A Closer Look at NAND Flash

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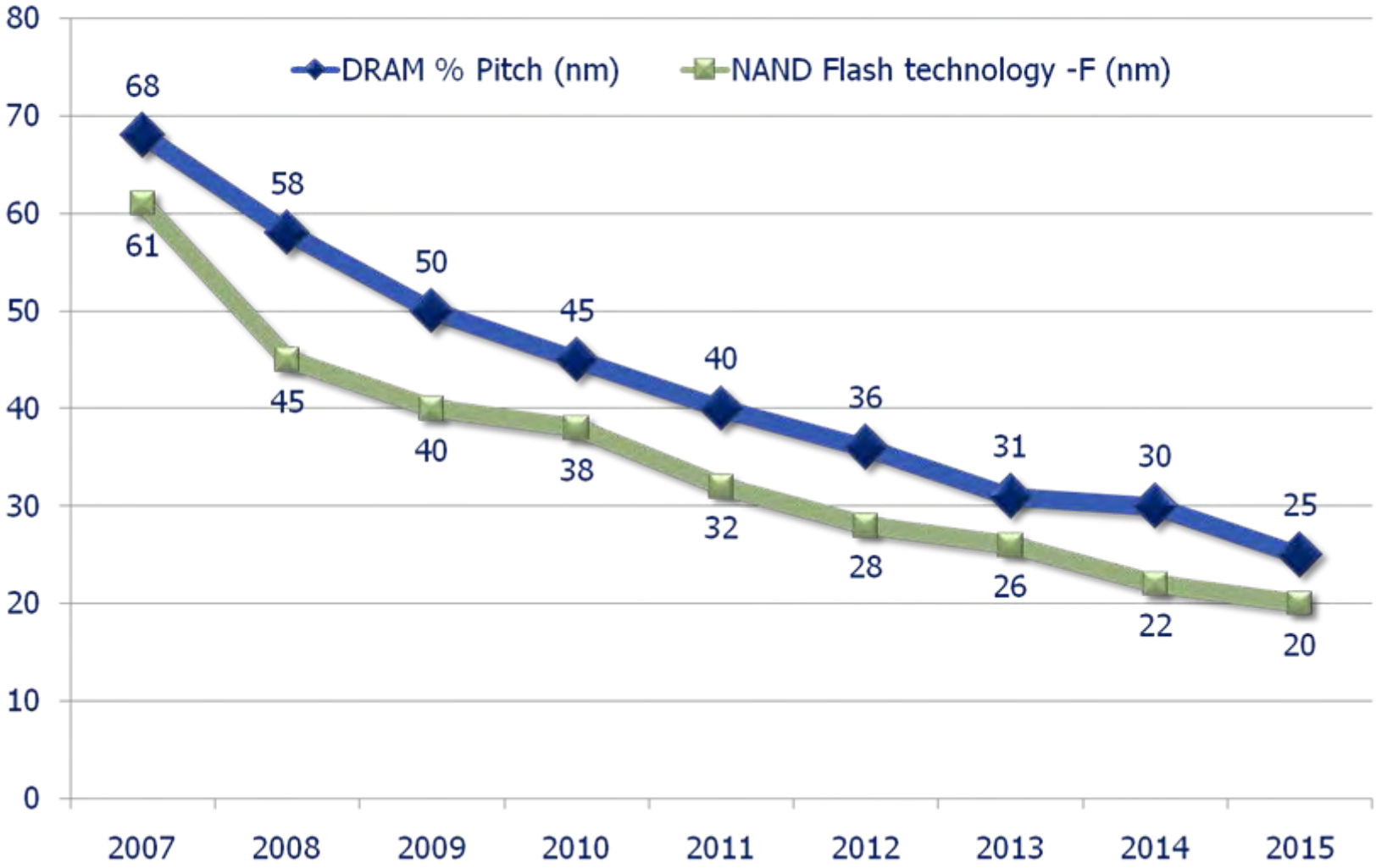
NAND World Dominance

Now, let's be honest.

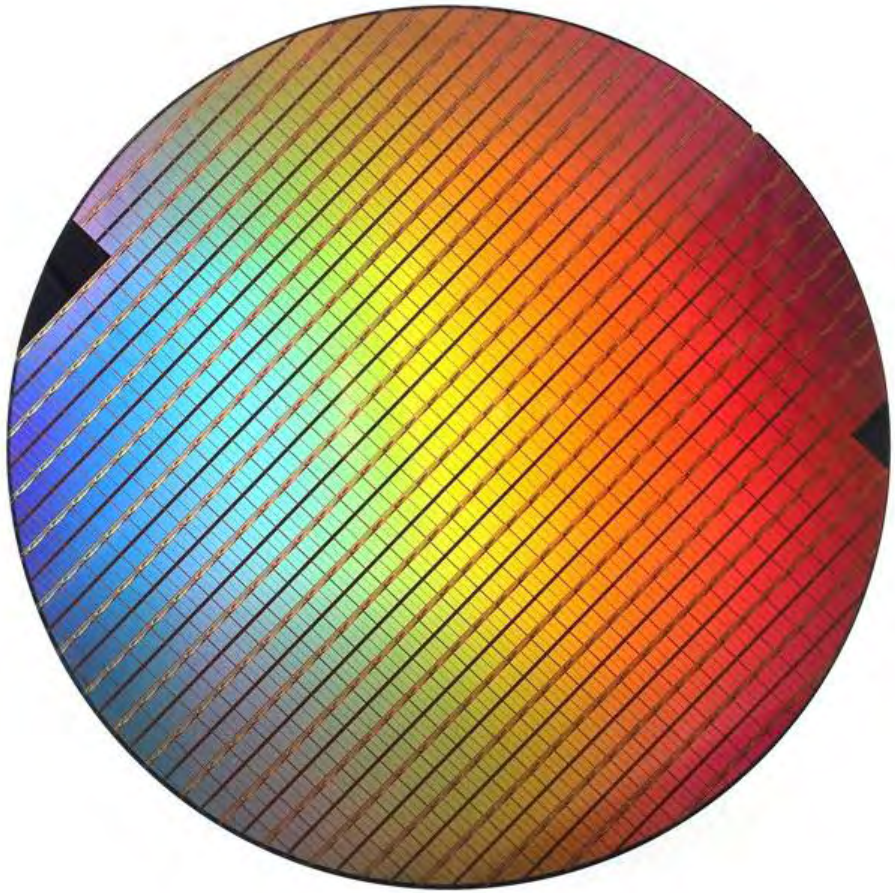
It's not about write cycles. It's about usage scenarios and choosing the "write" NAND for the application.

