NAND in the Driver's Seat

August 18, 2010

Jim Elliott
Vice President
Marketing & Product Planning
Samsung Semiconductor, Inc.

Flash Memory SUMMIT

SAMSUNG

Presentation Agenda

- NAND Market Overview
  - CAPEX & Growth
  - Demand & Pricing Trends
  - Application Trends
- Paradigm Shifts → NAND Growth Drivers
  - Mobile Internet & Social Networking
  - Tablets
  - Smartphones
- SSD Update
- Concluding Thoughts

Beyond Mega and Giga…

What is the highest defined unit of measurement (Metric Prefix)?

SAMSUNG

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SI Prefix	Symbol	10^n	Short Scale	Decimal
None	None	1	One	1
Deca-	Da	10^1	Ten	10
Hecto-	H	10^2	Hundred	100
Kilo-	K	10^3	Thousand	1,000
Mega-	M	10^6	Million	1,000,000
Giga-	G	10^9	Billion	1,000,000,000
Tera-	T	10^{12}	Trillion	1,000,000,000,000
Peta-	P	10^{15}	Quadrillion	1,000,000,000,000,000

?

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Exa-	E	10^{18}	Quintillion	1,000,000,000,000,000,000
Zetta-	Z	10^{21}	Sextillion	1,000,000,000,000,000,000,000

And Finally?

Beyond Mega and Giga…

What is the highest defined unit of measurement (Metric Prefix)?

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Mega-	M	10^6	Million	1,000,000

The combined space of all hard drives in the world does not amount to one yottabyte.

As of 2009 the entire Internet was estimated to contain close to 500 exabytes

What comes next???

Exa-	E	10^{18}	Quintillion	1,000,000,000,000,000,000
Zetta-	Z	10^{21}	Sextillion	1,000,000,000,000,000,000,000
Yotta-	Y	10^{24}	Septillion	1,000,000,000,000,000,000,000,000

What Comes Next?

- Googa-Byte?
- Jedi-Byte?

- Woza-Byte?

- Hella-Byte ?

Hella?

kilo-
mega-
giga-
tera-
peta-
exa-
zetta-
yotta-
HELLA.

10^{27}

UCDAVIS AGGIES

The Sacramento Bee

Forget 15 minutes of fame. Austin Sendek is getting hella minutes.

The UC Davis physics undergraduate has reaped international attention since March, when The Sacramento Bee wrote about his campaign to establish a new, scientifically accepted prefix, "hella," to be used in front of units of weight, distance or just about anything.

The sun's mass would be 2.2 hellatons releasing energy at 0.3 hellawatts

Hella has >63,000 Facebook Fans.

The international committee that decides such matters is expected to hear the idea at its September meeting in Paris. Chances of approval are considered to be hella slim.

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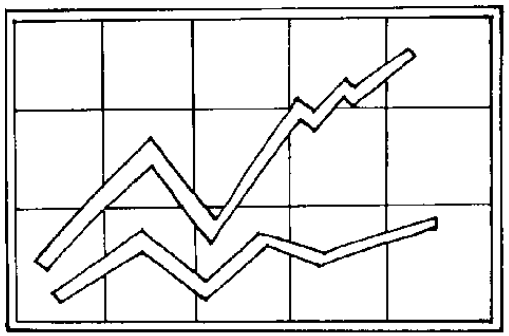
  - **Application Trends**



- Paradigm Shifts → NAND Growth Drivers
  - Mobile Internet & Social Networking
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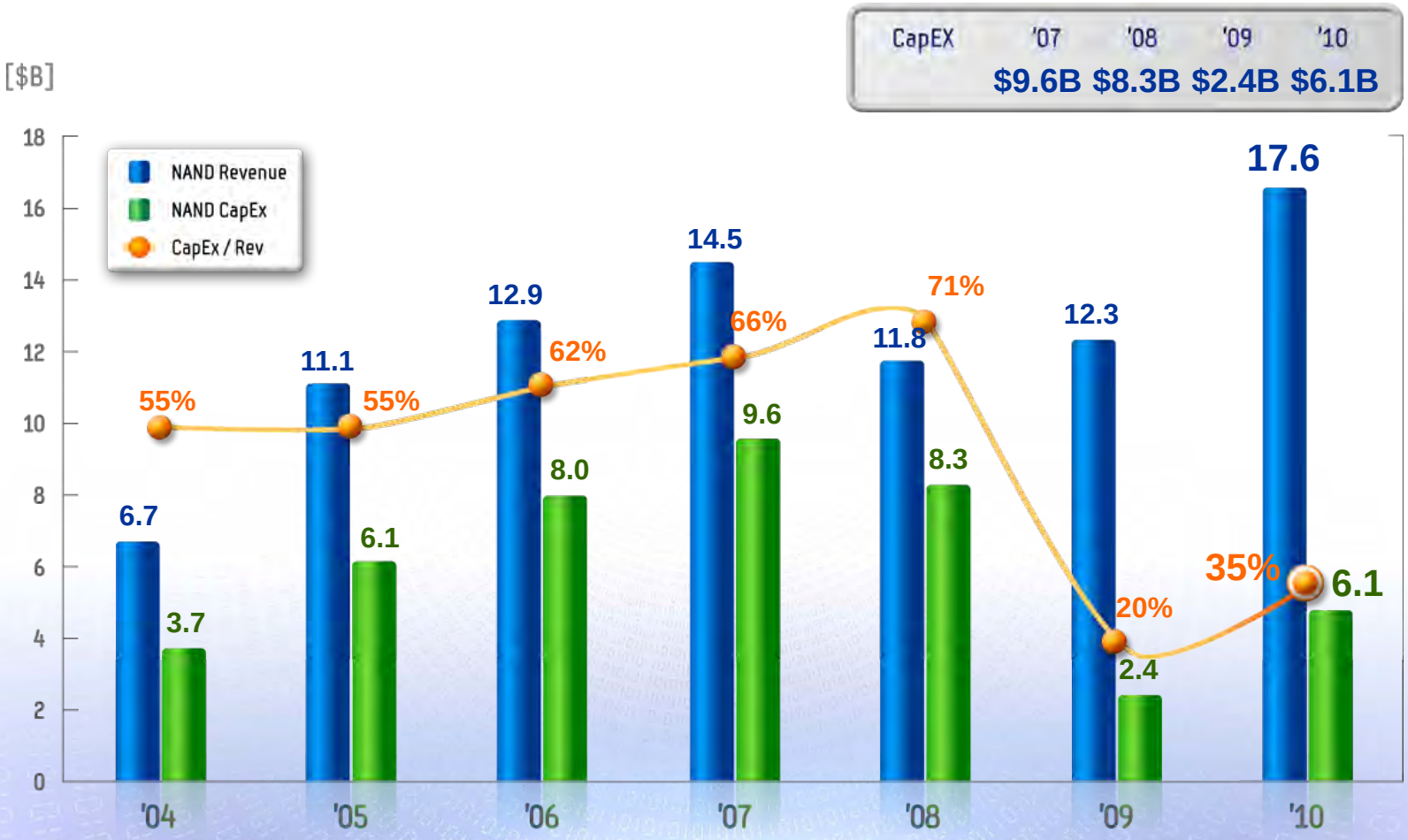
Memory Makers' Financial Health Status

Market in recovery as of late 2009 (after 10 consecutive quarters in the red)

