



# NAND Flash: The Ubiquitous Storage Medium

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# Presentation Agenda

- ❑ Some Industry Perspective...
- ❑ NAND Market Trends
- ❑ Key NAND Growth Drivers
- ❑ Innovative Product Showcase
- ❑ Concluding Remarks

# First, the Bad News...



**\$120-140 Oil**

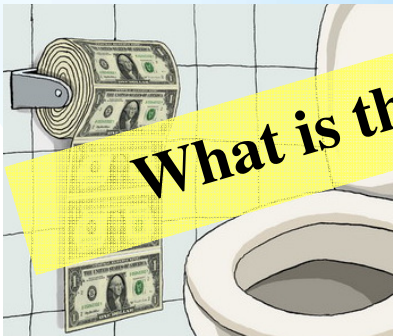


**Housing Crisis**



???

**Inflation**



**US Economic Malaise**



**What is the Outlook for NAND Given These Conditions?**

**Global Warming**



# Putting it into Perspective: “The New World Order” ...for Semiconductors



**China's Middle-Class will Increase 7X to 700M by 2020**



**India's Middle-Class will Increase 10X to 600M by 2020**



**Wal\*Mart's International Sales Grew 17.5% This Year  
International Revenue Now 24%, vs 8.9% 10 Years Ago**

**Technology  
Adoption  
Rates Vary  
Greatly**



Internet:



71%

**WW  
Avg**



20%

PC's:

80 per 100

13 per 100

Cell Phone:

~100 per 100

13 per 100

Semiconductors is a truly global business with tremendous growth opportunity  
Moore's Law will continue to inspire **innovation**...

# Storage Requirements Increasing Dramatically



**Multi-Media Files  
Full Length Movies  
(Over 10GByte)**



**Video Clip  
5mins DVD Quality  
(100MByte)**



**Picture  
3Mega Pixels  
(1MByte)**



**e-Mail  
(10KByte)**

**100X**

**100X**

**100X**

# New ID Presents Storage Challenges

Devices Getting Smaller, Portable, Multi-Functional  
Storage Progression: Tape → CD → NAND



