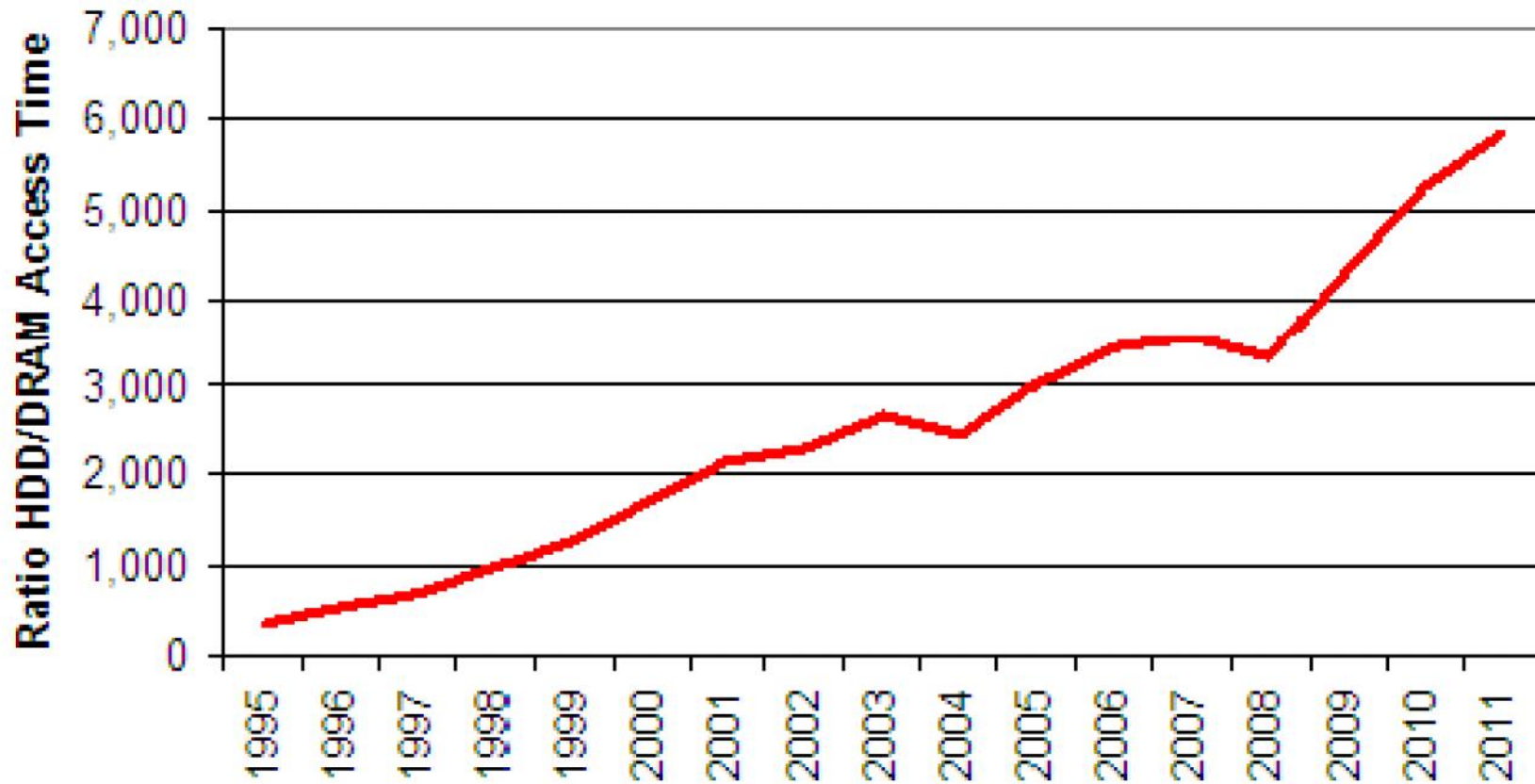


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