



Less Energy. More Memory.  
More Speed.

# NAND in the Driver's Seat

## August 18, 2010

**Jim Elliott**

Vice President

Marketing & Product Planning  
Samsung Semiconductor, Inc.



# 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)?**

# Beyond Mega and Giga...



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

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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?				

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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.

 $10^{27}$ 

## 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.

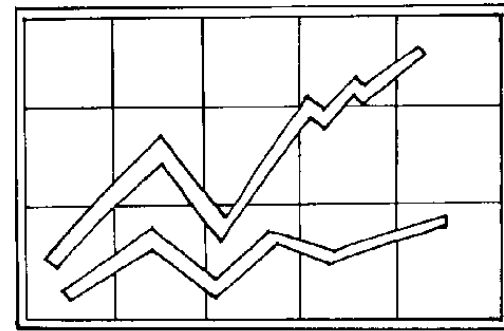
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# Presentation Agenda



## ❑ NAND Market Overview

- ❖ CAPEX & Growth
- ❖ Demand & Pricing Trends
- ❖ Application Trends



## ❑ Paradigm Shifts → NAND Growth Drivers

- ❖ Mobile Internet & Social Networking
- ❖ Tablets
- ❖ Smartphones

## ❑ SSD Update

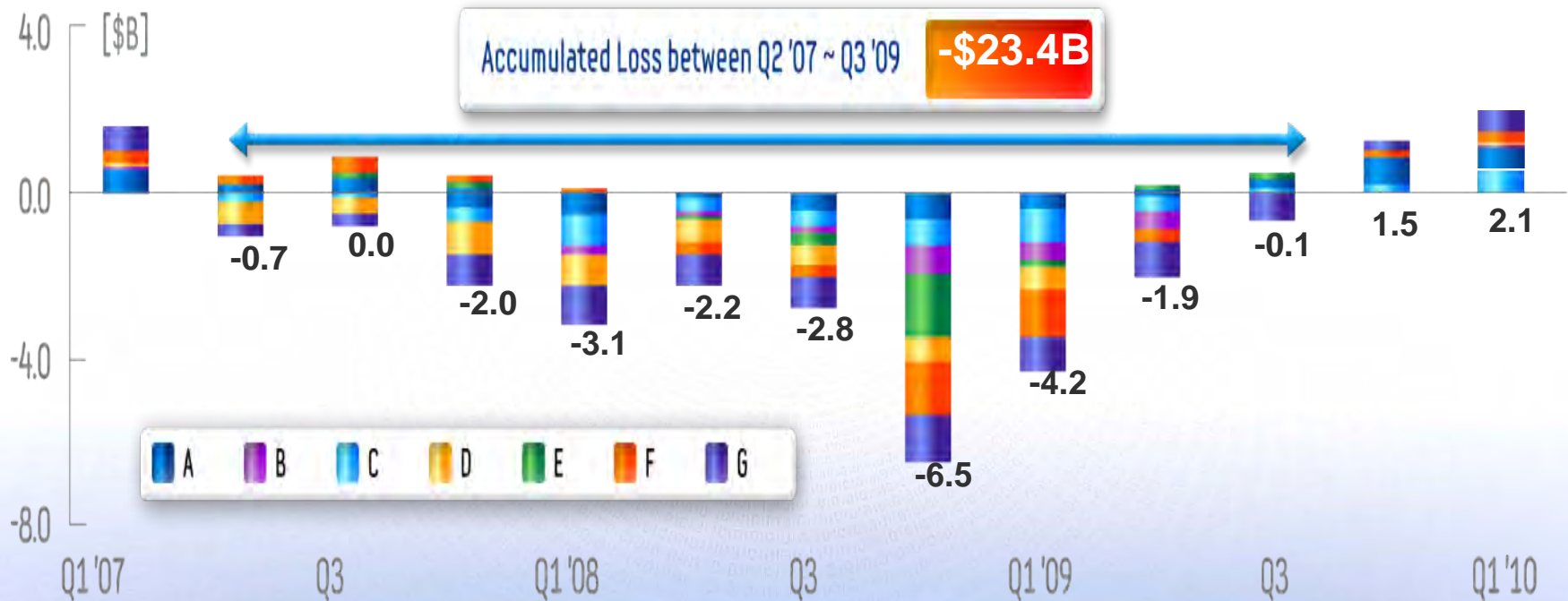
## ❑ Concluding Thoughts

# Memory Makers' Financial Health Status



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

Memory Makers' Operating Profit (excluding Samsung)







# NAND CAPEX vs. Revenue Trends

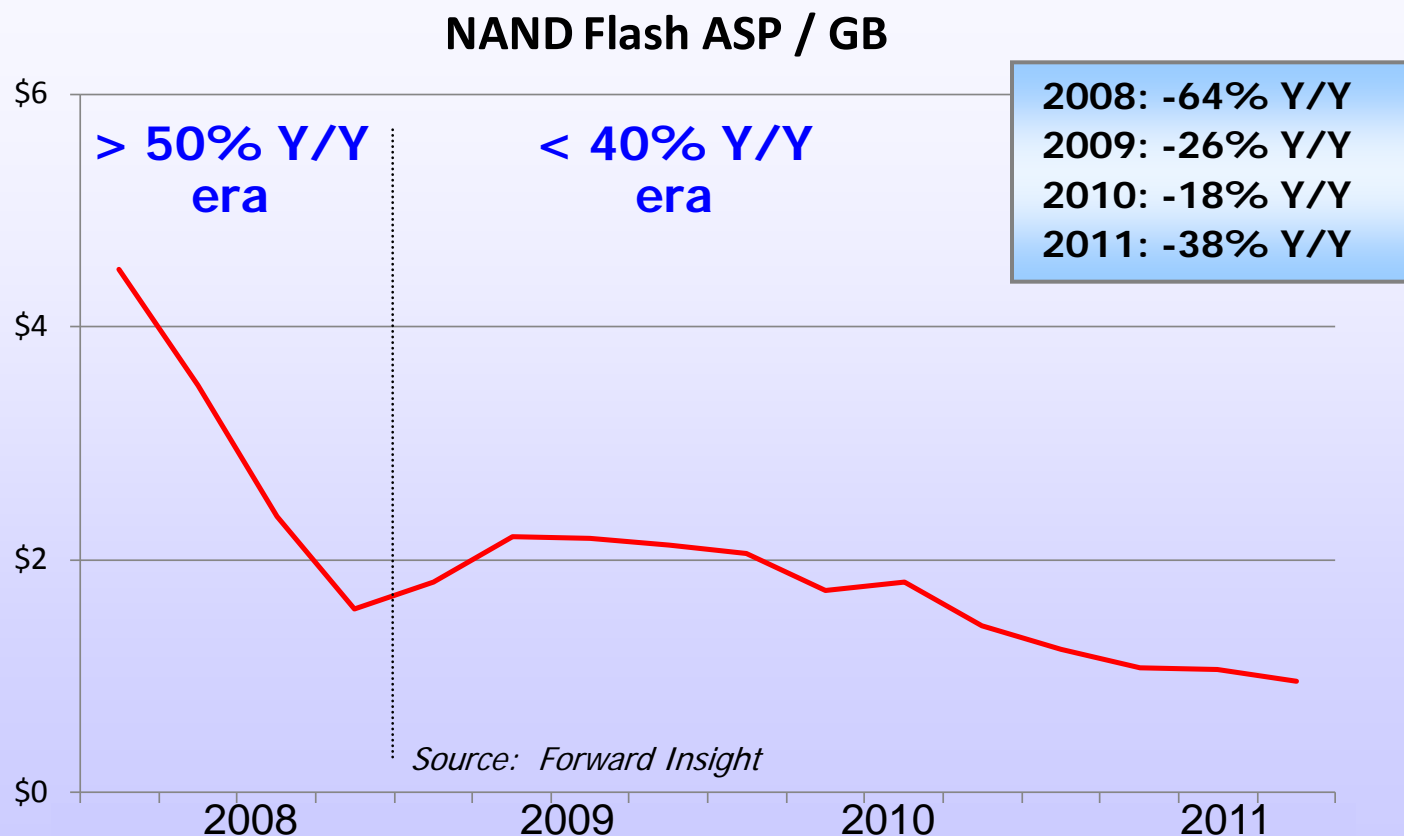
- CAPEX Investment Rebound in 2010 to ~\$6.1B
- Still Well Below Levels Seen This Decade...



