SSDs Driving Greater Efficiency in Data Centers

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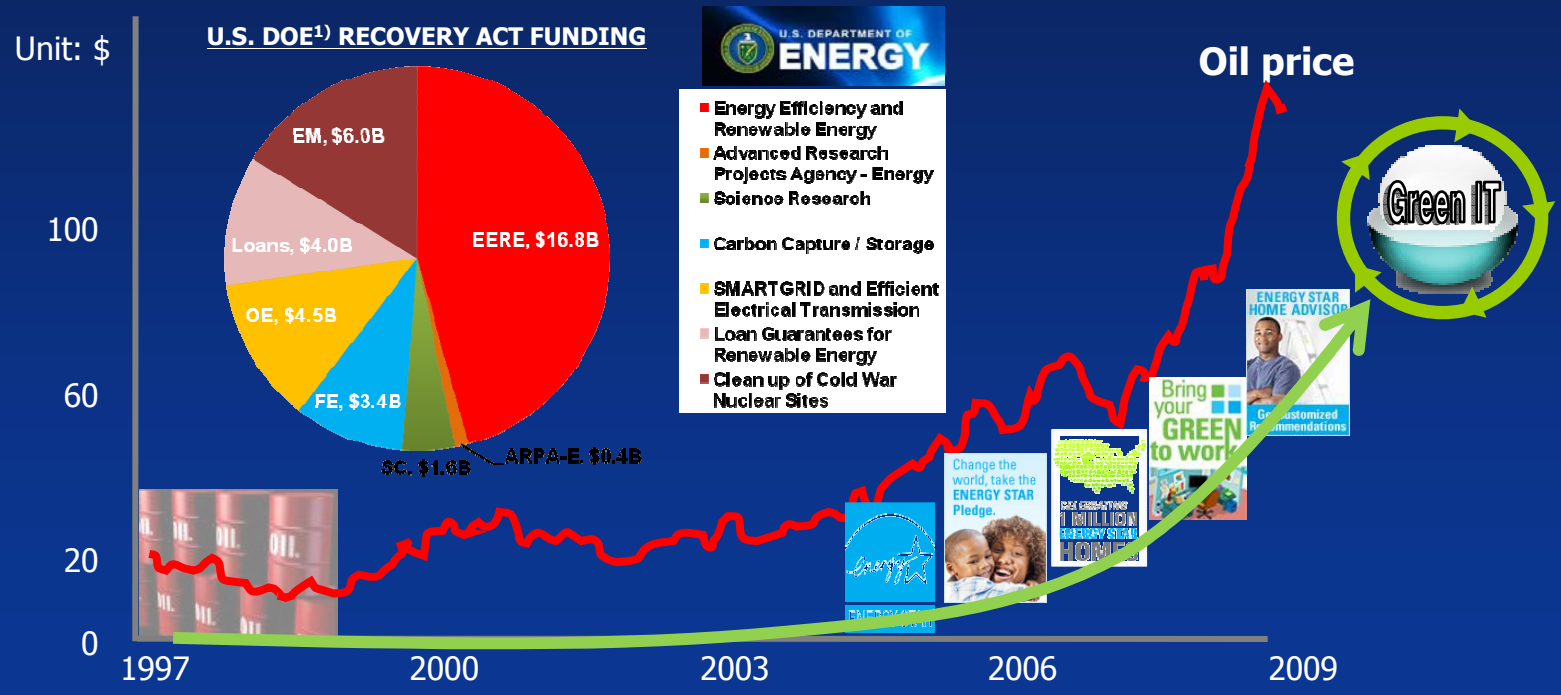
Cloud Computing

- Mobility
- Connectivity
- Market diversification

For Cloud Computing, optimized capacity and hi-reliability SSD best fit in commercial space

Green IT

- U.S. Depart. of Energy funds $16.8 billion for energy efficiency and renewable energy
- Surging oil prices have made more people think of Green IT seriously