**Video Camera**

**Cassette Player**

**Wired Phone**



**Video Camera**

**CD Player**

**Cell Phone**



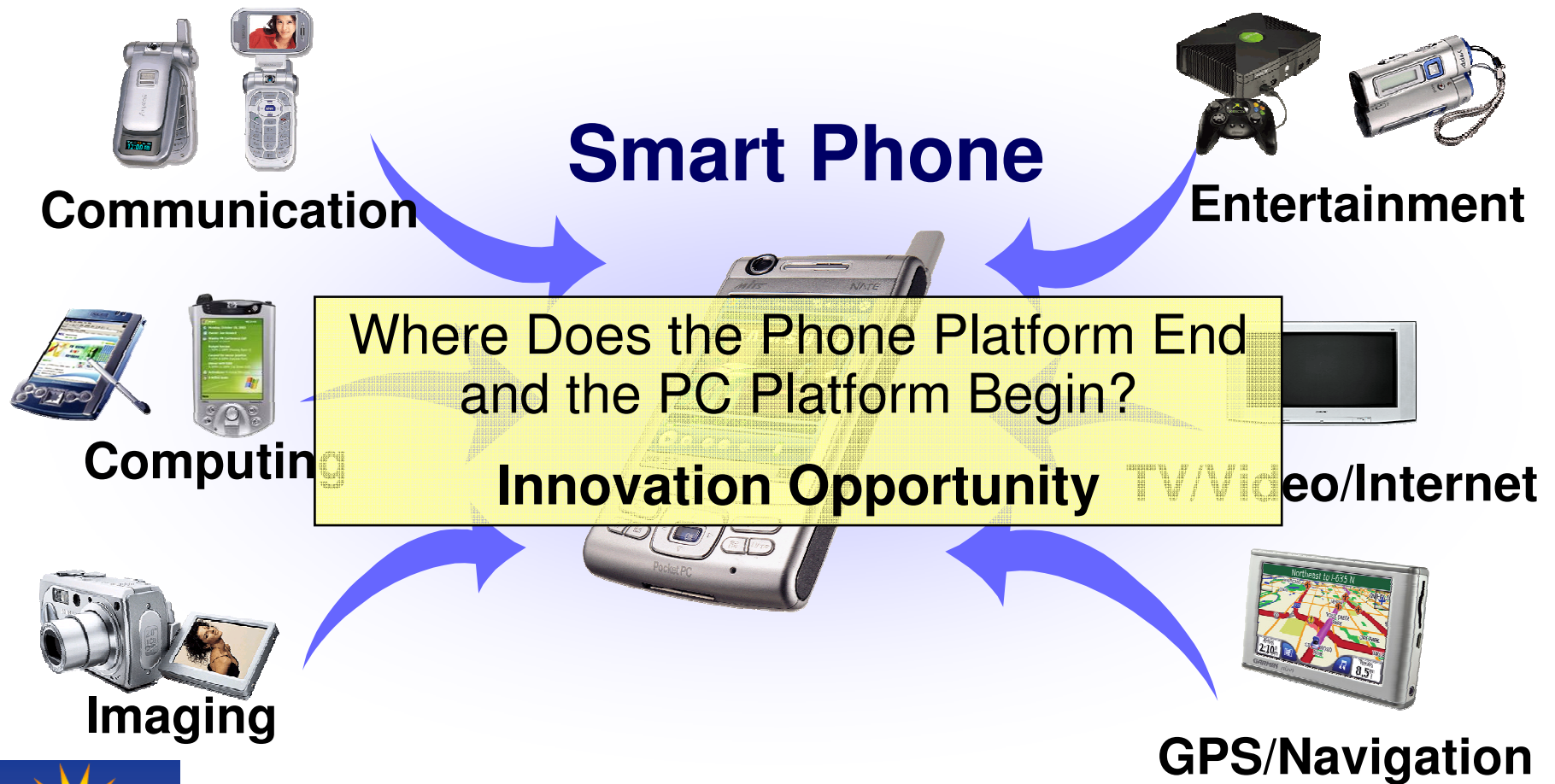
**Video Camera**

**MP3 Player**

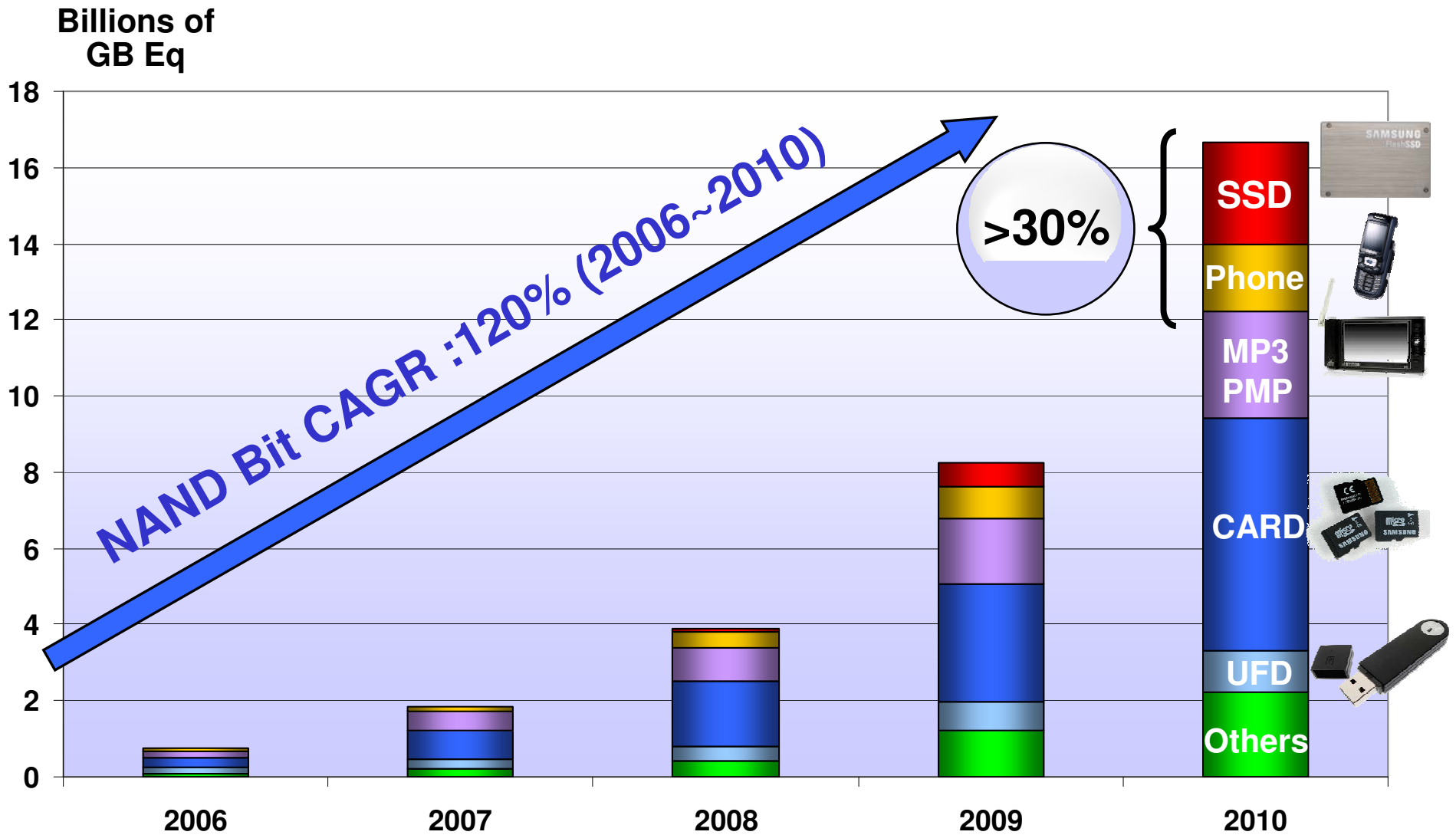
**Multimedia Phone**

# Multi-Functional Devices Proliferating

Increased Storage Needs: Embedded NAND & Flash Cards



# NAND Applications Proliferating

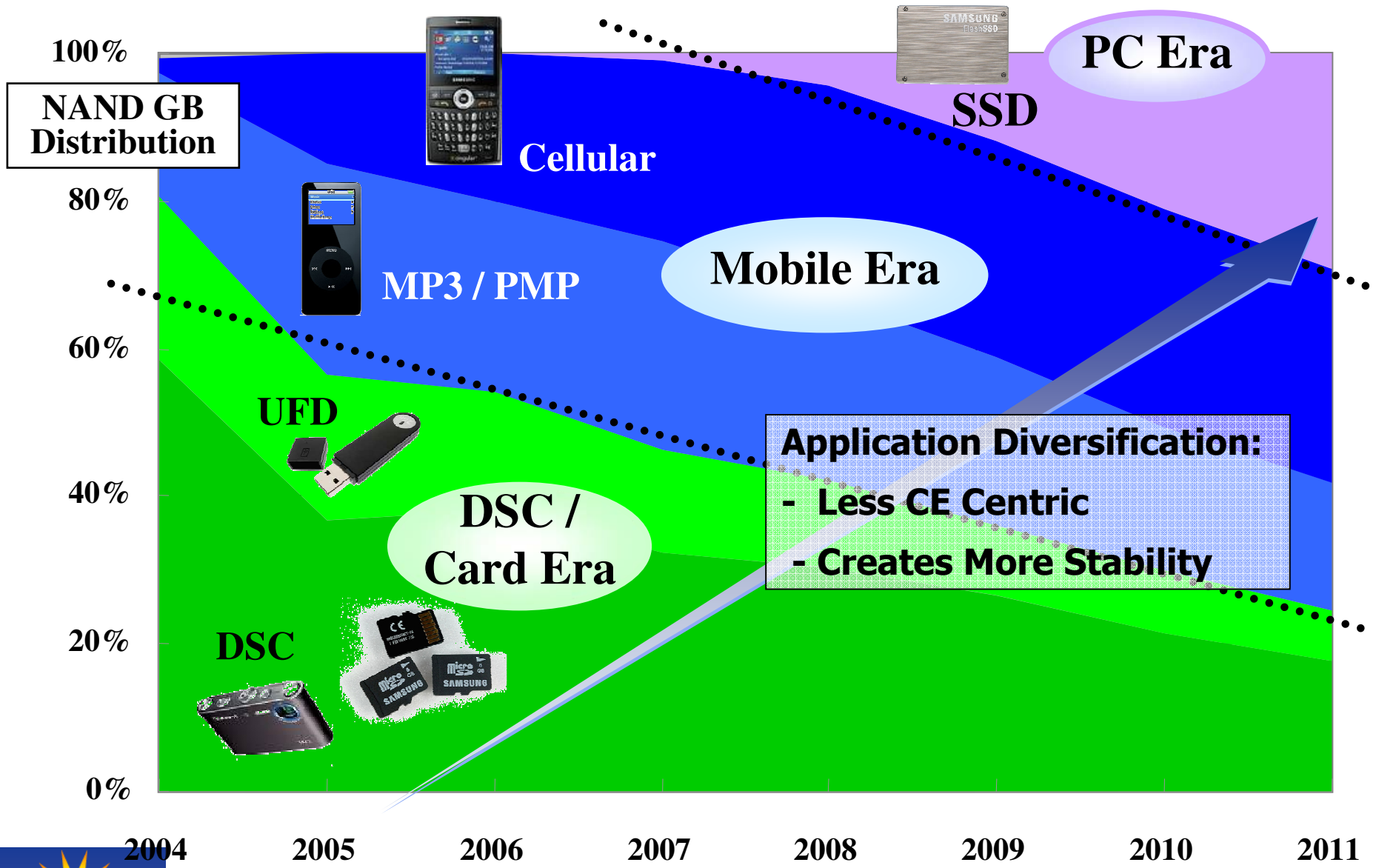


\*SEC Marketing

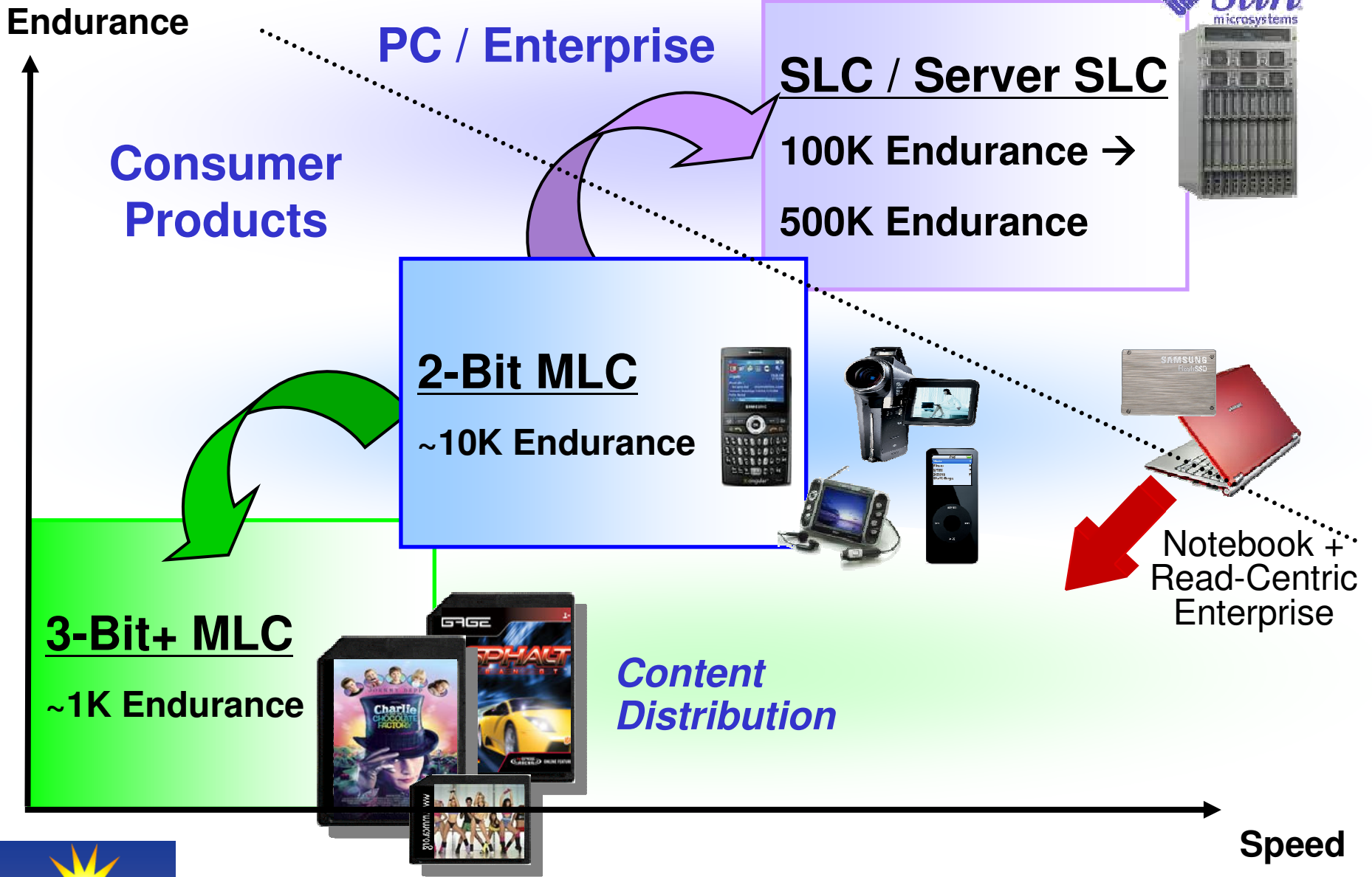




# NAND Transcending CE Arena...



# NAND Categories Emerging by Application



# NAND Growth Drivers

MP3/PMP



Video Driving Growth