Now, let's be brutally honest.



Source: INTERNATIONAL TECHNOLOGY ROADMAP FOR SEMICONDUCTORS 2007 EDITION PROCESS INTEGRATION, DEVICES, AND STRUCTURES

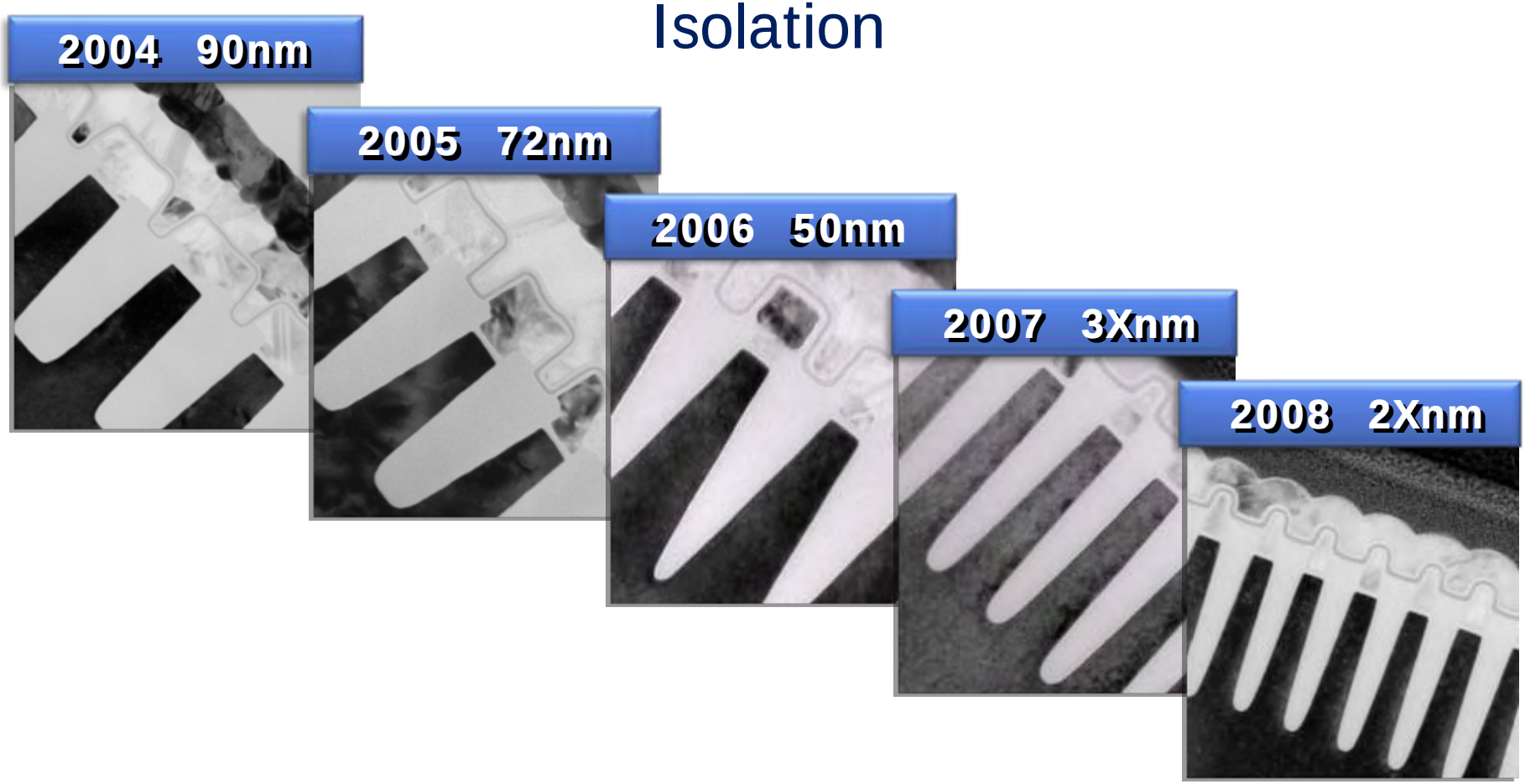
Micron 34nm, 32Gbit NAND



Approximately 1.6 terabytes of NAND per wafer

Rapid Scaling Driving Early Learning

Isolation



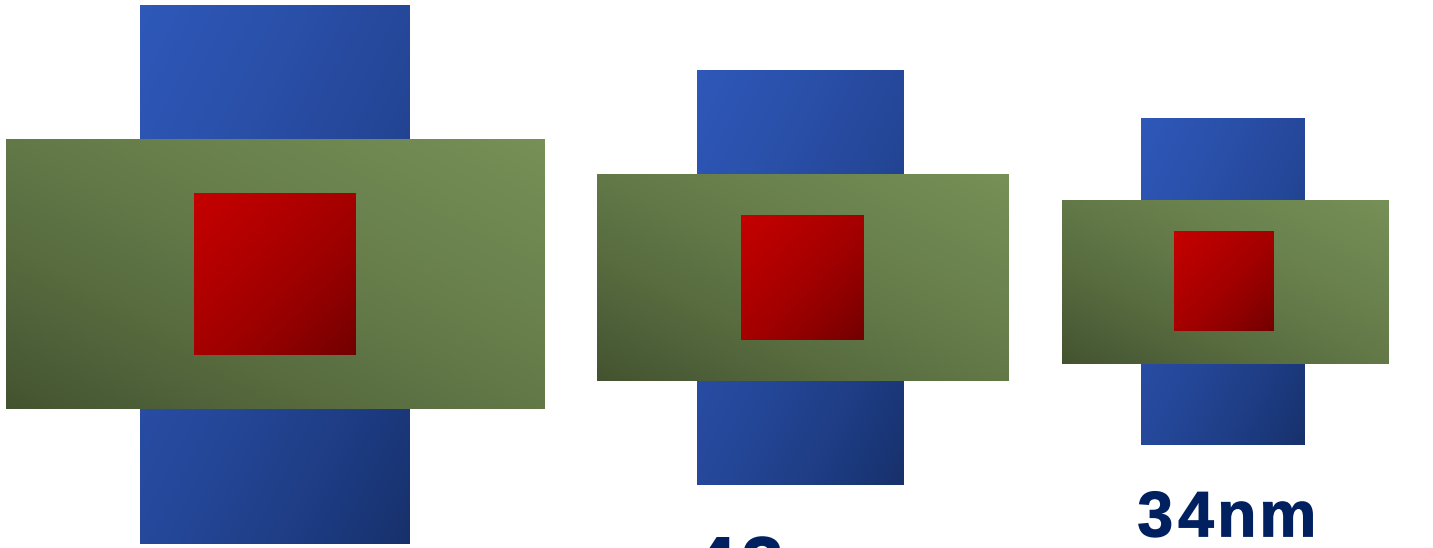
Comparative Memory Cells

Cell Size (u^2)	Tech Node (nm)	Cell size (F^2)	Endurance
IBM/Infineon MRAM			
0.74	130	44	Excellent
Freescale 6T-SRAM			
0.69	65	163	Excellent
Intel 45nm 6T-SRAM			
0.27	45	135	Excellent
Freescale TFS: Nanocrystaline			
0.13	90	16	Unknown
Freescale eDRAM			
0.12	65	28	Excellent
Samsung 512Mbit PRAM Device			
0.050	95	5.5	Good
Micron 40-series DRAM			
0.037	78	6	Excellent
Micron 60-series NAND			
0.0046	34	4	Good

Straight Talk: Bits vs. Shrink