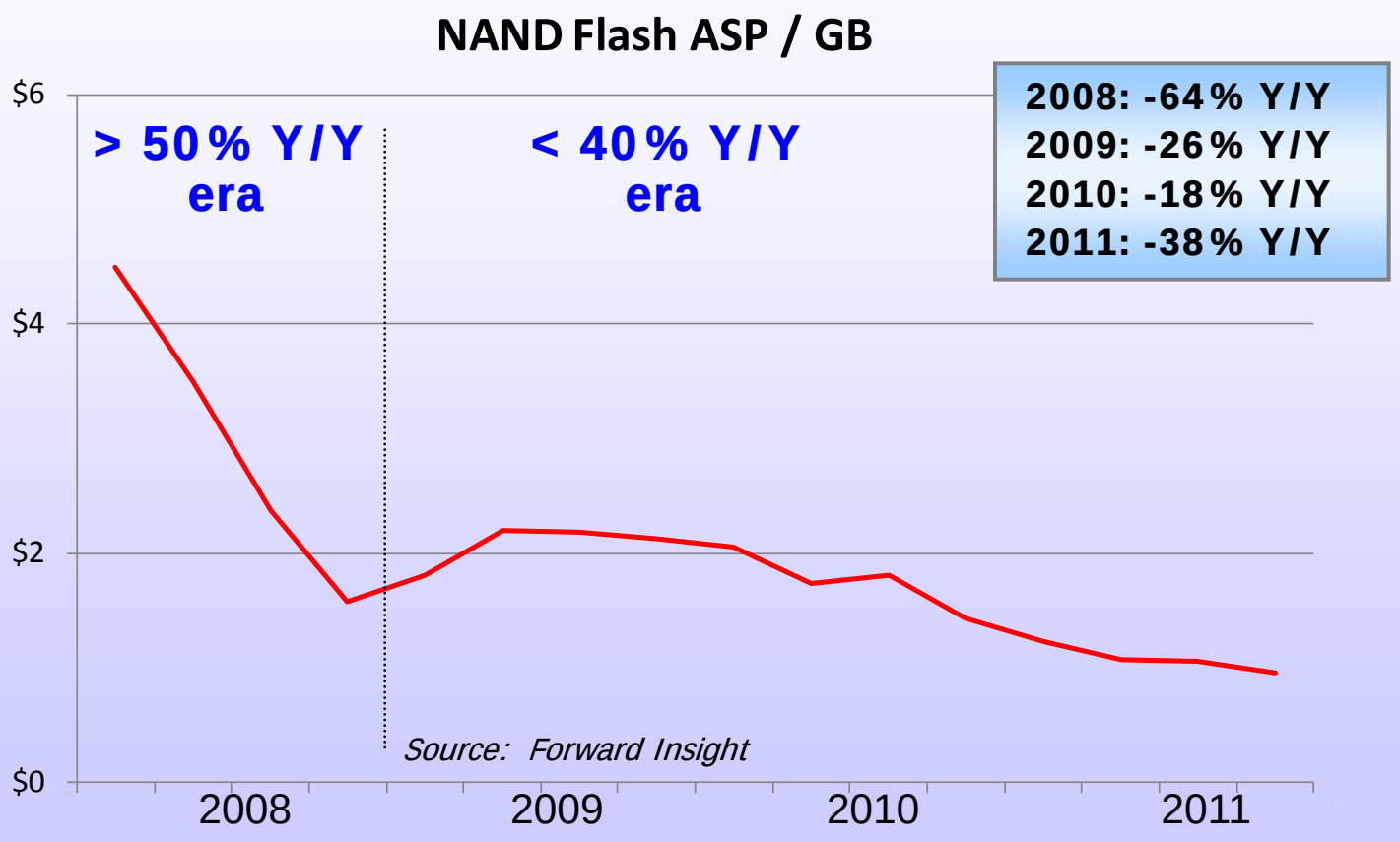
NAND CAPEX vs. Revenue Trends

- **CAPEX Investment Rebound in 2010 to ~$6.1B**
- **Still Well Below Levels Seen This Decade…**



* Source : Gartner, Company Reports, Samsung

NAND Flash Pricing Trends

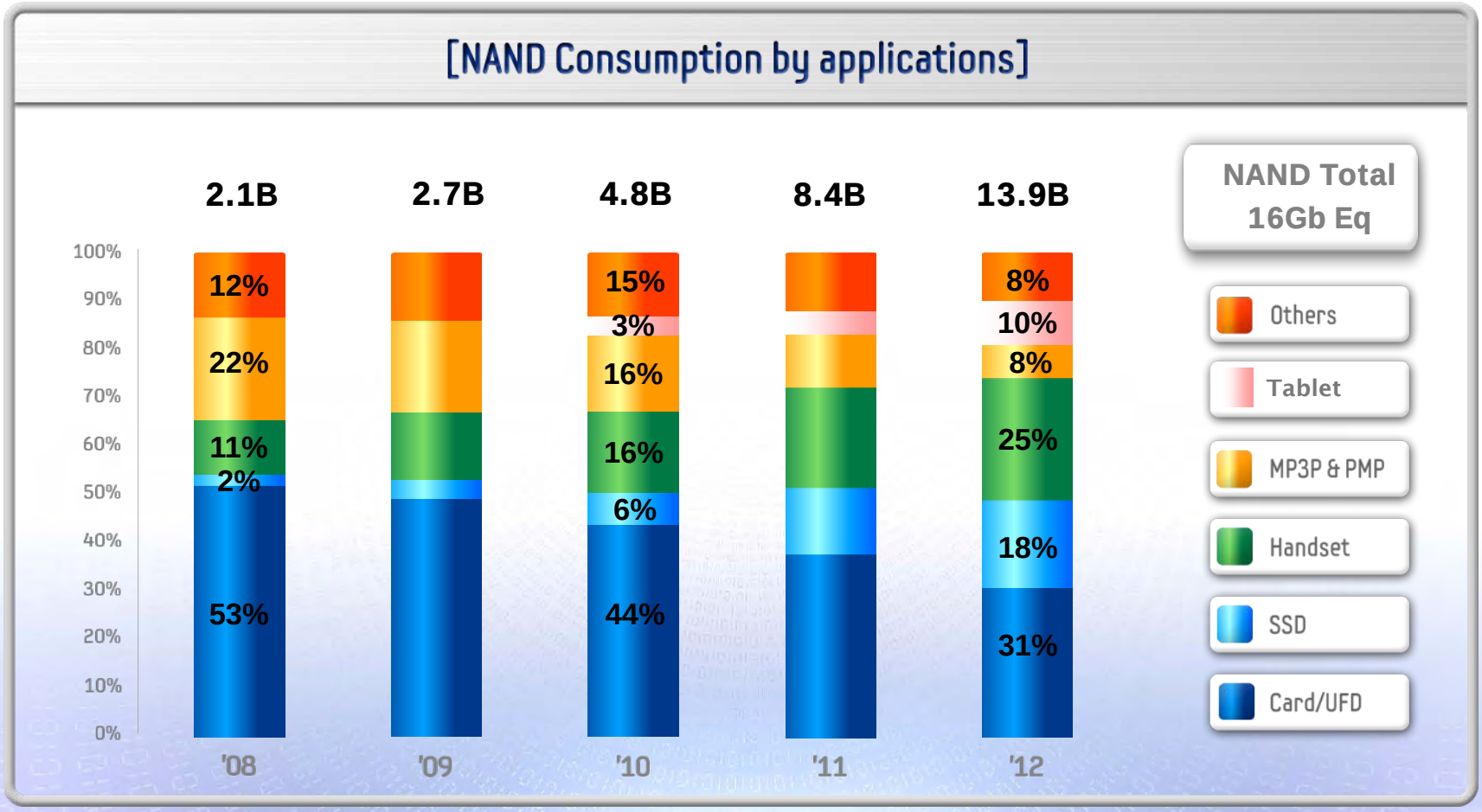


Factors Affecting Price per GB Trends:

- Supply Increases, Transition to 64Gb Mono
- 3bpc growth
- SSD Demand Elasticity Effect...

End Application Diversification

- **NAND Application trends → More Diversification → More Stability**
  - **Cards and USB Flash Drives no Longer the Driving Force**
  - **Tablets Coming into the Mix this Year…**



*Source: Samsung

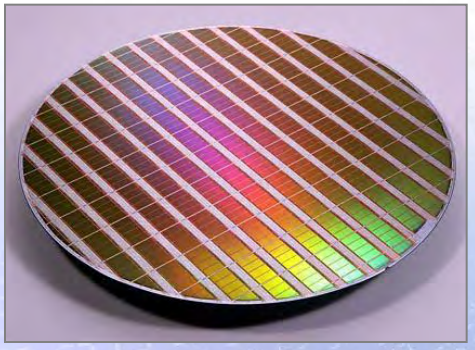
More Applications Driving NAND Growth

- NAND demand is expected to reach 9.5B GB's in 2010
  - Handset, SSD and Emerging Applications are Key Growth Drivers
  - Sharp Rebound since 2009, but well off historical levels...