Phone



Digital Convergence

Card



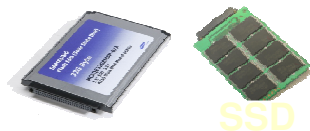
Riding Cell Phone Wave

UFD



Now Ubiquitous

SSD



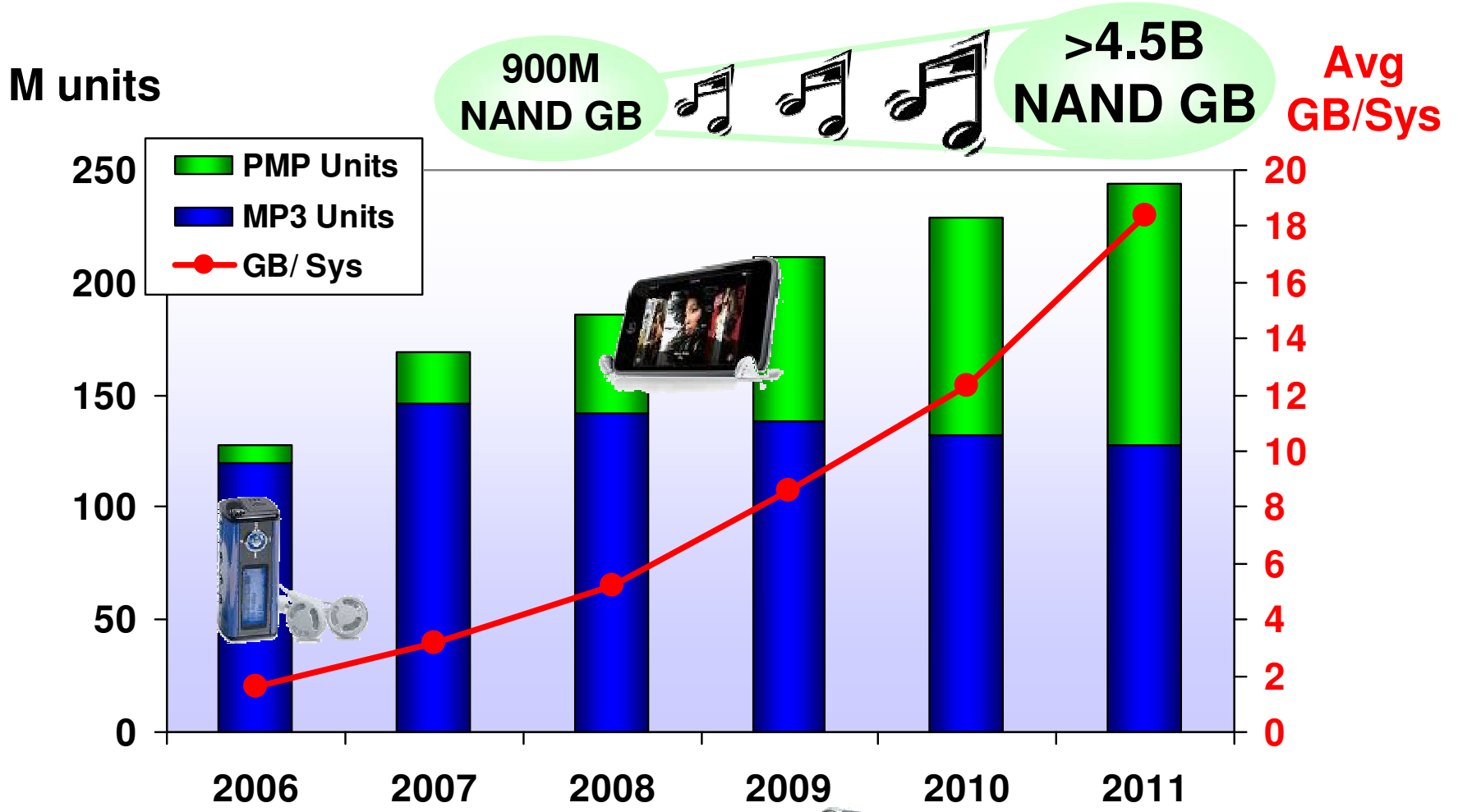
The Next Killer App...

Consumer



Ground Zero for Innovation

# MP3 / PMP: Video Driving GB Content



How to Define a PMP?

Wikipedia: Audio, Images and Video

Also, screen size can be a designator

\*Source: SEC

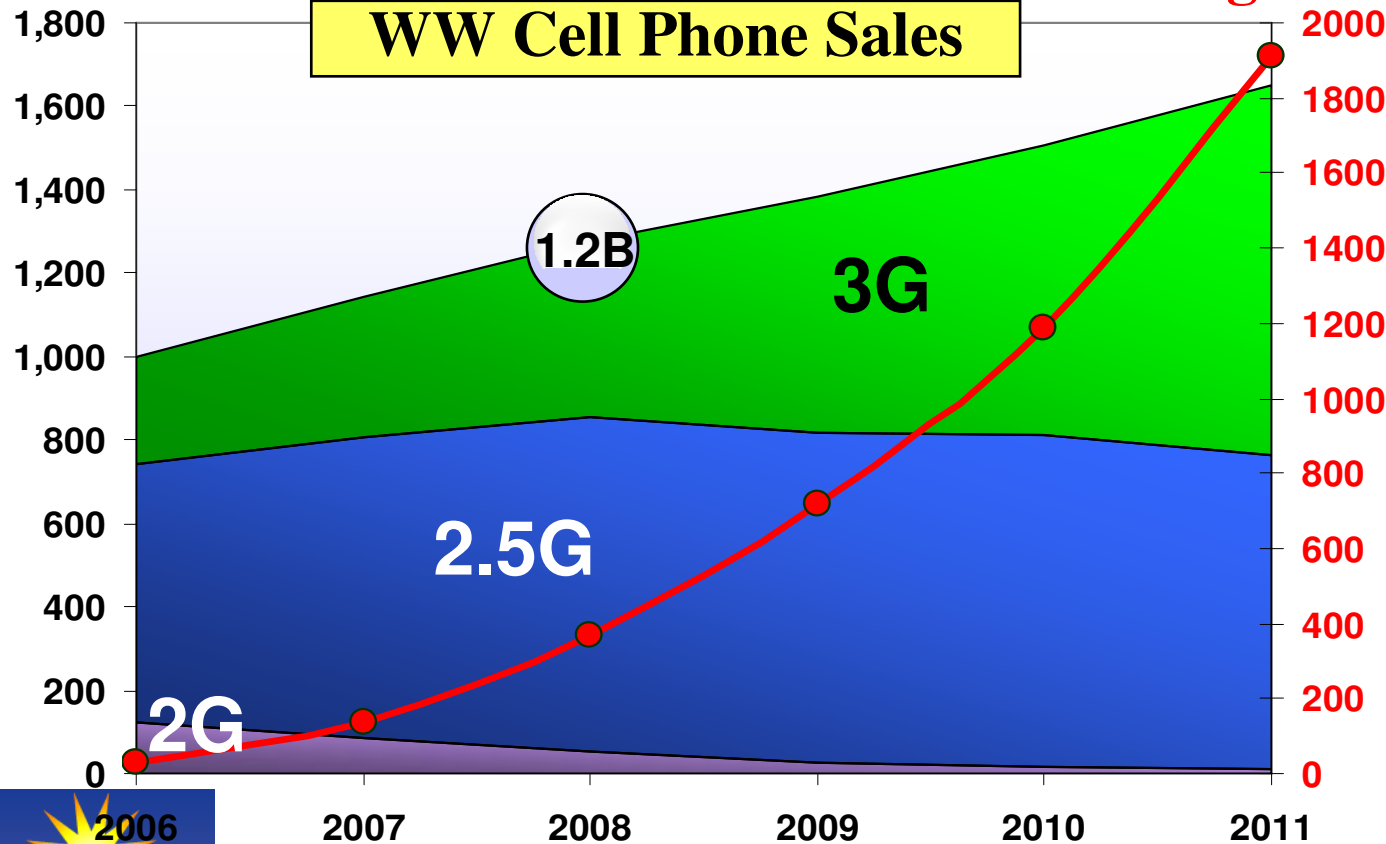


# Cellular + NAND: Demand Ringing off the Hook

- 2008: Mobile phones are the major market driver for flash cards
- 50 Photos + 1 Map + 200 Songs + 10 Games + 3 movie clips: ~ 2GB