\* Source : Gartner, Company Reports, Samsung



# NAND Flash Pricing Trends



## Factors Affecting Price per GB Trends:

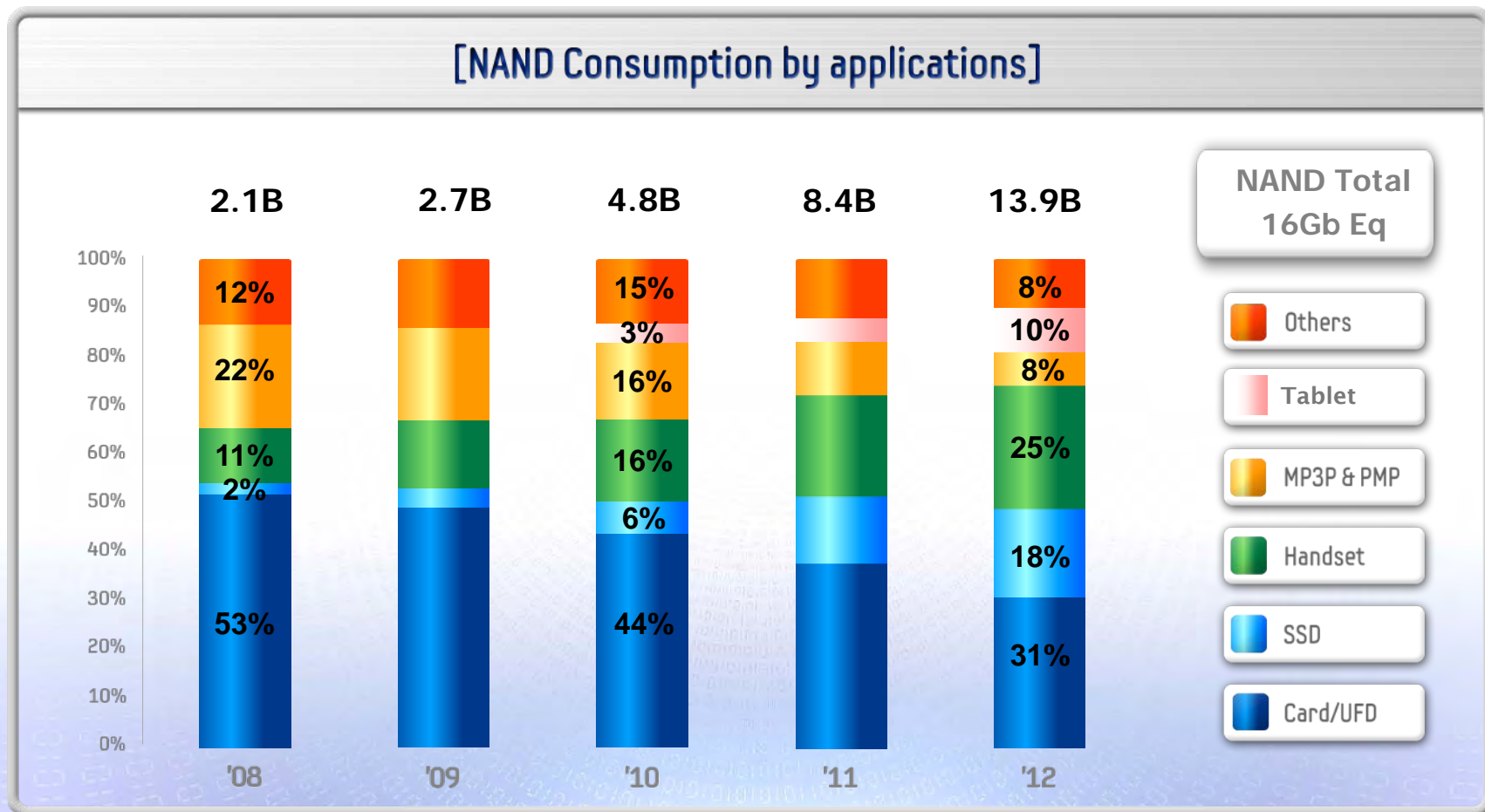
- Supply Increases, Transition to 64Gb Mono
- 3bpc growth
- SSD Demand Elasticity Effect...

# 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

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# More Applications Driving NAND Growth

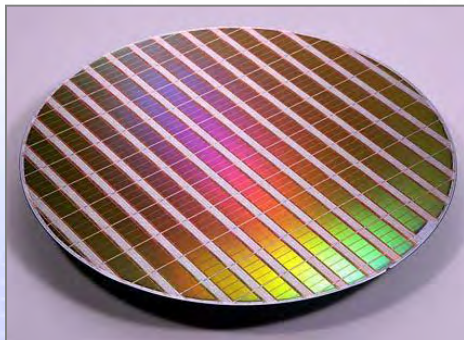
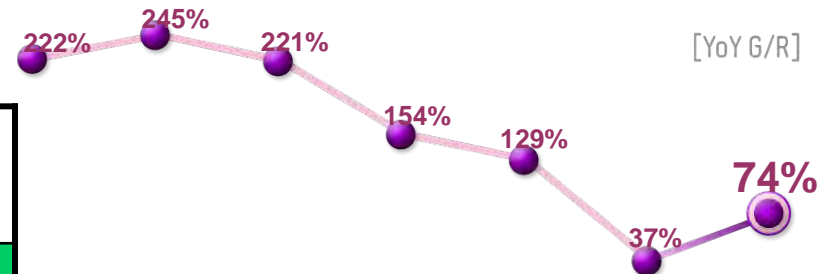


- NAND demand is expected to reach 9.5B GB's in 2010
  - Handset, SSD and Emerging Applications are Key Growth Drivers
  - Sharp Rebound since 2009, but well off historical levels...

## 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%



\* Source : Samsung

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- **Paradigm Shifts → NAND Growth Drivers**
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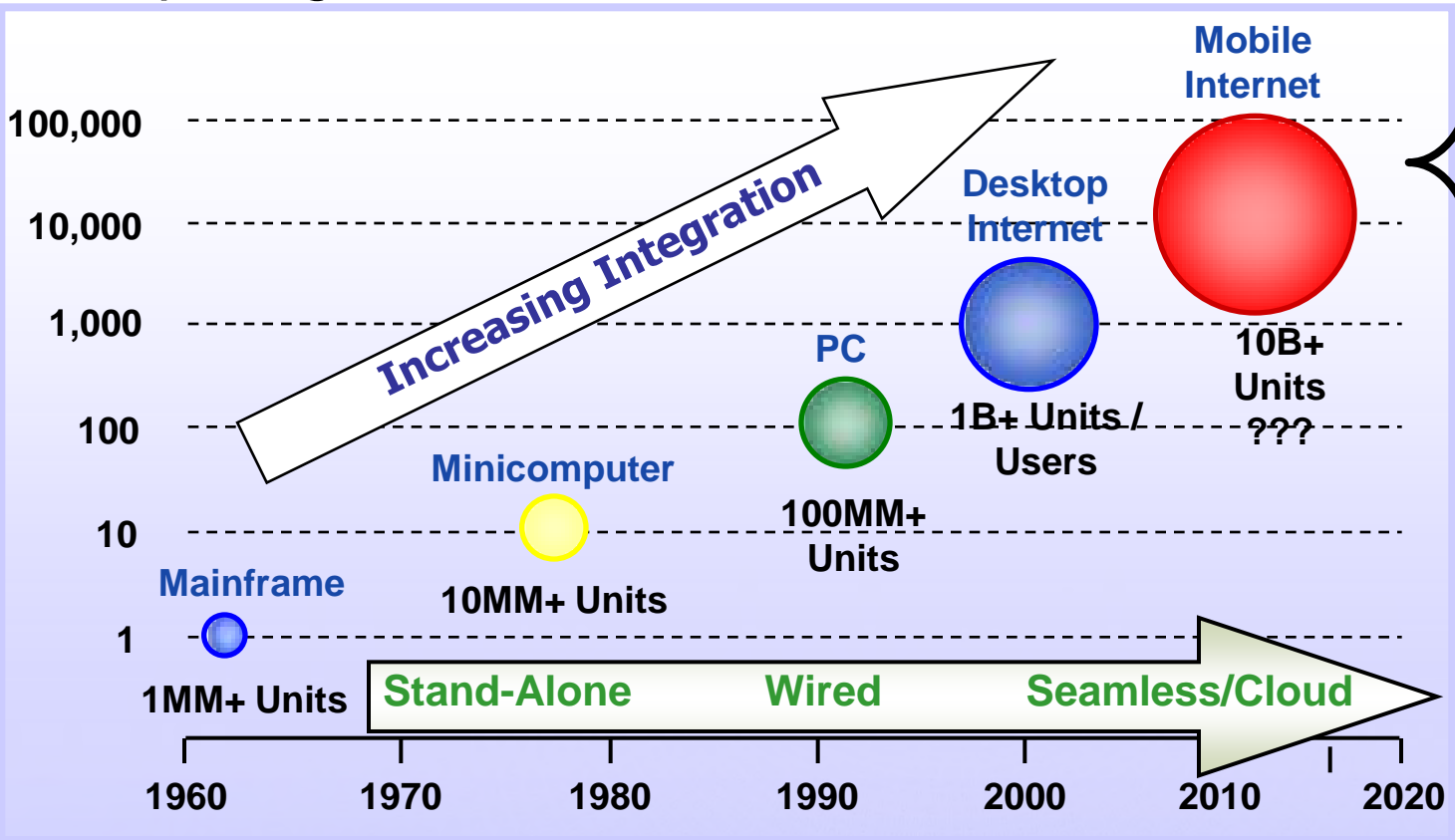






