

What a Difference a Year Makes



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The Information Network – What We Do

- Off-The Shelf Technical-Marketing Reports on High-Tech Sectors including HDDs, CMP, Semiconductors, Alternative Energy, LEDs, LCDs, MEMs, Processing Equipment, Processing Materials
 - Custom Studies in the above areas
 - Proprietary Leading Indicators correlating macroeconomic trends with projections of semiconductor and semiconductor equipment growth
-
- Formed in 1985
 - First report on the market analysis of CMP in the 90s

Monumental Changes Are Taking Place In The Competitive Storage Industry

- **SSDs continue to gain market share versus HDDs**
- **Solid State Hybrid Drive (SSHHD) Technology gained momentum in 2012**
- **Transition from planar NAND to 3D NAND**
- **Cold storage could represent considerable upside to NAND longer-term**

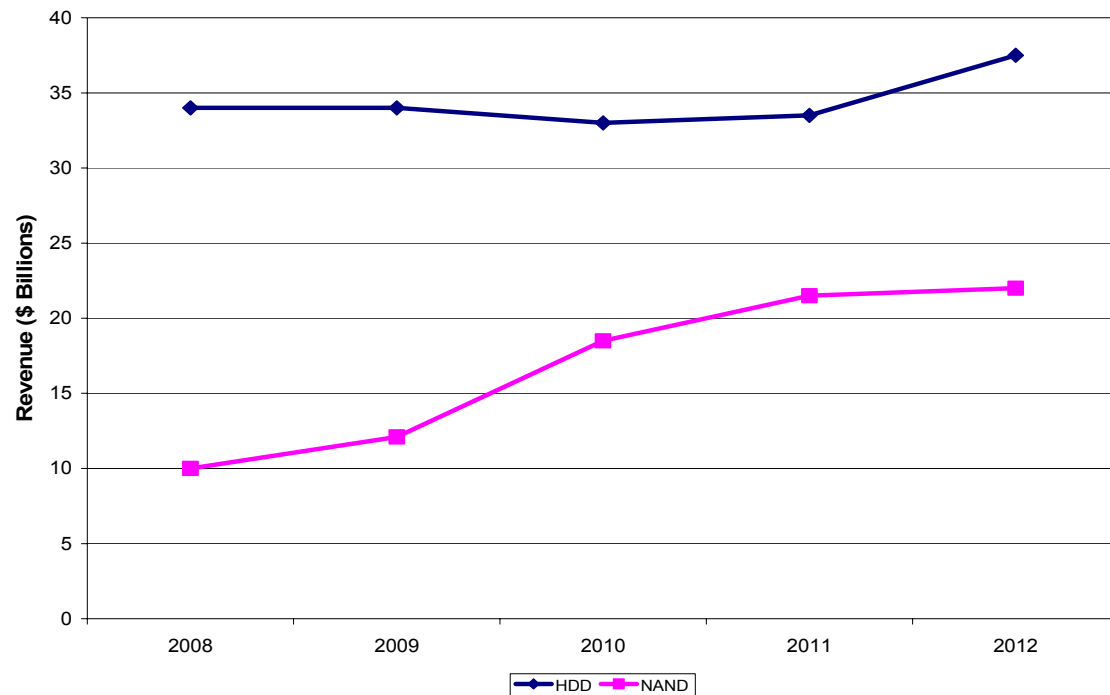
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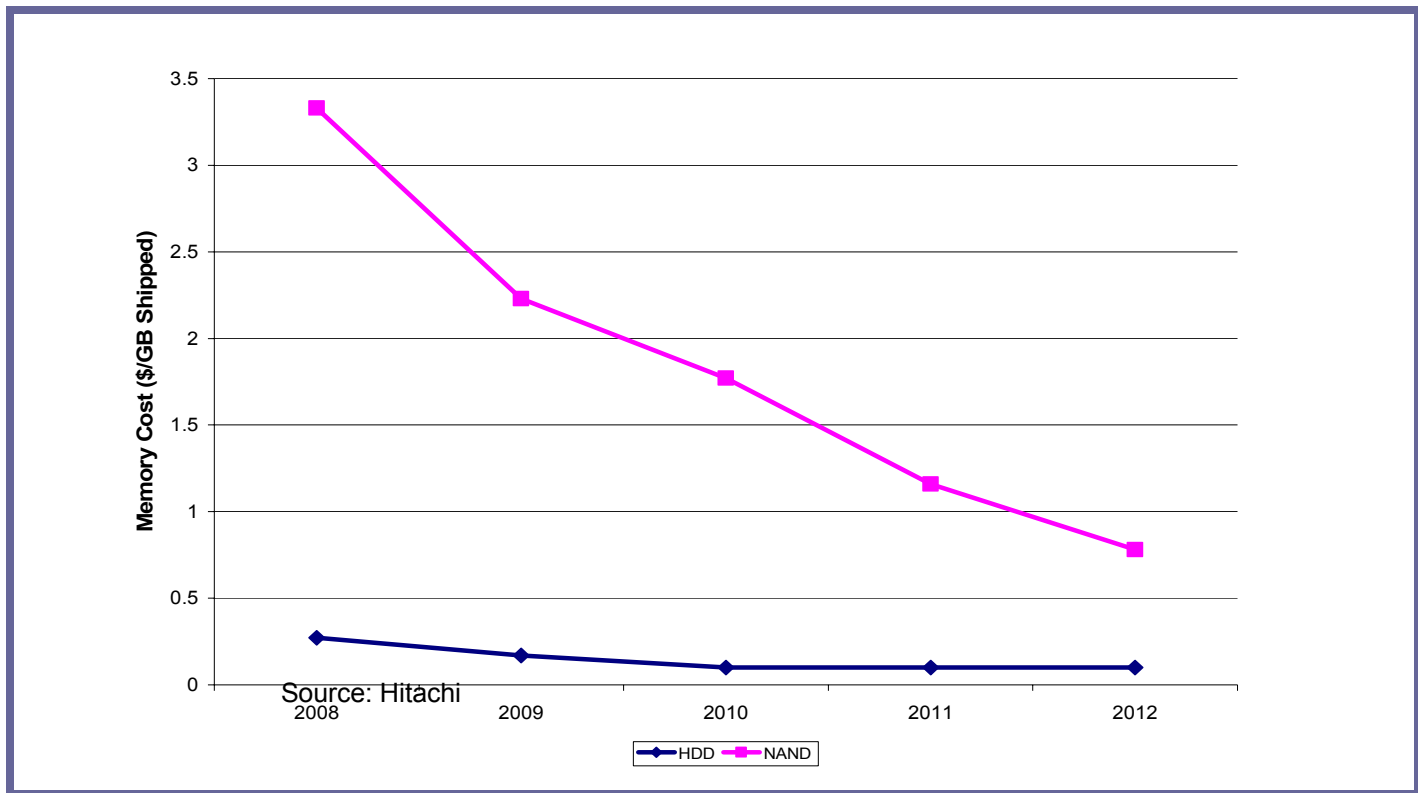
HDD Shipments Have Been Less Than Monumental