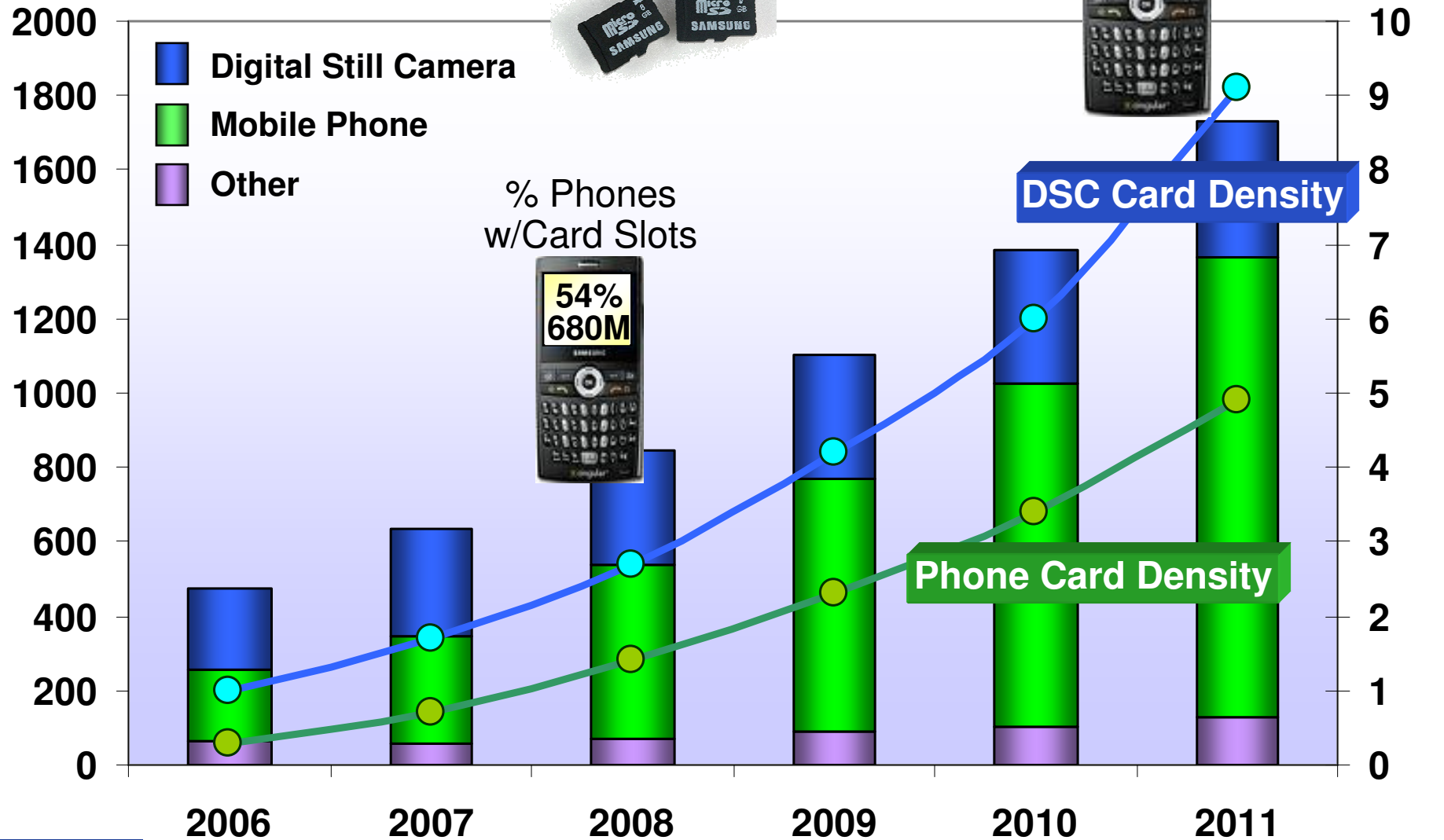


M Units



# Flash Card Market Growth

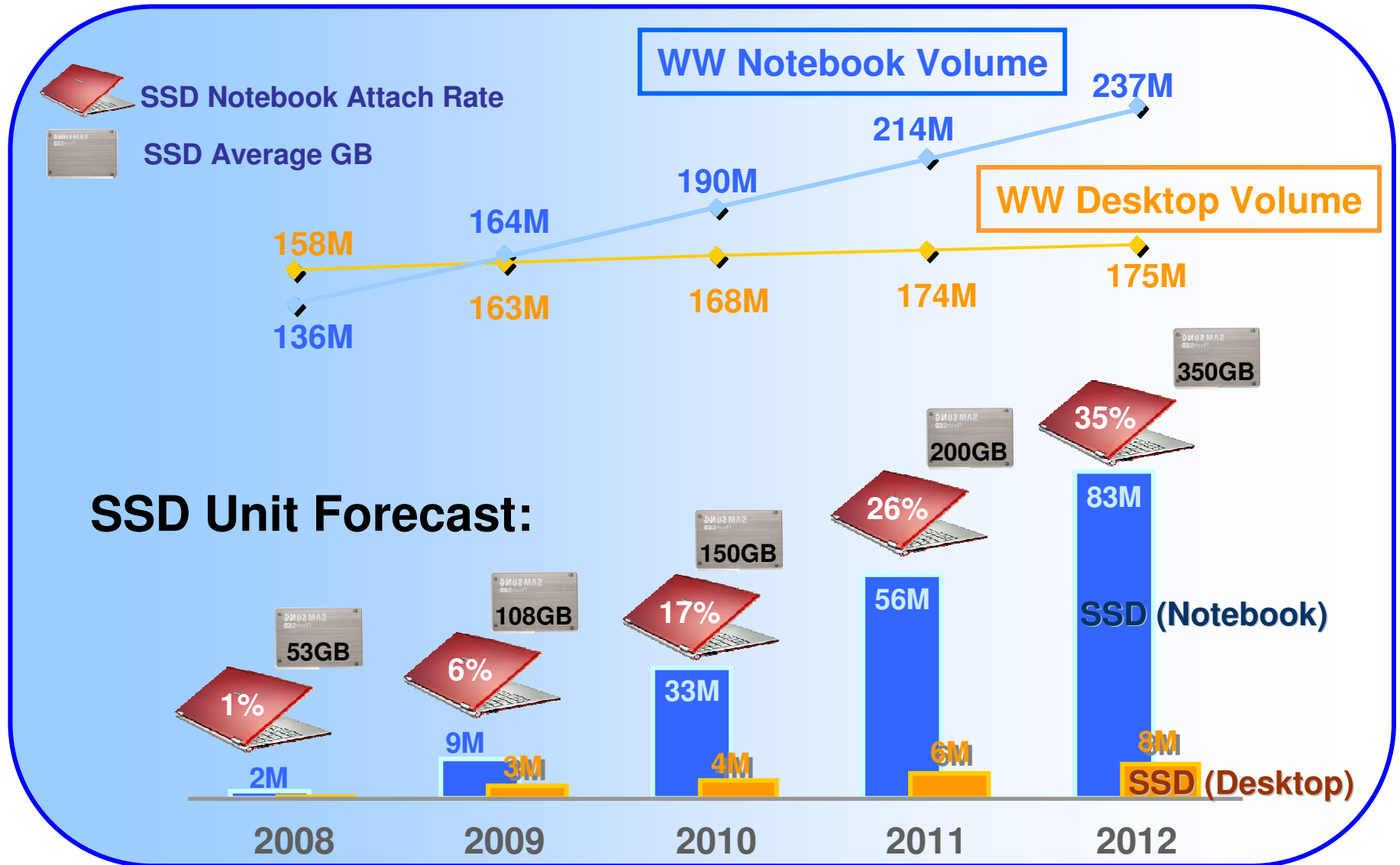
Card Units, M



\*Source : SEC Marketing



# SSD Volume, Attach Rate Forecast



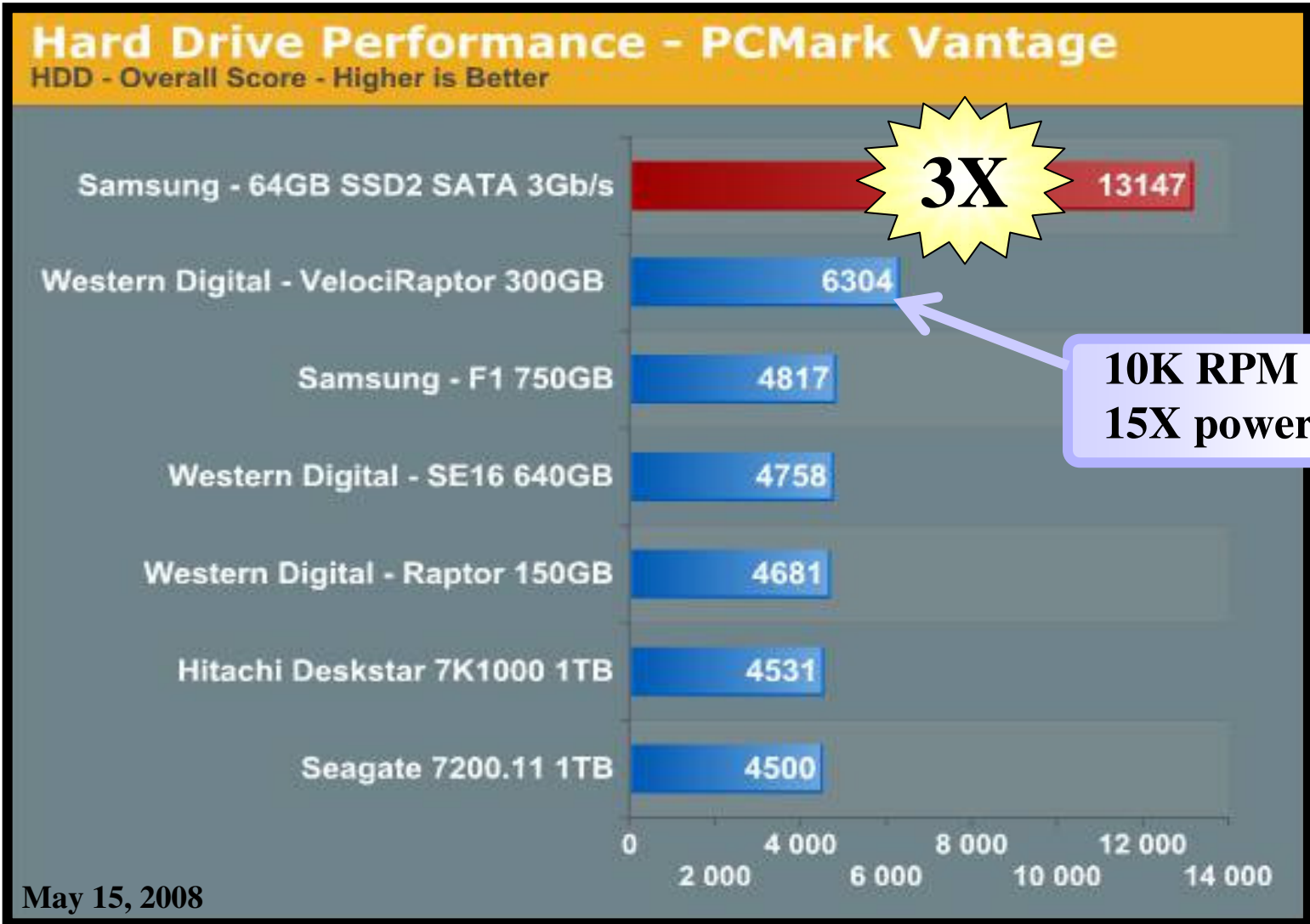
# SSD Value Proposition Recap

- ❑ Performance
- ❑ Density
- ❑ Endurance
- ❑ Reliability, Acoustics, Heat, Power