BREAKDOWN of 2010 NAND DEMAND GROWTH

	Card / UFD	Handset	MP3	SSD	Other
Portion of Growth	27 %	17 %	9 %	6 %	17 %
(Growth Rate)	54 %	120 %	48 %	142 %	115 %

74 %



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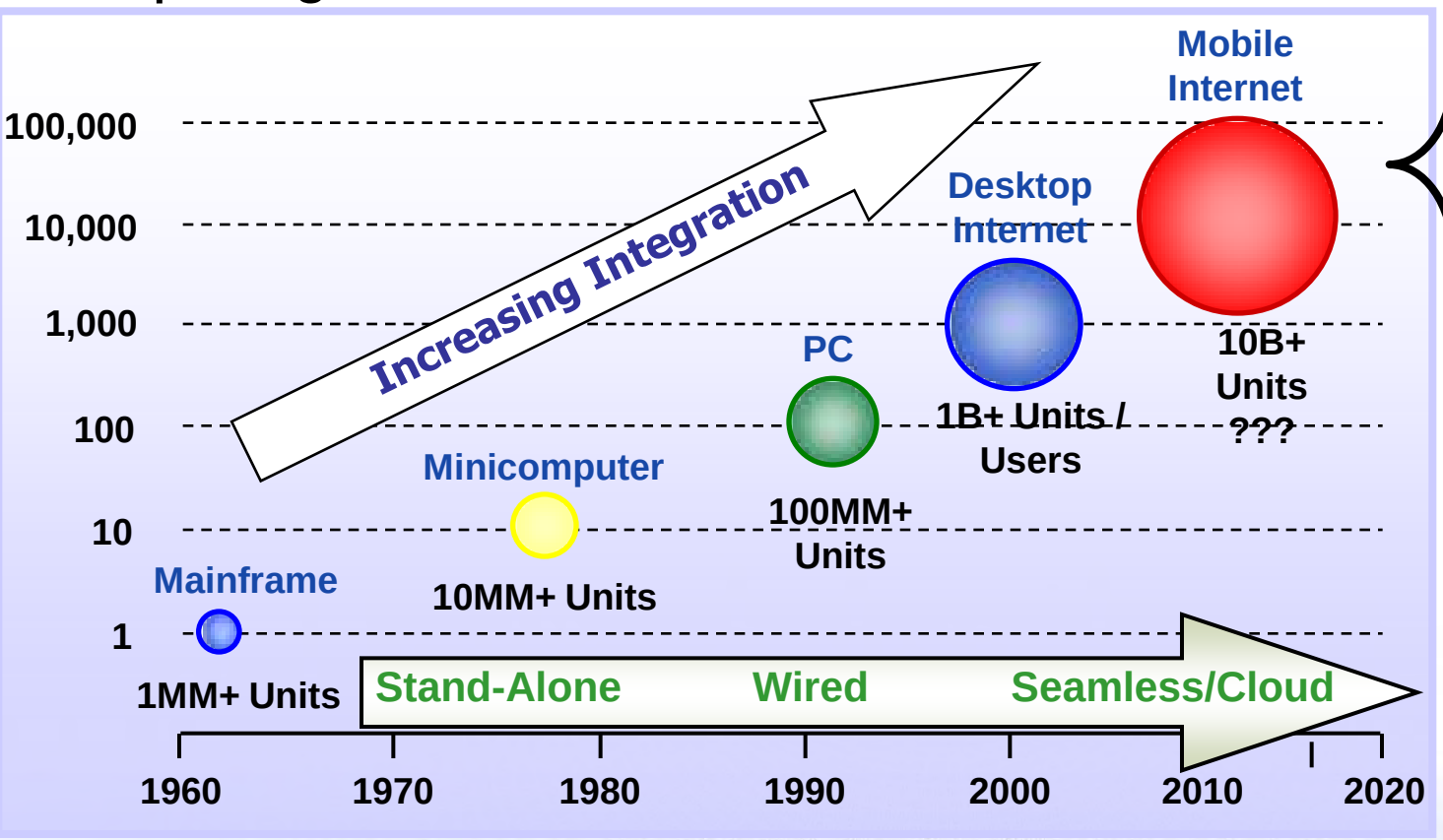
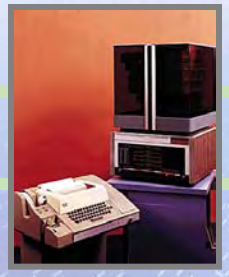
Mobile Internet will be 10X Desktop Internet

Computing Growth Drivers Over Time



Source: Morgan Stanley



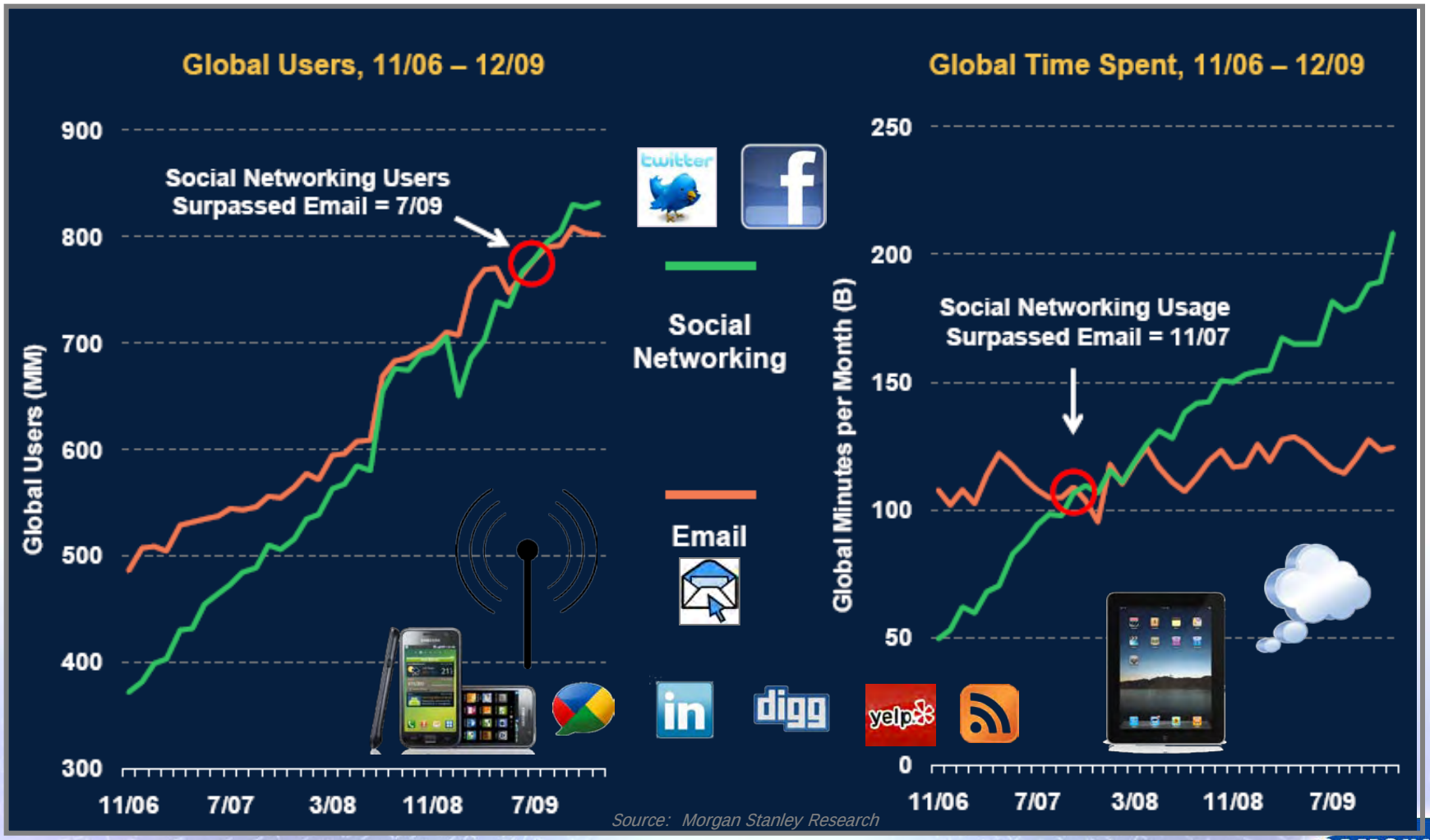
Web 3.0: Social Networking

Impact of facebook Keeps Growing…

	'09	'10
Rank	#3	#2
Active Users	250M	>500M
Use Daily	120M	200M
Photos / month	1B	3B
Videos / month	10M	>12M
Mobile Access	30M	>150M