# Mobile Internet will be 10X Desktop Internet

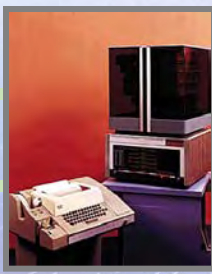
## Computing Growth Drivers Over Time



Web 3.0:  
Social Networking



Source: Morgan Stanley



# Impact of facebook Keeps Growing...



Welcome to the new Facebook

[Send feedback](#)

# facebook

☐ Remember Me

[Forgot your password?](#)

Password

Login

Facebook helps you connect and share with the people in your life.



## Sign Up

It's free and anyone can join

Full Name:

Your Email:

New Password:

I am:

Select Sex:

Birthday:

Month:

Day:

Year:

Why do I need to provide this?

Sign Up

By clicking Sign Up, you are indicating that you have read and agree to the [Terms of Use](#) and [Privacy Policy](#).

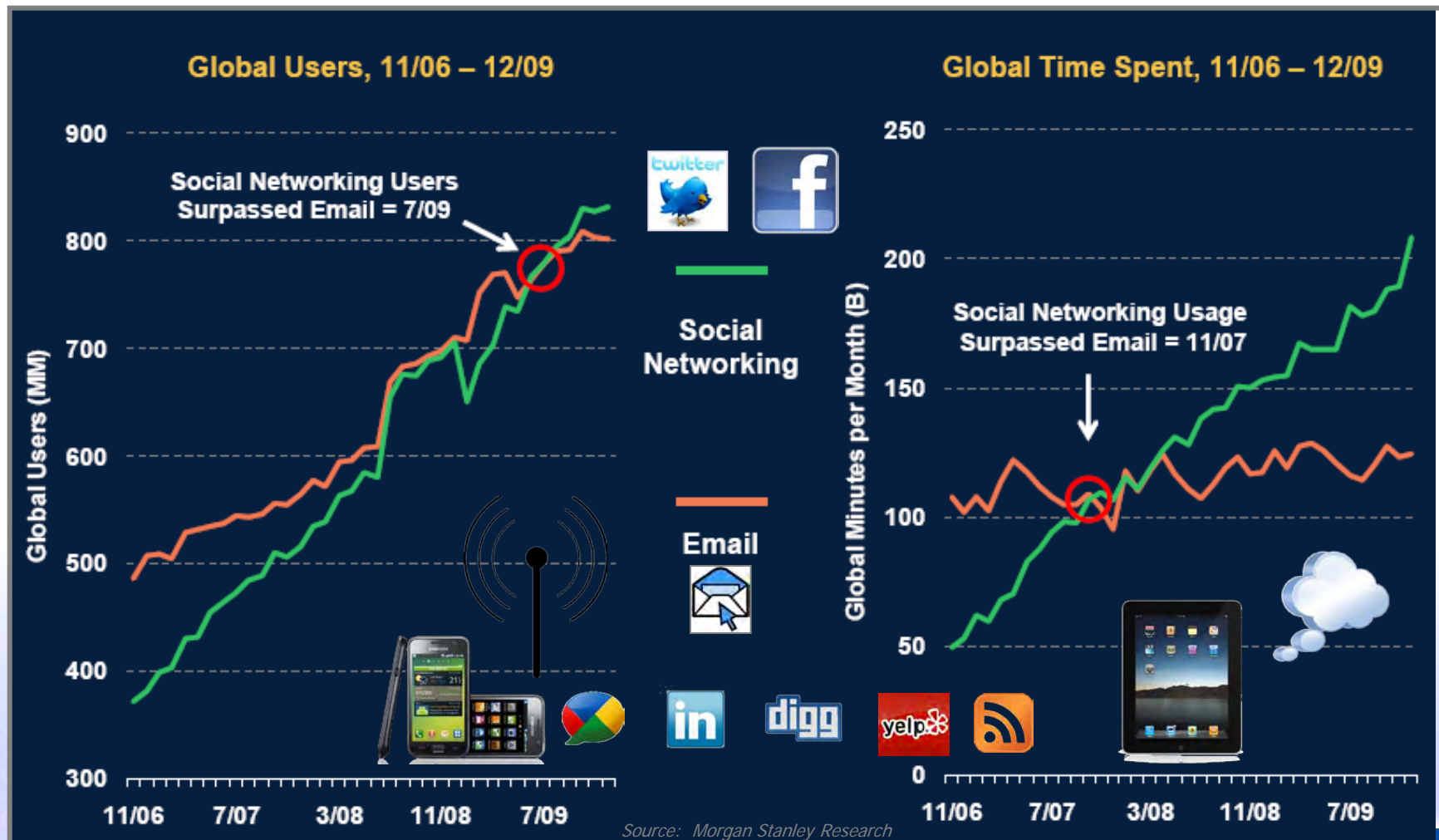
	'09	'10
Rank	#3	#2
Active Users	250M	>500M
Use Daily	120M	200M
Photos / month	1B	3B
Videos / month	10M	>12M
Mobile Access	30M	>150M

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# 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



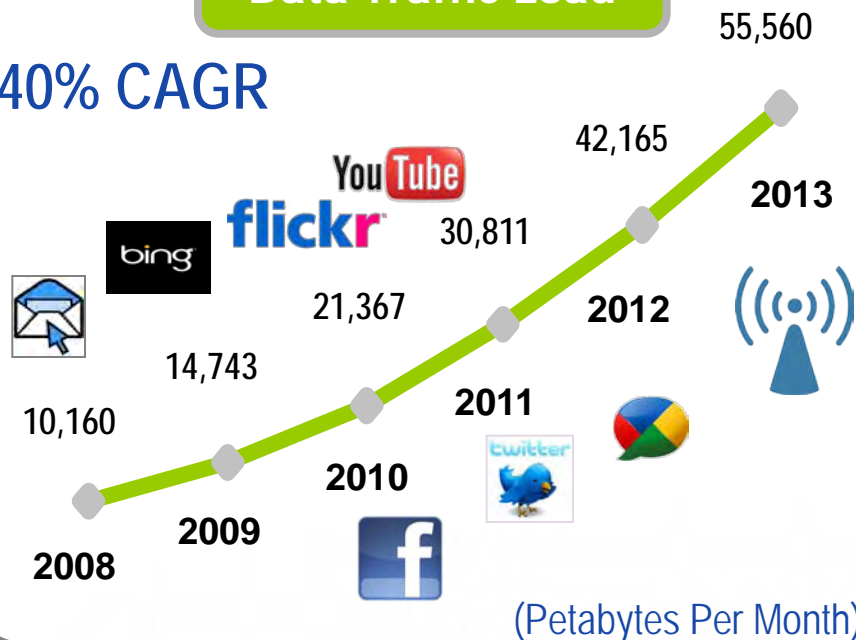


# Web 3.0 Impact on Traffic Load



Ever-increasing  
Data Traffic Load

40% CAGR



*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)

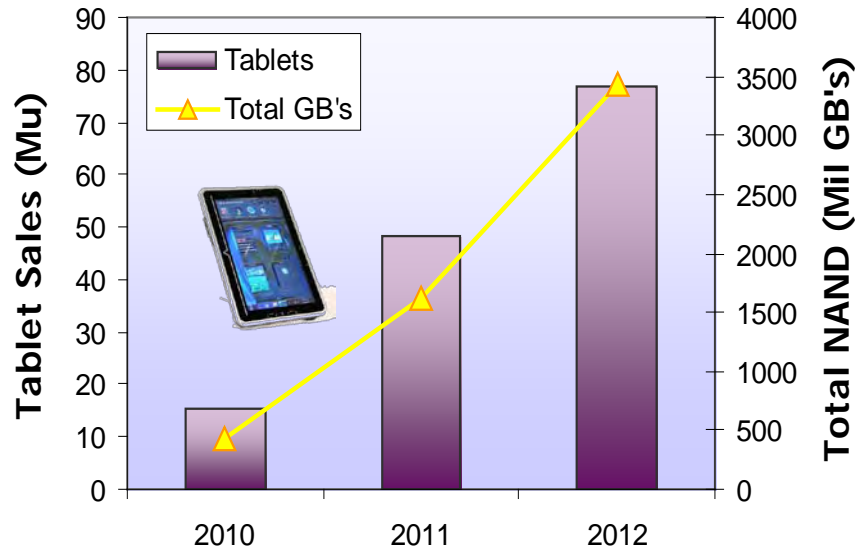
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# Tablet Revolution 2010