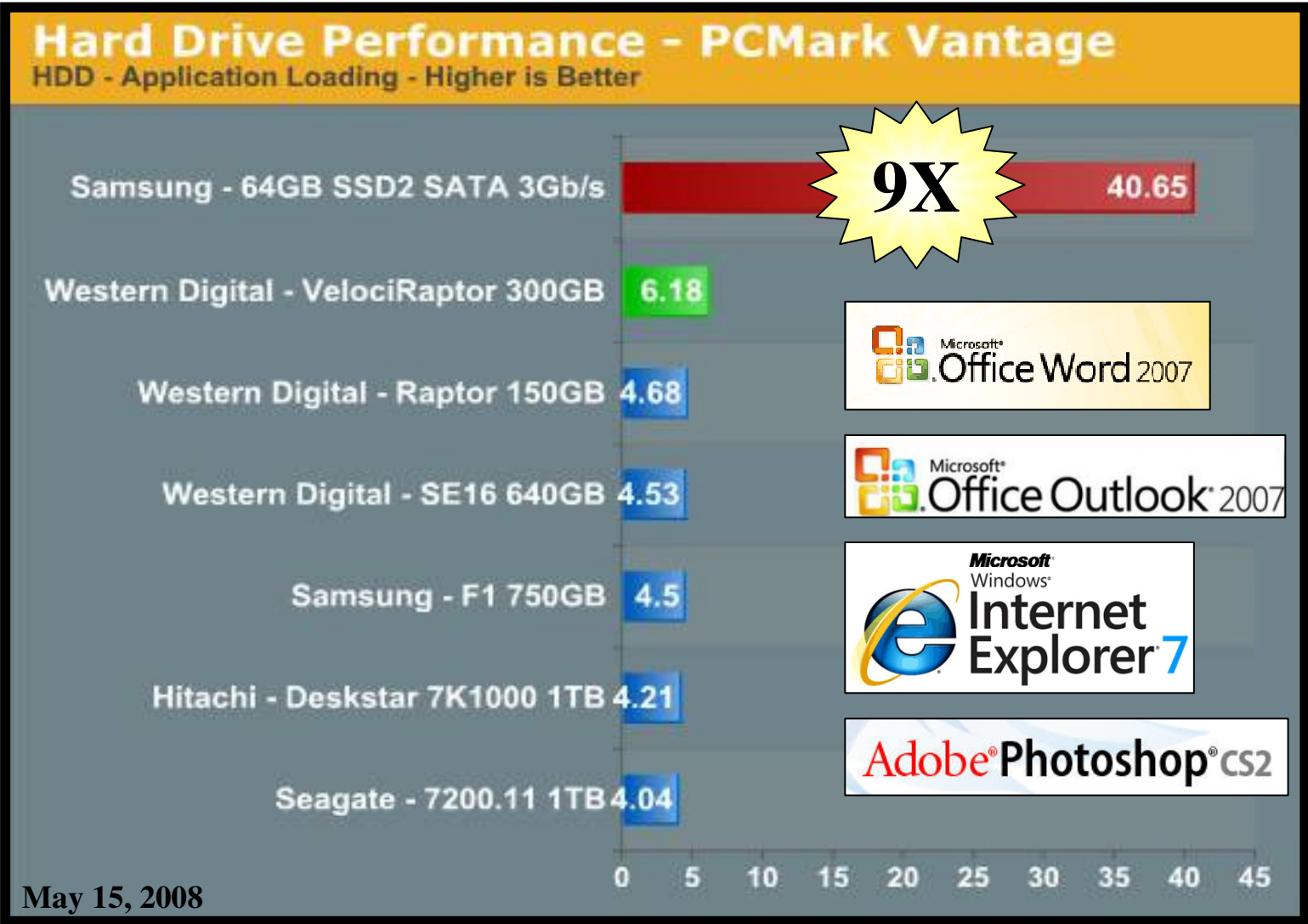


# SSD SATA-II vs HDD: Overall Performance Scores



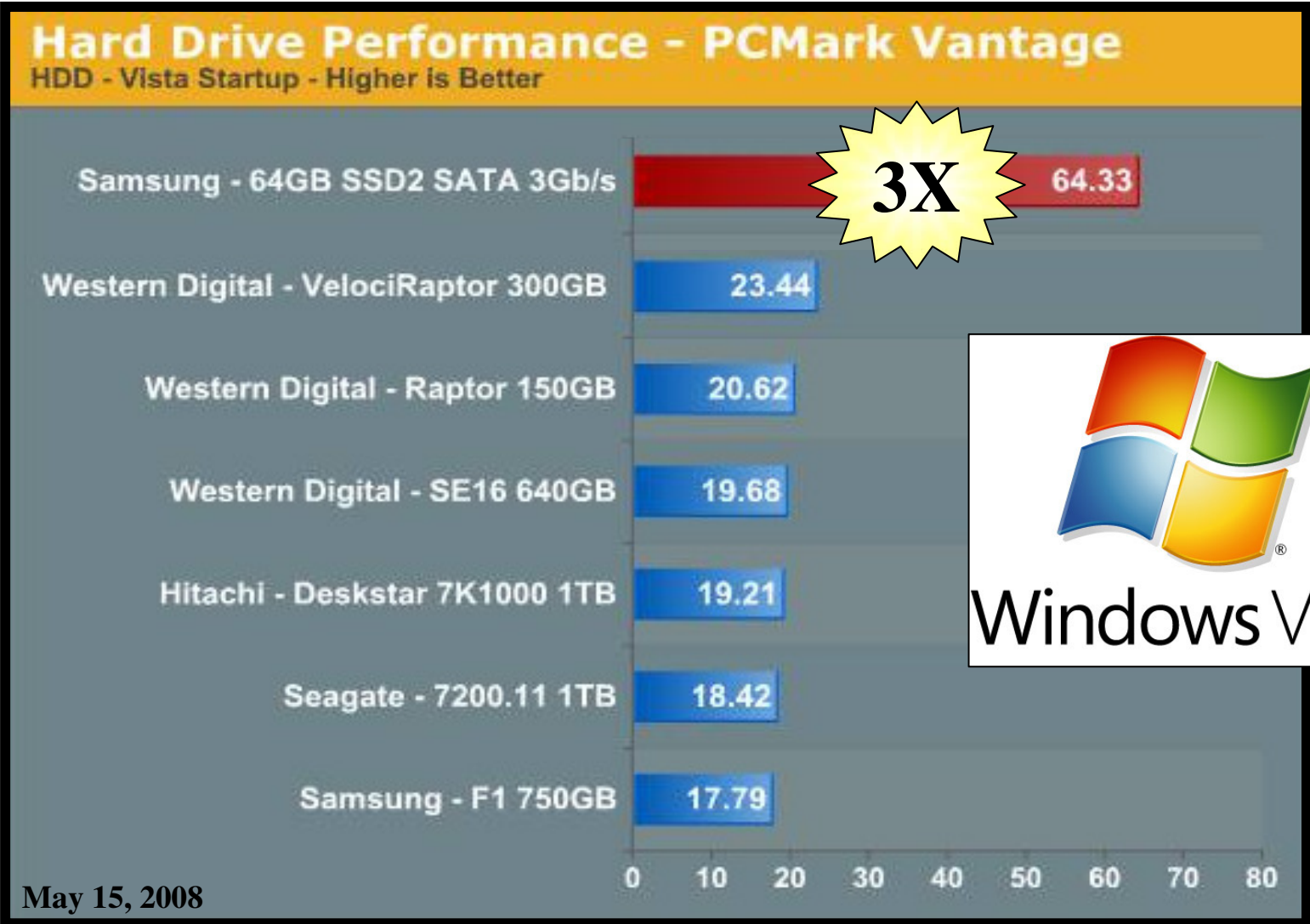


# SSD SATA-II vs HDD: Application Loading



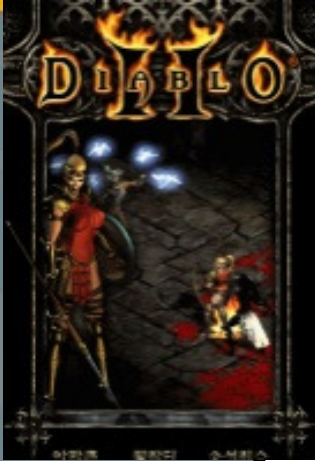
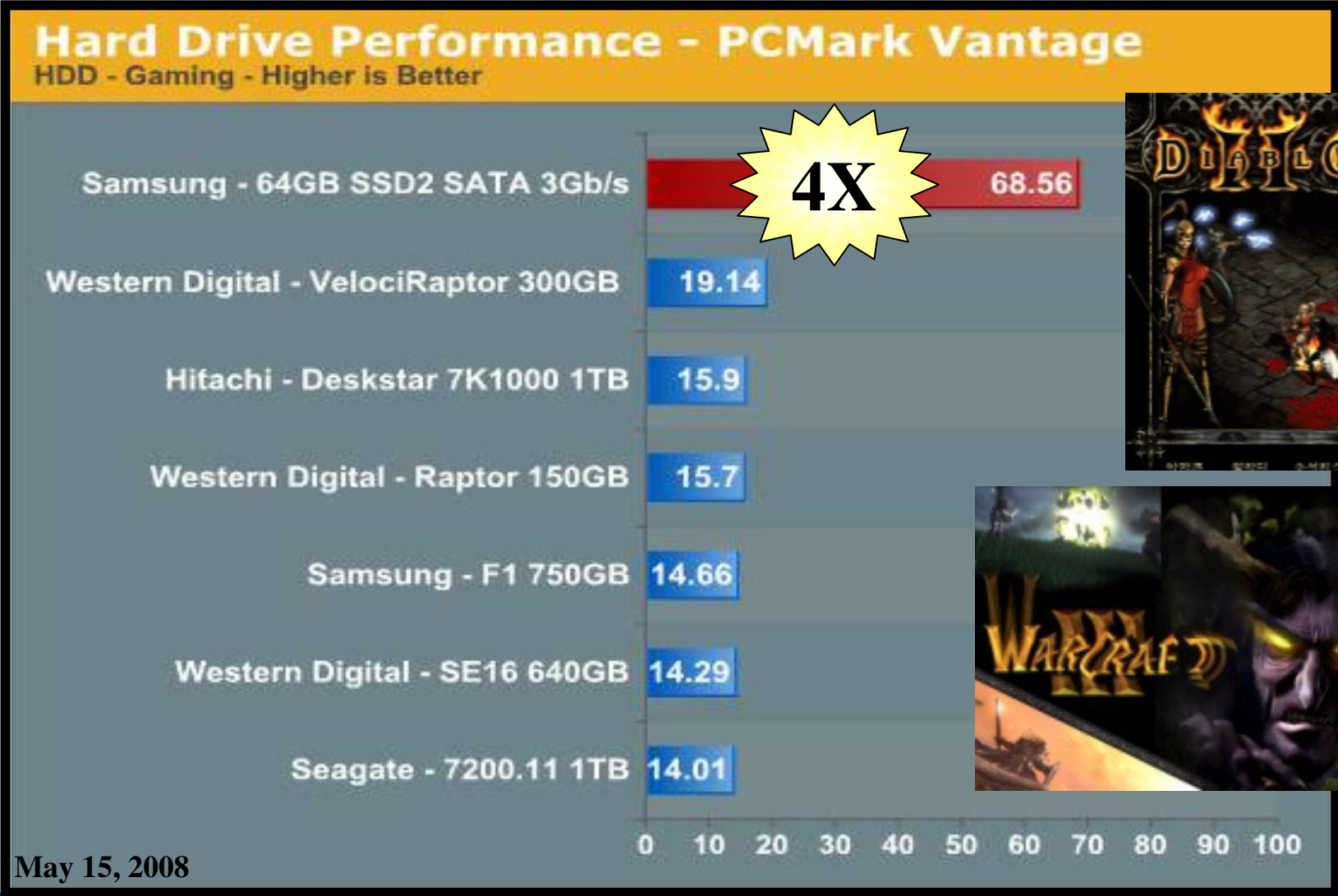