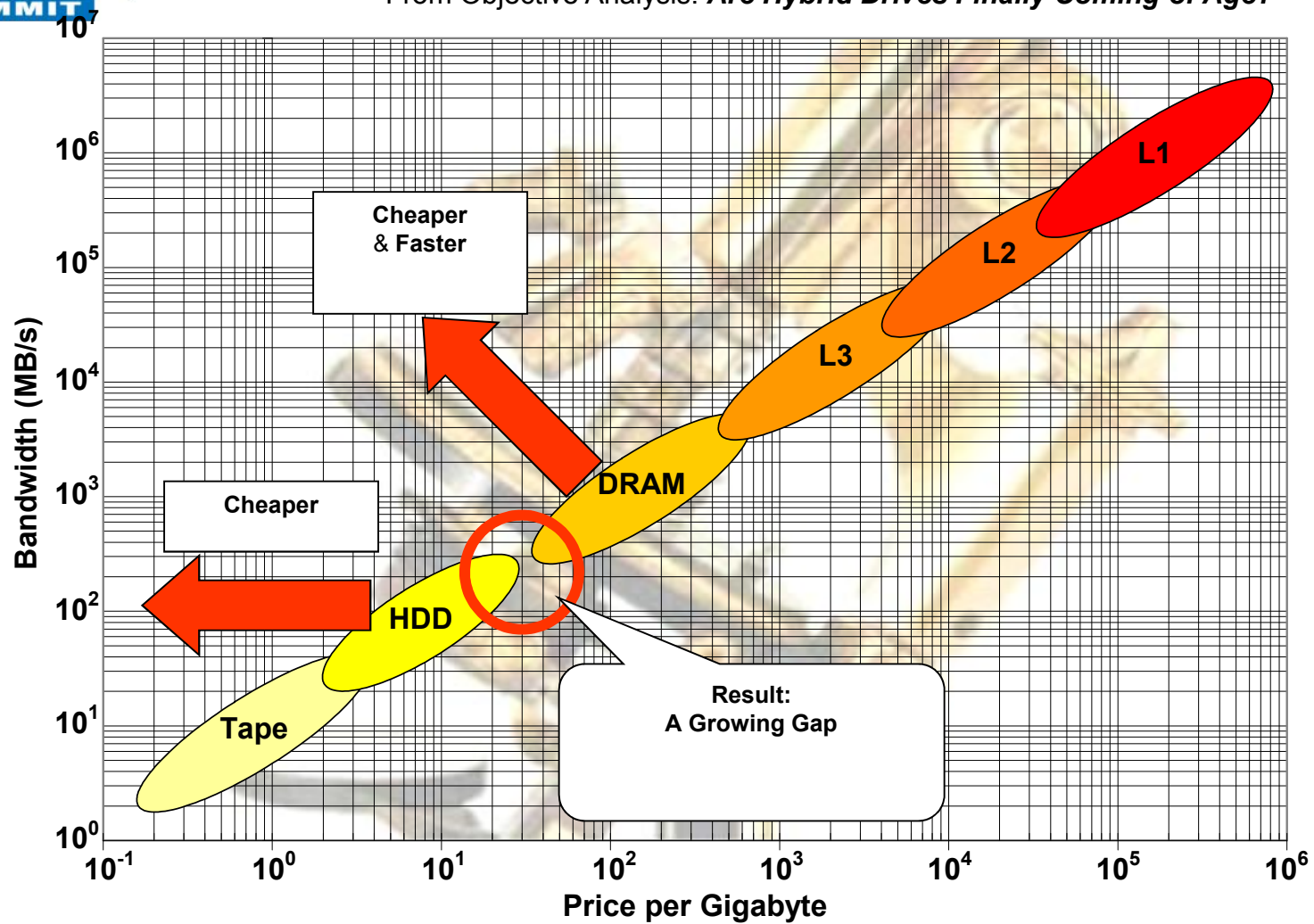
Today's DRAMs 6,000 Times HDDs' Speed



