

# Flash SSDs in the Enterprise: *Where, How and Why*

Marius Tudor  
Director, Business Development  
BiTMICRO Networks, Inc.

- ❑ Enterprise SSD Market Outlook
- ❑ Enterprise Storage Requirements
- ❑ Flash SSD Major Advantages
- ❑ Flash SSD and HDD Pricing
- ❑ Flash SSD Performance Class
- ❑ Enterprise Usage Models
  - ❑ Storage Performance Acceleration (Traditional)
  - ❑ Server and Blade Storage
  - ❑ Tiered Storage Environments
  - ❑ Flash SSD Technology Trends

## □ IDC (2008) SSD Market Projections

Worldwide Enterprise SSD Analysis, 2007–2012							
	2007	2008	2009	2010	2011	2012	2007-2012 CAGR (%)
Enterprise DRAM	0.5	0.7	0.9	1.1	1.3	1.6	24
Enterprise NAND High I/O	2.3	17.8	72.1	285.1	792.7	1,578.40	269
Enterprise NAND	4.1	21	116.1	216.8	396.4	662.2	176
<b>Total</b>	<b>7</b>	<b>39.5</b>	<b>189</b>	<b>503</b>	<b>1,190.4</b>	<b>2,242.3</b>	<b>217</b>
Revenue (\$M)	48.8	119.5	215.5	443.8	688.5	917.6	80
ASP (\$)	6,990.5	3,021.7	1,140.0	882.4	578.4	409.2	-43
TB shipped	271.0	2,219.4	10,685.5	41,566.5	121,643.6	273,374.9	299