2 bits, 4 bits, 6 bits a dollar?
All for NAND, stand up & holler

- Scaled Cell Sizes:



56nm

@ 3-bits/cell

=4181nm²/bit

43nm

@ 2-bits/cell

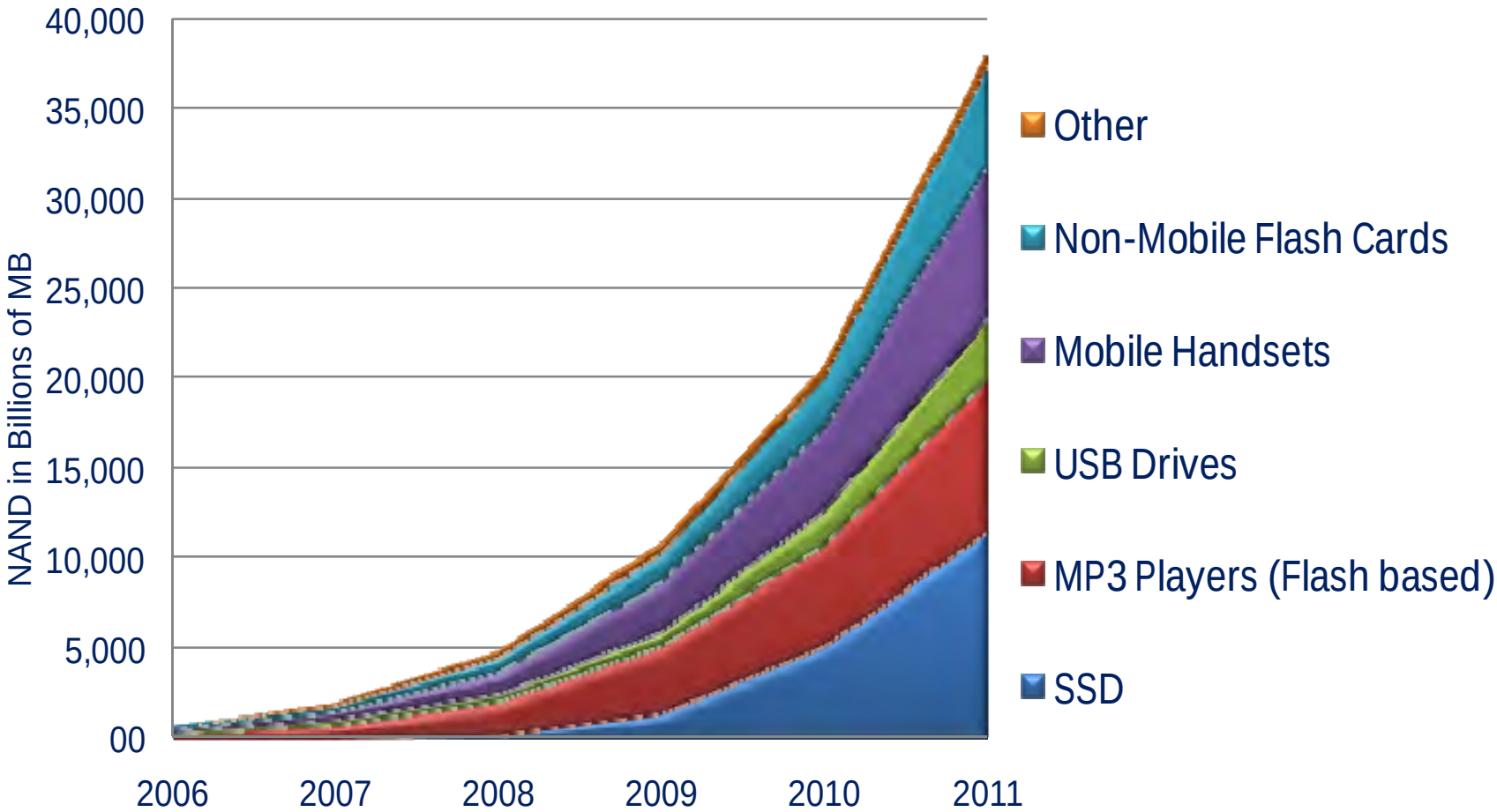
=3698nm²/bit

34nm

@ 2-bits/cell

=2312nm²/bit

NAND Will Adapt to the Market



Source: iSuppli JAN 08

Getting dialed in on the applications

- Interfaces optimizations
- Process optimizations
- Controller optimizations
- Design optimizations

NAND Optimizations: ONFI 2.0 HS-NAND

Feature	Standard NAND	High Speed NAND
“Standard” Asynchronous Interface	Yes	Yes
Synchronous Interface	No	Yes
tRC	≥ 25ns (SDR)	7.5ns (DDR)
tWC	≥ 25ns (SDR)	7.5ns (DDR)
Standardized	ONFI 1.0	ONFI 2.0
Scalable to higher performance	No	Yes
Cache Mode	Some	Yes
VCCq	3.3V	1.7V to 1.95V
VCC	3.3V	2.7V to 3.6V
Parameter Page	Some	Yes
Package	TSOP	BGA