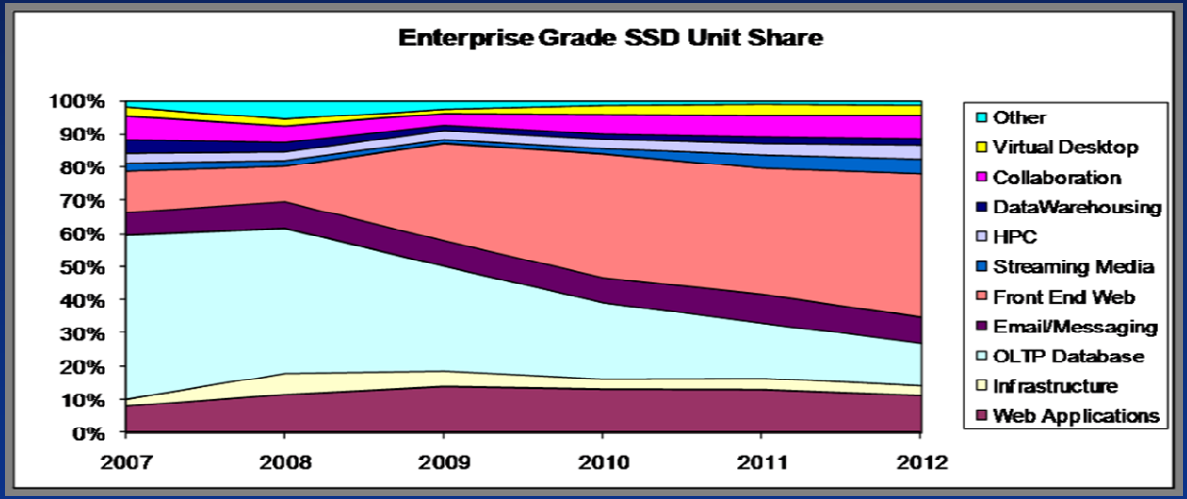


1) DOE: U.S. Department of Energy
2) DOE RECOVERY ACT FUNDING, Source: *http://www.energy.gov/recovery/index.htm*

Green IT starts with Energy Efficient Components

New Paradigm for Enterprise Market with SSD

- Enterprise market has started to utilize the benefits of SLC SSDs, i.e. High IOPS, Low Power & Reliability



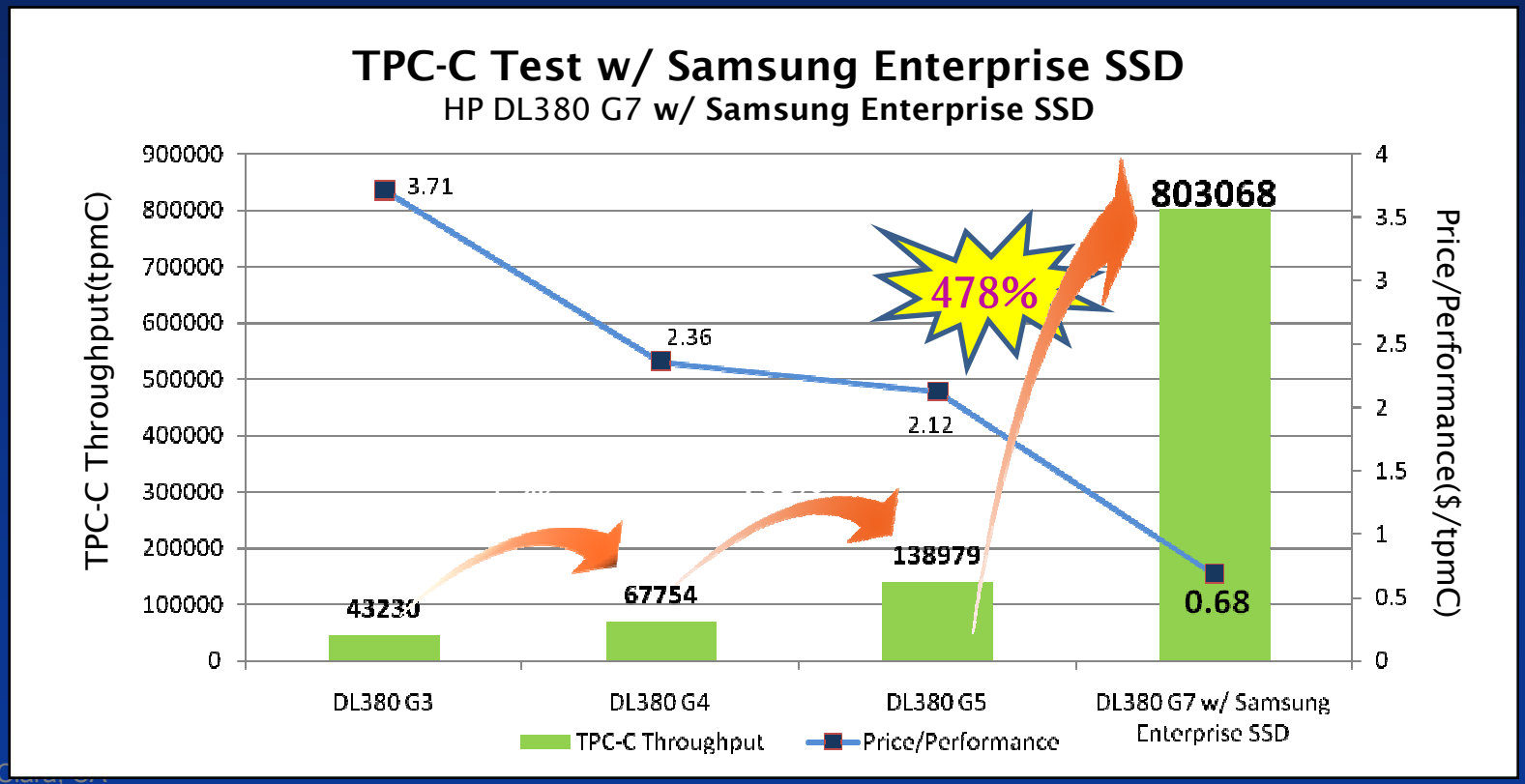
[Source : Gartner Q210]

