



Architectural Agility for Flash SSD

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Flash SSD Changes the Economics of Storage



Access Density

Service more customers
Flash SSD IOPS >20-40x
over best-in-class
Enterprise HDD

Areal Density

TeraBytes per CuFt
Flash SSDs packages
offer high volumetric
efficiency

Power Density

Watts per CuFt per TeraByte
Flash SSD <25% of
HDD power requirements

Service Life Reliability

Support per TeraByte
Optimize defect management
for Enterprise Service Life

Shift in Economics Driving Flash SSD Market



**Embedded
Market**

**Enterprise
Market**

**Performance
Durability
Special Features**

**\$20 - \$50 per GB
2006/2007**

Early Adopters In Enterprise Applications



Embedded Market

**Performance
Durability
Special Features**

Enterprise Market

**Access Density
Power Density**

**\$5 - \$10 per GB
2008/2009**

Flash SSD in “full depth rack” FF



Embedded Market

Enterprise Market

Performance
Durability
Special Features

Aerial Density
Access Density
Power Density

\$1 - \$5 per GB
2010/2011

One Size Doesn't Fit All

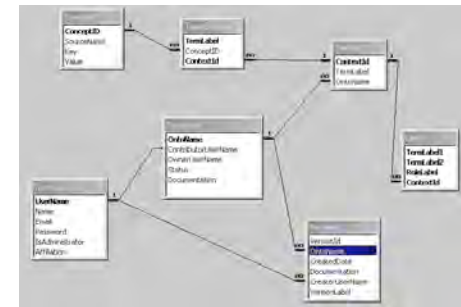


- Flash SSD architecture complexity tradeoffs
 - Random write performance measured by IOPS
 - Read data throughput of large block transfers
 - Service life achieved with lowest cost flash
 - Data integrity overhead of wear and error management
- Different applications have different requirements
 - Transaction Processing (high IOPS)
 - Streaming Data (high sustained performance)

Transaction Processing



- Operating characteristics
 - Small block size with fast access (high IOPS)
 - Data integrity demands multi-level EDC/ECC
 - 70% Read, 30% Write activity
 - 24x7 operation
- Flash SSD characteristics
 - Intelligent (small) block management
 - Optimized cache to overcome flash latency
 - High write endurance to meet service life
 - Additional embedded ECC to match Enterprise HDD



Streaming Data



- Operating characteristics

- Large record size with high read bandwidth
- 95% Read, 5% Write activity
- 24x7 operation

- Flash SSD characteristics

- Parallel memory arrays optimized for sustained read rates
- Low access time adequate with flash
- Service life achievable with SLC/MLC technology



Summary



- Enterprise market is shifting towards Flash SSD
- Flash SSD architecture either optimized for
 - Transaction Processing (high IOPS)
 - Streaming data (sustained throughput)
- Architecture will have trade offs between
 - Cost (cache size, controller complexity, S/W algorithm)
 - Service life (MLC/SLC)
 - Performance (IOPS/Sustained)
 - Reliability (EDC/ECC)
 - Additional features (SMART, encryption)