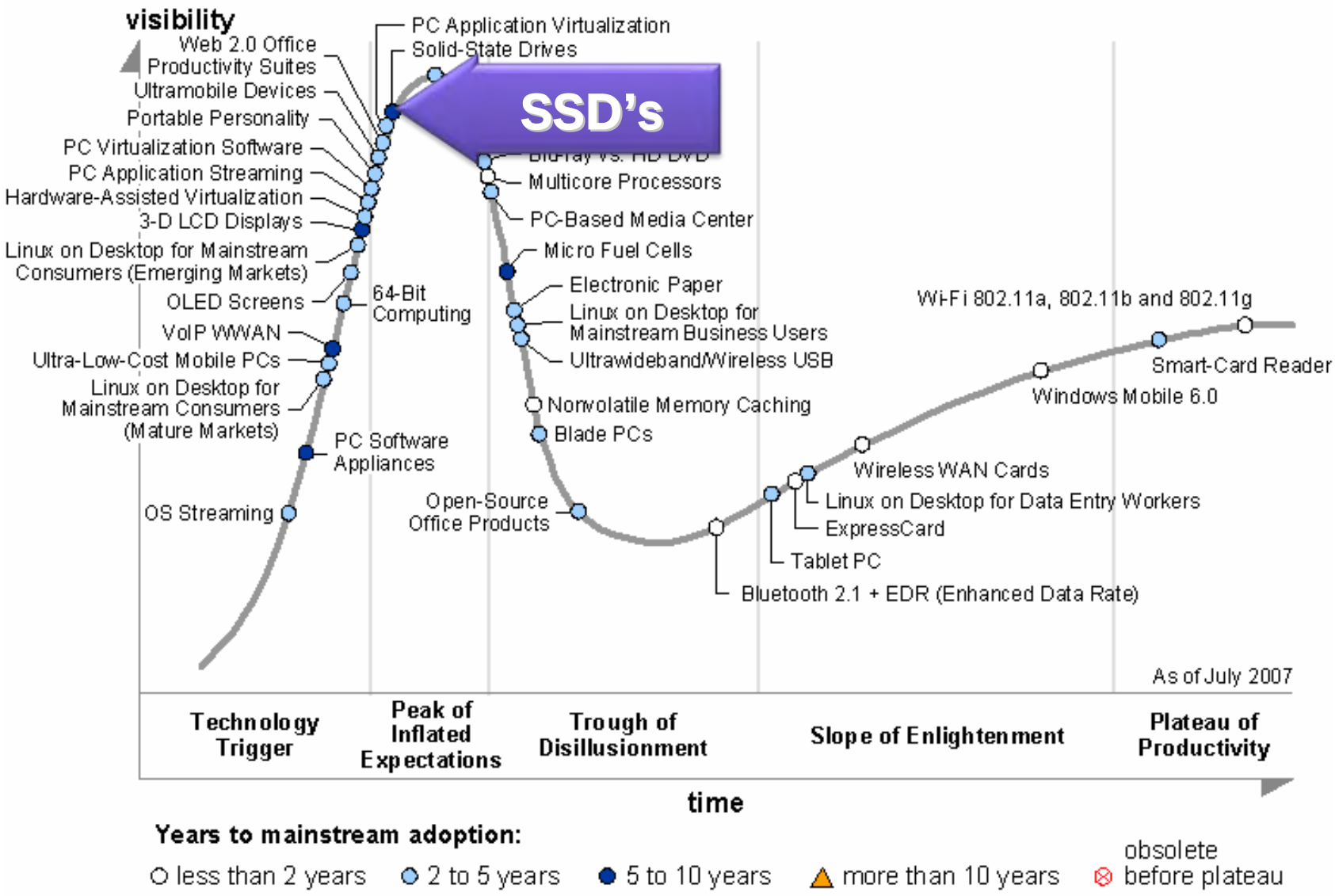
A natural extension to Standard NAND

Interface Optimization: Performance Comparison

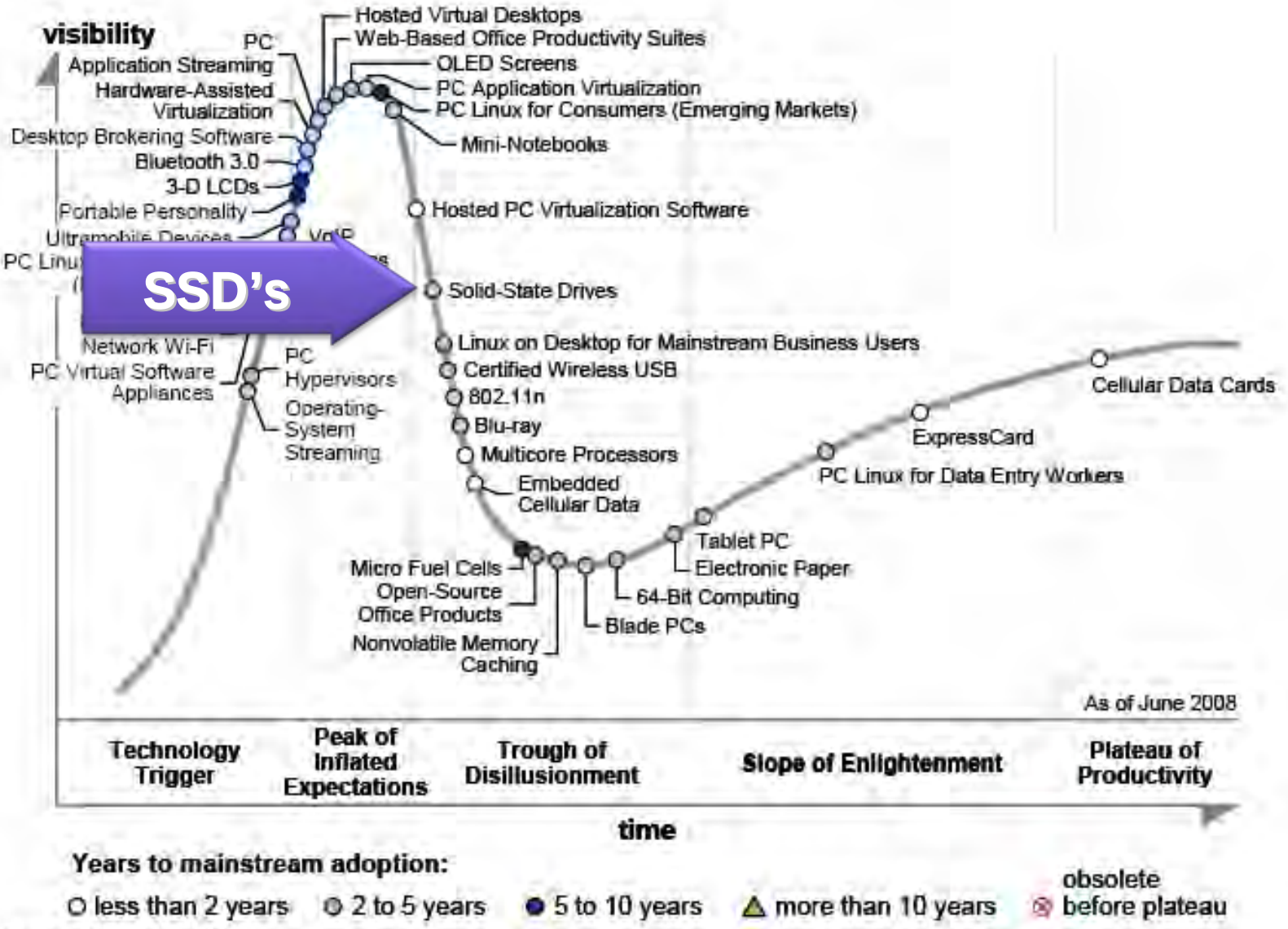
	High Speed NAND	Traditional SLC NAND	MLC NAND	MLC NOR
Read Performance	**200 MB/sec**	40 MB/sec	33 MB/sec	103 MB/sec
Write Performance	**100 MB/sec**	15 MB/sec	3.5 MB/sec	< 1 MB/sec
Erase Performance	**1.5 ms**	1.5 ms	2 ms	900 ms