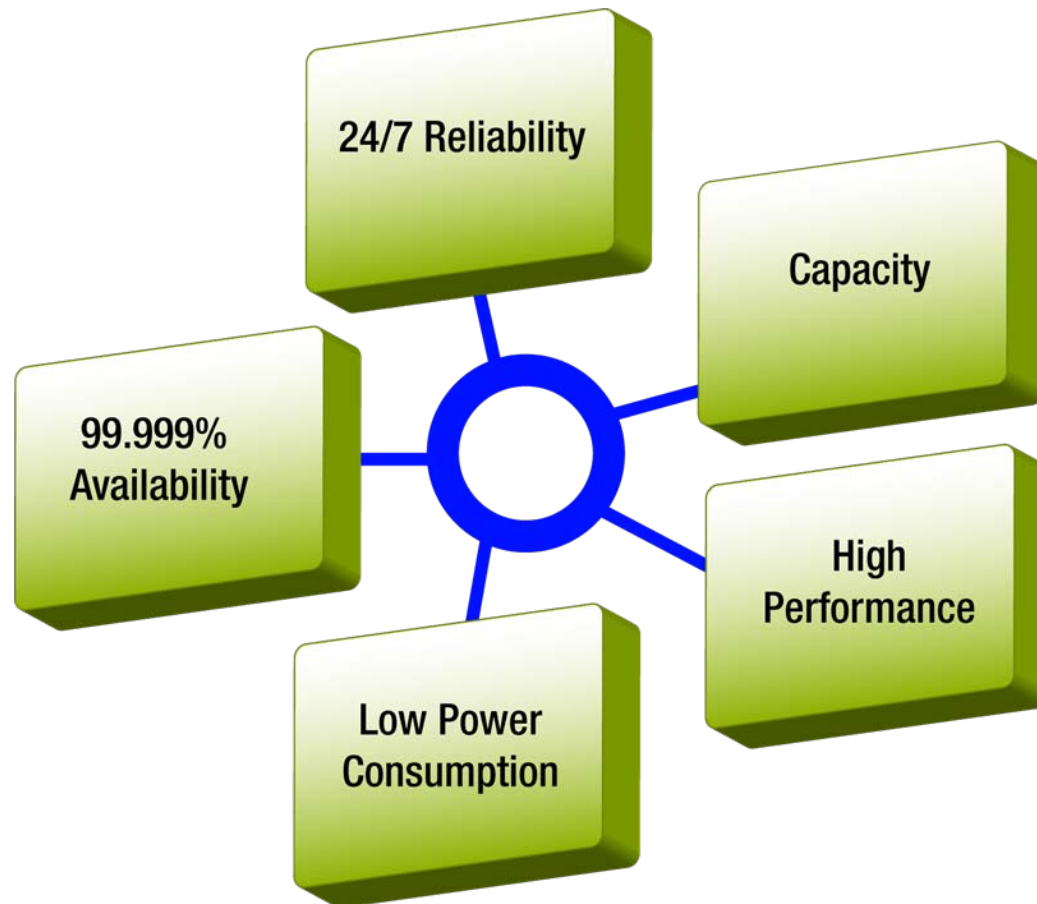
## □ Increase in SSD players

- SSD OEMS: ~50 manufacturers

### □ Enterprise Class SSD

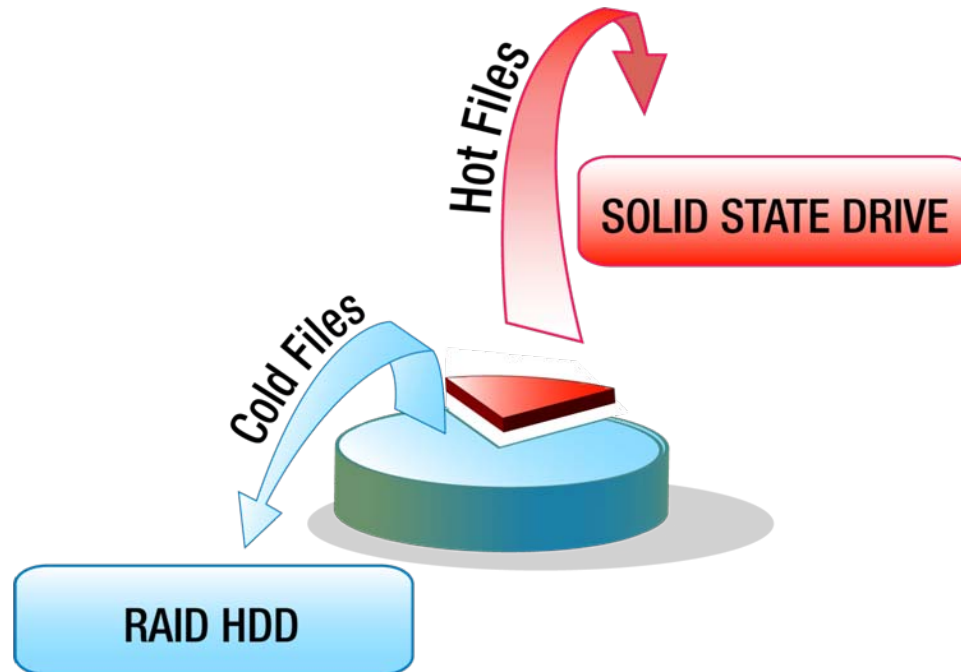
- Flash SSD: 7 manufacturers
- RAM SSD: 7 manufacturers