	2008	2009	2010	2011	2012	CAGR
HDD						
Units (HDDs millions)	540	557	652	620	577	1.7%
PetaBytes Shipped (PB)	125000	200000	330000	335000	380000	32.0%
Areal Density (Gb/in ²)	380	530	635	750	750	18.5%
Revenue (\$ billions)	34	34	33	33.5	37.5	2.5%
\$/GB Shipped	0.272	0.17	0.1	0.1	0.1	-22.1%
NAND						
Units ((2GBs millions)	1500	2715	5232	9326	14000	74.8%
PetaBytes Shipped (PB)	3000	5430	10464	18600	28000	74.8%
Areal Density (Gb/in ²)	200	280	330	550	550	28.8%
Revenue (\$ billions)	10	12.1	18.5	21.5	22	21.8%
\$/GB Shipped	3.33	2.23	1.77	1.16	0.78	-30.4%

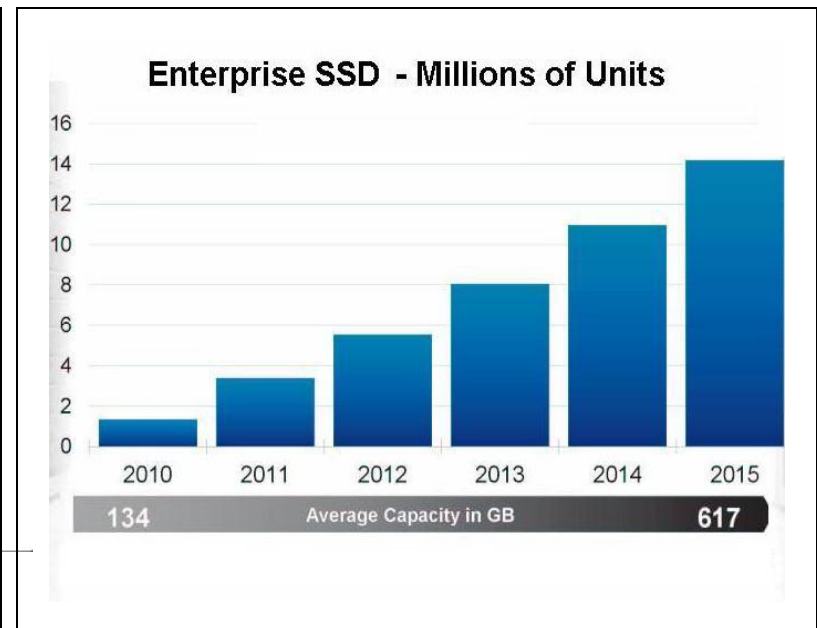
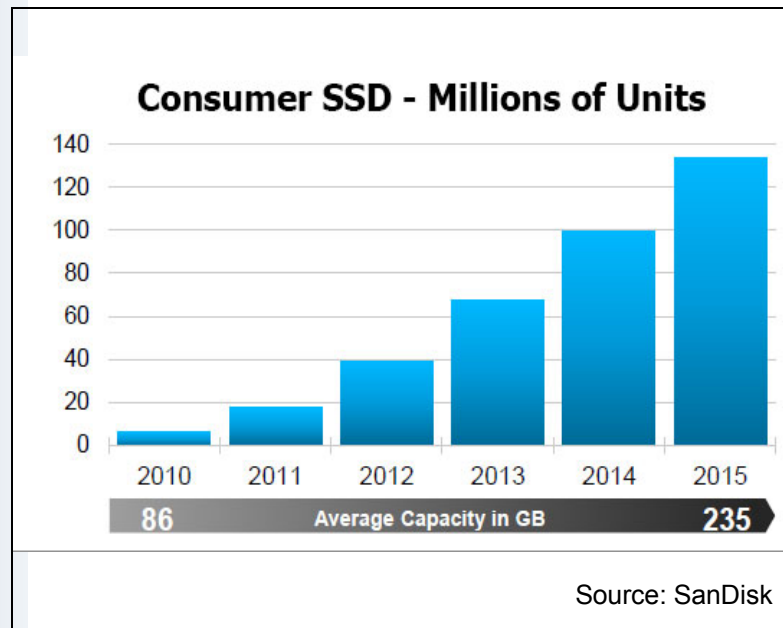
While Revenue Growth Has Slowed for Both HDD and SSD



The Decrease in Memory Cost For HDDs Has Slowed



Dropping Prices Have Helped Push the SSD Market



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Last Year's Slide Illustrating the Death of the HDD



But Hybrid Drives Will Help The HDD Industry for Portable PCs

HYBRID HDD IS HERE!