Solid State Drives

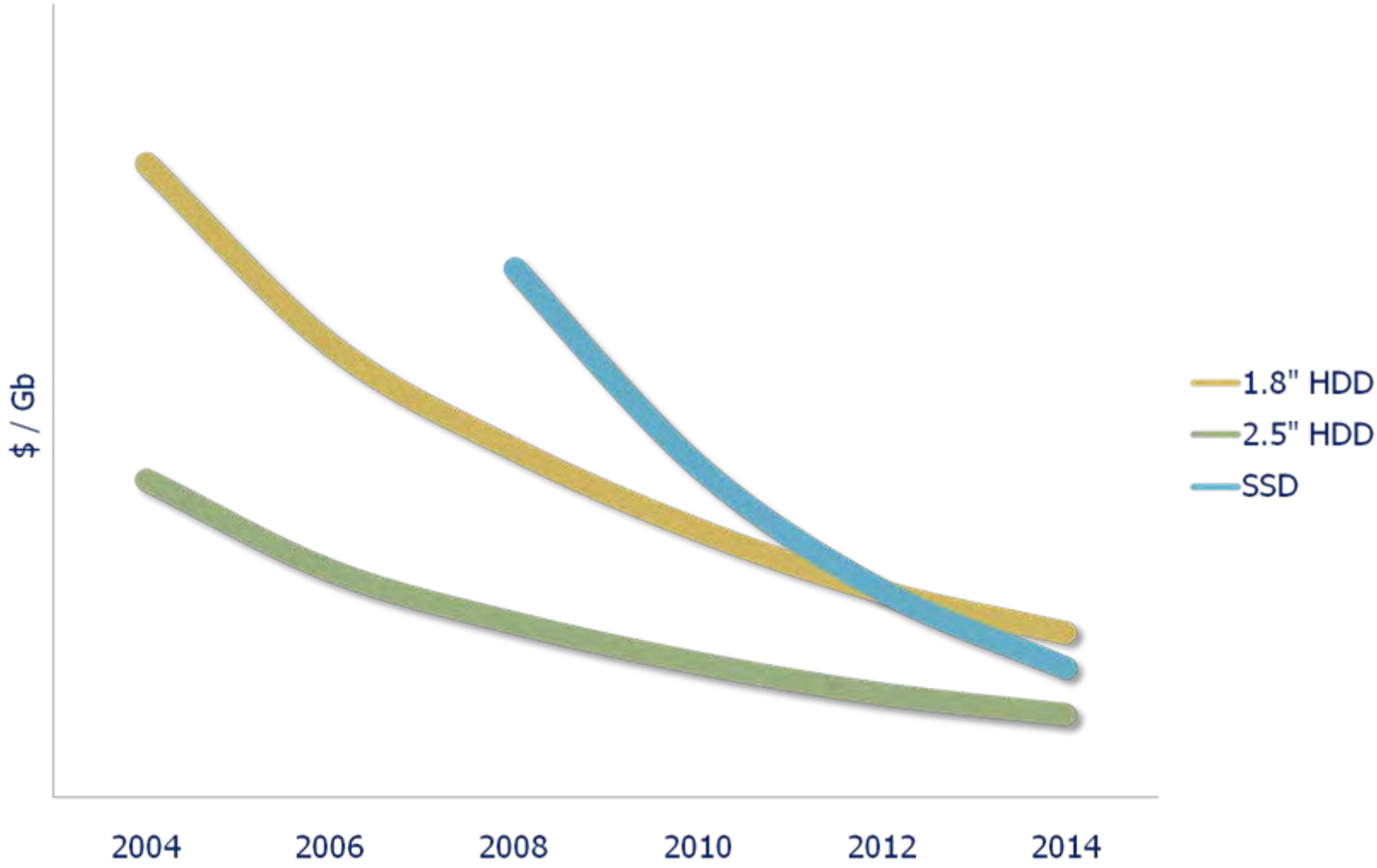
Gartner's Hype Cycle for PC Technologies 2007



Gartner's Hype Cycle for PC Technologies 2008



SSD Cost Parity?