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

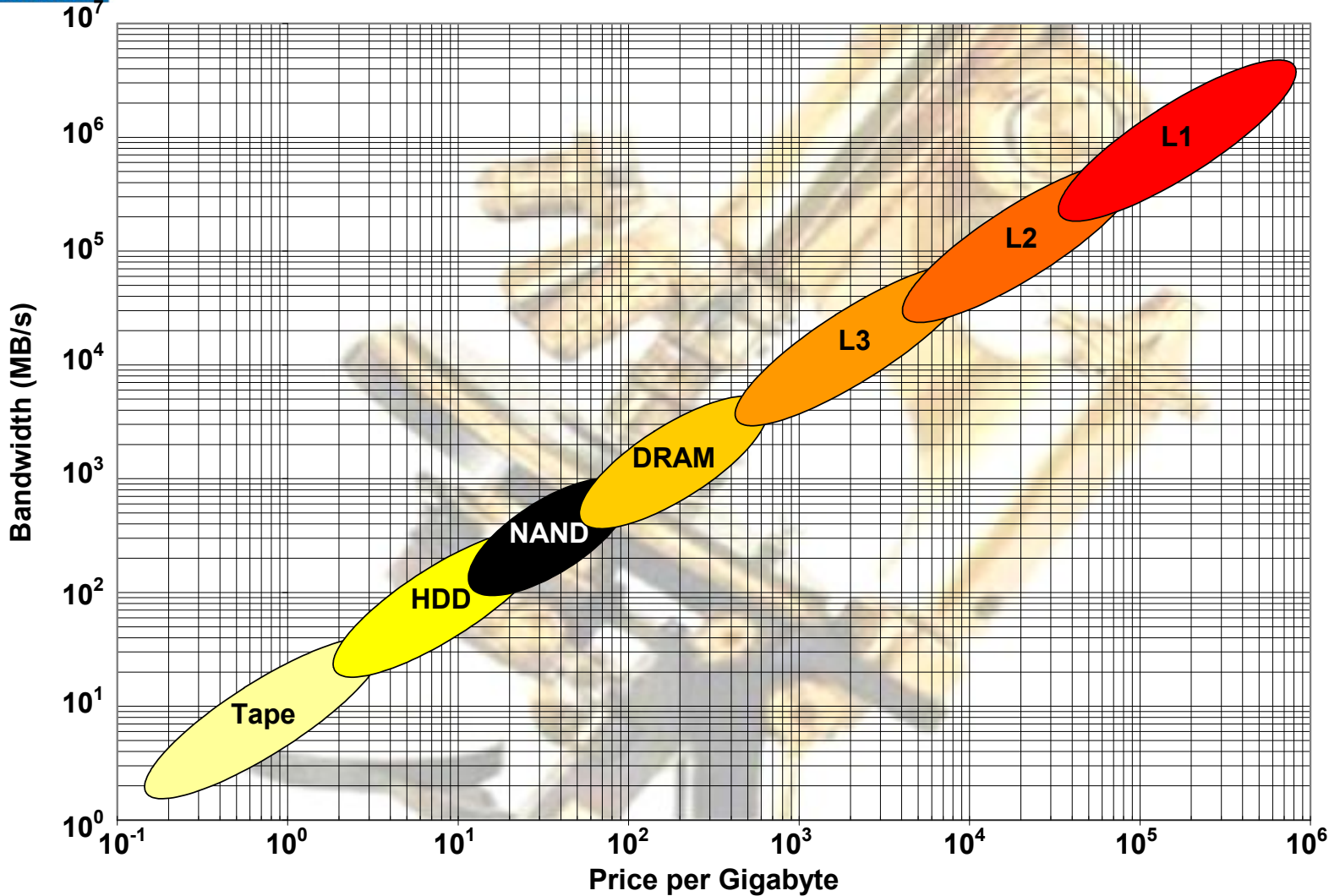
A Gap in the Storage Hierarchy

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



NAND Fills the Gap

