Host Memory Buffer (HMB) based SSD System

Forum J-31: PCIe/NVMe Storage

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Agenda

• Market Trends in Client SSD

• Introducing DRAMless architecture for SATA & PCIe

• Host Memory Buffer (HMB) scales up DRAMless PCIe SSD

• HMB DRAMless vs. DRAM-based SSD

• Ecosystem development
Market Trends

• Main drivers for SSD adoption have been:
  – Performance
    • PC Mark8 score from HDD to SSD: 1,200 to 4,800 points (SATA)
    • Latest PCIe Gen3x4 NVMe drives score over 5,100 points
  – Form Factor:
    • Ultrabooks require space to fit in battery
    • SSD can shrink to module size (M.2)

• BUT all came with a Premium to pay
Market Trends

- Now: cost parity of 128GB SSD and 500GB Mobile HDD
Developing DRAMless architecture

- 2015 SSD Architecture: Mainstream vs Entry-level

<table>
<thead>
<tr>
<th>128GB SSD</th>
<th>Mainstream</th>
<th>Entry Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAND CH</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>NAND speed</td>
<td>333MT/s</td>
<td>400MT/s</td>
</tr>
<tr>
<td>Capacity</td>
<td>64Gb MLC 16dies</td>
<td>128Gb TLC 8dies</td>
</tr>
<tr>
<td>Memory</td>
<td>16bit DRAM I/F</td>
<td>DRAMless</td>
</tr>
</tbody>
</table>
What I can get from a $30ish SSD?

- 20X HDD performance in full testing range
- Or 100X HDD IOPS in small 4GB or 8GB range
- And 1/20 space with M.2 2230 or even smaller with BGA
  - 1/10 in XY
  - 1/2 in Z-height
- And <2mW in Devslp mode
Enabling Host Memory Buffer

- Same BOM cost as Entry Level SATA drive!
- PCIe Gen3x1 NVMe SSD requests Host to allocate Memory space
  - In this case study: 128MB for the Look-up-Table
  - But it can claim any custom size of Host DRAM (partial LUT)
Performance benchmark 128GB TLC SSD

Sequential Read 512KB

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>MB/s</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATA (4CH DRAM based)</td>
<td>500</td>
<td>+28%</td>
</tr>
<tr>
<td>PCIe Gen3x1 NVMe HMB (2CH DRAMless)</td>
<td>600</td>
<td>+28%</td>
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<td>SATA (2CH DRAMless)</td>
<td>500</td>
<td>+28%</td>
</tr>
<tr>
<td>UFS (1CH DRAMless)</td>
<td>300</td>
<td>+188%</td>
</tr>
<tr>
<td>eMMC 5.1 (1CH DRAMless)</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

Test configuration: Chipset(Z97), Windows 8.1, Intel NVMe driver, CrystalDiskMark
Host Memory Buffer reduces latencies

Application to SSD IO Read Latency (QD=1, 4KB)

- SATA (DRAM based)
- PCIe Gen3x1 NVMe HMB (DRAMless)
- PCIe Gen3x1 NVMe (DRAMless)
- SATA (DRAMless)
- UFS
- eMMC 5.1

Latency (us) lower is better

- LUT access
- NAND Read
- NAND transfer
- Controller
- Link Xfer
- Platform+adapter
- Host SW

• Host Memory Buffer significantly reduces latencies:
  – Boosts IOPS with 50% over SATA and 100% over eMMC
Performance benchmark 128GB TLC SSD

Random Read 4KB / QD1

- SATA (4CH DRAM based)
- PCIe Gen3x1 NVMe HMB (2CH DRAMless)
- PCIe Gen3x1 NVMe (2CH DRAMless)
- SATA (2CH DRAMless)
- UFS (1CH DRAMless)
- eMMC 5.1 (1CH DRAMless)

IOPS

Test configuration: Chipset(Z97), Windows 8.1, Intel NVMe driver, CrystalDiskMark

13-Aug-15

Flash Memory Summit 2015
Performance benchmark 128GB TLC SSD

Random Read 4KB / QD32

- SATA (4CH DRAM based)
- PCIe Gen3x1 NVMe HMB (2CH DRAMless)
- PCIe Gen3x1 NVMe (2CH DRAMless)
- SATA (2CH DRAMless)
- UFS (1CH DRAMless)
- eMMC 5.1 (1CH DRAMless)

Test configuration: Chipset(Z97), Windows 8.1, Intel NVMe driver, CrystalDiskMark

Marvell
Client Workloads are light weight

- Review sites have developed trace based benchmarks
  - Capturing user behavior on Windows machine
  - Feeding commands to the SSD

- Example of queue depth distribution:
  - QD1-4 cover >90% of all cases
HMB Ecosystem development

• Operating system inbox driver & Bios support
  – Windows, Linux, Android, etc

• Chipset to support PCIe as storage interface
  – Coming in this year!

• Leading-edge SSD controller to support HMB
  – Marvell 88NV1140

• Deployment to PC OEMs
  – Configuration, integration and qualification

• Marvell is working in all areas to drive HMB
Summary

- A DRAMless SSD delivers good-enough performance and capacity for an entry-level client PC system
- Moving from SATA to PCIe Gen3 NVMe increases sequential read speeds and reduces latencies
- Enabling Host Memory Buffer boosts IOPS performance significantly
  - 50-100% compared to other DRAMless solutions
- Marvell’s 88NV1140 enables this without adding BOM cost
  - We are working with PC OEM to launch HMB soon
The Opportunity...

...is bigger than you’d expect:
- Tablets/Convertables become productivity devices
- eMMC performance doesn’t scale
- PCIe Gen3x1 is a strong alternative
- Advanced Marvell NVMe SSD controllers under development!

• The Future of NVMe is NOW!
- Marvell 88NV1140
- PCIe Gen3x1 NVMe 1.2 with Host Memory Buffer support

BGA SSD

$0.25 size

M.2230 SSD