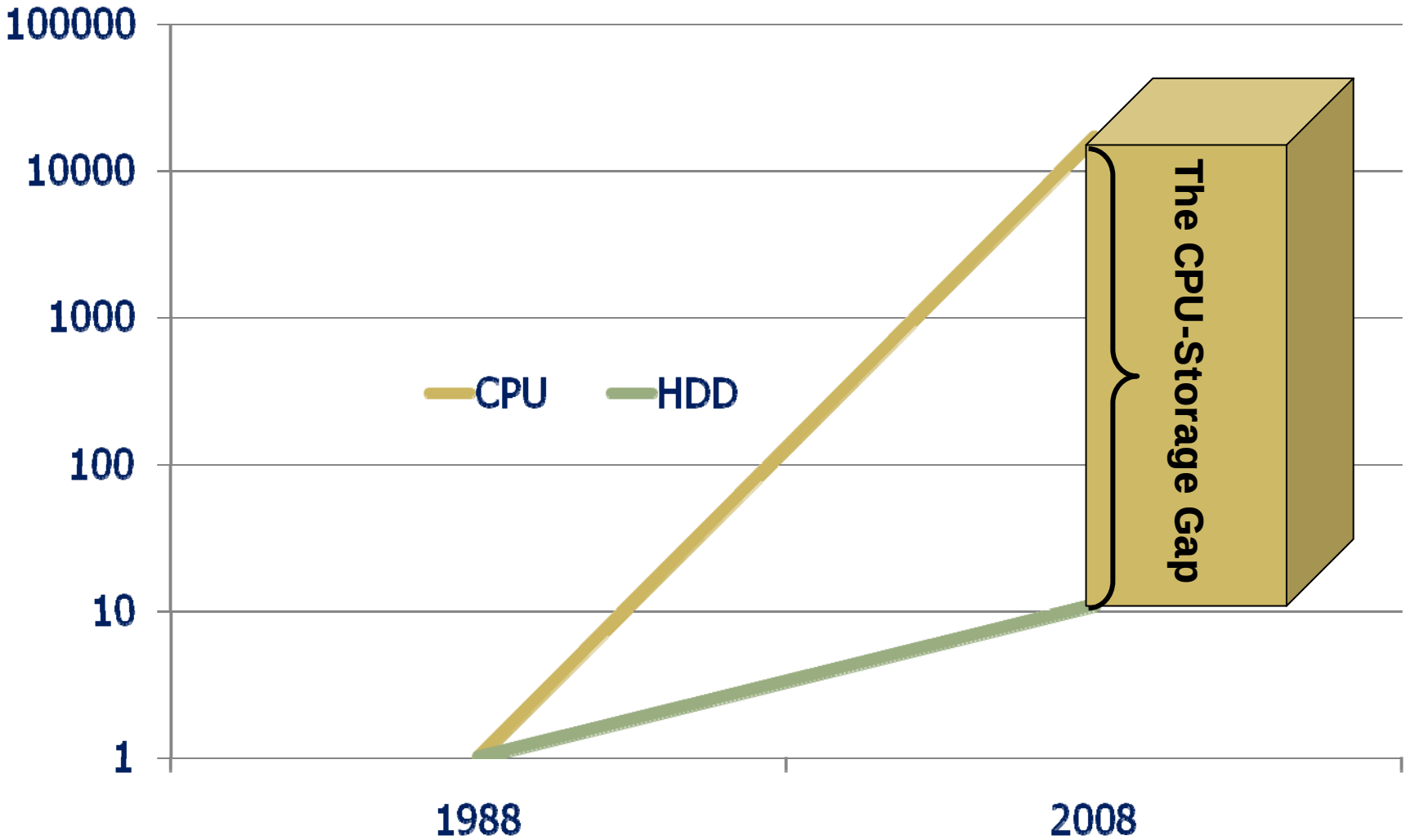


Why SSD's?

- Performance

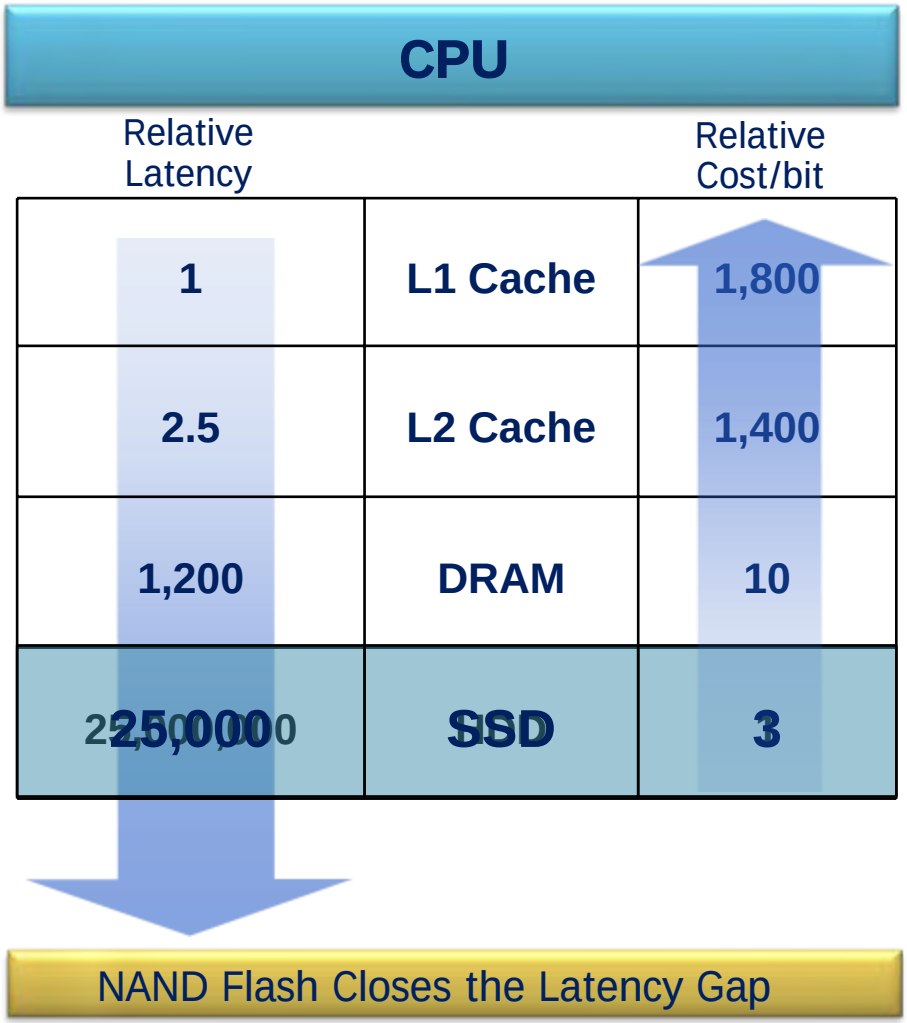
SSD – Performance

The Storage Gap



SSDs in Computing

NAND



Cost/bit Data as of November 2007

Why SSD's?