- Streaming and Web servers – especially with Read-centric applications – are considering use of MLC SSDs for their lower price and higher capacity

→ More Opportunity in Enterprise Market

TPC-C Benchmark Configuration (SSD vs. HDD)

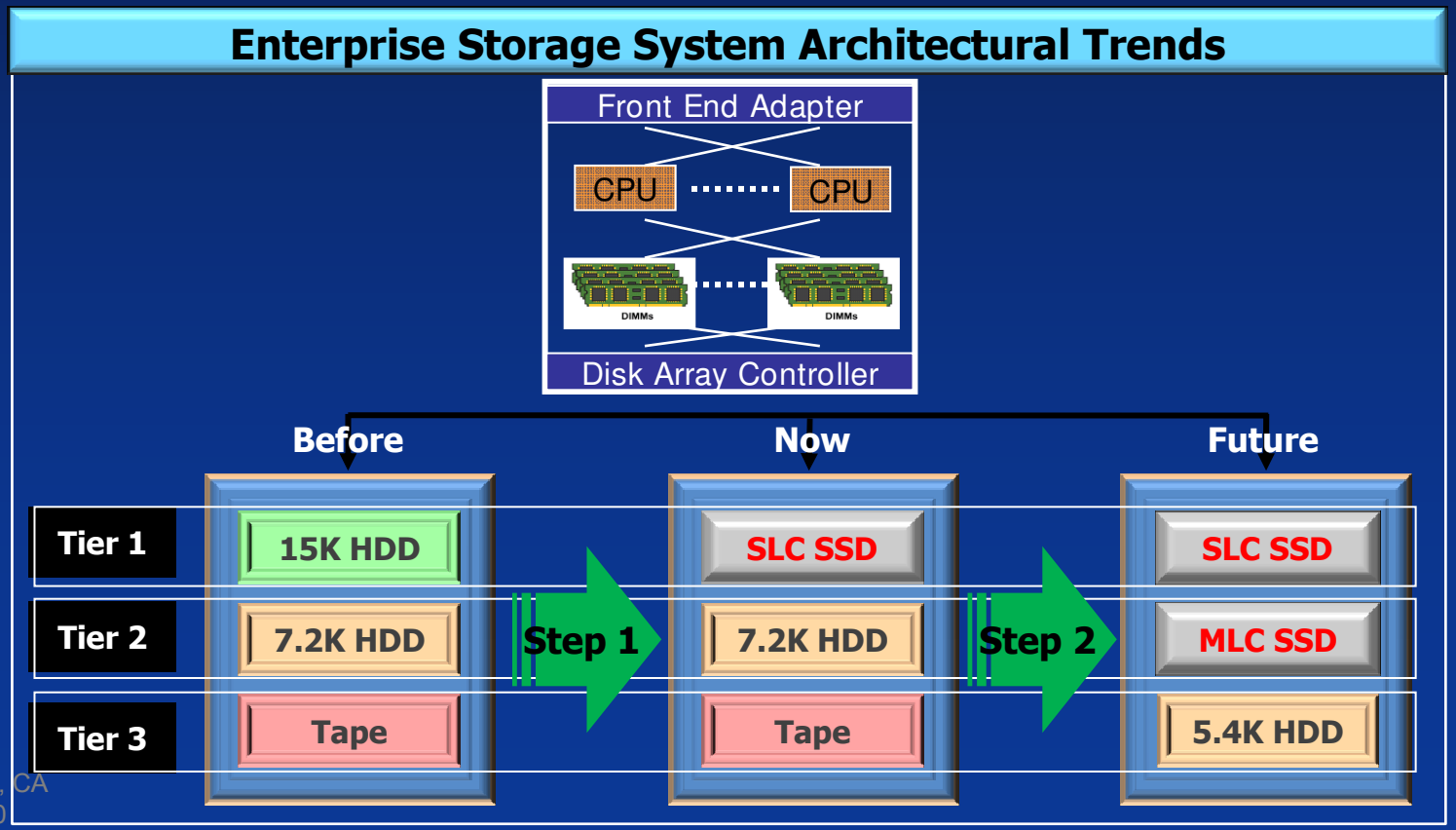
- HP DL380 G7 given highest score when using Samsung Enterprise SLC SSD in TPC Benchmark test
- #2 Overall 2 CPUs Server (6X Performance & 3X Price/Performance)