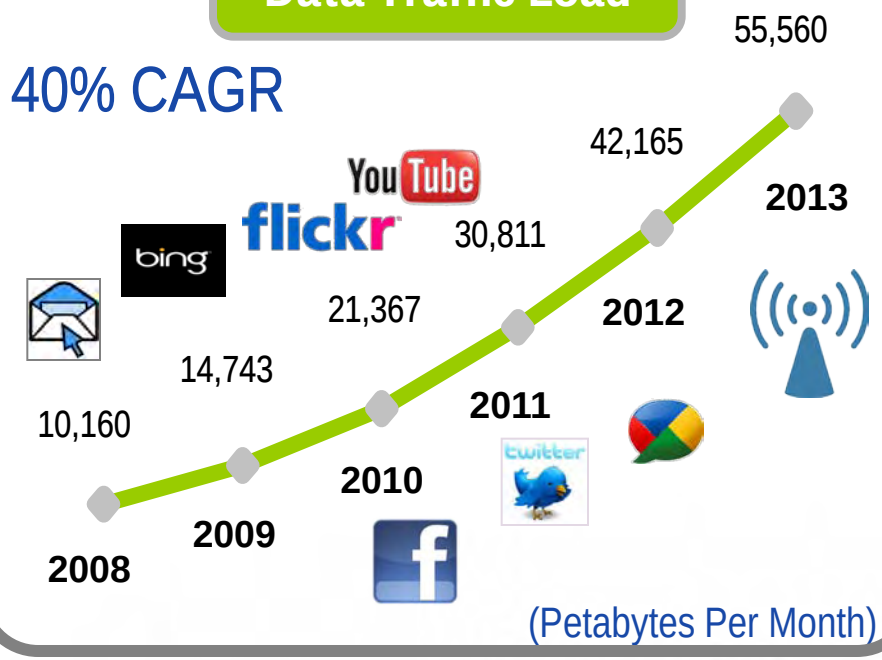
Internet Usage Driven by Social Networking

Social Networking Users > Email Users as of July '09
Time Spent on Social Networking Crossed over in Nov '07



Web 3.0 Impact on Traffic Load

Ever-increasing Data Traffic Load



The Cisco Visual Networking Index

Profound Impact on Connected Devices, Infrastructure, Ecosystem, Usage Models …

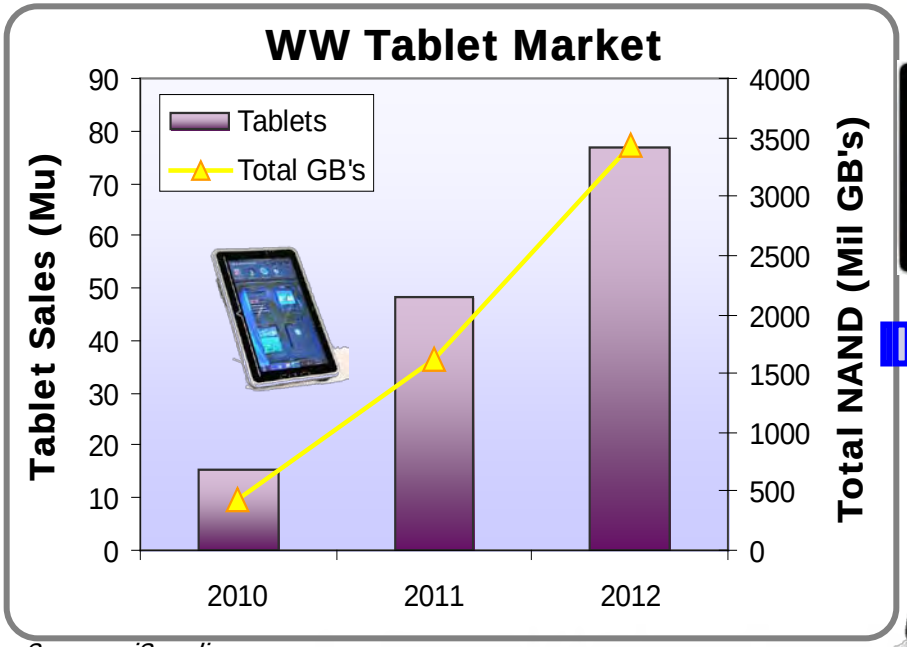
1PB = 13.3 yrs of HD Video or 4.7B eBooks

50PB = Entire written works of mankind, from beginning of recorded history, in all languages

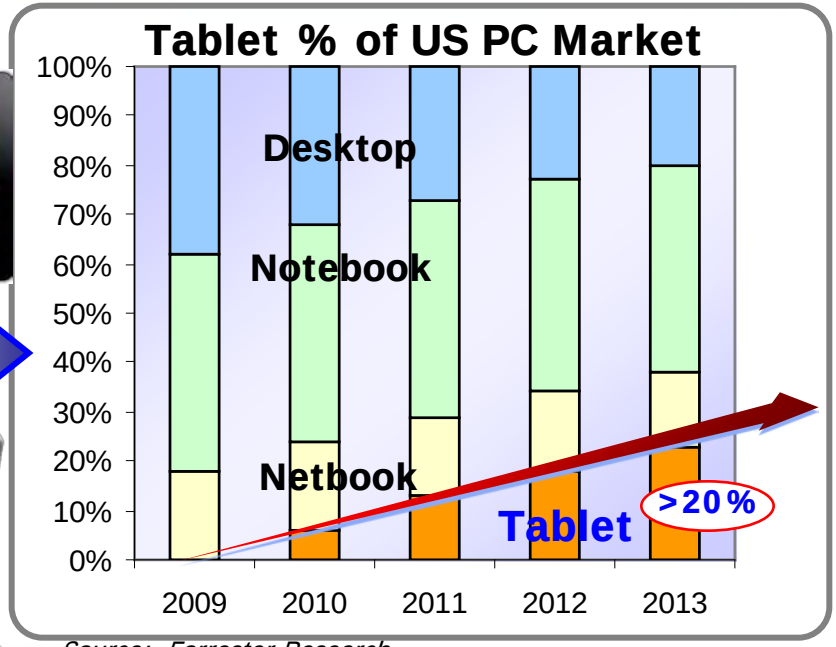
By 2020 = ~600,000 PB of data traffic per month (or 600 Exabytes)

By 2040 = ~0.5 YB of data traffic per month (0.0005HB)