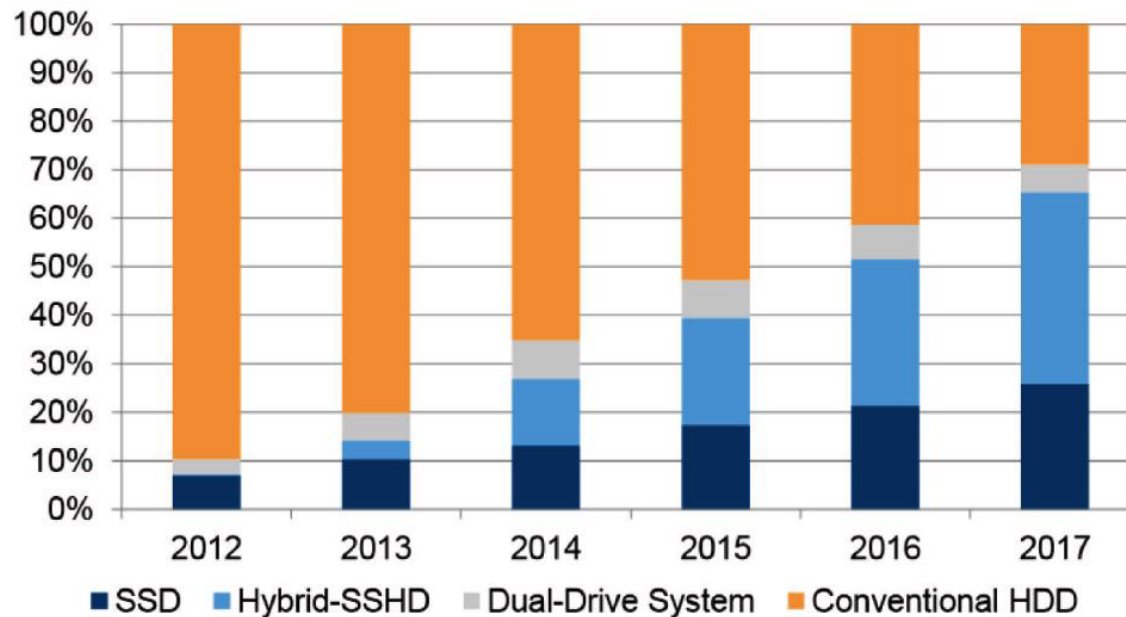
- Multiple announcements from all major HDD vendors
 - High-capacity HDD with 8-128GB NAND
- Ecosystem is being developed with chipset, drivers and OS support, and is moving in the right direction
- Two architectures exists:
 - Two-drive solution
 - HDD + SSD with chip or Southbridge running s/w for caching
 - Integrated hybrid
 - HDD + Flash with HDD SOC running s/w for caching
- Advantages of integrated hybrid HDD
 - Form factor
 - Ease of implementation
 - Cost



SOURCE: TREND FOCUS, WESTERN DIGITAL

As Conventional HDDs Markets Erode

Portable PC shipments by Storage Type



Source: Worldwide Solid State Drive 2012- 2017 Forecast – May 2013

Helped by Innovation

Hybrid Hard Drives



World's First

Western Digital

Uses SanDisk iSSD™ 24GB

5mm Solid State Hybrid Drive

Enabled by SanDisk revolutionary iSSD

SanDisk

2013 Investor Day | May 8, 2013

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The image is a promotional graphic for a Western Digital 5mm Solid State Hybrid Drive. It features a hand holding the drive, which is a thin, black, rectangular device. To the left of the drive, the text 'World's First' is displayed. Below the drive, it says 'Uses SanDisk iSSD™ 24GB'. To the right of the drive, the text '5mm Solid State Hybrid Drive' is shown, followed by a black box containing the text 'Enabled by SanDisk revolutionary iSSD'. The Western Digital logo is in the top left corner. The SanDisk logo is in the bottom left corner. At the bottom center, it says '2013 Investor Day | May 8, 2013'. In the bottom right corner, the number '172' is displayed.

Monumental Changes Are Taking Place In The Competitive Storage Industry

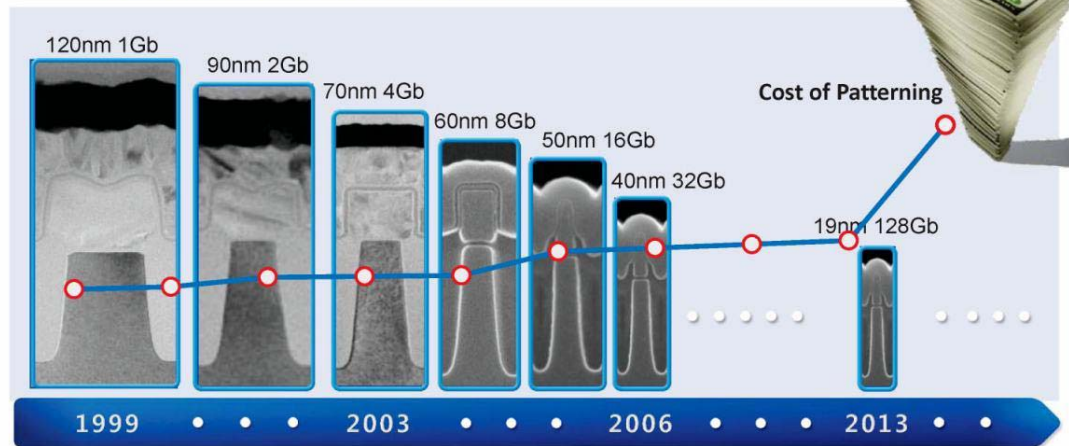
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3D NAND Reduces Costs and Increases Cell Reliability

Has Moore's Law Come to an End for NAND?