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

Storage System Trend Toward Green IT

- Automated tiering in storage system expedites SSD adoption
  - SSD can deliver fast response time with lower costs at top of the storage tier
  - Enterprise MLC SSD is expected to grow its position, including Tier 2



Challenge of Enterprise-class SSD

- Cost: Flash memory dominates the BOM; Cost reduction slow down (3Xnm → 2Xnm →1Xnm)
- Reliability: P/E cycle and Data retention are key to determining SSD lifetime
- Performance: lifetime trade-offs (IOPS, bandwidth – need to define real application usage)

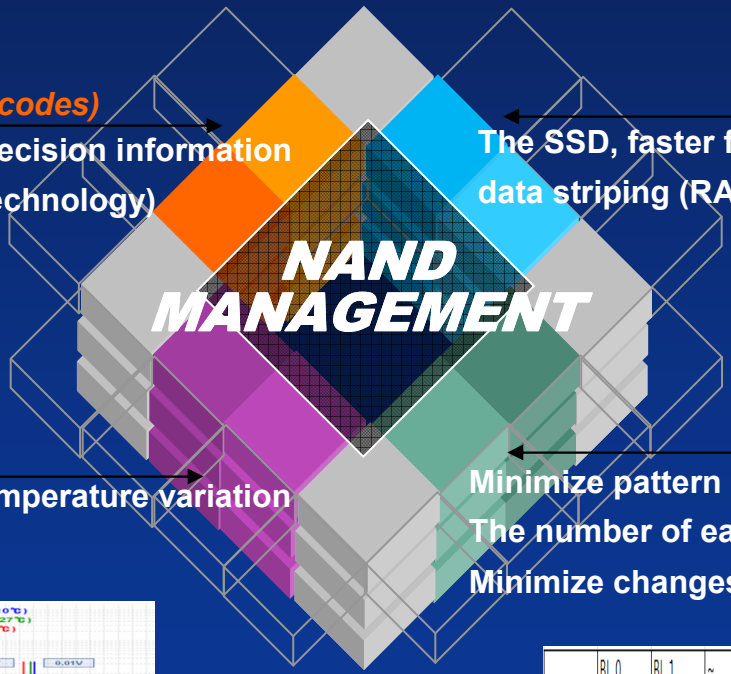
→ More Challenge on Enterprise class SSD

SSD Technology Trend: NAND Management

- NAND management technology is crucial for SSD reliability
  - Applying advanced DSP technology
  - HDD channel technology would be applied to SSD

• *LDPC*
(Low Density Parity check codes)

Powerful ECC decoding needs soft-decision information to improve reliability (existing HDD technology)

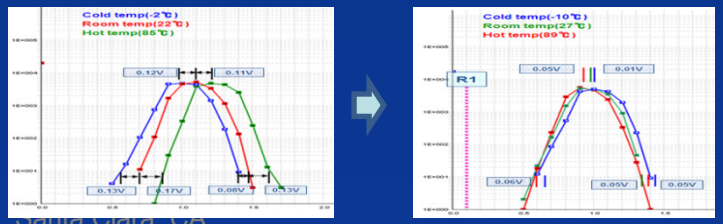


• *RAID*

The SSD, faster flash drives by implementing data striping (RAID 0) and interleaving.

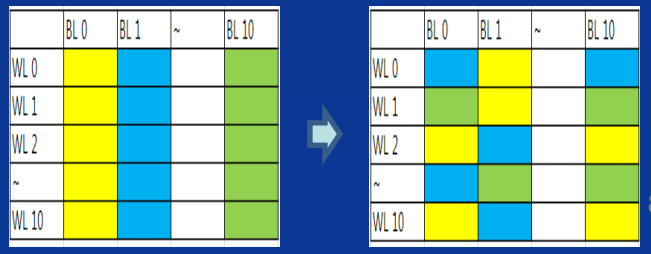
• *Temp Sensor*

It is an element which can sense a temperature variation and revise a voltage criterion.