# Enterprise Storage Requirements



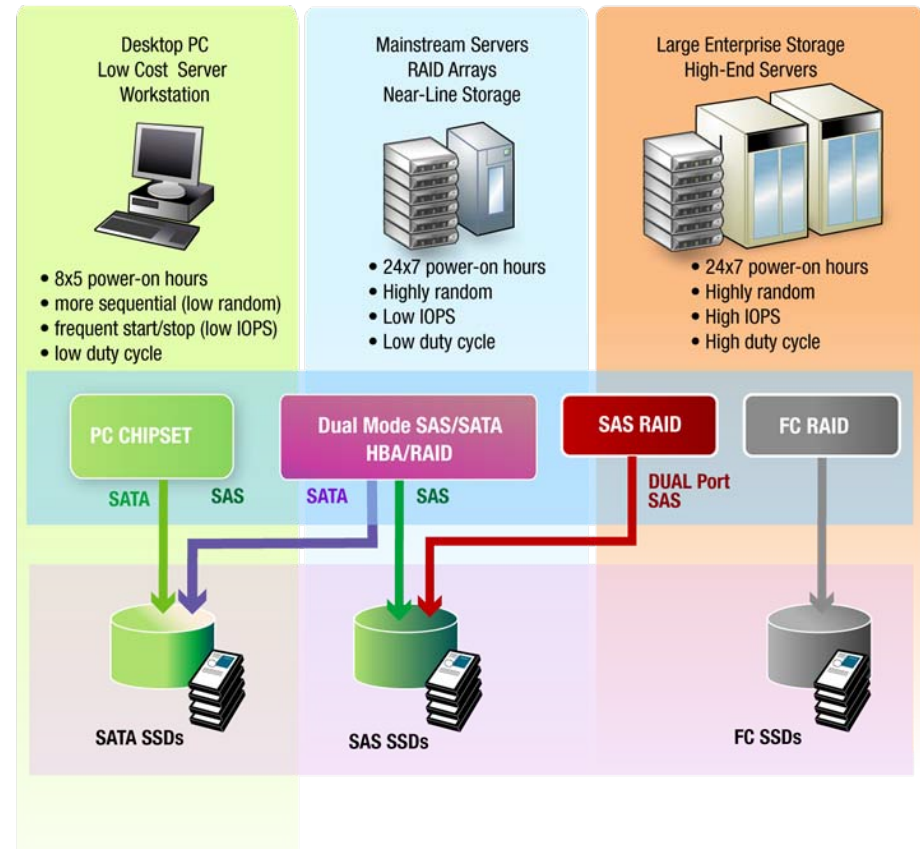
# Traditional SSD Application

- Storage performance acceleration



# Flash SSDs in the Enterprise

- ❑ Server and Blade Storage
  - ❑ Typically lower storage capacity requirements
  - ❑ SAS and SATA interfaces
  - ❑ Server and storage blades for boot and cache



# Flash SSDs in the Enterprise

- ❑ Performance vs. Power: Buzz vs. Fact
  - ❑ High Performance & Low Power typically is an Oxymoron
  - ❑ 1W Flash SSD beats a 12W consuming version, or does it?
  - ❑ Case in Point: SSD 'Uno' performs 600 IOPS and Flash SSD 'Duo' delivers 40k Random Write IOPS
  - ❑ Flash SSD 'Uno' is 5X Higher in Power consumption than Flash SSD 'Duo': .0016W/ IOPS vs. .0003W/IOPS
  - ❑ Million \$ Q: Which one is better in an Enterprise Storage environment?

*Note: This is solely an example depicting critical factors to consider; 'Uno' and 'Duo' are generic names and not meant to represent any one SSD or other brand;*

## □ \$/ Gbyte is Dead: Long live....\$/ IOPS

(...at least as far as Enterprise SSDs are concerned)

- **Flash SSDs really are NV buffers between front RAM & slower HDDs, right?**
- **Flash SSDs differ greatly when it comes to Random IOPS**
- **A 40k IOPS Flash SSD can displace 4X the HDDs that a 10k IOPS contender can**
- **20% premium for the 40k IOPS SSD derives better TCO**
- **Consider the lowest Denominator...Guess Who?**
- **Random Write IOPS**

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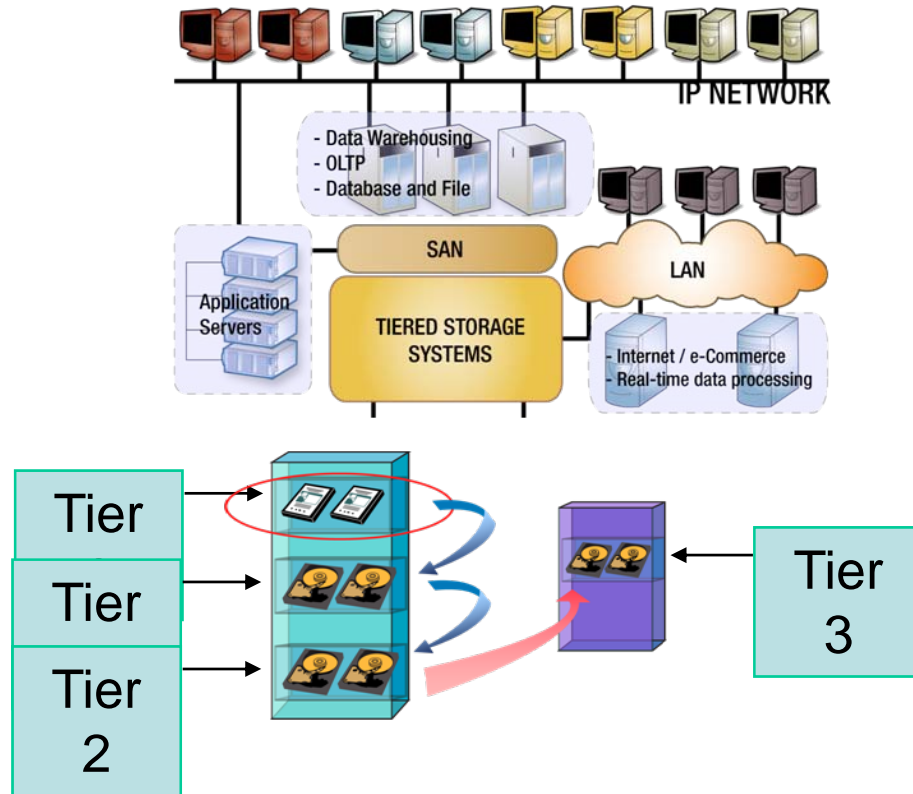
# Tiered Storage Requirements