- Performance
- Power

SSD – Energy

Notebooks: SSD's *Can* Improve Battery Life

A recent editorial review highlighted that power consumption **increases** when solid state drives are used in today's notebook computers.

HDD

SSD

Notebooks: SSD's *Can* Improve Battery Life

A recent editorial review highlighted that power consumption **decreases** when solid state drives are used in today's notebook computers.

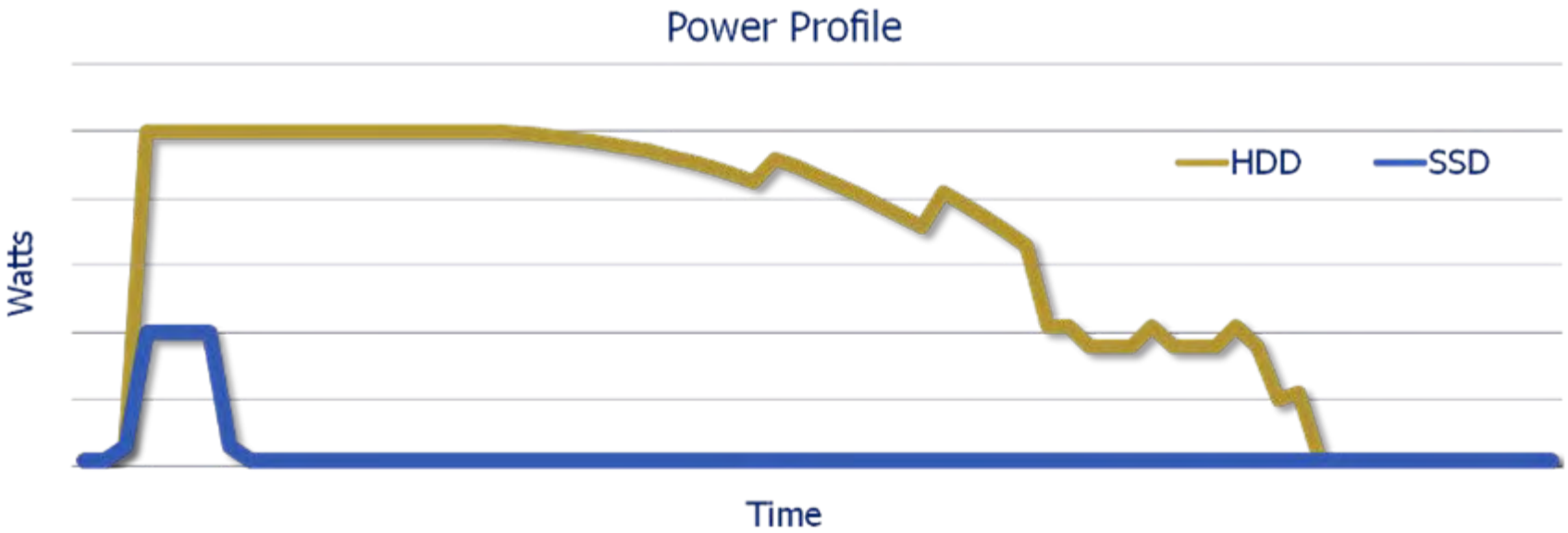
HDD

Notebooks: SSD's *Can* Improve Battery Life

- Requirements:
  - A well-designed SSD
    - Efficient Wear Management Algorithms
    - An Efficient Controller
  - Notebook Optimizations for SSD's
  - Operating System Improvements
    - New SATA commands: ID and Trim
    - Disable Defrag

SSD: Power and Performance

SSDs do more with less power



Why SSD's?