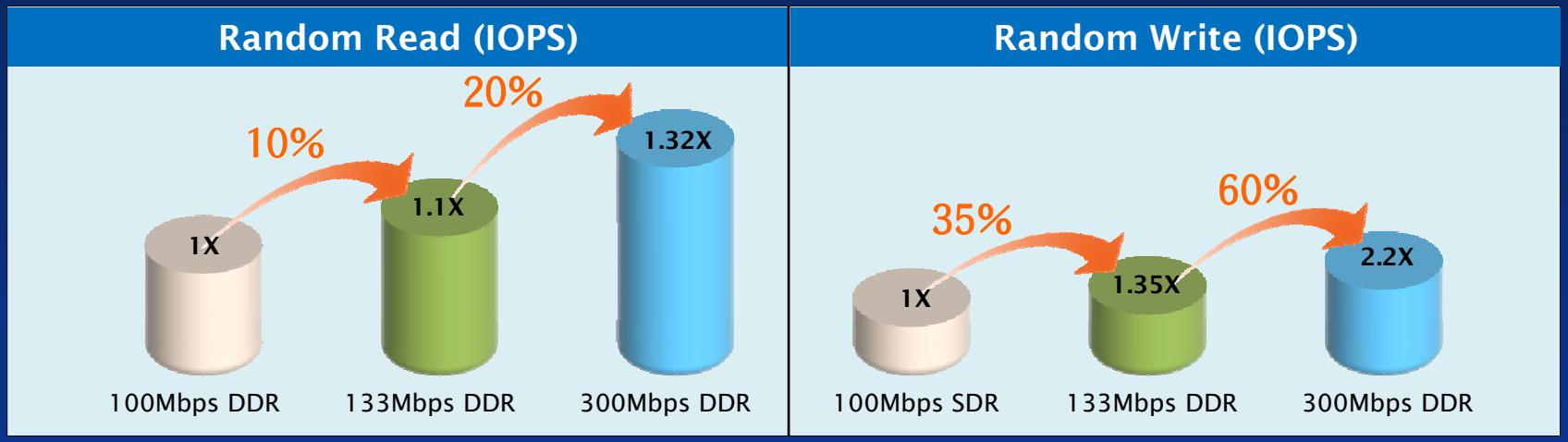
• *Randomizer*

Minimize pattern dependency
The number of each state's cell is equally distributed
Minimize changes; verify/read level each data pattern