Tablet Revolution 2010



Source: iSuppli



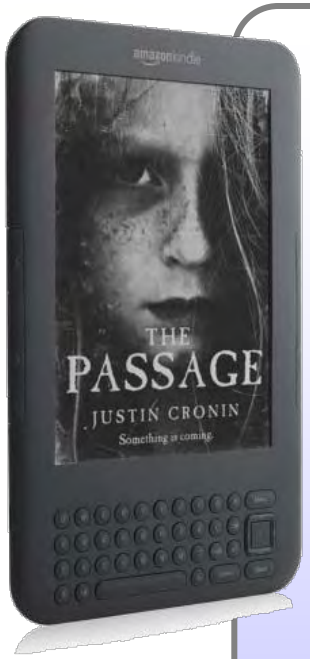
Source: Forrester Research

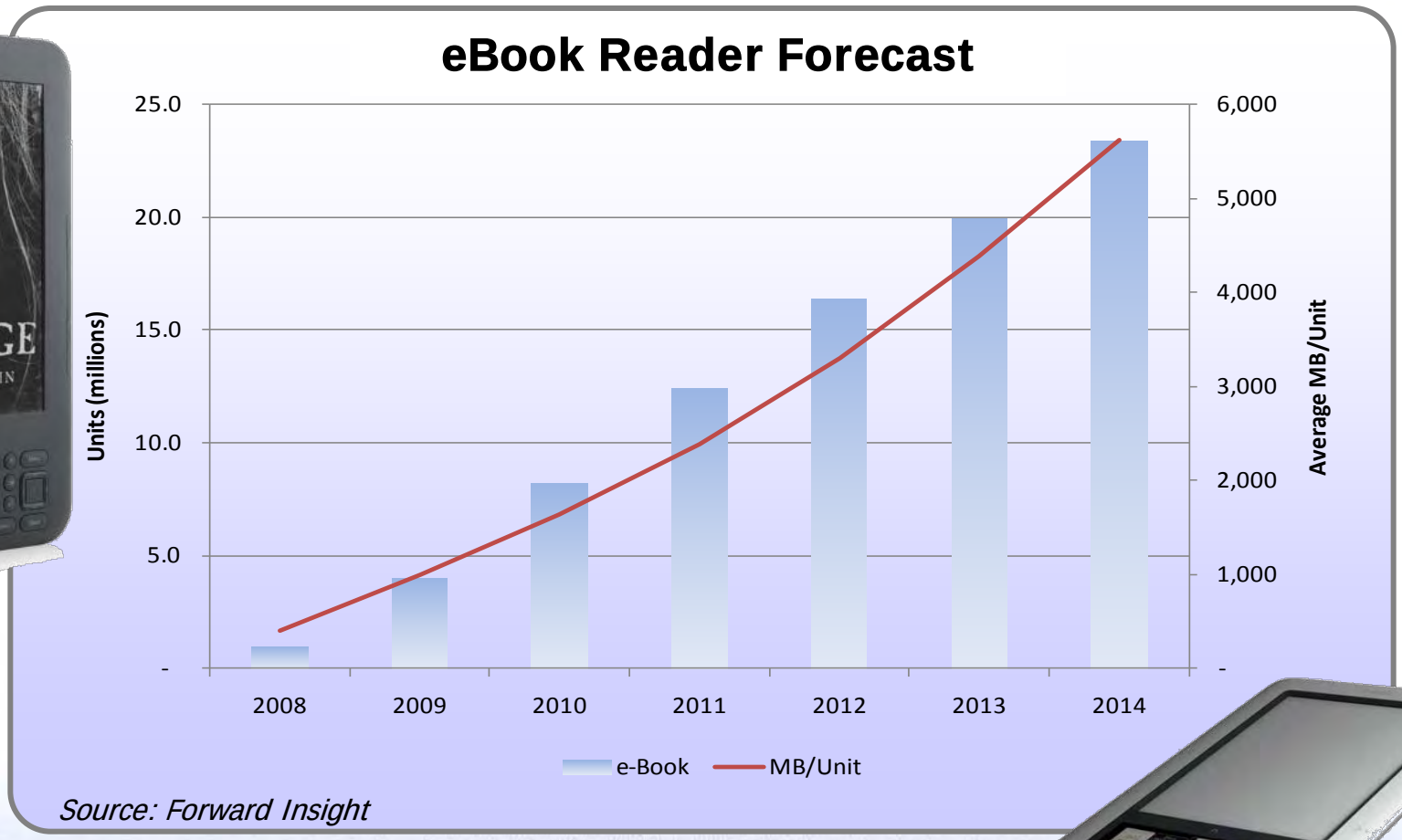
Tablets vs PC Sales	2010	2011
Total Cannibalization	40%	40%
Netbook Portion	95%	50%
Notebook Portion	5%	20%

Goldman Sachs Research Estimates

- **PC Paradigm Shift → New Product Category**
  - ~60% of Sales are *Incremental*
- **Industry Crossroads: Mobile, PC, Networking**

eBook Readers: Growth Despite Tablet





Source: Forward Insight

- Unit CAGR = 70% despite Tablets. 100% NAND Based.
- Razor and Razor Blade Business Model ($139)
- Tablet & Smartphone sales increasing content sales (Kindle App)
- Amazon eBooks outsell hardcover now & vectoring to outsell paperback in 1 yr

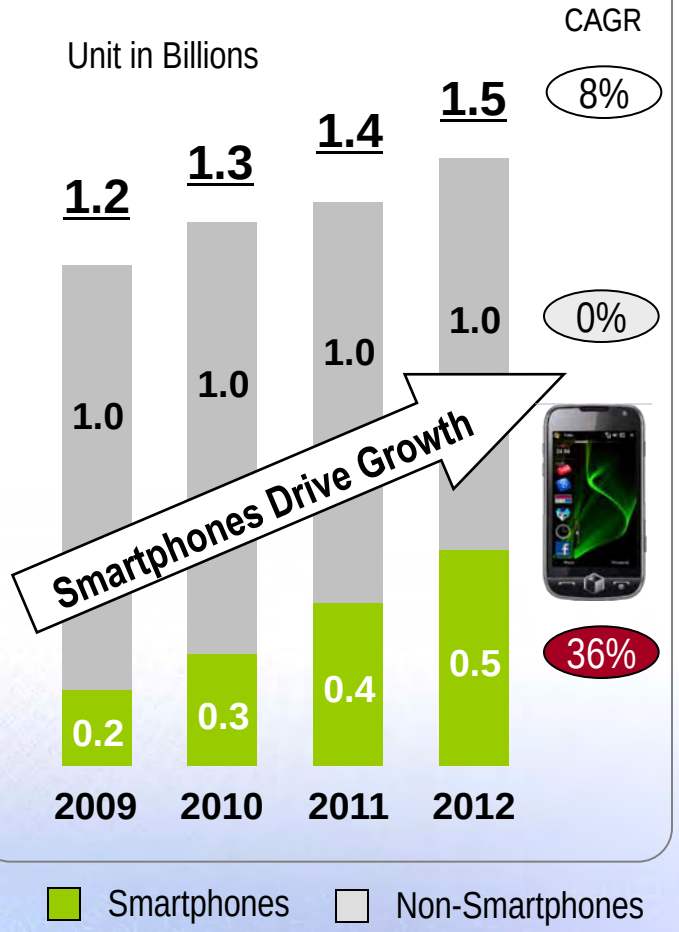
Smartphones Driving Mobile Experience

Breakdown of Smartphone Usage Time

Seamless Connectivity
At Home, At Work & On the Go

iSuppli, Gartner

Mobile Phone Production

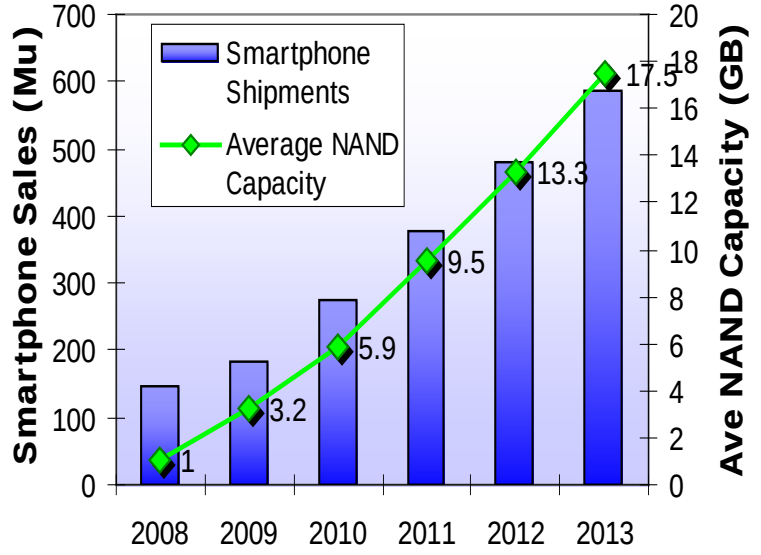


"For Class of 2014, Email is Already Dead…"

Smartphones Driving NAND Growth

Web 3.0: Multi-tasking, HD Content, Web Browsing & Apps

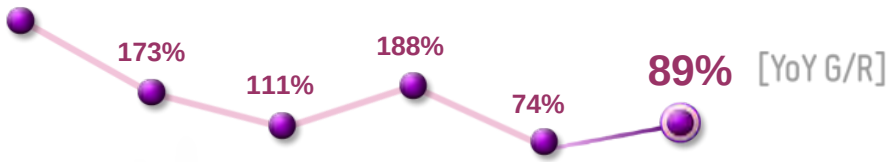
Smartphone: Embedded NAND Content



* Source: Forward Insight

16GB eMMC
+
16GB µSD

32GB Flash Content!