■ Maintaining planar evolution so far... But, Scaling is getting difficult

- Sub-1ynm hitting the limit of cell reliability → Enterprise ?
- Tremendous investment cost required to continue → Consumer ?



Future die shrinks:

Prohibitively expensive, reliability concerns, diminishing wafer productivity

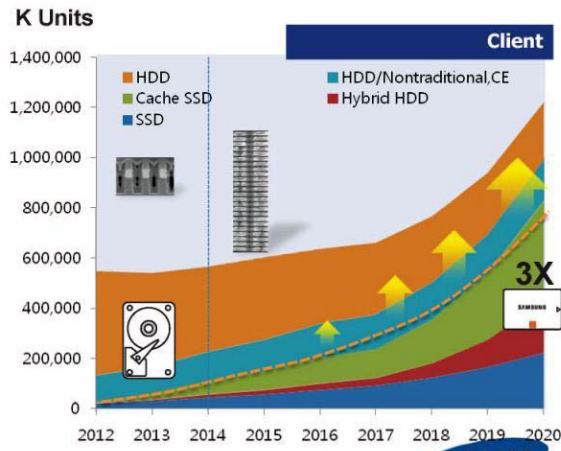
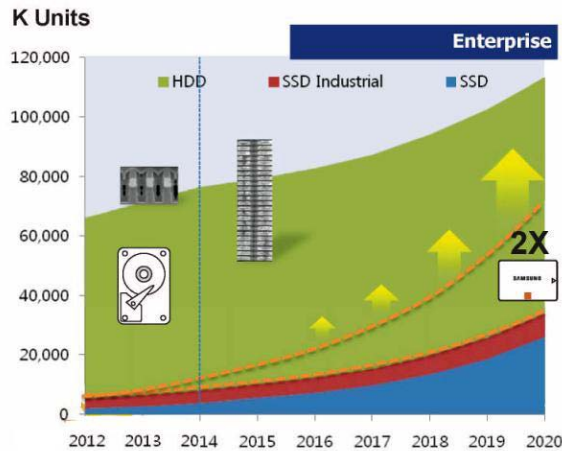
How to power the Internet of Everything with NAND?

SAMSUNG

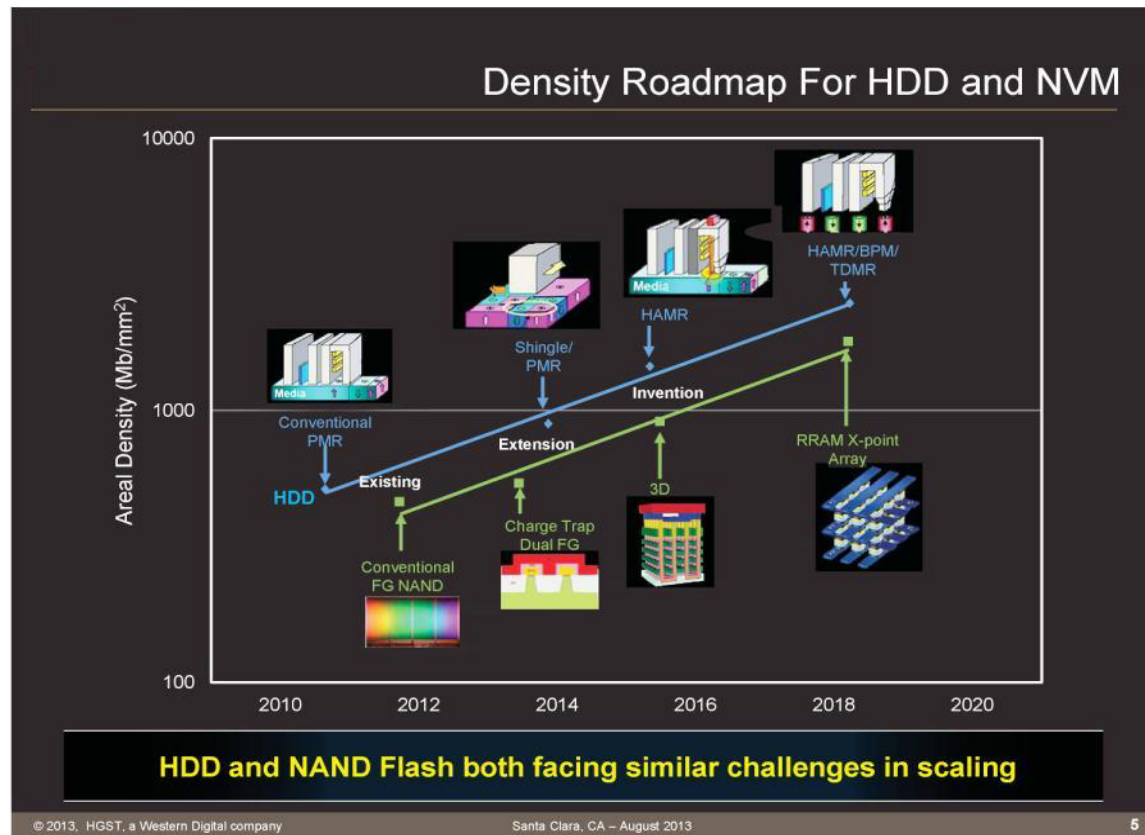
3D-NAND Could Increase the Market for SSDs

SSD Market Forecast with V-NAND Impact

"SSD for Everyone!"