SSD Technology Trend: High-Performance NAND

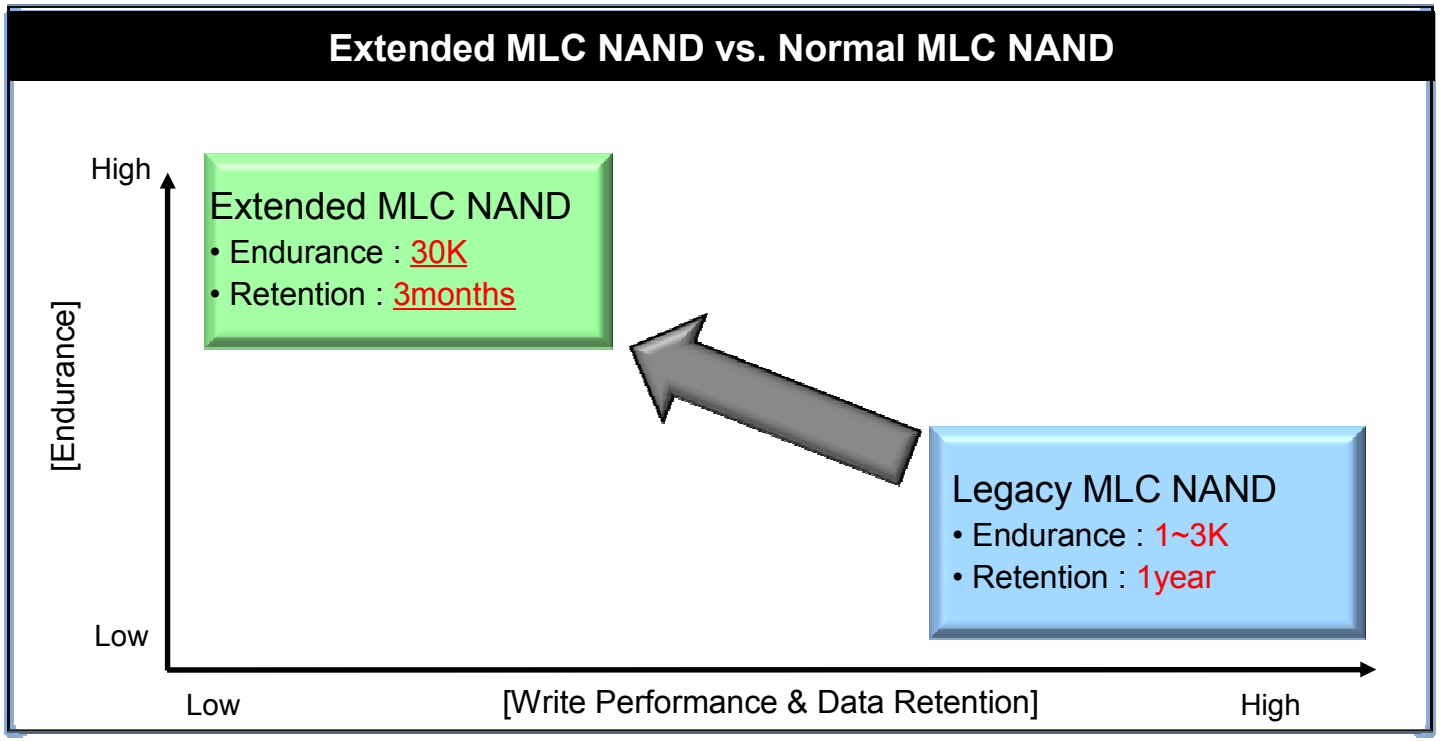
- NAND flash is following SSD market trend
- Step 1: Performance improvement with Toggle-mode NAND
  - Interface: 40Mbps → 133Mbps → 400Mbps



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

SSD Technology Trend: Extended Life-span MLC

- Meets Enterprise requirement of 24/7 for long period of sustained performance
- Extended life-span; cost-effective MLC with 30K P/E cycle

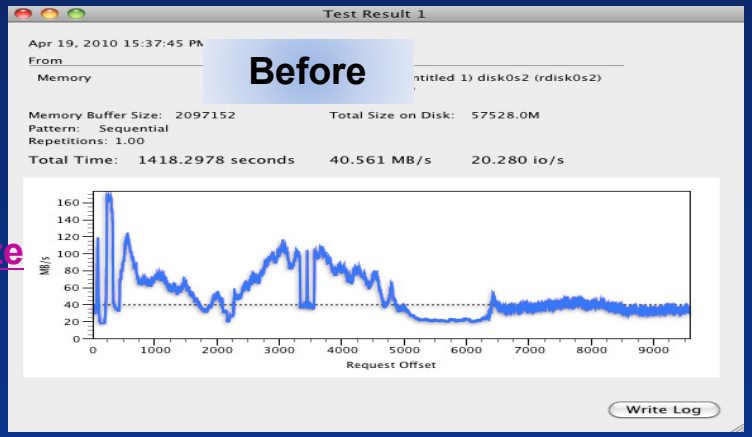


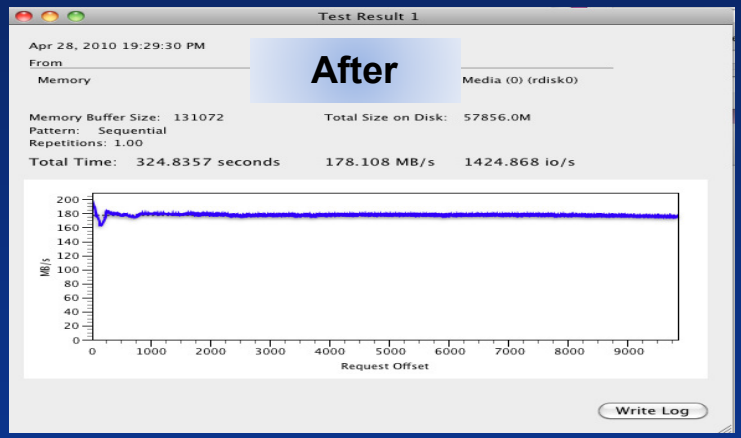
*32nm 32Gb MLC Target Spec. (TBD)

SSD Technology Trend: NAND Management

- Push for sustained performance
  - FW optimization, Over-provisioning and Supercap technology keep improving end user experiences by enabling sustained performance
  - Eco-system (OS, Filesystem) is becoming friendlier for SSDs