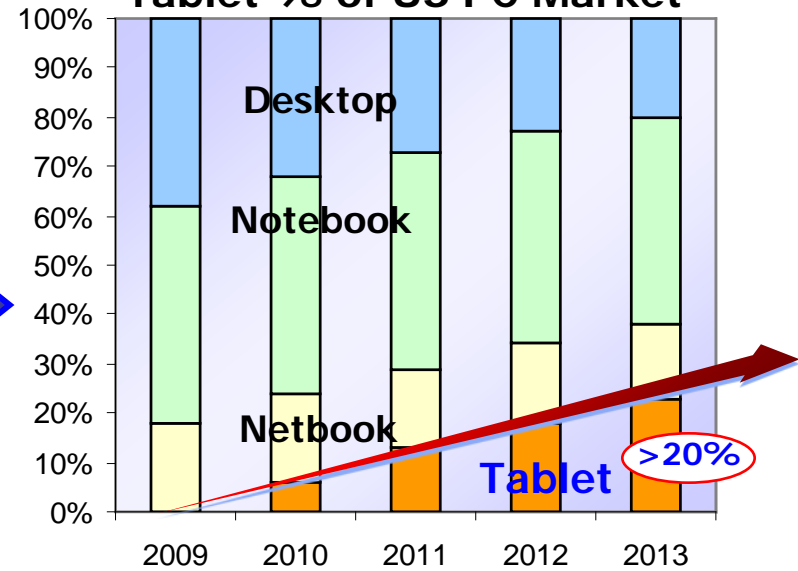


## WW Tablet Market



Source: iSuppli

## Tablet % of US PC Market



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

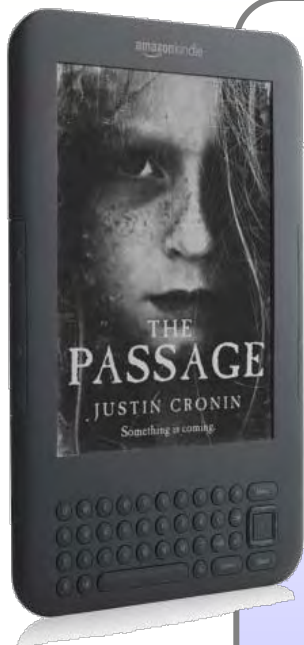
❑ PC Paradigm Shift → New Product Category

❑ ~60% of Sales are *Incremental*

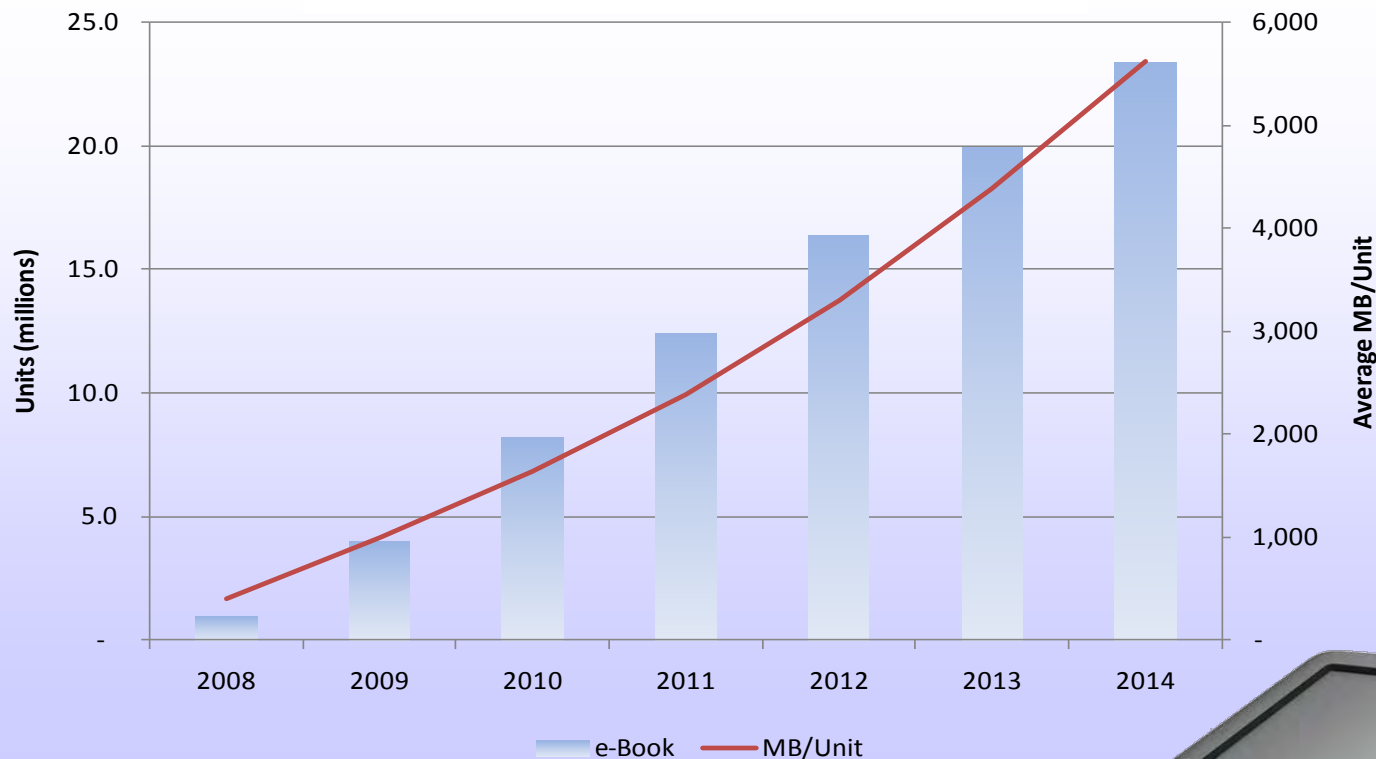
❑ Industry Crossroads: Mobile, PC, Networking

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# eBook Readers: Growth Despite Tablet