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

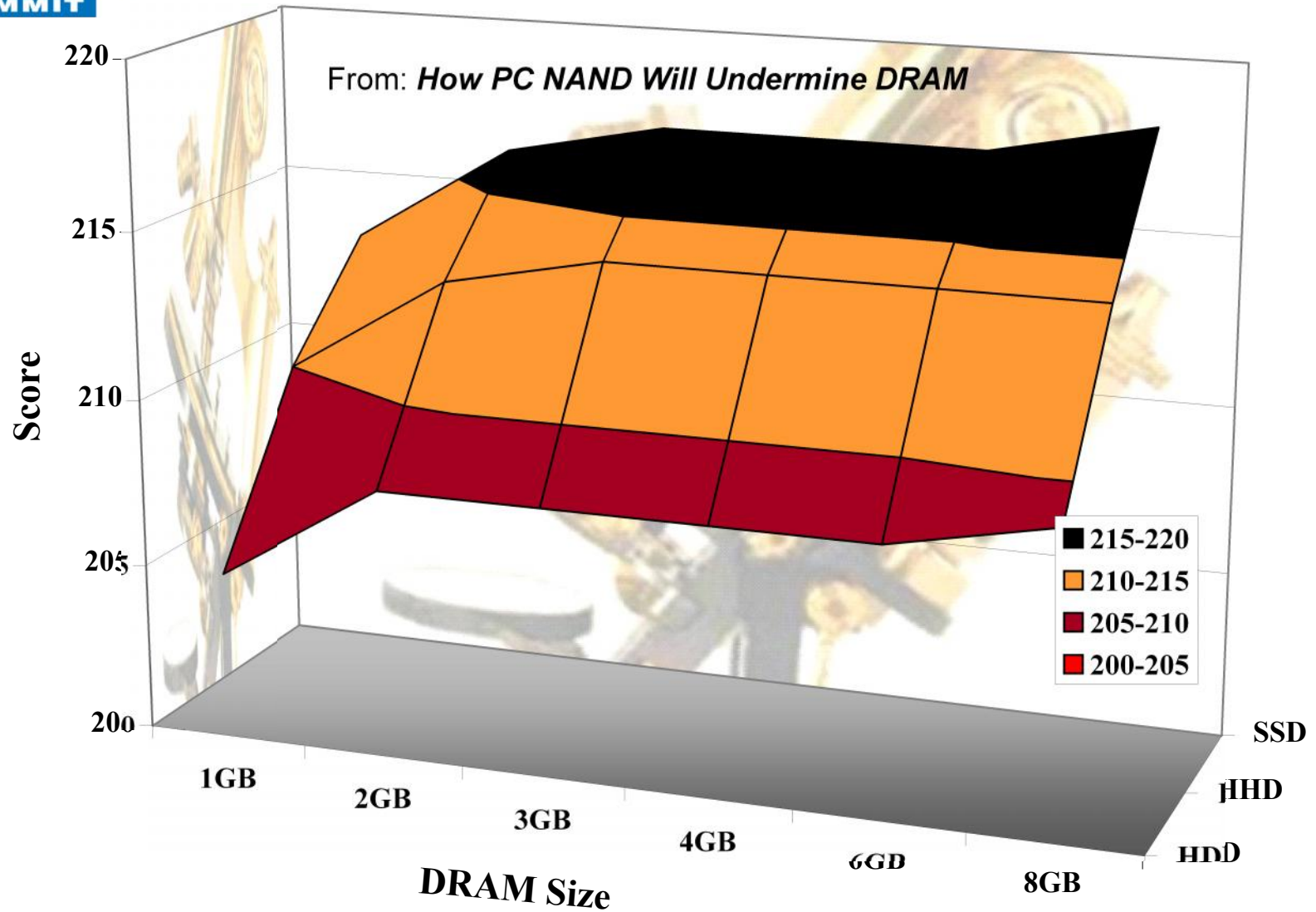




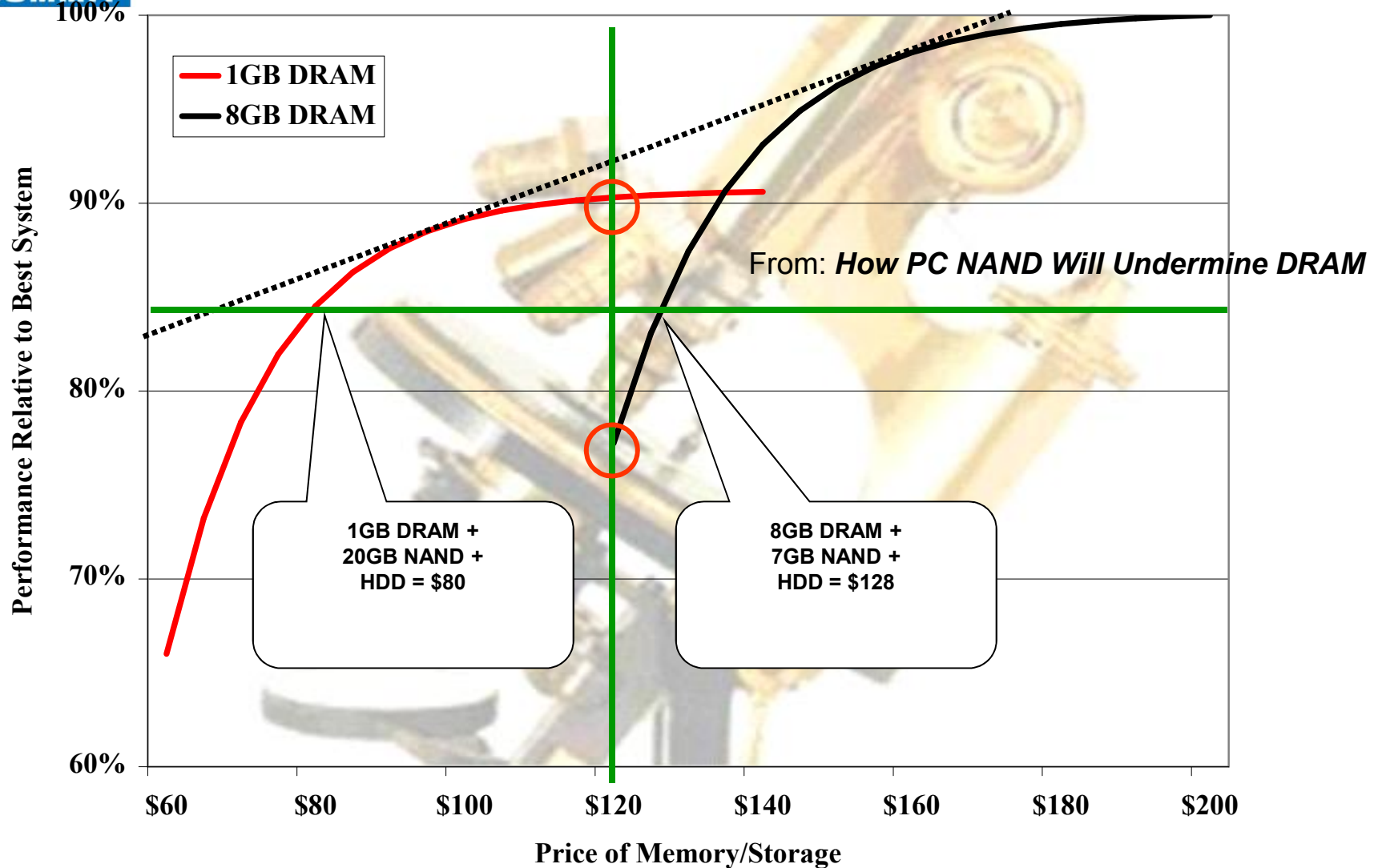
Why Flash Fits

- 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