But HDD is Rising to the Challenge



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Not Only Do We See Hybrids at the Enterprise

New Approach: SSD + HDD = Cost Savings

HDD-ONLY CONFIGURATION

- Slower Mechanical Drives
- Inefficient I/O Transfer Rates
- Smaller Form Factor Drives
- Over-provisioning of HDDs
- Lower Capacity HDDs
- Latency and Bandwidth Issues



Sandisk

HYBRID CONFIGURATION

- Faster I/O Performance
- Lower System Cost \$/GB
- Tiered Data Storage – ‘Hot’ Data on SSDs
- Improved Reliability
- Increased Capacity with a Smaller Footprint



But Now All SSD With Cold Flash

Flash (solid state storage)

Today: Flash SSD drives are commonly used in databases and applications that need low-latency high-throughput storage.

The flash industry has focused on driving higher and higher write-endurance and performance. By looking in the opposite direction--low-endurance and poor-performance--a “cold flash” storage option is possible.

Facebook

Counter Intuitive Thinking

Cold Flash*

The Facebook Ask?

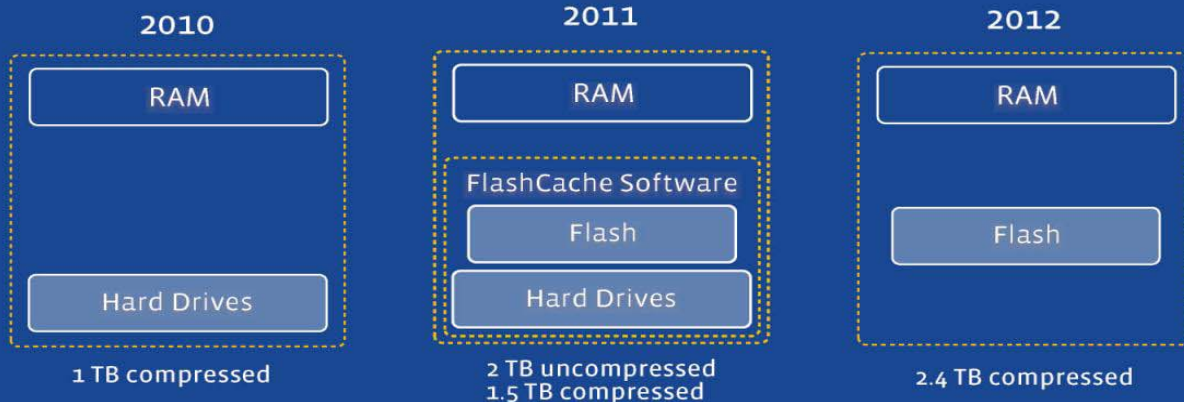
Make the worst flash possible--just make it dense and cheap.

Long writes, low endurance and lower IOPS/TB are all ok.

* Other solid-state technologies may also work for “cold flash.”

Facebook Has Gone From All HDDs in 2010 to All Flash in 2012

Flash in User Databases

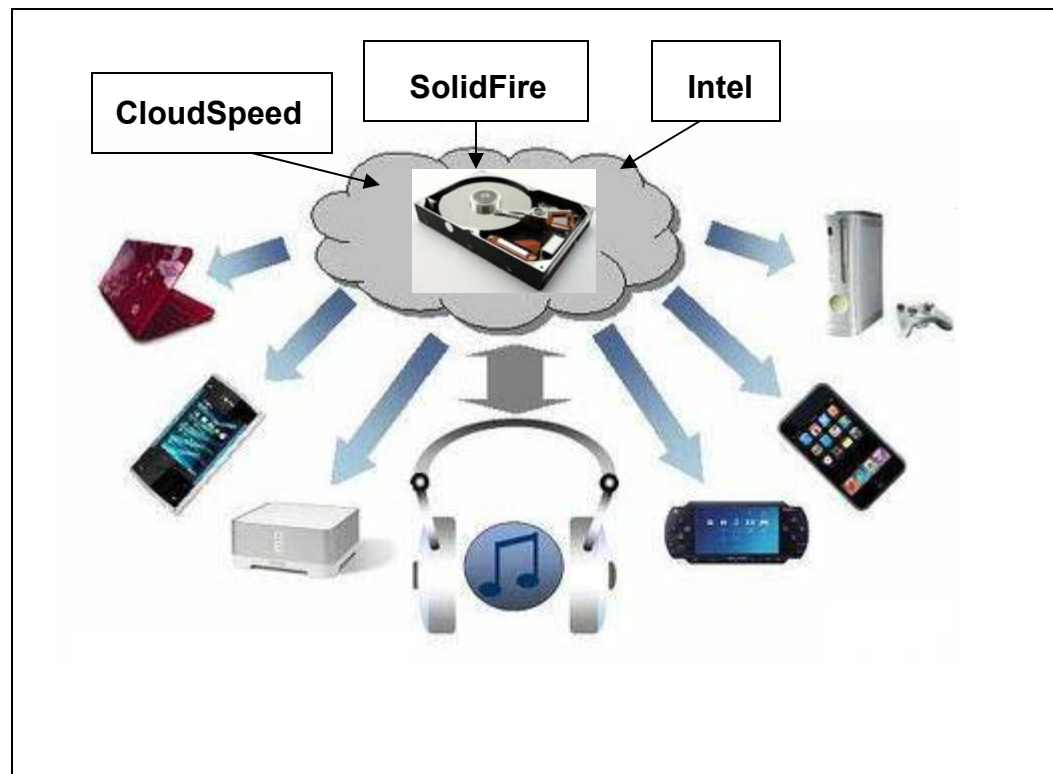


Each iteration increased capacity and lowered latency outliers.