## eBook Reader Forecast



Source: Forward Insight

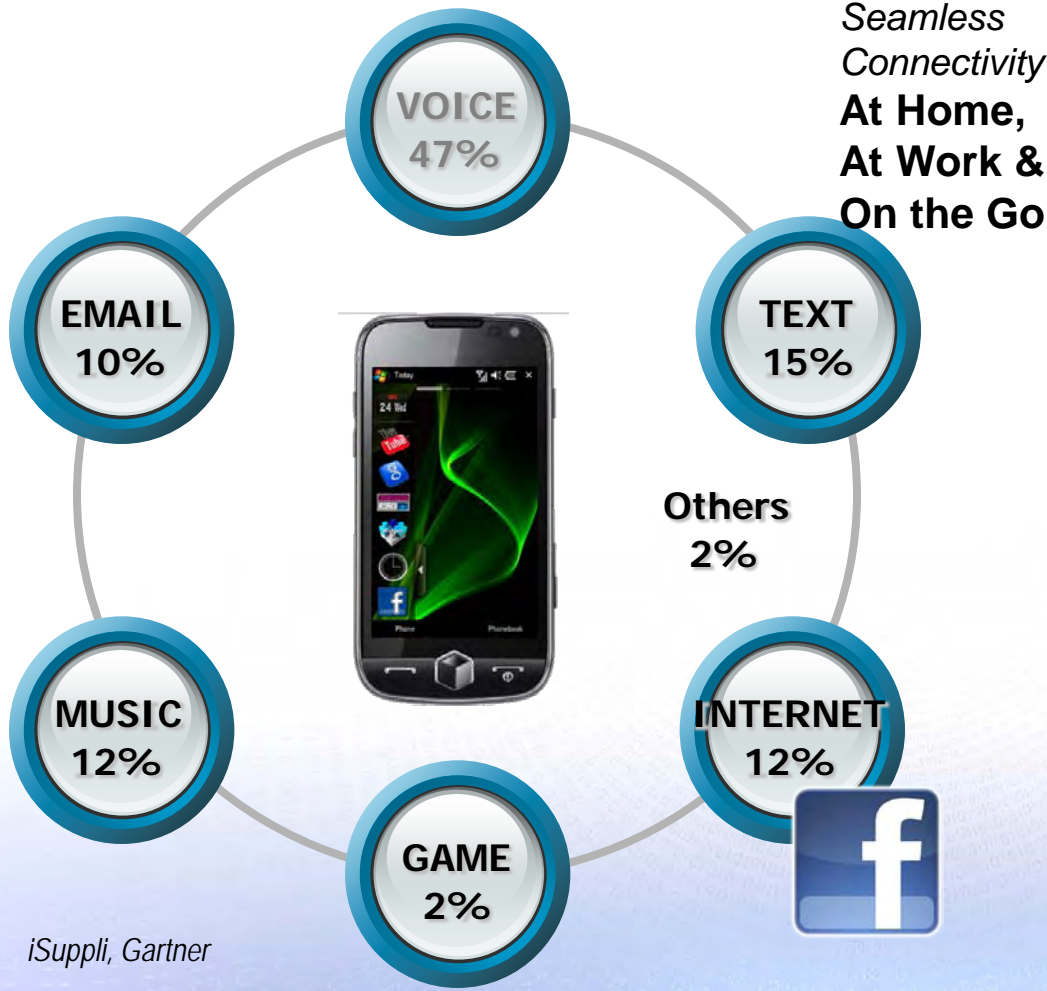


- ❑ Unit CAGR = 70% despite Tablets. 100% NAND Based.
- ❑ Razor and Razor Blade Business Model (\$139)
- ❑ Tablet & Smartphone sales increasing content sales (Kindle App)
- ❑ Amazon eBooks outsell hardcover now & vectoring to outsell paperback in 1 yr

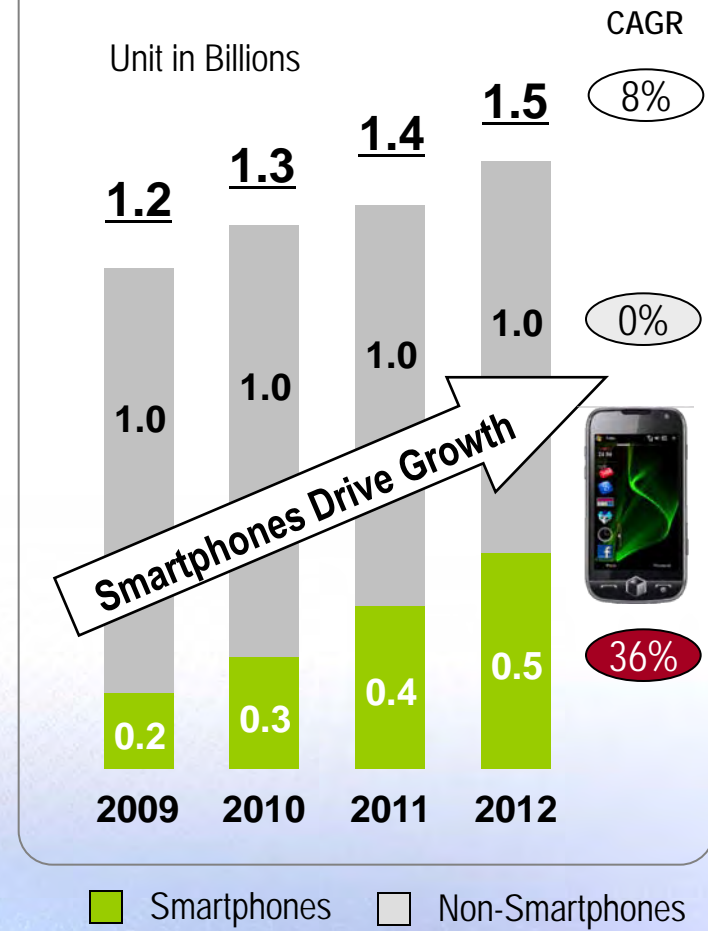
# Smartphones Driving Mobile Experience



## Breakdown of Smartphone Usage Time



## Mobile Phone Production



“For Class of 2014, Email is Already Dead...”

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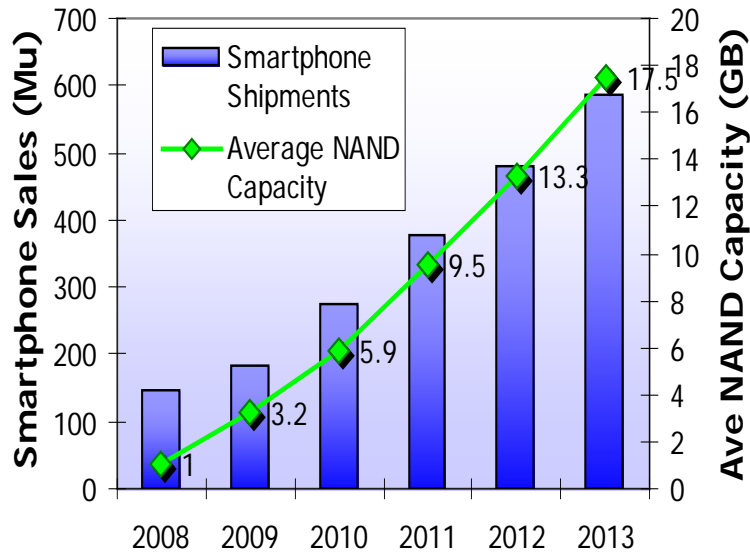
# Smartphones Driving NAND Growth



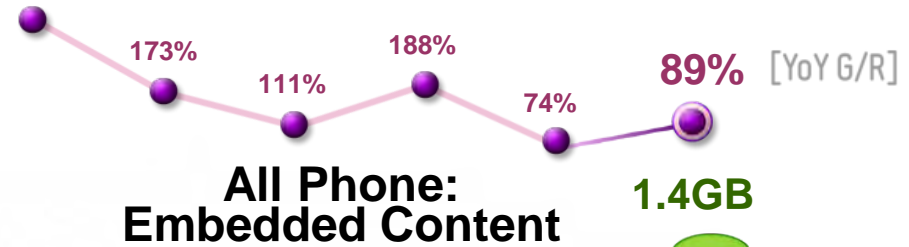
Web 3.0: Multi-tasking, HD Content, Web Browsing & Apps



Smartphone: Embedded NAND Content



\* Source: Forward Insight



'01~'09 CAGR 273%



[MB/Sys]

0.02

'01

1.0

'02

3.8

'03

6.2

'04

26

'05

70

'06

148

'07

426

'08

744

'09

1.4GB

'10

DRAM

NAND

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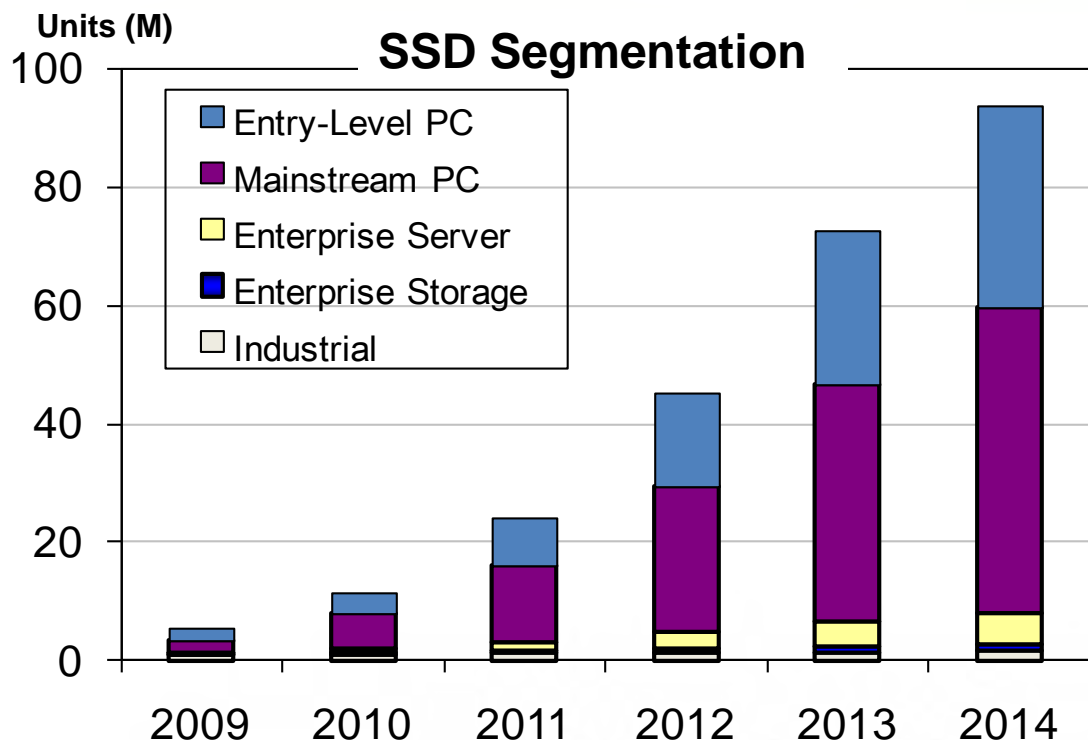
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# 5 Classes of SSD: All Driving Growth



