Can Embedded Applications Utilize the Latest Flash Storage Technologies?

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Agenda

- Storage Tech Headlines!
- Embedded Applications Value set
- Flash Storage Technology Review
  a) Industry Standards
  b) Form-factors
  c) SSD Feature Set
  d) Media
- Back to the Question?
- Food For Thought…
Storage Tech Headlines!

Feb. - SanDisk Fusion ioMemory SSD announcement 3.2TB SSD - $17,870.00!!
Feb. - Shannon Systems Direct-IO 6.4TB Enterprise SSD – $ Call
Mar. - Intel 2.5” NVMe SSD 480GB - Random R/W 480K/170K IOPS
Mar. - Samsung Introduces World’s Largest SSD – 15.36TB!! (inc. free shipping!)
Mar. - Seagate & Micron Enterprise 12Gbps SAS SSD – 3.2TB, 10 DWPD
Mar. - Intel Announces New 3D NAND And Dual-Port NVMe SSDs – 2TB, 32 Layer 3D NAND
Mar. - Intel SATA 6Gbps, 1TB TLC SSD – 0.1 DWPD “Read Centric”
Apr. - Toshiba PCIe Gen 3 NVMe 1.0 2.5” Enterprise SSD - 4TB, Random R/W 660K/ 185K IOPS
Apr. - SK Hynix Enterprise M.2 SSD – 36 Layer 3D NAND, NVMe 1.2, 1.3 DWPD
May - Seagate Nytro XP6500 Enterprise SSD – Flash Accelerator - Random R/W 300K/100K IOPS
**SSD Market Review**

**Client & Enterprise:**
- C&E has and will always dominate the WW SSD market, CAGR >40% thru CY22
- CY14 Client dominated the C&E Revenue, but Enterprise SSD has a greater YoY growth share

**Embedded:**
- Embedded estimated to be a $2B WW market, assuming a CAGR of 20% = $11.5B CY22
- Smaller market, supported by a large array of technologies & solutions sets
- Trend is toward leveraging solutions driven by C&E market, less customization, a little more compromise, but....

Source: TMR Analysis (August 2015)
**Top 5 Storage Selection Criteria**

<table>
<thead>
<tr>
<th>Consumer/Client</th>
<th>Embedded</th>
<th>Enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Reliability</td>
<td>Performance</td>
</tr>
<tr>
<td>Cost</td>
<td>Endurance</td>
<td>Capacity</td>
</tr>
<tr>
<td>Cost</td>
<td>Lifecycle</td>
<td>Power</td>
</tr>
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<td>Cost</td>
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</tr>
<tr>
<td>Capacity</td>
<td>Power</td>
<td>Reliability</td>
</tr>
</tbody>
</table>

**Embedded Applications, typically (but not always) value**

- Reliability & Endurance over Performance
- Product Lifecycle over Leading Edge Technologies
- Quality/Service/Support (TCO) over Lowest “Initial” Cost
Embedded Application Value Set

**Applications**
- Industrial
  - Metering & Measurement
  - Automation
  - Medical
- Netcom
  - Gaming
- Automotive
  - Infotainment
- Defense
  - C2, C3, ...
  - ADAS/EDAS
- Comm’s
- Appliances

**Use Case**
- Boot
- OS Storage Applications
- Table Analytics
- Data Logging
- Vaulting

**Function**
- Read-only
- Mixed R/W
- Write Intensive
- Seq. vs Ran. IO
- Service Life

**Workload**
- Op. Temp
- Shock & Vib.
- ESD/EMI
- Power Budget
- Fault Tolerant
- Field Serviceable

**Environment**
- Lifecycle
- Cost/TCO
- Ind. Standard
- Reliability
- Form-Factor
- Performance

**Value Set**
- Endurance
- Supply Chain
- Environmental

Flash Memory Summit 2016
Santa Clara, CA
Flash Storage Technology Review

- Industry Standards (Interface)
- Form-factor (Module vs Embedded)
- SSD Feature Set (Controller)
- Media (NAND Flash)
Storage Interface Roadmap

Flash Memory Summit 2016
Santa Clara, CA

Original Source: Flash Memory Summit 2012
<table>
<thead>
<tr>
<th>Standard</th>
<th>Strengths &amp; Weaknesses</th>
<th>Embedded Adoption</th>
</tr>
</thead>
</table>
| **USB 3.0**  | + Interface is pervasive & mature  
- 8b/10b encoding                                                                        | ✔ ✔               |
| **eMMC 5.1** | + CMD Queue Depth: 32  
+ Reliable Write Mode  
- Performance Limited                                                                  | ✔ ✔               |
| **UFS 2.1**  | + Serial Attached SCSI  
- Many Chips sets lack dual port support                                                  | ? ✗               |
| **SATA 3.1** | + Interface is pervasive & mature  
- Power Consumption                                                                      | ✔ ✔               |
| **PCIe 3.0** | + Bi-directional R/W  
+ No Protocol Trans. Layer  
- Power Consumption                                                                     | ✔                 |

Flash Memory Summit 2016
Santa Clara, CA
### SSD Feature Set (Controller)

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Firmware</th>
<th>Software/Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECC BCH, LDPC</td>
<td>ABS</td>
<td>%OP</td>
</tr>
<tr>
<td>PFail</td>
<td>Throttling MB/s &amp; °C</td>
<td>LTM Tools</td>
</tr>
<tr>
<td>Security</td>
<td>GC Passive, Active, ??</td>
<td></td>
</tr>
<tr>
<td>FDE - AES</td>
<td>SLC Caching</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wear Leveling (Terase)</td>
<td></td>
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**Flash Memory Summit 2016**
Santa Clara, CA
Media (NAND Flash)

- 2D Planar (SLC, pSLC, MLC) – anticipate a decline in production and market tightening, as the semi’s focus their attention on the emerging 3D NAND market demand

- 3D MLC is here, expect good traction for higher capacity embedded (Infrastructure) drives, but only after it is a proven solution for the target use cases

- 3D TLC will likely remain in the C&E space, Embedded customers don’t need the capacity and will value the endurance over GB’s

- NVM technologies (e.g., PCM, STT-MRAM, etc.) are coming but still “years” from being a real challenger to displace NAND

“Micron, Samsung in Flash Battle”
EETimes, Feb. 2016
“Can Embedded Applications Utilize the Latest Flash Storage Technologies?”

• Yes! - Embedded Storage Applications have and will continue to benefit from the Latest Storage Technology developments driven by the Client & Enterprise market.

• Expect the NetCom market will actively leverage the PCIe transport and NVMe protocol benefits in next generation platforms (currently in development).

• Traditional Embedded Industrial applications are more likely to rely “Tried and True” (e.g., SD, eMMC, SATA, etc.) versus “Fast and Furious” (e.g., PCIe NVMe)
Food for Thought…

Given the Embedded Applications Value set…

*Is it possible that the majority of Embedded customers stay the course, picking up incremental C&E Storage Technology improvements (e.g., SSD Feature Set, NAND, etc.),*

…and hold out for the “Big Bang!” disruptive innovation of NVM working memory/storage (i.e., Shared Memory) solution sets in the CY20+ timeframe?
Thank You for Listening

Quality is not an act, it is a habit.

Aristotle, 352 BC