# SSD SATA-II vs HDD: Vista Startup

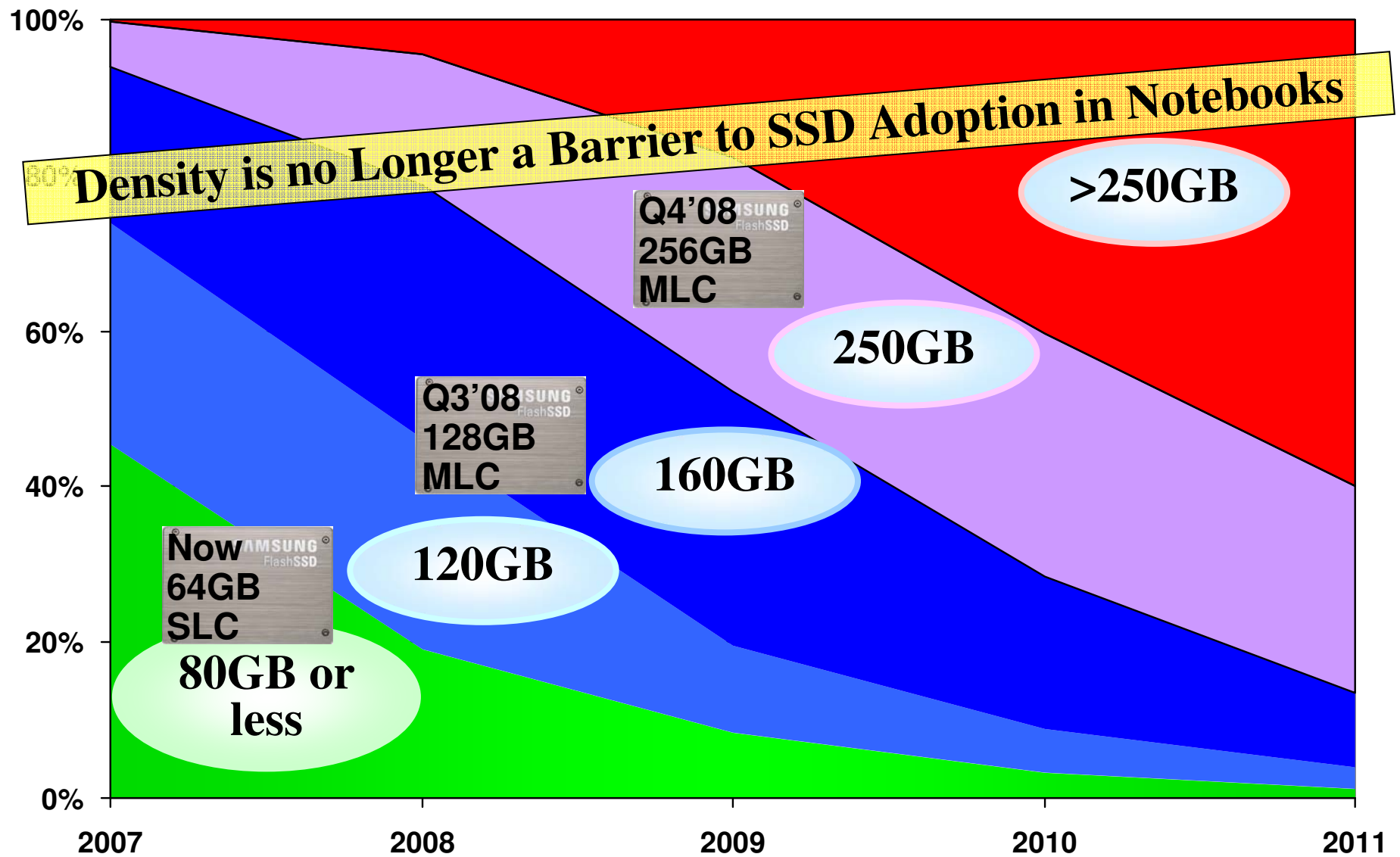




# SSD SATA-II vs HDD: Gaming

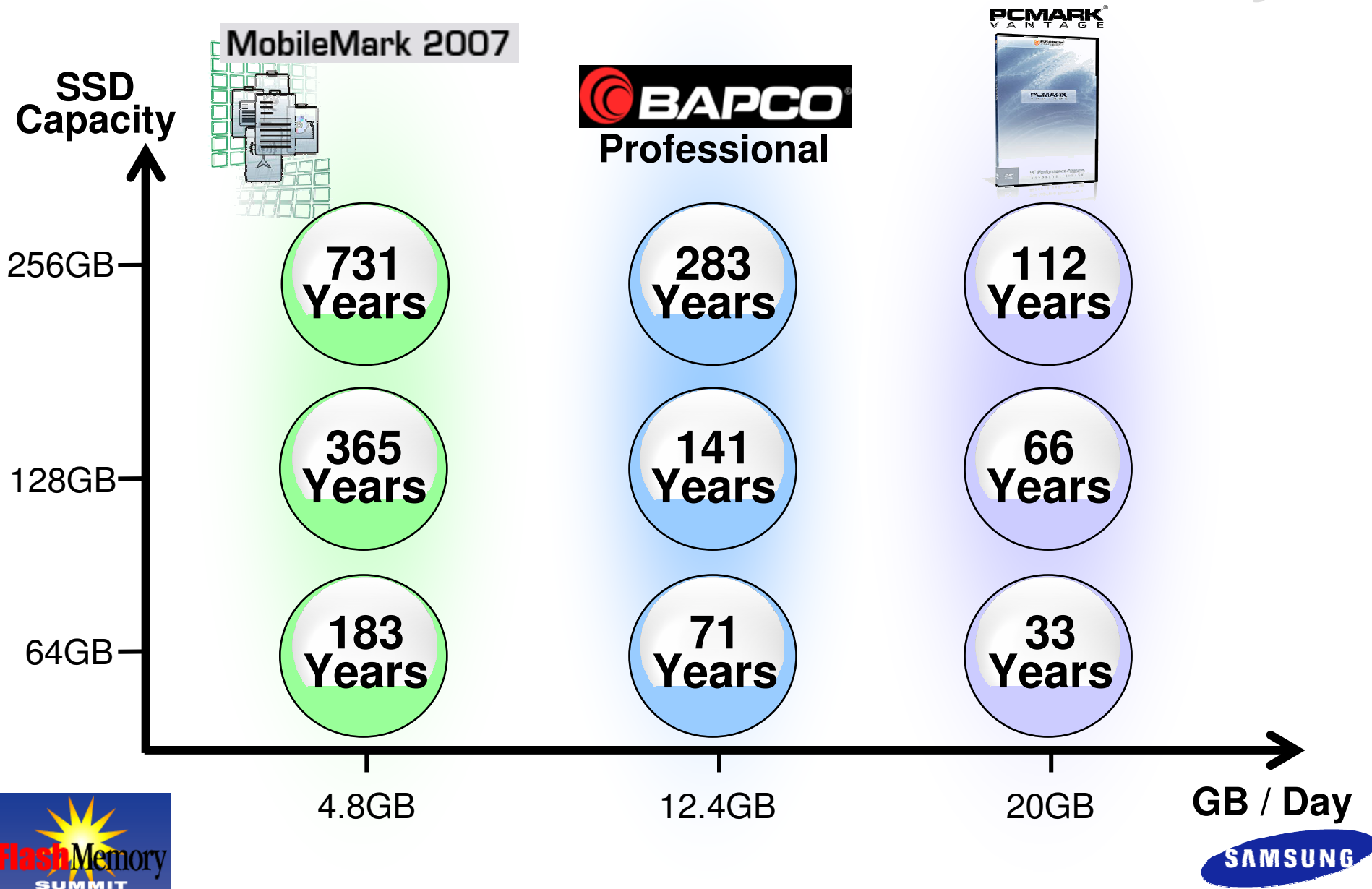


# Notebook 2.5" HDD Capacity



# MLC SSD Estimated Notebook Lifetime

## Do You Need a Million Mile Auto Warranty?



# SSD Value Proposition Recap

- ✓ Performance: Superior
- ✓ Density: 256GB covers >90%
- ✓ Endurance: More than Enough + Predictable
- ✓ Reliability, Acoustics, Heat, Power

# SSD Value Proposition Recap

- ✓  Performance: Superior
- ✓  Density: 256GB covers >90%
- ✓  Endurance: More than Enough + Predictable
- ✓  Reliability, Acoustics, Heat, Power
  
- Pricing
  - ❖ Notebook: System-Level Optimization
  - ❖ Enterprise: \$/IOPS and IOPS/Watt



# Hybrid Car Analogy: Camry vs Prius

Hybrid “Configure  
To Orders”



Prius: Hybrid-Only



| Metric                     | Camry: Hybrid CTO                        | Prius: Hybrid Only   |
|----------------------------|--|--|
| Car Facts                  | #1 Selling Car Brand in US               | #1 Registered Car in Santa Clara County                    |
| Hybrid Design Optimization | None: Conventional Gas + Electric Add-on | Holistic Approach: Thin Tires, Aerodynamic, Lighter Weight |
| Fuel Economy               | Improved: 26 → 33 MPG                    | Best in Class: 46 MPG                                      |
| MSRP                       | \$20K → \$25.7K (+ \$5.7K)               | \$21.5K Entry Level  |
| <u>Pricing Decision</u>    | <u>Mileage Needed to Break Even</u>      | <u>Total System Value</u>                                  |