## TOTAL SSD

### 5 Year Outlook (09-14)

- Unit Growth: 76%
- MB Growth: 127%

2014: NB Attach Rate ~22%

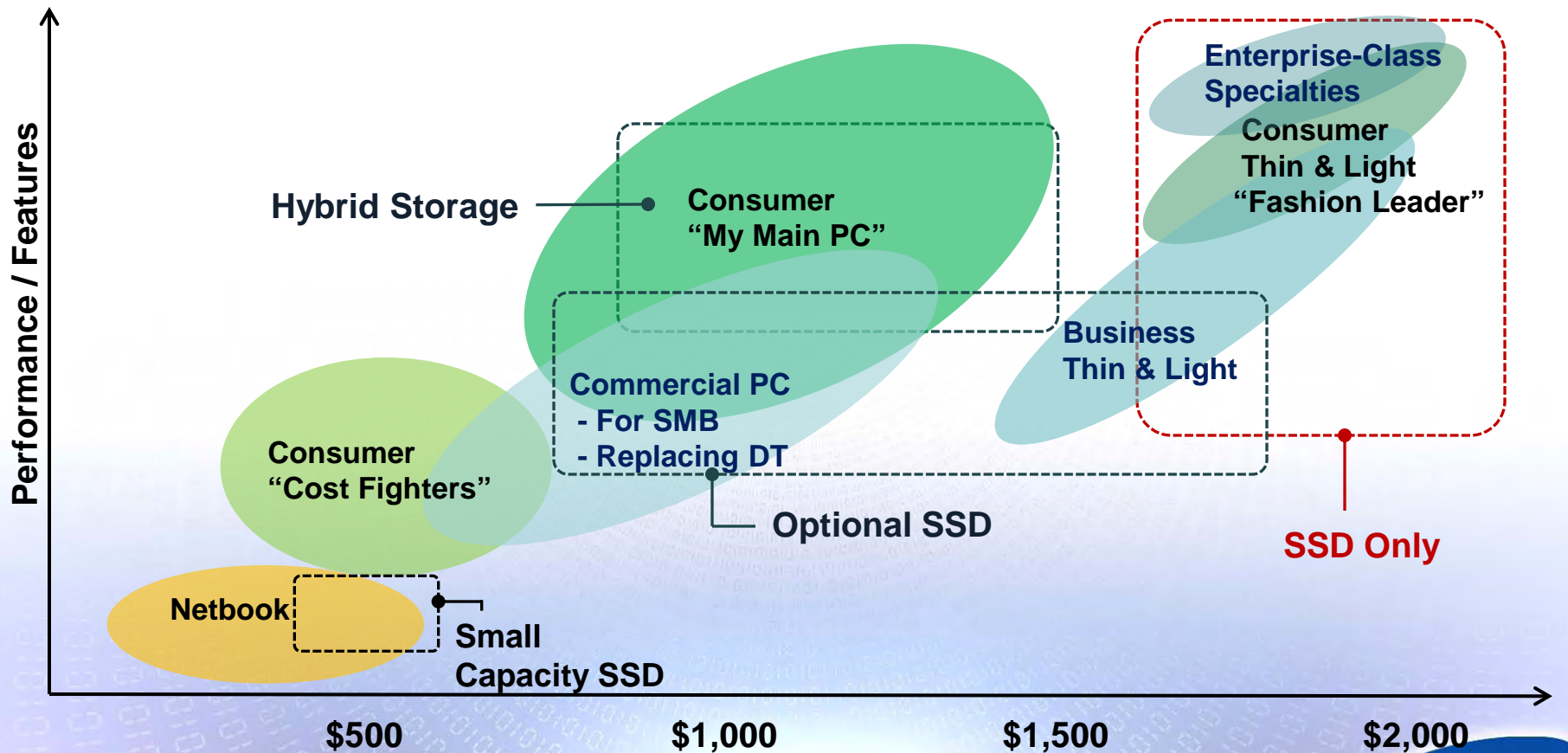
• Entry-Level PC	2009: 2.0M Units, \$64M	→ 2014: 34.1M Units, \$0.7B
• Mainstream PC	2009: 2.3M Units, \$541M	→ 2014: 51.9M Units, \$3.8B
• Enterprise Server	2009: 0.2M Units, \$167M	→ 2014: 5.2M Units, \$1.9B
• Enterprise Storage	2009: 0.1M Units, \$318M	→ 2014: 1.1M Units, \$1.7B
• Industrial	2009: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

# 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...

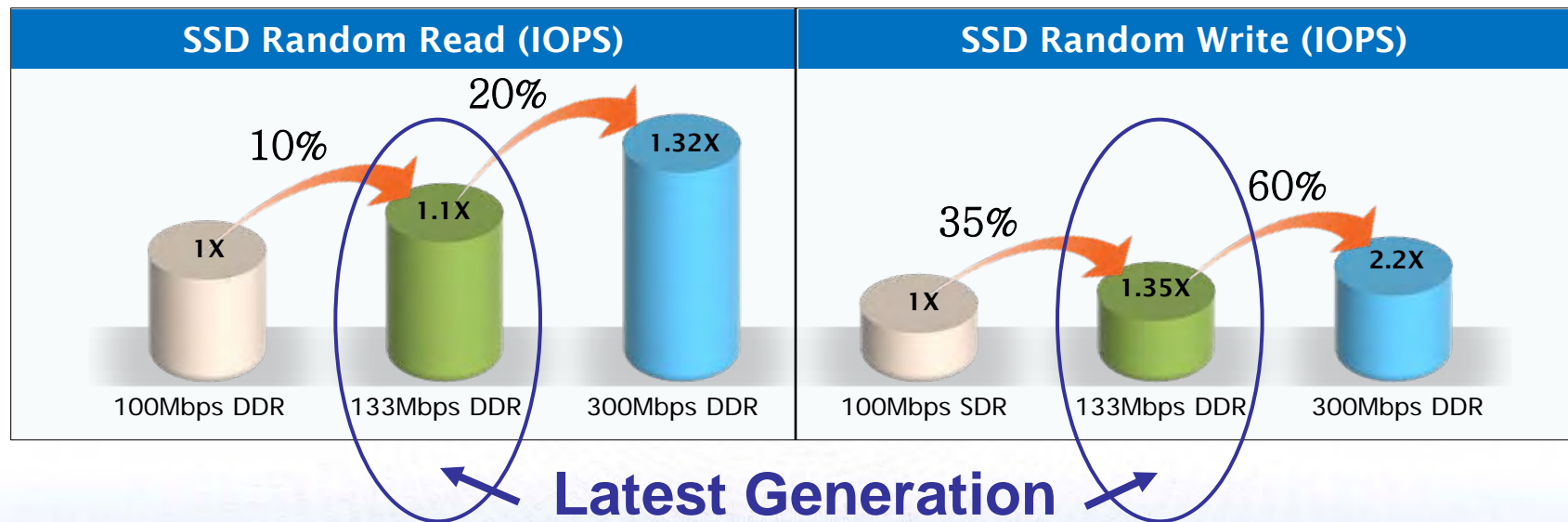






## Flash Components Aligned with SSD market trends:

- 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



## 1<sup>st</sup> 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



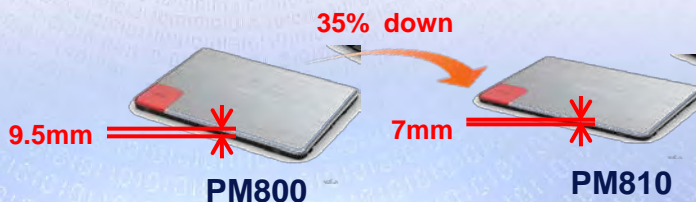
### Lower Idle Power

- 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 SOLID STATE DRIVE. MAXIMIZE YOUR COMPUTER.  
**FASTER. STRONGER. BETTER.**  
YOUR BIG MEDIA WON'T DROP FRAMES, STUTTER OR HANG.