FW optimize

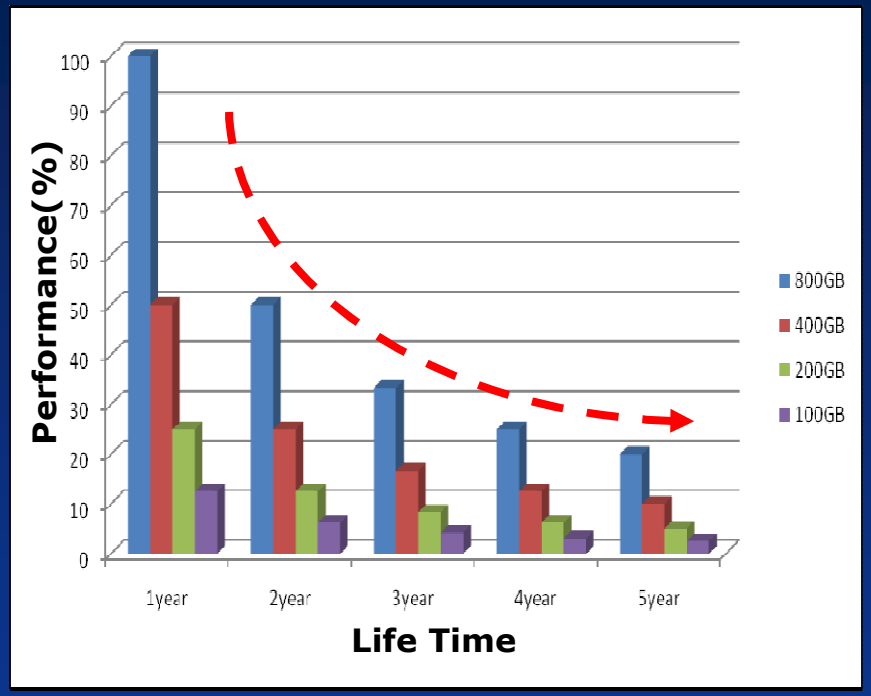




- 'Sustained performance' represented as standard SSD performance
  - SNIA defines PTS (Performance Test Specification) for Client and Enterprise
  - 'Steady State' region represents device's performance during normal working life

SSD Technology Trend: Lifetime with FW

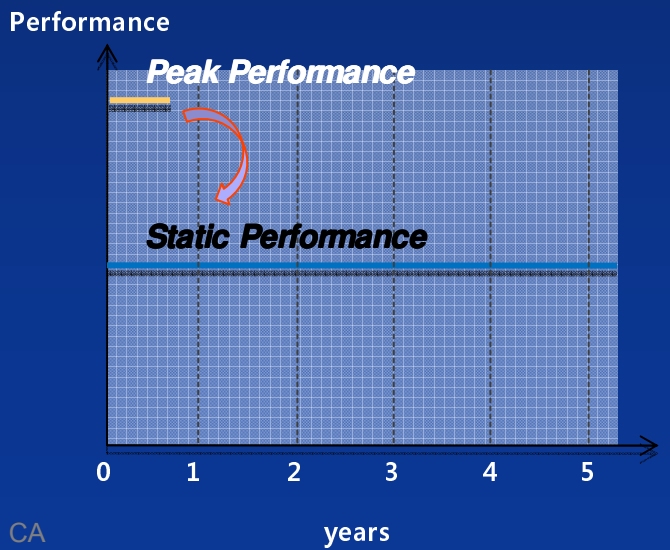
- Random performance is more important in server applications
  → Greater impact on Lifetime of SSD
- Lifetime highly depends on daily workload (especially Rand. Write)
- The guaranteed year can be extended with larger capacity