All Phone: Embedded Content

1.4GB

'01~'09 CAGR 273%

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- **SSD Update**

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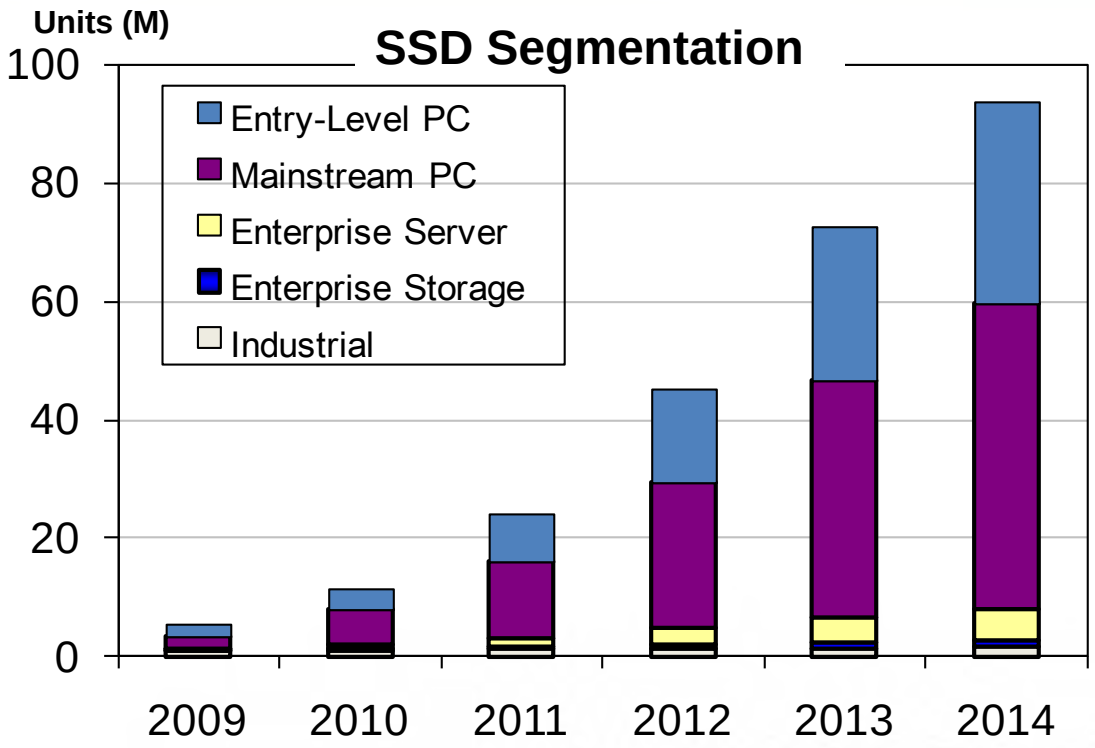
5 Classes of SSD: All Driving Growth



TOTAL SSD
5 Year Outlook (09-14)
- Unit Growth: 76%
- MB Growth: 127%

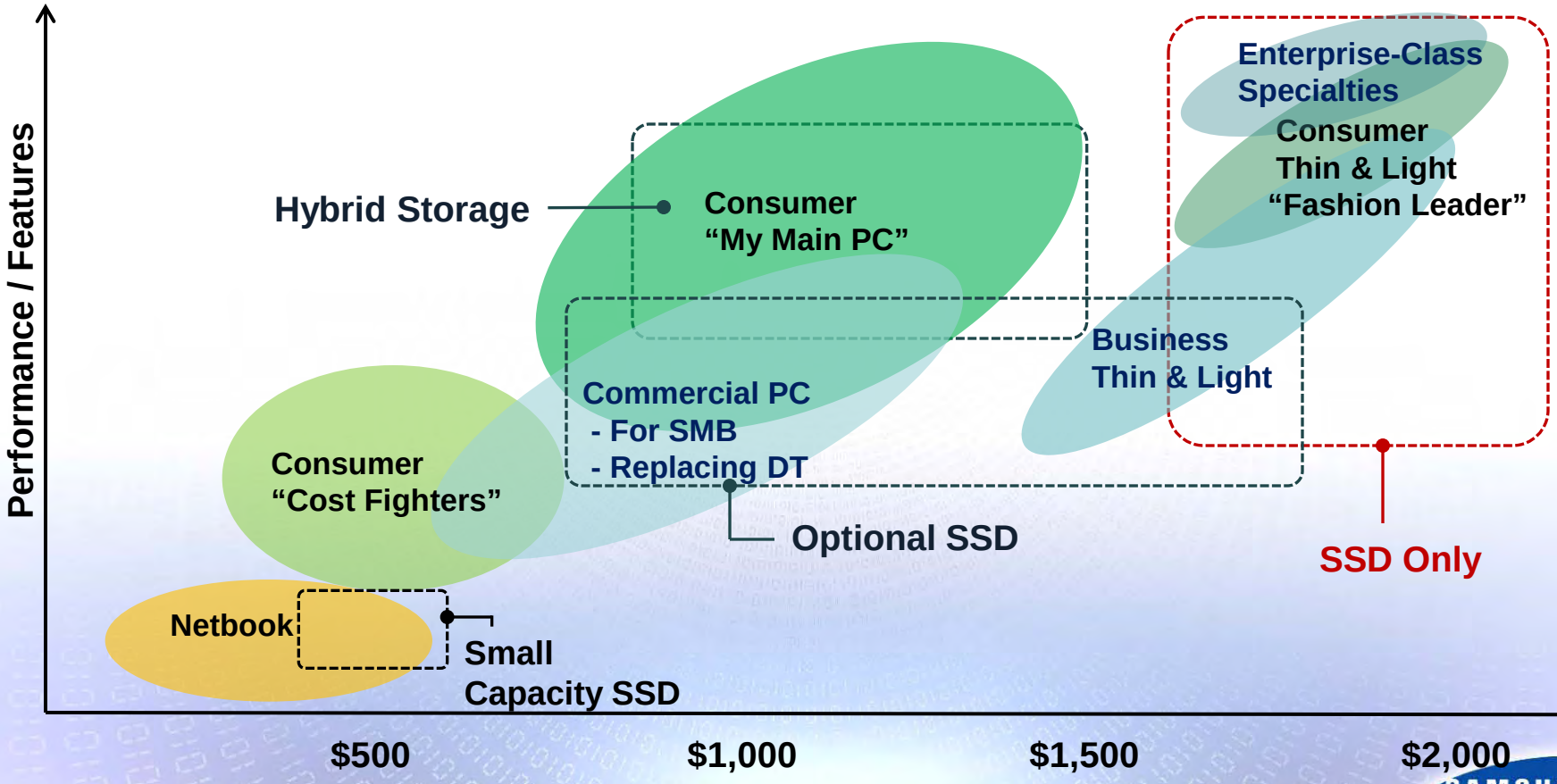
2014: NB Attach Rate ~22%

• Entry-Level PC	2009: 2.0M Units, $64M	→	2014: 34.1M Units, $0.7B
• Mainstream PC	2009: 2.3M Units, $541M	→	2014: 51.9M Units, $3.8B
• Enterprise Server	2009: 0.2M Units, $167M	→	2014: 5.2M Units, $1.9B
• Enterprise Storage	2009: 0.1M Units, $318M	→	2014: 1.1M Units, $1.7B
• Industrial	2009: 0.9M Units, $133M	→	2014: 1.5M Units, $166M
	2009: 5.5M Units, $1.2B	**→**	**2014: 93.8M Units, $8.3B**