Last Year's Talk Had the Cloud Saving the Day



But SSD Is Also Moving to the Cloud



What Do the Customers Think?



What The Client Wanted



How The Engineer Designed It



What The Client Received



What The Client Really Needed

Concept of Cost Changed Dramatically From 2012 to 2013

My organization plans to completely replace HDDs and deploy SSD as primary storage:

Never. It will always be more expensive than HDD and be used only for applications which can justify the added cost

When SSDs are the same \$/GB of HDDs

When SSDs are within 50% of the \$/GB of HDDs

When SSDs are within 40% of the \$/GB of HDDs

When SSDs are within 30% of the \$/GB of HDDs

When SSDs are within 20% of the \$/GB of HDDs

When SSDs are within 10% of the \$/GB of HDDs

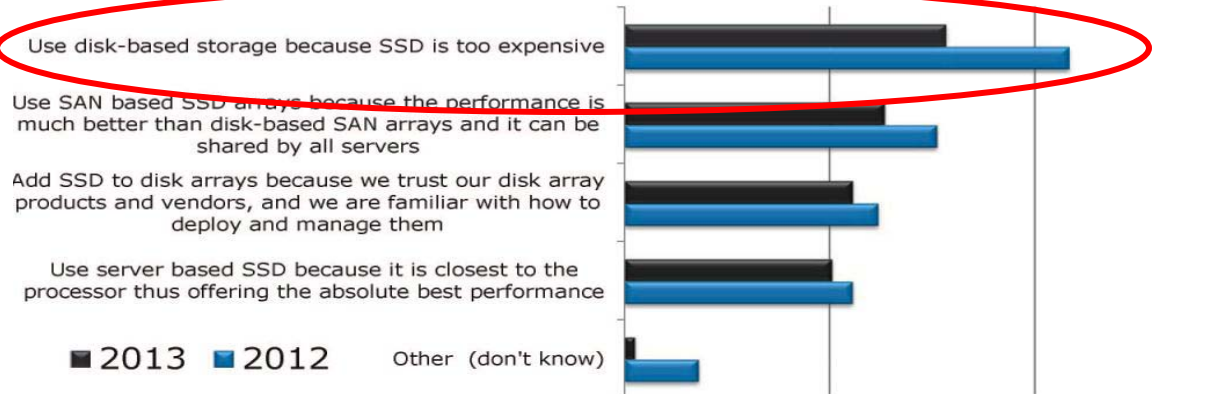
■ 2013 ■ 2012

Other

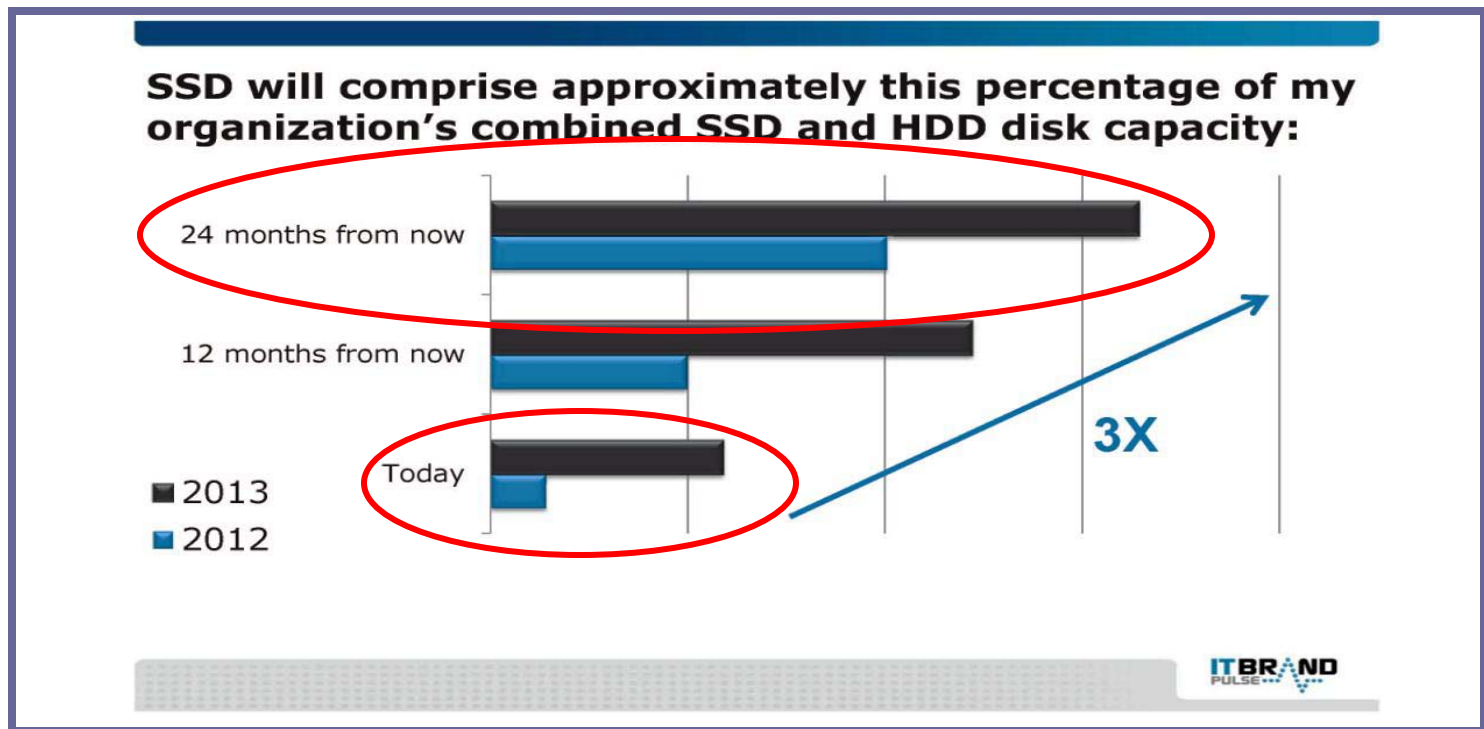
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Again, Cost