- Migration toward tiered storage environments within datacenters
  - Combination of very-high performance, Flash SSD-based transaction-intensive tier;
  - High performance HDD; and
  - “Bulk” storage capacity, low-cost HDD tier

	Fibre Channel SSD	SAS SSD	Fibre Channel HDD	SAS HDD	SATA SSD	Enterprise SATA HDD
Applications	Tier 0	Tier 0	Tier 1	Tier 1 or 2	Tier 2 or 3	Tier 2 or 3
Interface Speeds	4GFC	3Gb/s	4GFC	6Gb/s & 3Gb/s	3Gb/s	3Gb/s
Capacities (GB)	640GB	160GB	146, 300 & 450GB	250, 300, 500, 750GB and 1TB	160GB	250, 500, & 750GB, 1TB
Access Times	30 - 100 $\mu$ s	30 - 100 $\mu$ s	5-8 ms	5-8 ms	30 - 100 $\mu$ s	12 - 14 ms
MTBF (hours)	2 million	2 million	1.6 million	1.6 million	2 million	1.2 million
Form Factors	3.5"	2.5"	3.5"	2.5"/3.5"	2.5"	3.5"
Sustained Rates	Up to 230MB/s	Up to 230MB/s	170 MB/s	Up to 170 MB/s	Up to 100 MB/s	100 MB/s
Dual Ports	Yes	Yes	Yes	Yes	No	No
Vibration Tolerance	Hgh	Hgh	Hgh	Hgh	Hgh	Medium