Gartner July 2010

PC SSD Market Segmentation

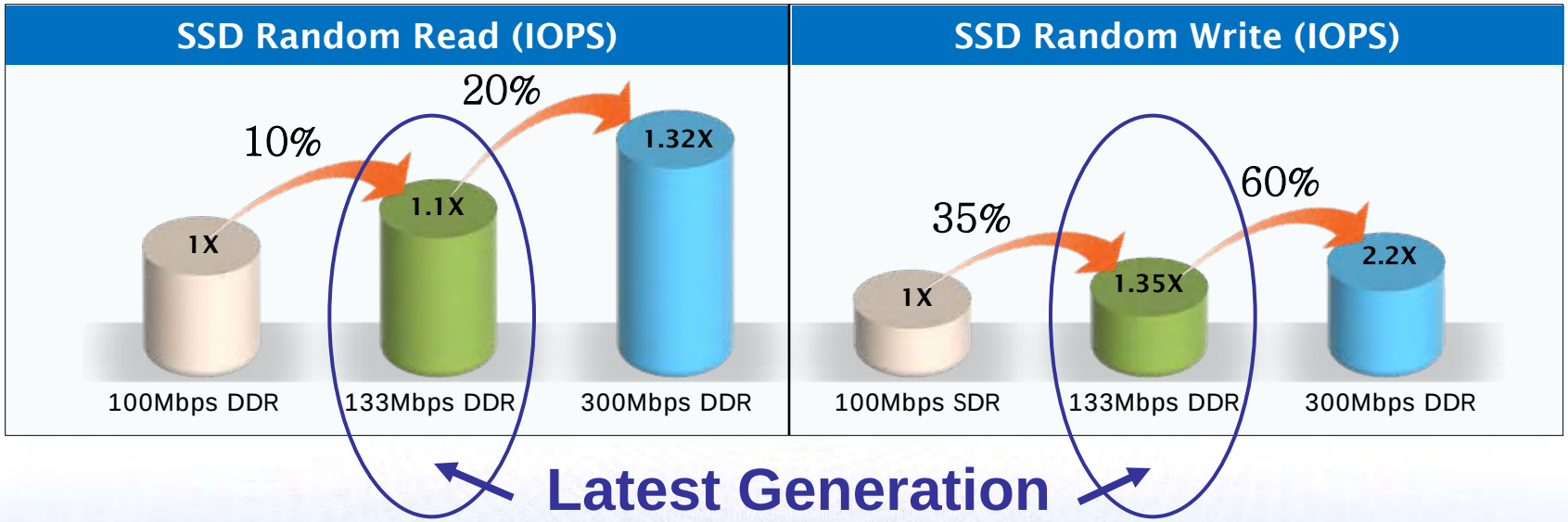
- **Each PC segment requires different SSD solution**
  - High-End: SSD Only Candidate
  - Mid-Range: SSD Option (Commercial) / Hybrid Solution (Consumer)
  - Low-End: Small Capacity SSD (Netbook)
  - **Summary: NAND will Proliferate into PC Applications…**



Toggle Mode NAND Driving SSD Performance

Flash Components Aligned with SSD market trends:

- Step 1: Performance Improvement with Toggle-mode NAND
  - Interface: 40Mbps → 133Mbps (Current) → 300/400Mbps



- Step 2: Low Power Consumption
  - I/O operating voltage (VccQ) 3.3V → 1.8V (Future)
- Step 3: Enhancing MLC endurance for Enterprise applications
  - 3K P/E cycle (Legacy) → 30K P/E cycle (Enterprise)

Samsung's Branded SSD

1st SSD to Incorporate Toggle Mode NAND

Available Capacity:	**64GB / 128GB / 256GB in SATA II**
Sequential Read/Write:	**250MB / sec Read. 200/220MB/sec Write**
Benchmark Score:	**52000 (PC Mark 05), 40000 (PC Vantage)**

Better Performance

- World Class Performance
- 36% faster than Previous

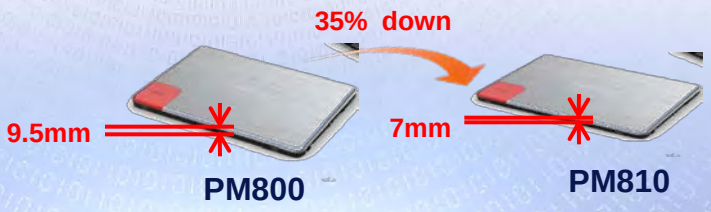
Lower Idle Power

- Save 16% of Idle current
- Dominant factor in battery time

Thinner Form Factor

- Thickness 9.5mm → 7mm

  Slim Form Factor



Major Improvements vs. Prior Generation

Samsung Brand SSD

campaign creative:

Tech Trendsetter

Samsung Brand SSD

campaign creative:

Digital Thrill Seeker

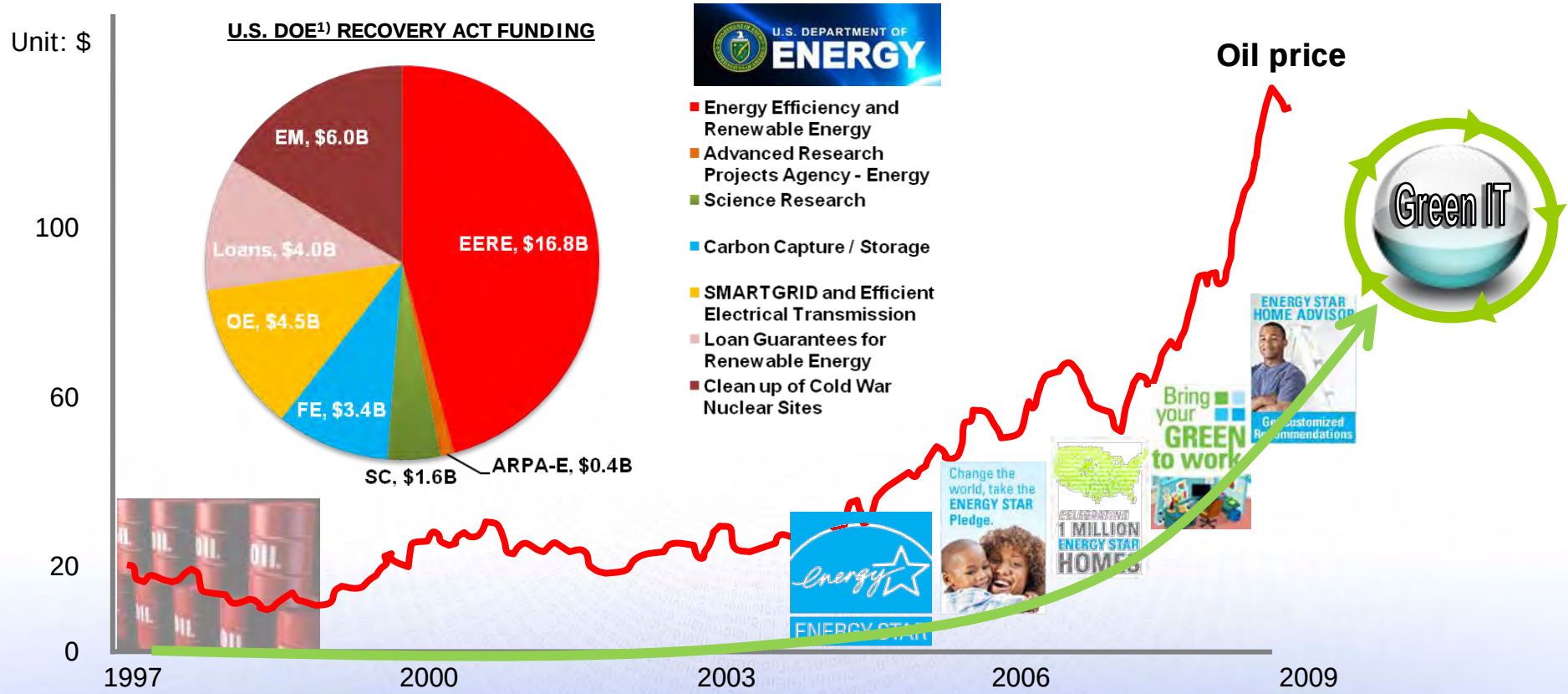
Samsung Brand SSD

campaign creative:

Demanding Productive

Green IT Update

- U.S. DOE funds $16.8B for energy efficiency and renewable energy
- Surging oil prices have made Green IT a focal point



1) DOE: U.S. Department of Energy
2) DOE RECOVERY ACT FUNDING, Source: *http://www.energy.gov/recovery/index.htm*

→ Green IT starts with Energy Efficient Components

SSD TCO → 'Instantaneous Breakeven'

Green IT

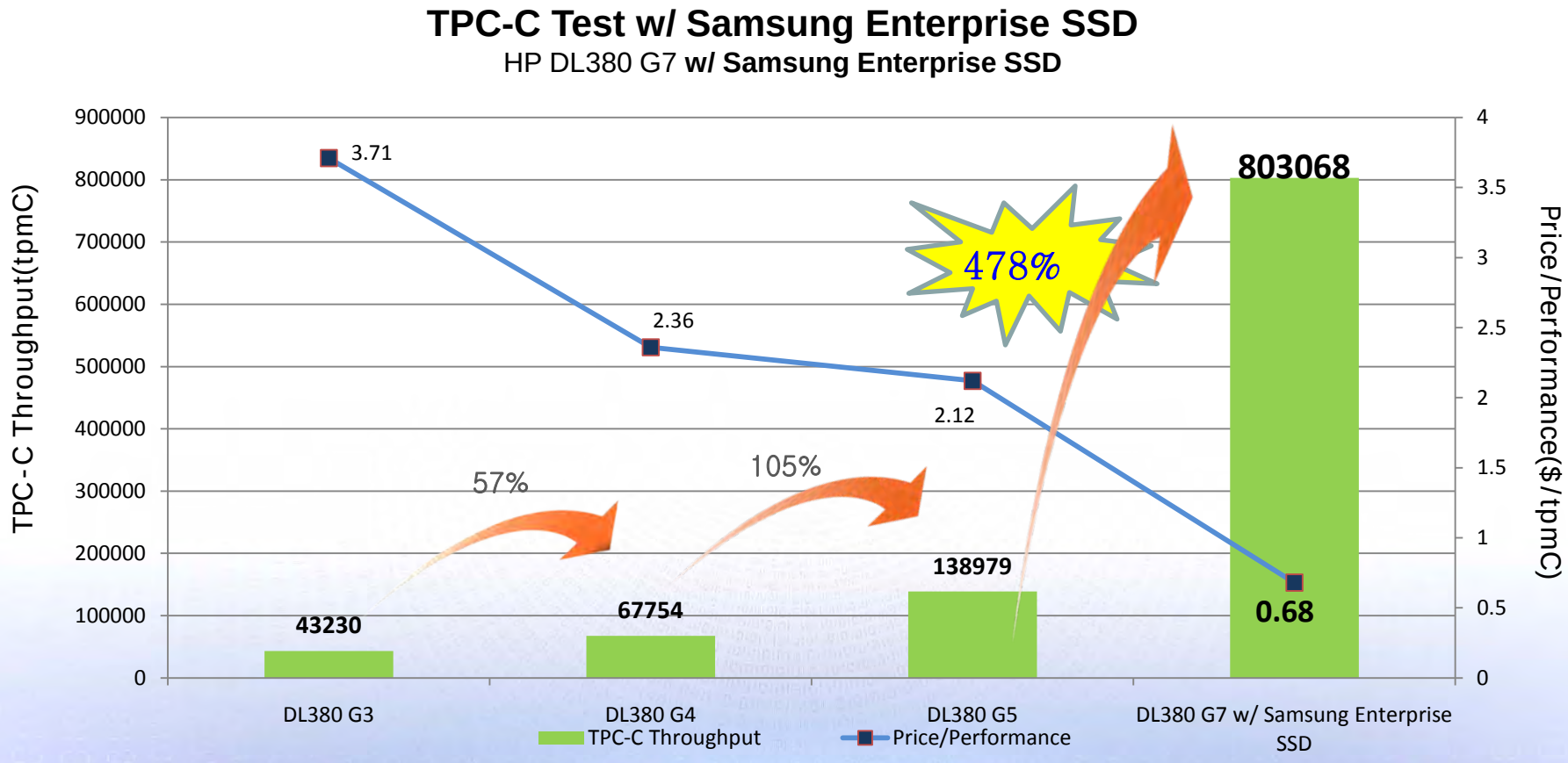
TCO

	SSD 2.5" SATA	15K HDD 2.5" SAS
Capacity	120 GB	73 GB
Max Read	230 MB/s	108 MB/s
Avg. IOPS	15,000	358
Active Power	~ 1.7 W	4.6 W
GB/W	**71** **4X**	**16**
IOPS/$	**15.00** **17X**	**0.90**
IOPS/W	**9000** **120X**	**75**

Source: Storagereview.com, March, 2009, IOPS calculated by IOMeter File Server average 1 I/O to 128 I/O w/ RR70% and RW30%

Samsung / HP Enterprise SSD Solution

- HP DL380 G7: #1 score using Samsung Enterprise SSD on TPC Benchmark



[Source : TPC website, http://www.tpc.org]

Delivering World-Record HP ProLiant Performance

Achieving #1 benchmarks with HP memory and storage options using Samsung Green DDR3 and Enterprise SSD technology

HP ProLiant SL2x170z G6 - Upholds #1 on SPECpower_ssj2008 benchmark – July 2010
HP ProLiant DL380 G7 - Highest x86 2-socket performance world record on TPC-C benchmark
HP ProLiant DL585 G7 - #1 non-clustered result for 300GB TPC-H benchmark – June 2010

SSD Controller Announcement Feedback…

Seagate and Samsung Announce Agreement to Jointly Develop Controller Technology for Enterprise SSDs

Business Wire
August 12, 2010

Seagate Technology plc (NASDAQ: STX), the world leader in hard disk drives and storage solutions, and Samsung Electronics Co., Ltd., the world leader in advanced memory technology, today announced that they have entered into a joint development and licensing agreement.

Under the agreement, the two companies will jointly develop and cross-license related controller technologies for solid state drive ("SSD") storage devices to attain the high levels of performance, reliability and endurance demanded by enterprise storage applications.

The joint development effort builds on the existing SSD capabilities of each company while combining Seagate's leadership in enterprise storage technology with Samsung's flash memory technology specific to 30 nanometer-class MLC NAND. The jointly developed controller will be utilized in Seagate's enterprise-class SSDs.

Let's hear what the experts have to say:

Joe Unsworth (Gartner)

"It's About Time!"

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MLC memory adoption for SSDs in the enterprise is an unequivocal must and Samsung's jointly developing controller technology with Seagate presents a real opportunity to deliver truly compelling, cost-effective enterprise SSD controller solutions.

Jeff Janukowicz, John Rydning (IDC)

IDC believes that Seagate and Samsung's agreement represents a win-win situation for both companies...we expect future SSD products for enterprise markets leveraging the strengths of both companies.

John Monroe (Gartner)

They are sending a signal to be prepared for a new class of enterprise-quality SSDs.

Less Energy. More Reliability.

The Samsung Solid State Drive

Samsung's unique enterprise SSD, made with genuine Samsung flash memory chips, increases system performance up to 38%(1) uses 32% less energy(2) and is far more reliable than your average HDD. It has no moving parts, which means lower failure rates – 40% less(3). It all adds up to technology that's better for your business, better for your bottom line, better for everyone. Look to the leader in memory technology, a worldwide leader in consumer electronics, to bring you innovations that improve your investment portfolio as well as your world.

For more information, please visit www.samsung.com/ssd

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(1), (2) Based on data provided by a major server storage company using an HDD-only system and SSD applied systems.
(3) Based on Samsung's evaluation of average failure rate under 24/7 operating conditions.

Thank you

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