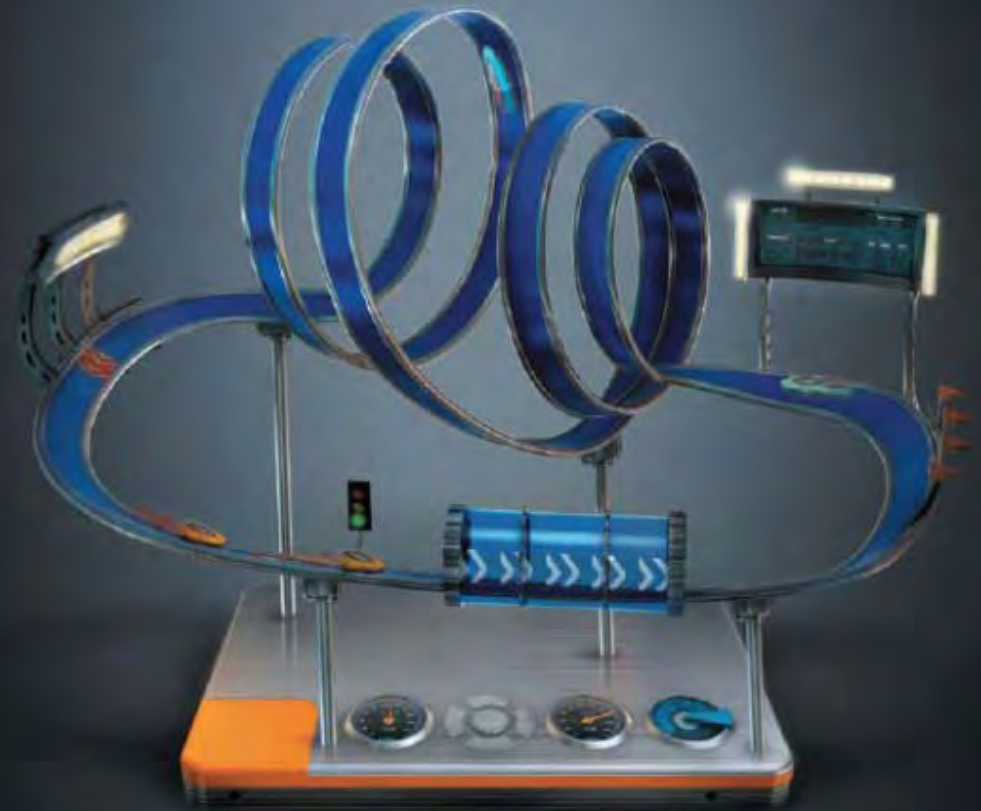
GET MEMORY FOR YOUR LIFE AT [SAMSUNGSSD.COM](http://SAMSUNGSSD.COM)



# Samsung Brand SSD

campaign creative:

Digital Thrill Seeker



SAMSUNG SOLID STATE DRIVE. MAXIMIZE YOUR COMPUTER.  
**THE WAIT IS OVER. GET LOADED.**  
250MB/s READ. 220MB/s WRITE. ADD TO YOUR VICTORIES.



GET MEMORY FOR YOUR LIFE AT [SAMSUNGSSD.COM](http://SAMSUNGSSD.COM)

# Samsung Brand SSD

campaign creative:

Demanding Productive



SAMSUNG



SAMSUNG SOLID STATE DRIVE. MAXIMIZE YOUR COMPUTER.  
**LOAD ALL YOUR APPS. AT ONCE.**  
IT'S JUST HOW IT'S SUPPOSED TO BE. ONLY FASTER AND QUIETER.



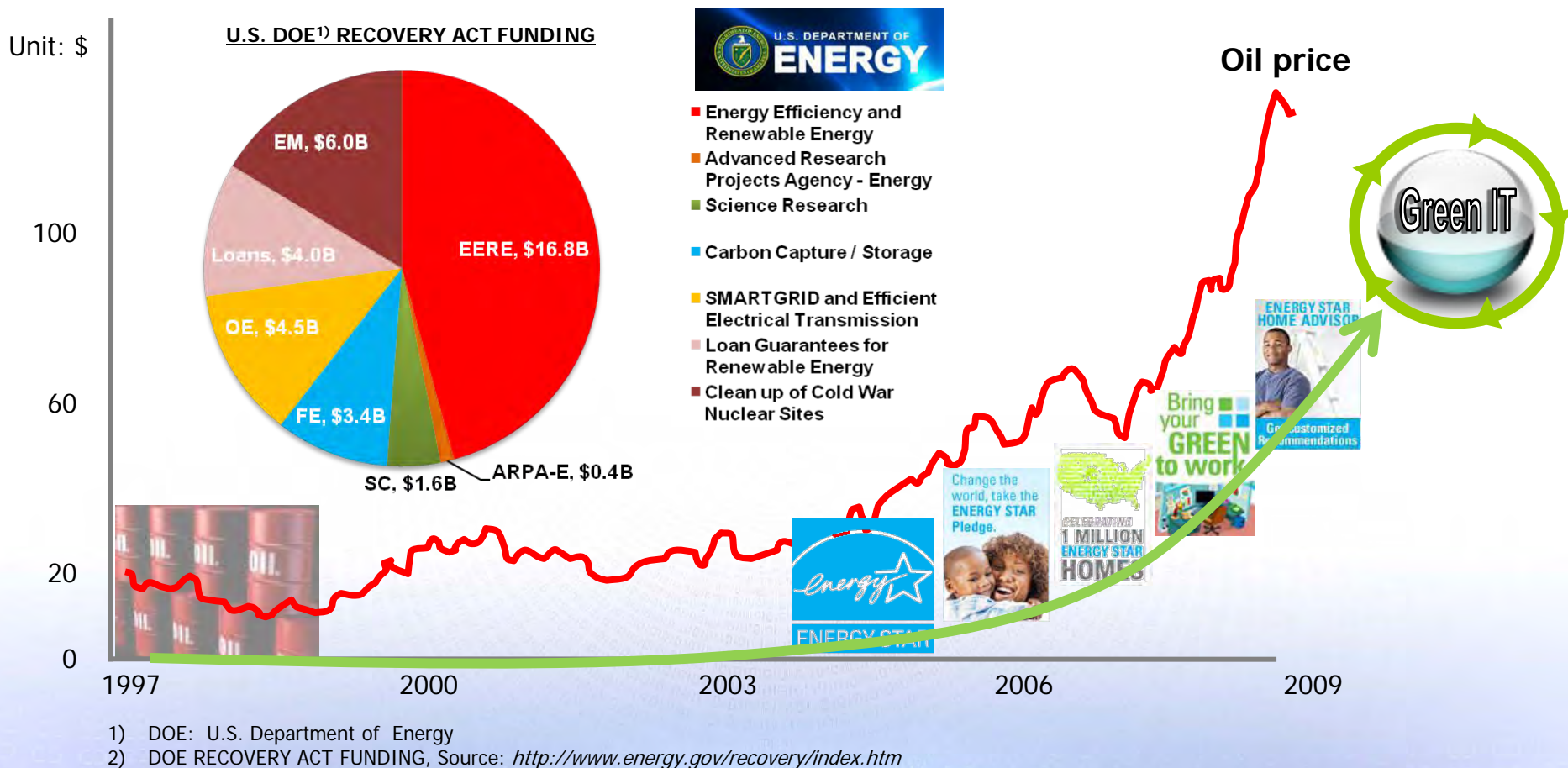
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# Green IT Update



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



→ Green IT starts with Energy Efficient Components

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# SSD TCO → 'Instantaneous Breakeven'

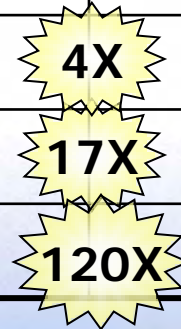


Green IT

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	16
IOPS/\$	15.00	0.90
IOPS/W	9000	75