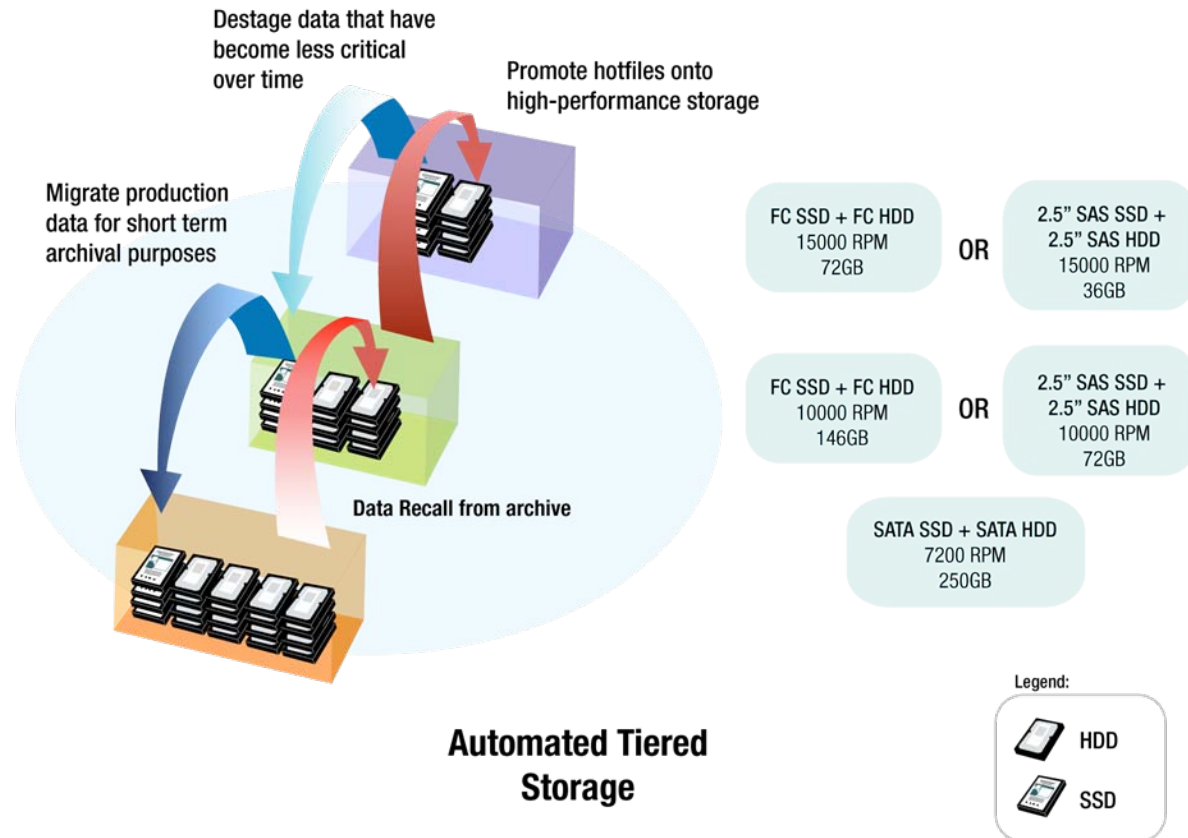
# Balancing Cost & Performance

## □ Tiered Storage Application #1 – Tier 0 Storage Subsystem



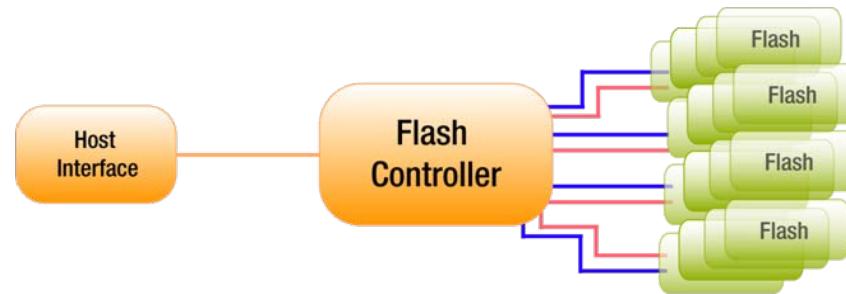
# Balancing Cost & Performance

## □ Tiered Storage Application #2 – Hybrid SSD and HDD Arrays



# Flash SSD Technology Trends

- ❑ Increased Parallelism of Flash Operations
  - ❑ Increase in number of flash buses