| Customer                   | “Fence sitter”                           | Eco-friendly, Trend-Setter                                 |
| Product Perception         | Engine Option Only                       | Leading-edge Innovation, Green                             |

# Notebook Analogy: CTO vs. SSD-Only

## Configure to Order



## SSD Only



| Metric                      | CTO / Menu                | SSD-Only  |
|-----------------------------|---------------------------|---|
| SSD Configuration           | Usually "Opt In"          | SSD-Only at System Level                                |
| CPU Optimization            | None                      | Speed Downgrade → Save \$\$\$,<br>Save Power, Less Heat |
| Battery Optimization        | None                      | Smaller and Lighter → Save \$\$\$,<br>Less Heat         |
| <b><u>Pricing Logic</u></b> | <b>Upgrade Price, ROI</b> | <b>Total System Price</b>                               |
| Marketing Approach          | Shotgun (Non-Specific)    | Rifle (Road Warrior, Security)                          |
| Product Perception          | Storage Option Only       | Leading-edge Innovation                                 |

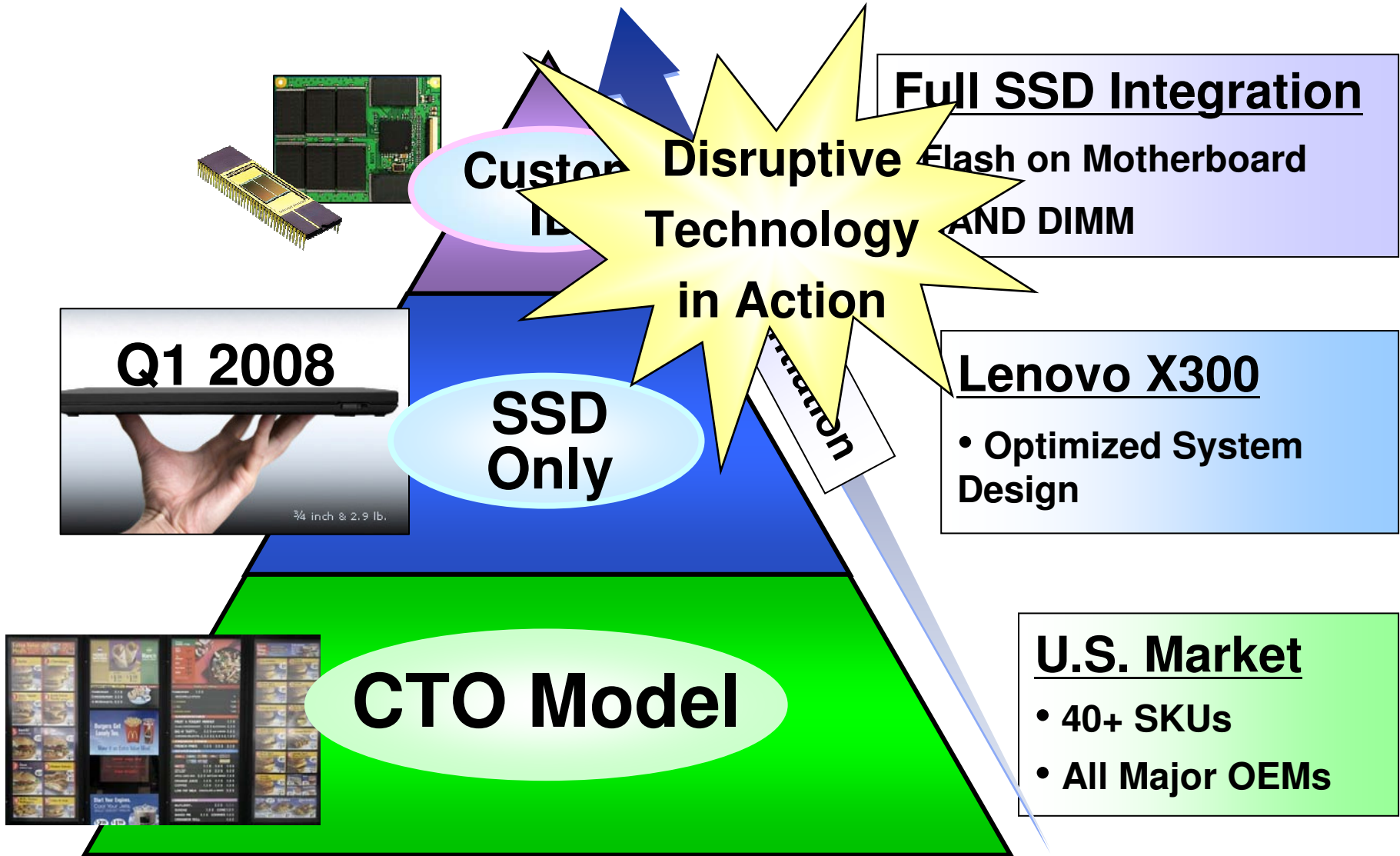


# The SSD-enabled Lenovo X300

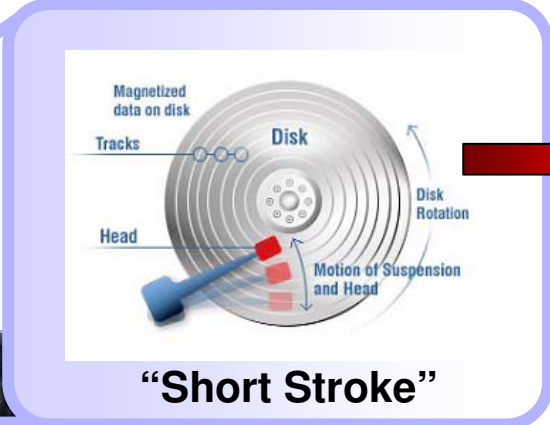


- ❑ First “Mainstream” SSD Only Notebook
- ❑ 64GB Solid State Drive
  - ❖ No HDD Option or “Opt Out”
- ❑ Represents an Irreversible Industry Trend...