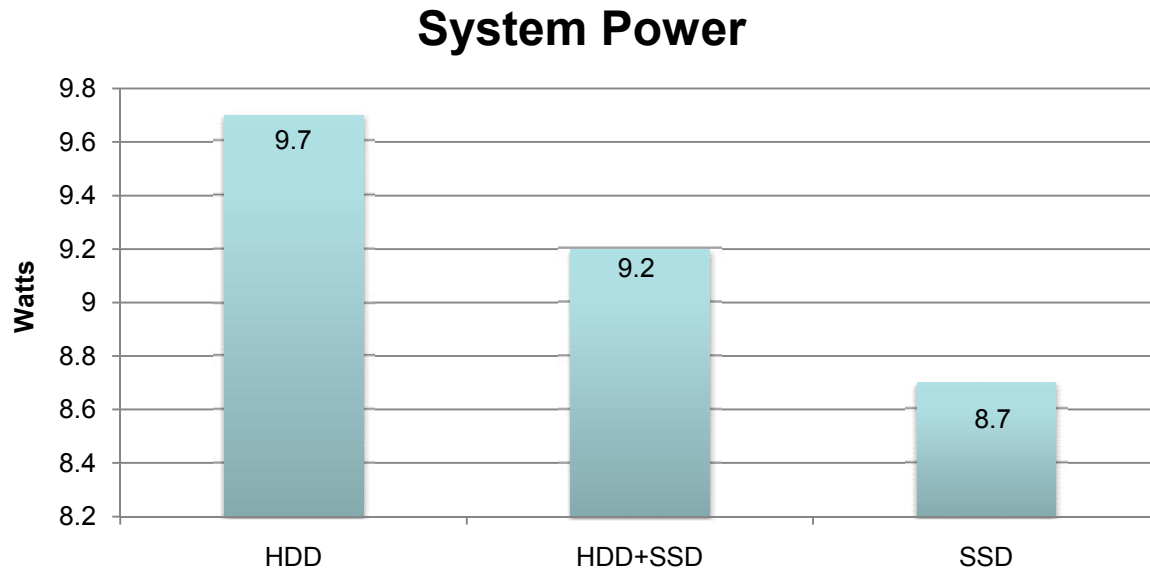


Speed/Price Advantage





Even Partial SSD Saves Power



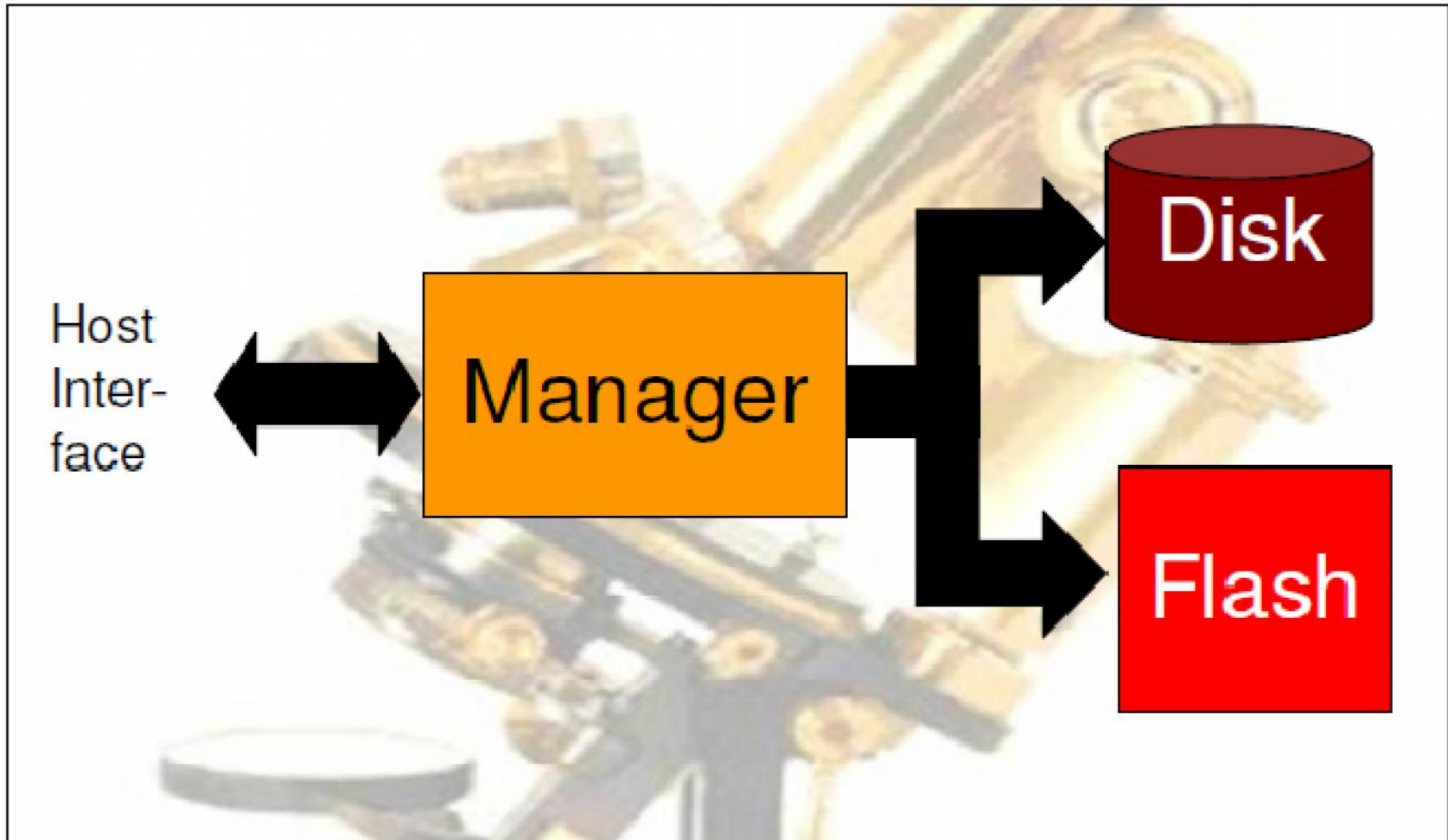
- SSD-based system consumes lowest energy
- Two-drive system comes next
 - ◆ Most common files loaded onto SSD
 - ◆ All else on HDD
 - ◆ HDD spun-down ~97% of time
- HDD alone consumes most power
 - ◆ Results from Intel, MobileMark* 2007 workload, Intel® 80GB SSD vs. 5,400rpm HDD