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

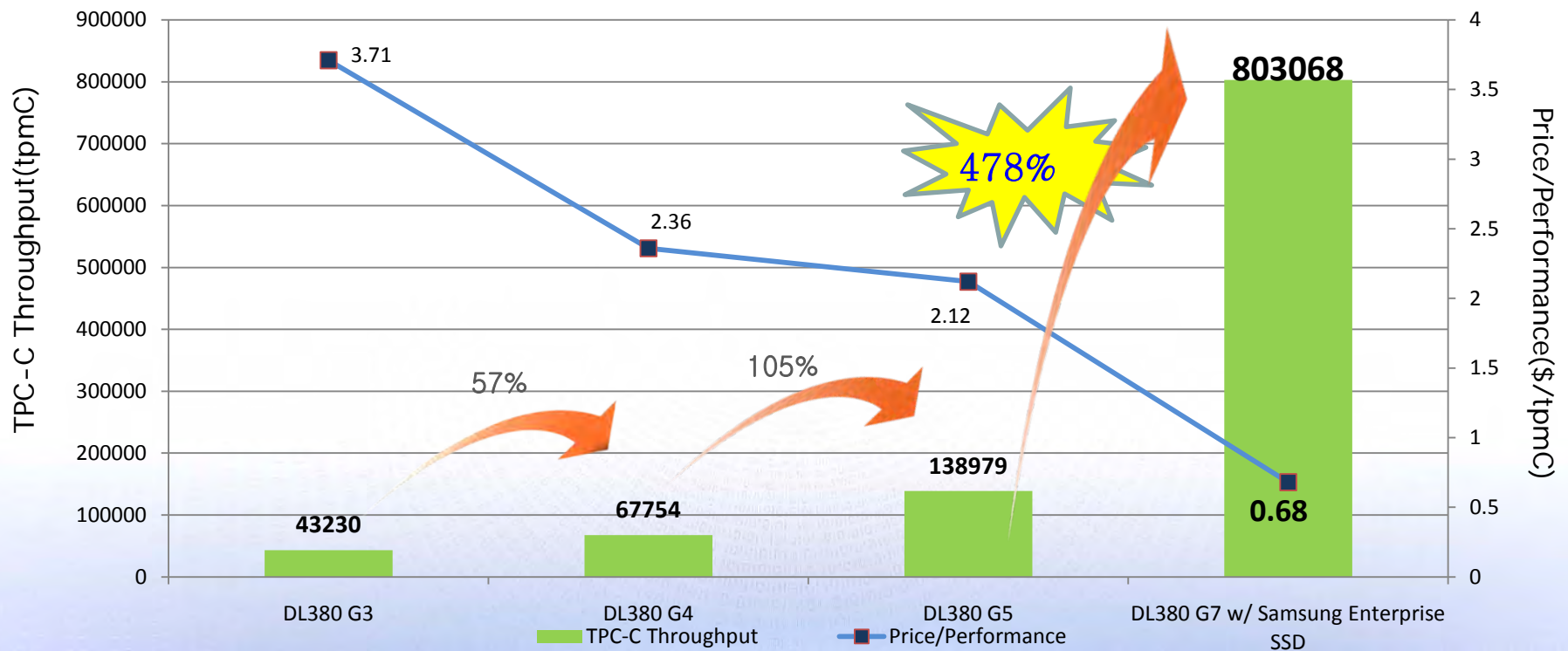
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# Samsung/HP Enterprise SSD Solution



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

**TPC-C Test w/ Samsung Enterprise SSD**  
HP DL380 G7 w/ Samsung Enterprise SSD



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

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# Delivering World-Record HP ProLiant Performance



#1  
Results

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

### SPECpower\_ssj2008 Performance Brief

HP ProLiant SL2x170z G6 holds leadership result on SPECpower\_ssj2008® benchmark  
Server scores 3,210 overall ssj\_ops/watt

July 2010

#### Executive summary

The HP ProLiant SL2x170z G6 establishes another world record performance result on the SPECpower\_ssj2008® benchmark.

#### Key Take Aways:

- HP ProLiant SL2x170z G6 is the industry leader in energy efficient server performance.
- HP ProLiant SL2x170z G6 is the top multi-node performer.
- HP ProLiant SL2x170z G6 holds two of the Top Five results.
- Excellent proof point for industry-leading energy efficient high density solutions.

Figure 1. Five results over 2000 overall ssj\_ops/watt on the SPECpower\_ssj2008 benchmark



Delivering the data center of the future with Converged Infrastructure

Industry is at an inflection point where our technology is coming together to help our clients build the data center of the future, and it will be based on a Converged Infrastructure. Over the next 90 days, HP will accelerate innovation, with new standards based solutions in every core area of the data center and beyond. These innovations will deliver a new level of simplicity, integration and automation to enable our clients to focus on meeting business demands.

HP Virtual Resource Pools to deliver a common modular infrastructure. HP is the only company that can deliver a single common, modular architecture across the data center from x86 to Supermicro and from simple DAs to cloud storage to multi-PB scaled storage.

Data Center Smart Grid. Through groundbreaking innovations, HP can offer unmatched functionality, including Set of Sensors to monitor energy consumption and automatically adjust cooling resources, and Thermal Logic reduces energy consumption and lets you reclaim data center capacity.

### TPC-H Performance Brief

FIRSTS and WORLD RECORD for HP:  
ProLiant DL585 G7 breaks 100,000 QphH @ 300GB and earns  
#1 non-clustered result for 300GB TPC-H benchmark

June 2010

#### Executive summary

The new HP DL585 G7, the obvious choice for virtualization/consolidation environments and corporate data center infrastructure, became the first non-clustered server to achieve over 100,000 QphH@300GB, thus earning the #1 non-clustered result for the TPC-H@300GB. With 117,561.7 QphH@300GB, 11.08USD/QphH@300GB, 9.58 Watts/TPC-H@300GB, the ProLiant DL585 G7, one of the newest HP Scalable x86 servers, is the ideal solution for mission-critical data center deployments and virtualization environments.

#### Key Take Aways:

- HP ProLiant DL585 G7 is #1 in non-clustered performance for the TPC-H@300GB performance category
- HP ProLiant DL585 G7 is #1 in non-clustered performance for the TPC-H@300GB benchmark

### HP ProLiant DL585 G7

#1 non-clustered TPC-H@300GB

Performance - largest in server category

HP ProLiant DL585 G7

117,561.7 QphH@300GB

11.08 USD/QphH@300GB

9.58 Watts/TPC-H@300GB

Up to a 5x better performance

Figure 1. Best non-clustered TPC-H@300GB results for each vendor

HP provides the most comprehensive portfolio of Scale-Up ProLiant servers optimized for the most demanding, data-intensive x86 workloads.

The ProLiant DL585 G7 is part of the HP Converged Infrastructure portfolio, which integrates servers, storage, network devices, and facility resources into a single environment, allowing it to meet the business demands of HP ProLiant modular, standard-bus architecture clients toward a converged infrastructure.

Results as of 06/21/10, as implemented as compared to HP ProLiant DL585 G7 result. Top single-server result on TPC-H@300GB.



NEW HP ProLiant DL380 G7 scores highest with x86 2-socket performance world record on TPC-C benchmark  
First x86 2-socket server to break 800,000 tpmC barrier, excellent price/performance

May 2010

#### Executive summary

Living up to its name, "the versatile, dependable workhorse", the ProLiant DL380, with its latest Generation 7 technology, has obtained another #1 performance result. With 903,046tpmC @ \$5.60USD/tpmC, the ProLiant DL380 G7 acquired the highest x86 2-socket result performance and is the TOP TEN for price/performance on the TPC-C benchmark.

The latest Intel Xeon technology lived up to the promise of improvements in performance for faster productivity and efficiency for a broad range of applications ranging from data transactions to workstations, according to Intel's TPC-C benchmark.

#### Key Take Aways:

- #1 x86 2-socket performance
- HP dominates with 50% of the top TEN for 2-socket performance
- HP rules with 80% of the top TEN for 2-socket price/performance

Business transformation times are changing. HP is helping our clients build the data center of the future, and it will be based on a Converged Infrastructure. Over the next 90 days, HP will accelerate innovation, with new standards based solutions in every core area of the data center and beyond. These innovations will deliver a new level of simplicity, integration and automation to enable our clients to focus on meeting business demands.

HP Virtual Resource Pools to deliver a common modular infrastructure. HP is the only company that can deliver a single common, modular architecture across the data center from x86 to Supermicro and from simple DAs to cloud storage to multi-PB scaled storage.

Data Center Smart Grid. Through groundbreaking innovations, HP can offer unmatched functionality, including Set of Sensors to monitor energy consumption and automatically adjust cooling resources, and Thermal Logic reduces energy consumption and lets you reclaim data center capacity.

Why the ProLiant DL380 G7 is the world's best-selling rack server, continuing its dominant share in the 2U, 2-socket market with new G7 models. Its rack server format delivers on its heritage of engineering excellence, flexibility and performance, enterprise-class uptime and manageability, 2-socket Intel Xeon performance for a variety of applications.

Other key benefits include:

- 6-core /4-core Intel Xeon Performance for demanding scale-out applications and virtualization
- Flexible, ready to deploy for complex, dynamic environments
- Powerful administration management tools
- Versatility and availability for a wide range of deployments
- Increased performance, durability, and energy efficiency



- 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



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# 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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### Joe Unsworth (Gartner)

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 Memory.  
More Speed.

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%<sup>(1)</sup>, uses 32% less energy<sup>(2)</sup> and is far more reliable than your average HDD. It has no moving parts, which means lower failure rates - 40% less<sup>(3)</sup>. 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](http://www.samsung.com/ssd)

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Thank you



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