PCle/NVMe in Mobile Devices

Better Storage Enables Better Mobile Devices

Elad Baram, Senior Director, Product Management for Client Platforms Solutions, SanDisk Corporation
Forward Looking Statements

During our meeting today, we may make forward-looking statements.

Any statement that refers to expectations, projections or other characterizations of future events or circumstances is a forward-looking statement, including those relating to market position, market growth, product sales, industry trends, supply chain, future memory technology, production capacity, production costs, technology transitions, construction schedules, production starts, and future products. This presentation contains information from third parties, which reflect their projections as of the date of issuance. Actual results may differ materially from those expressed in these forward-looking statements due to factors detailed under the caption “Risk Factors” and elsewhere in the documents we file from time to time with the SEC, including our annual and quarterly reports. We undertake no obligation to update these forward-looking statements, which speak only as of the date hereof or the date of issuance by a third party, as the case may be.
- Tablet or Laptop?
- ARM or x86?
- Windows / Android?
- Mobile?
Client Platforms Convergence

- Smart client device segments converging/blurring
- Mobile platforms are computing platforms
  - Content creation / productivity is the key differentiation today
- Computing platforms become truly mobile
Storage Solutions in Smart Client Devices
Current View

- e.MCP
- eMMC
- SATA
- PCIe/NVMe

- InAND 8GB e.MCP
- InAND 128GB e.MMC
- Flash Memory Summit

- Budget Smart Phone
- Entry Level Tablet
- Flagship Smart Phone
- Phablet
- Chrome Book
- Productivity Tablets
- 2-in-1’s
- Entry-Level PC
- HDD Replacement
- Mainstream PC
- High-End PC

Client-Grade Server & Workstation

5
Alternatives for Future Storage Solutions in Mobile

- Extend eMMC
  - HS400 → HS533 → HS667
- UFS
- PCIe/NVMe
PCle is The Future of Mobile Storage

- Key advantages of PCIe/NVMe
  - Bandwidth and scalability
  - Availability, compatibility
  - Lowest latency SW stack
  - Simplicity
  - Smart architecture & design
## Technical Comparison

<table>
<thead>
<tr>
<th>Item</th>
<th>eMMC</th>
<th>UFS 2.0</th>
<th>PCIe/NVMe</th>
<th>PCIe/NVMe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phy/link</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface</td>
<td>HS400→HS533</td>
<td>M-Phy Gear 3</td>
<td>Gen2</td>
<td>Gen3</td>
</tr>
<tr>
<td>Bus speed MB/s</td>
<td>400 → 533</td>
<td>583</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>PHY overhead</td>
<td>N/A</td>
<td>8/10</td>
<td>8/10</td>
<td>128/130</td>
</tr>
<tr>
<td>Pin Requirements</td>
<td>10</td>
<td>6 (per lane)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>HW</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Architecture</td>
<td>Master-Slave Host controller</td>
<td>Master-Slave Host controller</td>
<td>Smart device – Bus Master</td>
<td>Smart device – Bus Master</td>
</tr>
<tr>
<td>Host Memory Buffer</td>
<td>N/A</td>
<td>Complex (UMA)</td>
<td>Native</td>
<td>Native</td>
</tr>
<tr>
<td><strong>SW</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol Complexity</td>
<td>eMMC - simple</td>
<td>SCSI + UFS Complex</td>
<td>NVMe Simple</td>
<td>NVMe Simple</td>
</tr>
<tr>
<td>Overhead</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Queue architecture</td>
<td>Single queue</td>
<td>Single queue</td>
<td>Multi queue</td>
<td>Multi queue</td>
</tr>
</tbody>
</table>
- PCIe has the best scaling path for Mobile applications
  - 1GB/s in single lane
  - Growth up to 2GB/s
- PCIe used for connectivity today
- Storage - data transactions manage by AP & host controller
- No direct connection between sub systems and storage
- **Fastest** download/upload speeds
  - Efficient data transfer paths

- **Lowest** power architecture

- Minimize AP involvement in transactions
NVMe has Superior SW Stack

- **Low Latency**
  - Efficient driver stack
  - Short code paths

- **Supports parallelism in platform**
  - Mobile SoC are quad core today, and increasing
  - Increasing multitasking in Mobile

- **Simple stack**
  - Supportability
  - Easier development
Enabling NVMe on ARM/Linux

- NVMe is part of standard Linux Kernel
- NVIDIA TK1 reference Platform (ARM, PCIe port)
- NVMe SSD immediately enabled with open source driver

*SanDisk internal development system based on NVIDIA reference design*
- Define small package for Mobile
- NVMe: ROM based boot scheme
Storage Solutions in BGAs

DRAM-less PCIe/NVMe SSDs can be packaged in 11.5 x 13mm
Storage Solutions in Smart Client Devices

Future Vision

e.MCP
PCIe/NVMe

Flagship Smart Phone
Phablet
Chromebok

Productivity Tablets

2-in-1’s
Entry-Level PC
HDD Replacement
Mainstream PC

High-End PC
Client-Grade Server & Workstation

Budget Smart Phone
Entry Level Tablet

e.MMC
The best evolution for Mobile storage is PCIe/NVMe

- Leverage the investments in client compute platforms
- Consolidation of storage solutions
- NVMe superiority over SCSI
- PCIe scalability
- PCIe bus architecture
- PCIe exists in Mobile platform today

Impact beyond storage – better SoC design
Thank You

Questions? Please visit SanDisk Booth #207