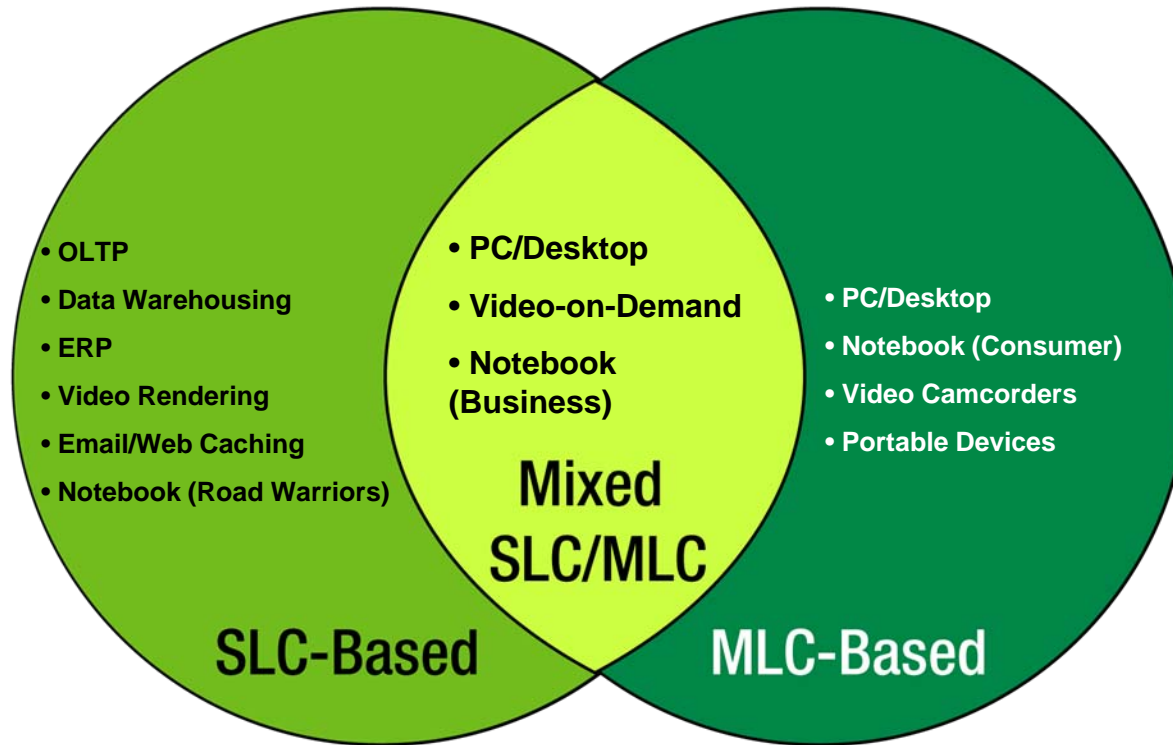
- ❑ Increase in parallel flash access
  - ❑ Multi-page writes
  - ❑ Multi-block erase
- ❑ Migration from SLC and mixed SLC-MLC SSDs to MLC
  - ❑ **Need to address reliability issues (next →)**

# Persistent Reliability concerns

- ❑ Dealing with Flash Block degradation:
  - ❑ Permanent vs. Recoverable NAND Flash Failures
  - ❑ Recoverable Failures
    - Program Disturb, Read Disturb, Over-Programming, Data Loss
  - ❑ Wear-Leveling techniques: Dynamic & Static
  - ❑ ECC: RS ECC vs. BCH, which is Best & Why?
    - Memory Scrubbing
    - SLC vs. MLC ECC: is increasing the ECC for MLC based SSDs to 20+ bits per block sufficient?