My organization uses the following SSD strategies (select all that apply):

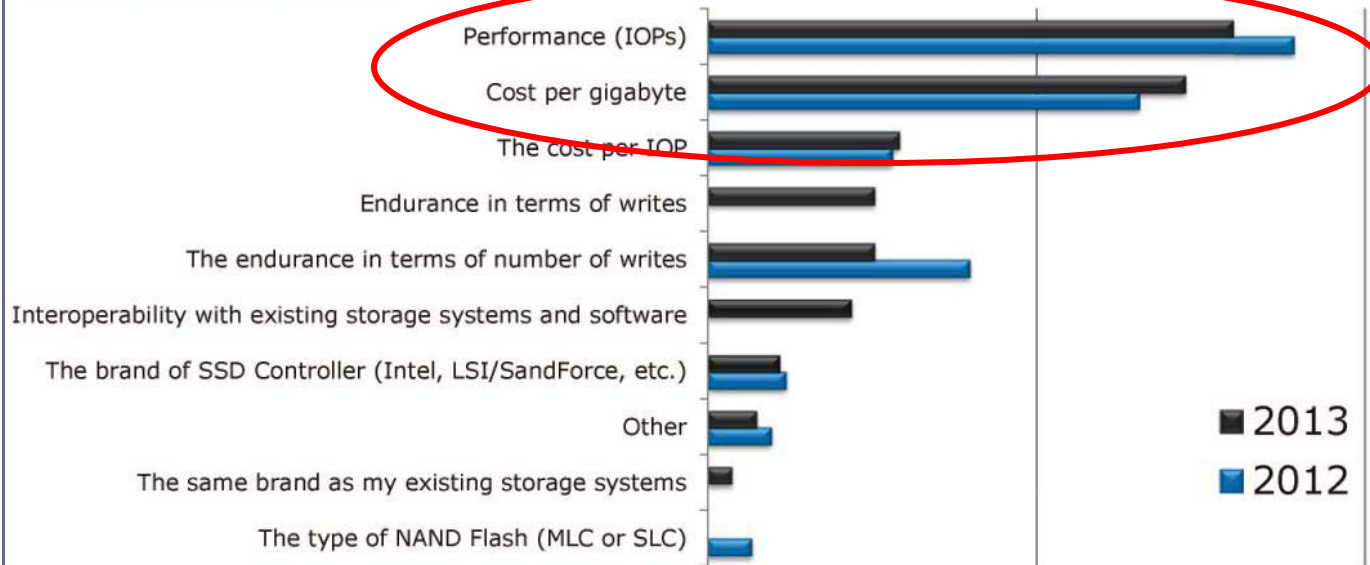


SSDs a Small Percentage in 2012, Not So in 2013, And Growing



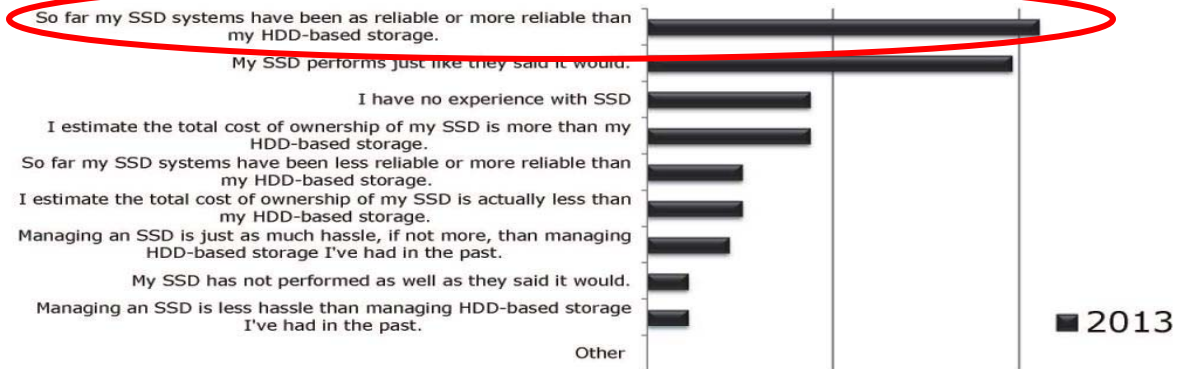
Cost and Performance Too Issues

The most important feature of an SSD for my environment is:



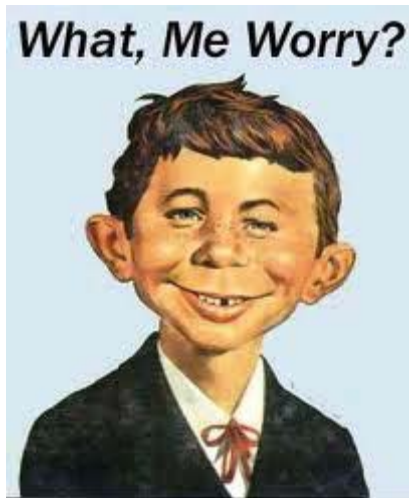
Reliability of SSDs is High

My experience with SSD so far (all that apply):