- Performance
- Power
- Reliability

SSD – Reliability

Cost of Ownership Analysis from SSDs in Notebooks

Notebooks at Micron:
2000 units

Avg lifespan of notebook:
36 months

% of employees w/notebook that would benefit from an SSD:
75%

IT hours to repair HDD failure:
5 hours

IT hours to recover from HDD fatal error:
5 hours

HDDs with fatal error per annum:
15 units

Number of hours employee is idle as a result of HDD repair:
5 hours

Higher Reliability
$208,300

Increased User Productivity
+ $415,775

Increased Battery Efficiency
+ $151,260

Additional Cost for SSDs
- $300,000

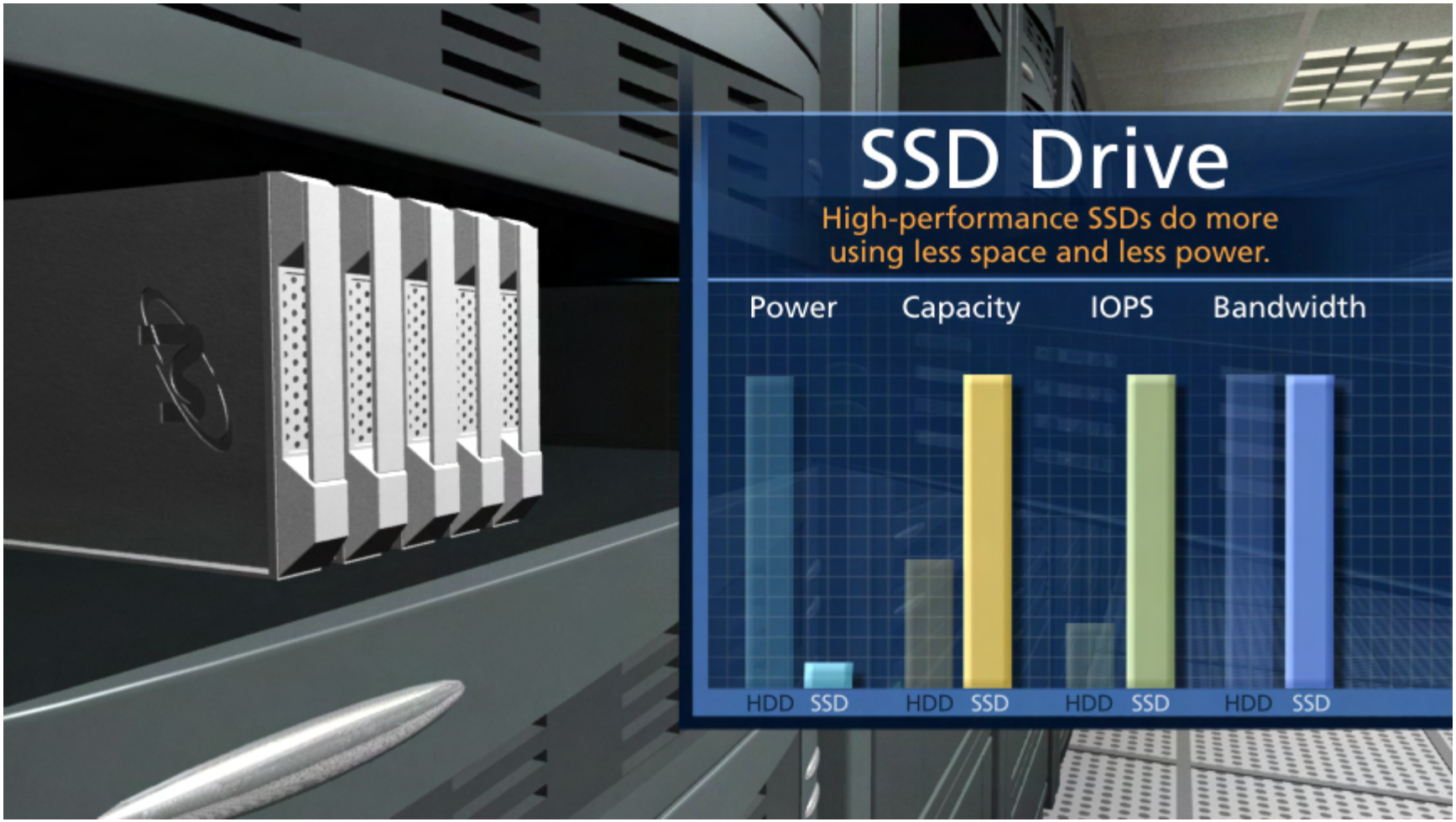
= $475,335 net savings

SSD's are not just for Notebooks

- Industrial Applications
- VOD and IPTV
- Enterprise

HDD & SSD in the Enterprise Server Market

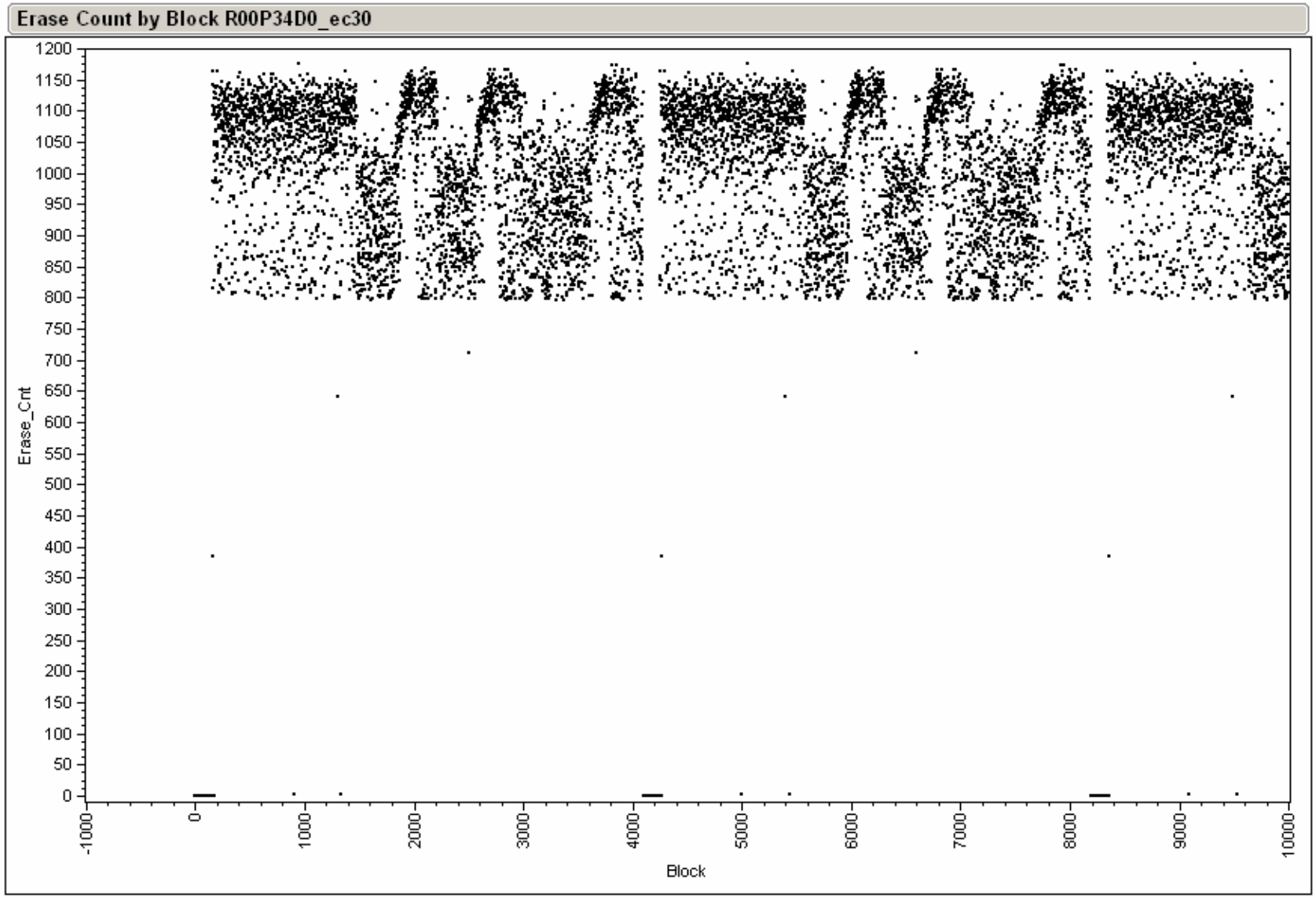
HDD & SSD in the Enterprise Server Market



Making SSD's Enterprise-Ready

- Performance
- Power
- Reliability
- Endurance

Endurance: Wear Leveling




Micron