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The Hybrid HDD



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

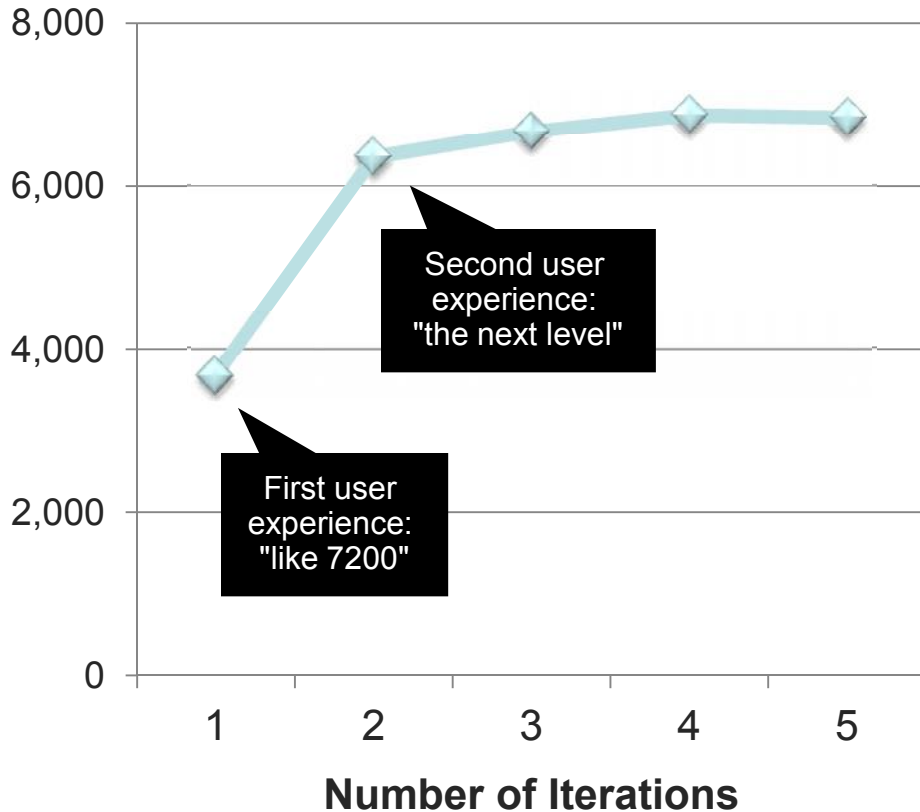


Example Hybrid HDD

Seagate Momentus XT

Adaptive Memory™ Learns Quickly

PCMark Vantage – HDD Score

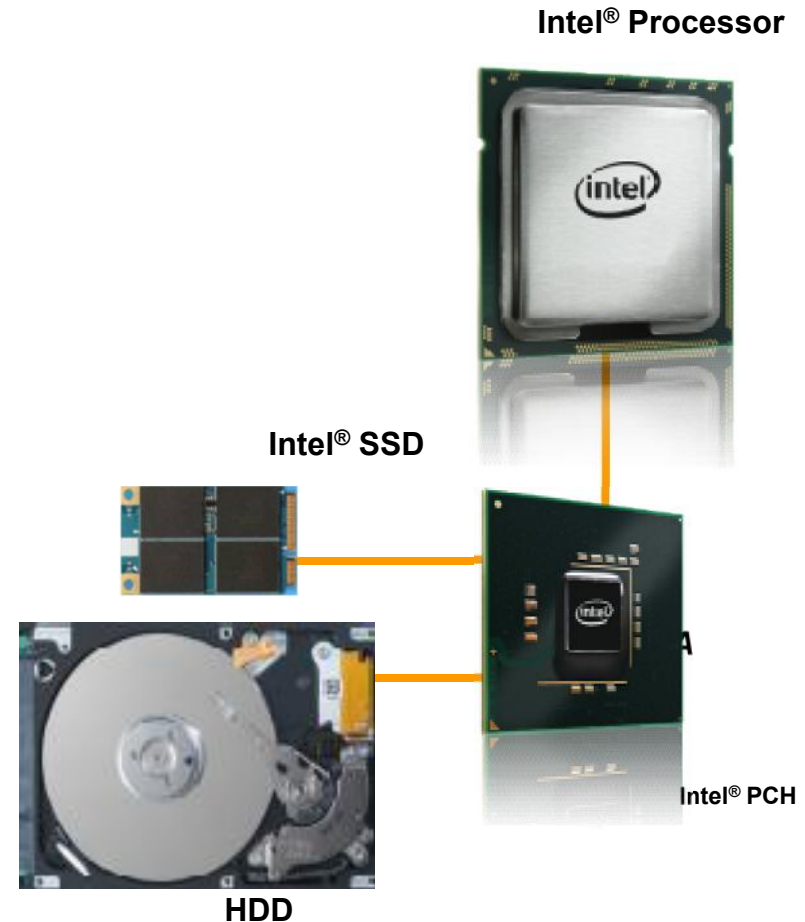


From Seagate Momentus XT Introduction Presentation, 2010

- 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

Braidwood Memory Technology: I/O Acceleration
2010 Platform Technology



Dramatically speeds up performance by reducing the time it takes to power up, access and run programs

- Enhanced system response
- Faster application starts
- More efficient use of total system memory

Available on selected
2010 Intel® 5 Series Chipset platforms



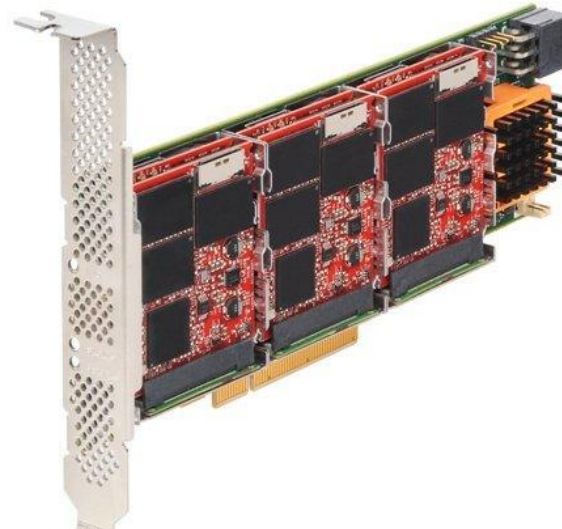
- Past Failed Attempts
 - Intel TurboMemory
 - Intel Braidwood
 - NAND on the motherboard
 - Managed by chipset & firmware
 - SSD speeds with HDD capacities
 - Low-priced option
- This approach will resurface!
 - The fundamental concept is very good