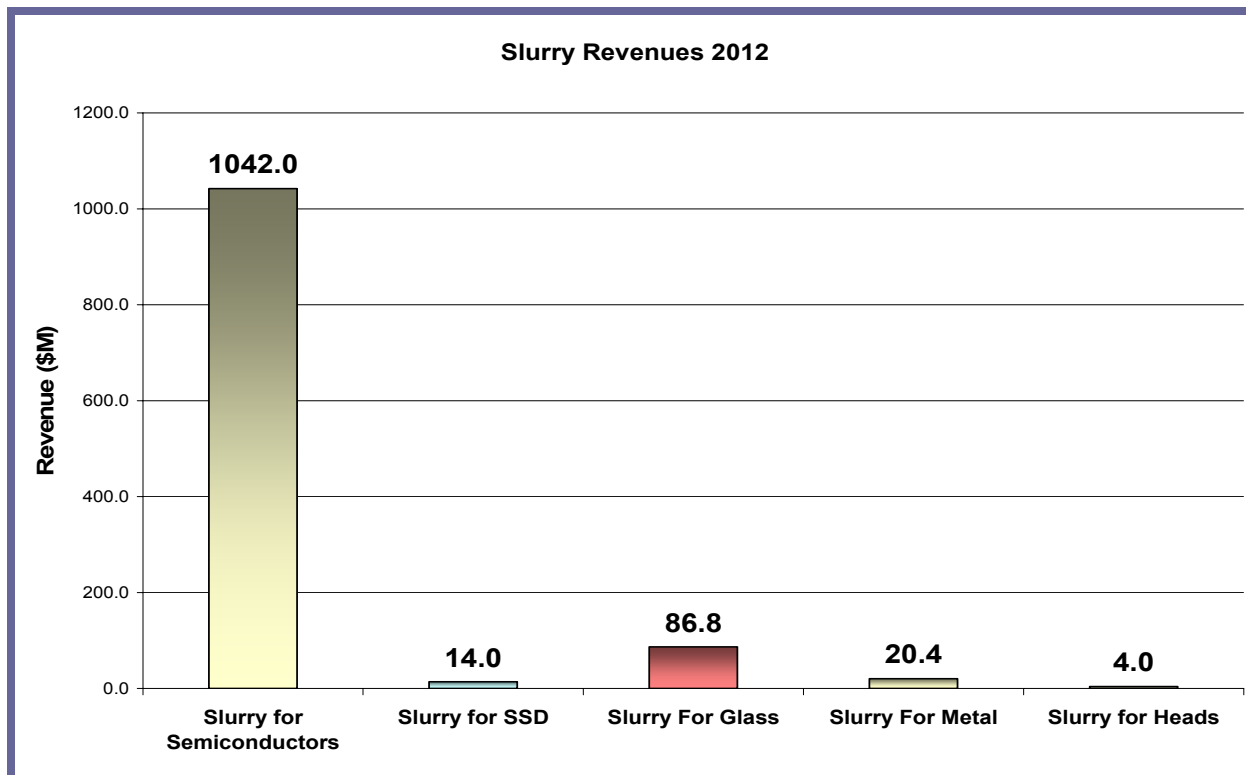


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Maybe!



With CMP, Slurry Revenues Are Small Anyway



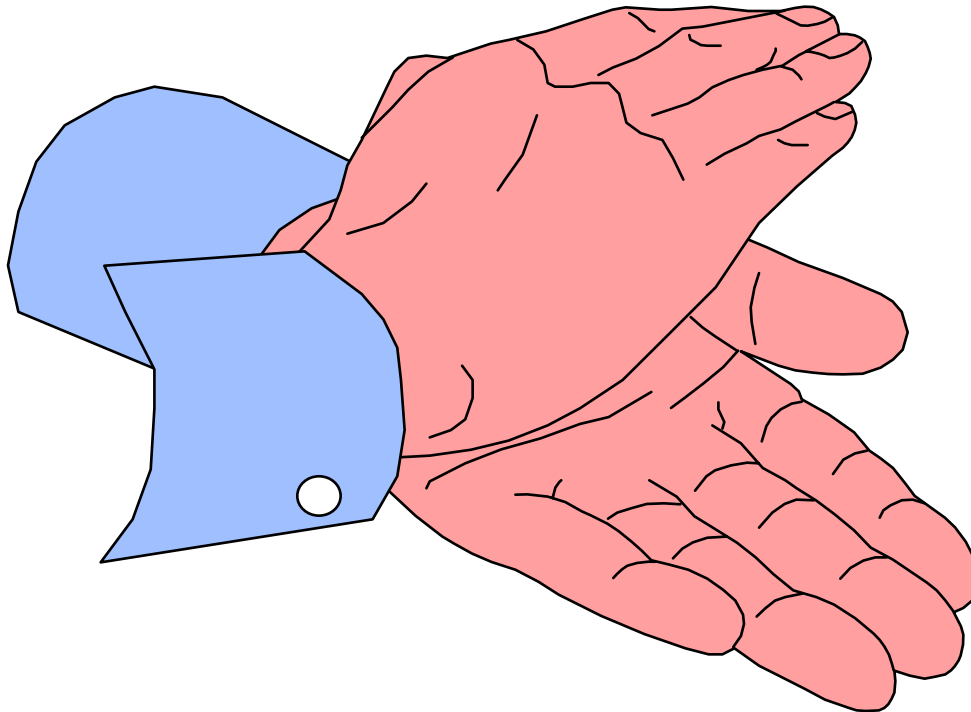
Source: The Information Network

And There Aren't Enough Megafabs to Make All the NAND

	NAND Replaces All HDD	NAND Replaces HDD Enterprise
PentaBytes	380,000	50,000
MSI	9,907	1,304
MEGAFABS	247	33
CAPITAL	\$864B	\$115B

Source: IBM

Thank You



Source: The Information Network