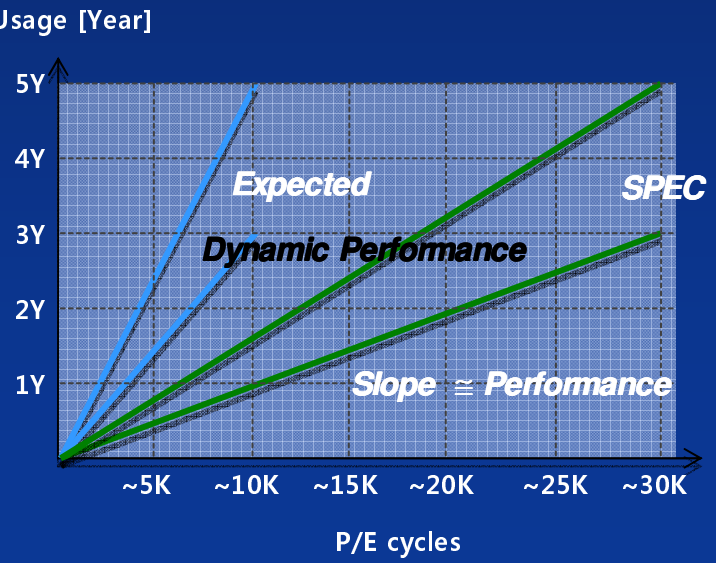


Minimized WAI from advanced firmware could guarantee normal lifetime from MLC SSD

SSD Technology Trend: Performance Throttling

- ‘Performance throttling’ technology could be utilized for differing lifetime expectations from various customers
  - **Static performance throttling**
    Depending upon customer decision for lifetime warranty, performance can be throttled statically → Fixed once decision made for a specific application
  - **Dynamic performance throttling**
    Online workload monitoring can enable dynamic performance throttling
    → Consistent performance is important for enterprise applications

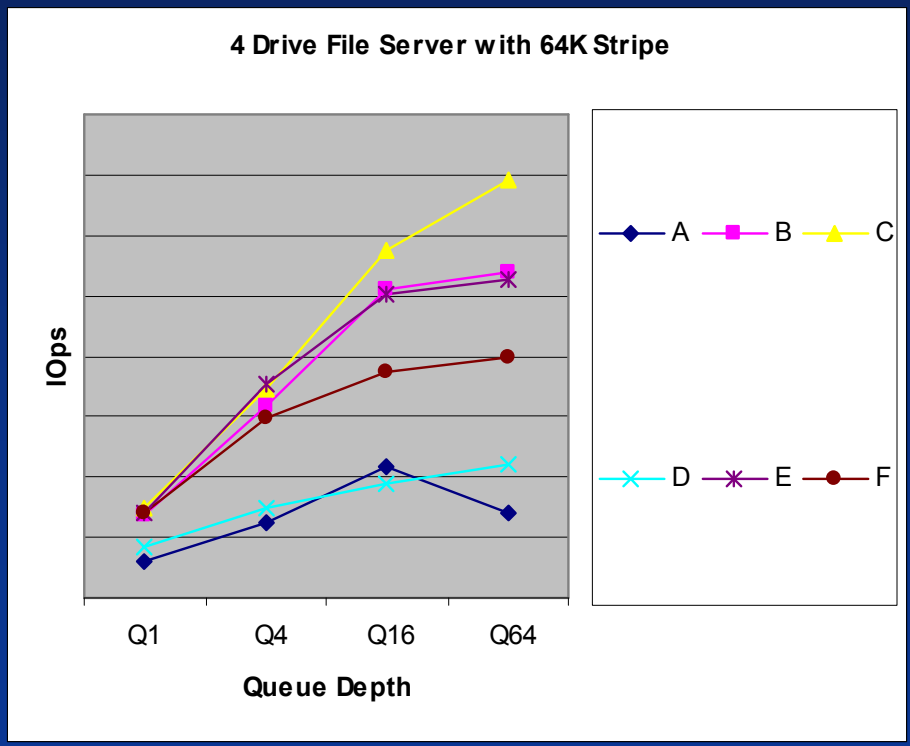




SSD Technology Trend: Enhancing Ecosystem

- Needs of SSD-friendly Storage Infrastructure:
  - System architecture, OS and File System optimization and application, etc.

  - ➢ Current HBA/RAID tech. bottleneck for SSD performance, because it has been optimized only for HDDs
  - ➢ RAID/HBA features are to be optimized to be SSD-friendly due to low HDD performance
  - ➢ Samsung is working closely with RAID/HBA vendors to maximize SSD performance



File Serve : 100% Random, 80% Read

Summary

- Green IT, cloud computing and new IT trends will take advantage of Green SSD Solution
- Started with reliable SLC SSD drives, leapfrogging the best performance and entering new paradigm with MLC SSD
- The balance among speed, safety and $$ becoming more important than higher IOPS:
- Cost reduction is main driver for growing use of MLC NAND
- MLC SSD needs to be designed to provide breakthrough performance and extend lifetime; it requires new evolutionary technology mainly for NAND management
- System architectures must advance to fully exploit SSD

Thank you

- Visit our booth #500 to see a Demo of high-performance, energy-efficient memory and SSD solution
- For more information, please visit www.samsung.com/SSD