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



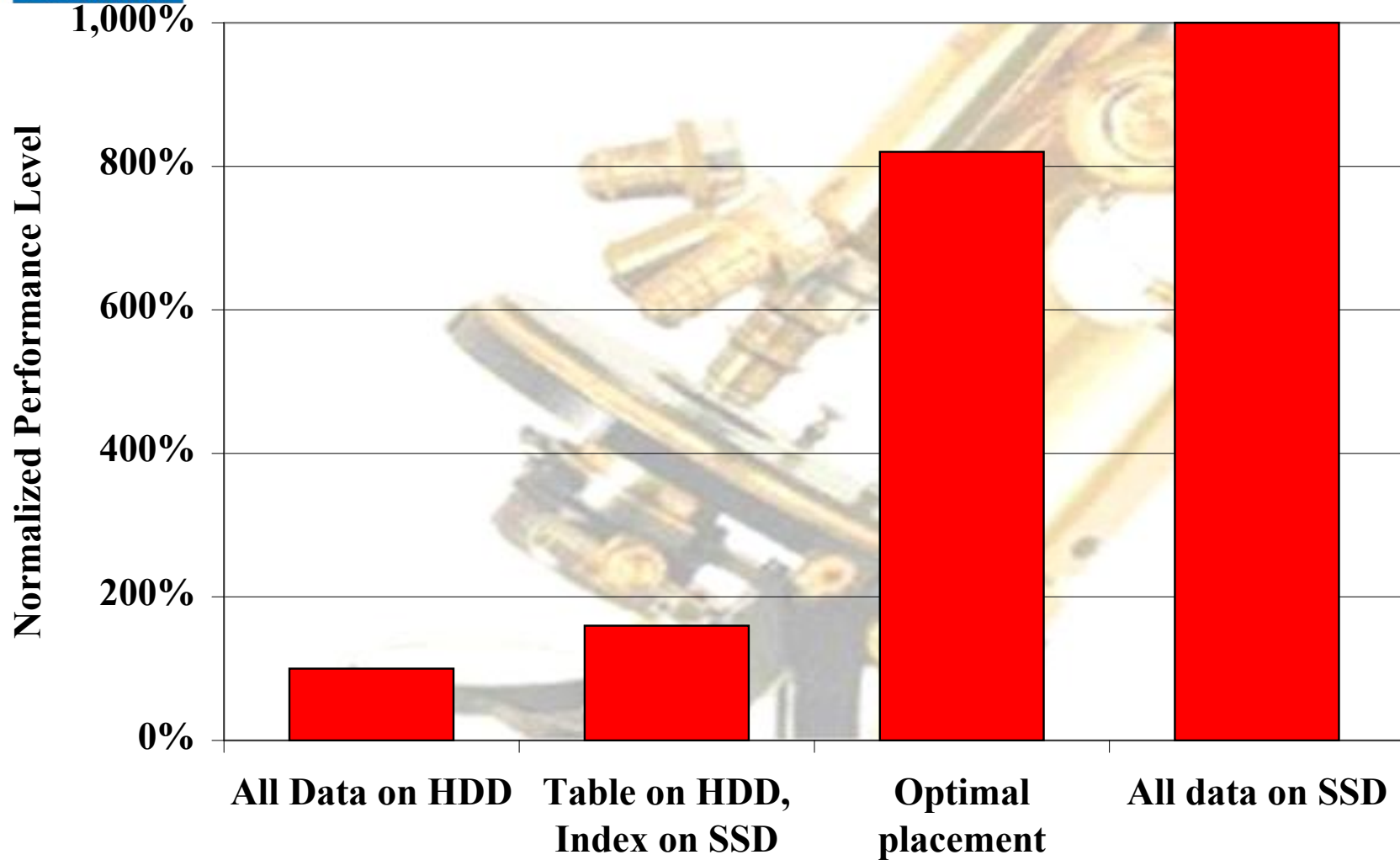


Flash Capacity Data Points

- 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