# Notebook SSD Evolution



# Server SSD Performance Comparison

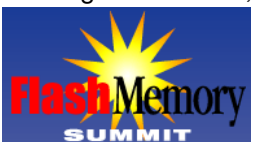


|                   | 15K HDD<br>3.5" | 15K HDD<br>2.5" | SSD 2.5"      |
|-------------------|-----------------|-----------------|---------------|
| <b>Capacity</b>   | 146GB           | 73GB            | 64GB          |
| <b>Read</b>       | 93 MB/s         | 108 MB/s        | 100 MB/s      |
| <b>IOPS</b>       | 650             | 570             | 8000          |
| <b>Price Est.</b> | ~ \$280         | ~ \$470         | ~ \$600       |
| <b>Avg. Watts</b> | 15 W            | 8.3 W           | <u>0.41 W</u> |
| <b>\$ / GB</b>    | \$1.9           | \$6.2           | \$9.3         |
| <b>\$ / IOPS</b>  | \$0.43          | \$0.82          | \$0.07        |
| <b>IOPS / W</b>   | 43              | 70              | 19512         |

**6X**  
**450X**

**11X**  
**280X**

\*SSD: IOPS: random read @ 512B, Data (SEC Marketing)  
\*HDD: Price and Data from storagereview.com; IOPS: average read speed



# Innovative Product Showcase

# pulse™

S M A R T P E N

**1GB and 2GB  
NAND Based**

**RECORD AND LINK AUDIO**  
to what you write.

**LISTEN TO YOUR RECORDINGS**  
by tapping on what you wrote.

**SEARCH AND SHARE YOUR NOTES**  
from your computer.

**NEVER MISS A WORD™**

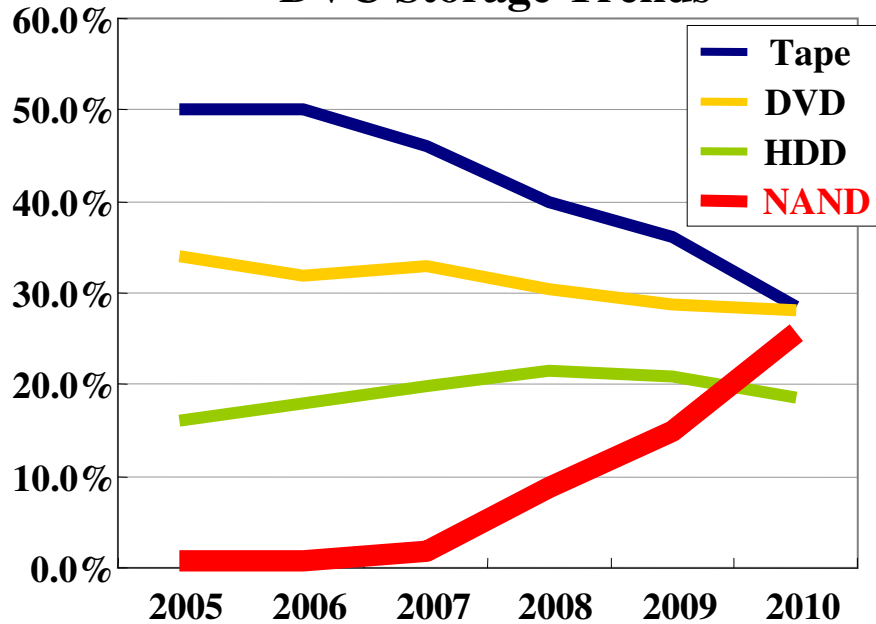


 livescribe.  
[www.livescribe.com](http://www.livescribe.com)

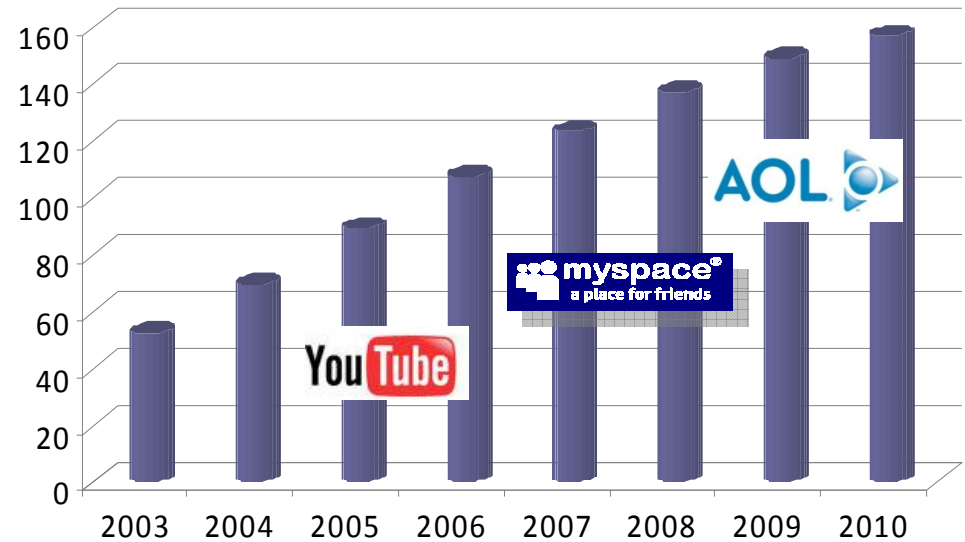


# Enabling “Content Creators” at \$179

DVC Storage Trends



US Online Video Viewers (M)



Pure Digital- Flip Video

#1 Selling Camcorder in the US

60 Minutes of VGA Video: \$179

2GB Embedded NAND



Source: ComScore; eMarketer, NPD June '08





# Eye-Fi

Wi-Fi Enabled 2GB SD Card

Wireless Uploads to the Web and your Computer



Hotspot Access at 10,000 Wayport Restaurant, Hotels & Airports

Automatic Geo-tagging

Take Pictures



Wirelessly Upload



Automatically Save



Easily Share



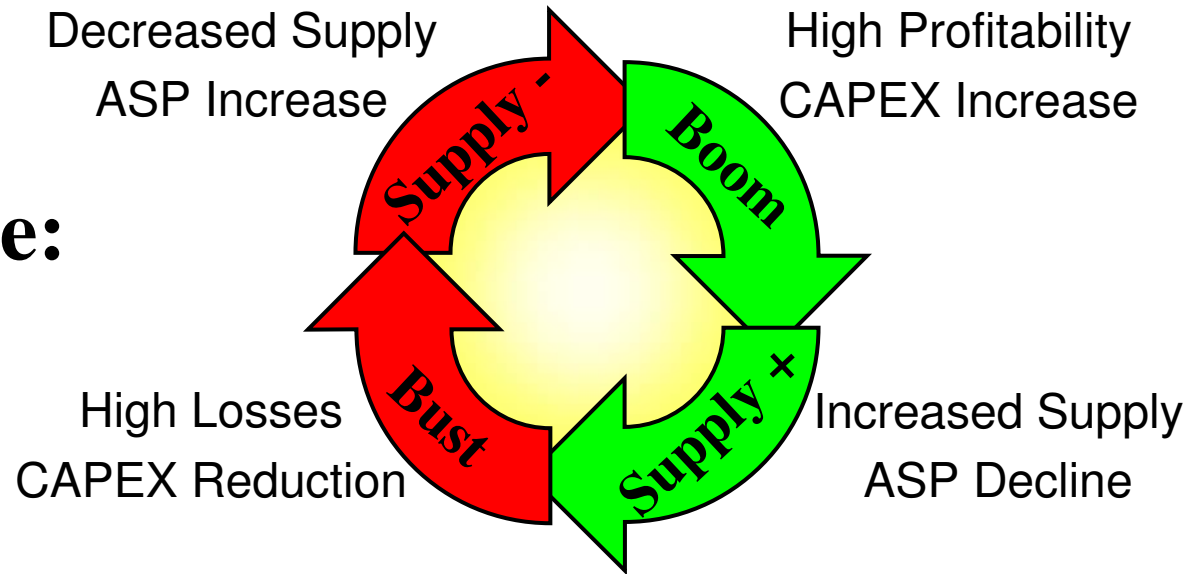


# So Where is the Market Headed?



# Concluding Thoughts

## Traditional Memory Cycle:



## Future Prospects:

Moore's Law Continues to Inspire Innovation.

Innovation Will Drive Growth...



**Thank You!**