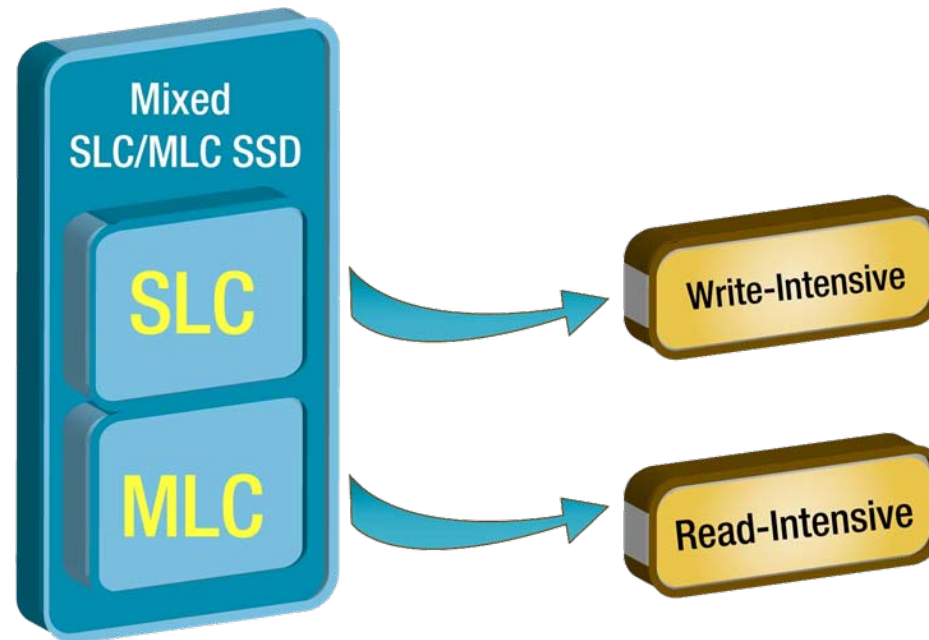
# Flash SSD Technology Trends

## □ Flash SSD variants

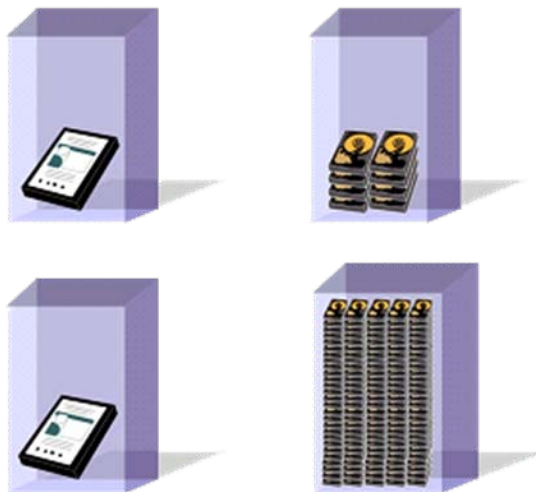
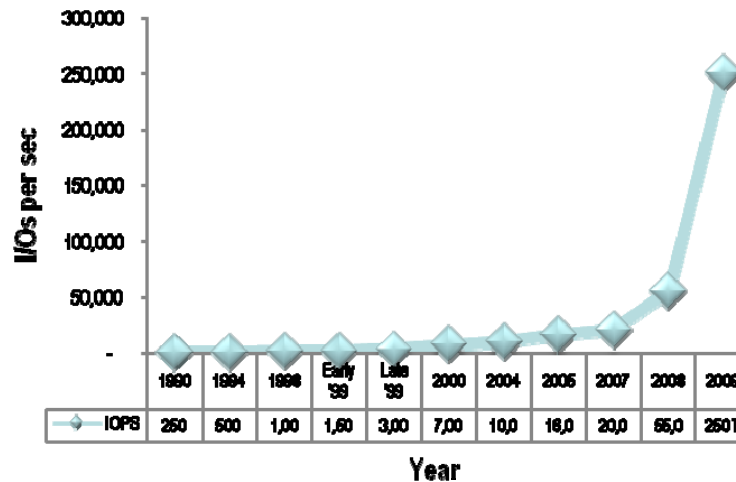
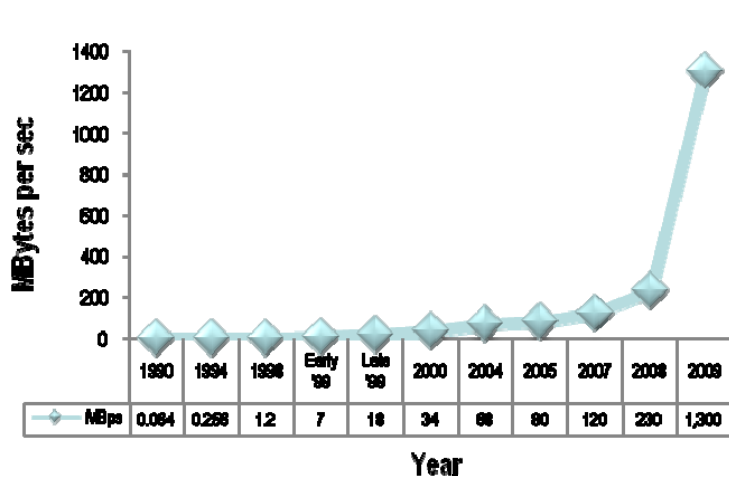


# Flash SSD Technology Trends

## □ Tiered NVM Architecture



# Flash SSD Performance Trends



## Year 2010

Max. **Sustained Transfer Rate** = 1.3 GB/s

**6-8x** HDDs' est. of 200 MB/s

Max. **Random IOPS** = 250,000

**500x** HDDs' est. of 500 IOPS



# Concluding Thoughts

- ❑ Flash SSDs have crossed over from military/industrial applications to enterprise computing mainly because of realized benefits in performance, availability, reliability and precipitous decline in price points
- ❑ Balance between cost and performance should still be considered when deploying Flash SSDs in enterprise computing to achieve lower TCO
- ❑ Leverage on enterprise storage implementations and data classification strategies
- ❑ There is a continuous effort by Flash SSD manufacturers to address cost and performance concerns in enterprise computing

# Thank You!

*“There is nothing so powerful  
as an idea whose time has come.”*  
– Victor Hugo