Design challenges in building an Advanced NAND Flash Array controller for 19/20 nm MLC

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# Evolution of NAND Flash

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<th>SSD</th>
<th>Card</th>
<th>Appliance</th>
<th>Primary</th>
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<td>HDD replacement</td>
<td>Server cache</td>
<td>High performance</td>
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<td>Plug and play</td>
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<td>Special uses</td>
<td>Scalable</td>
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<td>Encumbered by HDD protocols</td>
<td>Direct Attached Storage</td>
<td>Doesn’t scale</td>
<td>Affordable</td>
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<td>Expensive to manage</td>
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<td>Built from ground-up</td>
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Enterprise Adoption of Flash is Limited Because of High Cost

- High End: < .3% Enterprise Storage
- Mainstream Enterprise Storage
- Entry Level
The High Cost of Older Technology

- SLC: $30
- 24/25 nm MLC: $15
- 19/20 nm MLC: $2.99

Price / GB
Latest Generation Flash Breaks the Cost Barrier

- 19/20 nm MLC Flash breaks the cost barrier
  - Optimized for high density/low cost: < 60¢/GB

- But what about endurance?
  - Degrades rapidly with geometry
  - 19/20 nm MLC – few thousand writes

- Enterprise requires 100x more write endurance
100x Life Amplification of Latest Generation of Flash

- Minimize writes to the Flash
- New RAID algorithm
- New DSP/ECC
- Adaptive reads and writes
- Device physics manipulation
Optimize the Storage Stack

❖ **System**
  - Compression, de-duplication, encryption in hardware to minimize writes to the flash

❖ **RAID**
  - Must achieve better than RAID-6 reliability with much fewer writes to flash

❖ **Flash Controller**
  - Develop more sophisticated DSP and ECC algorithms

❖ **FTL**
  - Flash physics manipulation to optimize for system-wide wear-leveling
  - Adaptive reads and writes based on usage patterns
Proprietary algorithms extend MLC life to 5 years
- No existing flash memory controller can achieve this
- Life Amplification™ reduces damage to flash oxide layer

SSD Lifetime = \frac{\text{Endurance} \times \text{Capacity}}{\text{Throughput} \times \text{Duty Cycle} \times \text{Write\%} \times \text{Write Amplification}}

Skyera SSD Lifetime = \frac{3 \times 1 \text{TB} \times \text{(Life Amplification)}^1}{370 \text{MBps} \times 80\% \times 30\%} = 5 \text{ years}

ASIC investment in Flash Memory Controller

\(^1\) Life amplification is equivalent to 100x lower than industry standard 5x write amplification
Flash Memory Controller

- **Flash Translation Layer**
  - Wear Leveling
  - Block Manager

- **Power Management**
  - Crypto

- **Life Amplification Manager**
  - De-Dup
  - Compress
  - ECC DSP

- **PCIe**
  - Flash

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Flash Translation Layer

- Page-based flash translation layer
- Power fail protection
- Multi-processor concurrency
- Designed to support read retry
- Extremely low write amplification
- Native support for in-line de-dup and compression
Flash Memory Management

- Life Amplification Management
- Native support for snapshot & cloning
- 256-bit AES encryption
- Abstracted interface for advanced Flash operation
Questions...