NVM Express™ and PCI Express® for Mobile

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SanDisk
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NVMe™/PCIe® evolving for client/mobile

NVM Express V1.0/V1.1 (2011-2012)
- Data Center
- Workstation / Server

NVM Express V1.2 (2014)
- PC
- Tablet
- Smart Phone

NVM Express V1.3

<table>
<thead>
<tr>
<th>NVM Express</th>
<th>PCI Express</th>
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<tbody>
<tr>
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- No HBA
- ?
- ?
What more is needed in NVMe for mobile?

• Boot protocol for non-BIOS boot
  – Add Boot Partitions (BP) to store boot code
  – Read BP’s with MMIO-based mechanism
  – Write BPs with enhanced FW commands
  – Protect/Lock BP’s with RPMB

• Additional
  – Namespace Write Protect
    • General namespaces
    • Does not apply to boot partitions
Completing the pieces for NVMe/PCIe Mobile

NVM Express V1.0/V1.1
- Host memory buffer
- Replay Memory (RPMB)
- Enhanced Power Mgmt

NVM Express V1.2
- M.2
- BGA for compute
- L1.2 Sub-states

NVM Express V1.3
- Non-BIOS boot
- Namespace WP

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Data Center
Workstation / Server
PC
Tablet
Smart Phone
PCI Express and Power – Conventional Wisdom

• Conventional Wisdom
  – PCIe uses too much power for mobile
PCI Express and Power - Reality

• Reality - Today
  – PCIe already used in mobile for wireless solutions
  – PCIe topology is simple in mobile
    • Few endpoints
    • Short channels

• Reality - When PCIe storage in mobile
  – Devices will be targeted at Mobile performance, not Client/Enterprise

PCIe in handsets today; will target mobile performance when in storage
Status quo in mobile storage interfaces

- Storage managed by host controller
  - eMMC
  - UFS (M-PHY)
PCI Express and Power - Reality

Single lane link power estimates

<table>
<thead>
<tr>
<th>Item</th>
<th>PCIe Gen3</th>
<th>PCIe Gen2</th>
<th>M-PHY Gear3</th>
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<tbody>
<tr>
<td>Active Power* [mW]</td>
<td>60 (L0)</td>
<td>46 (L0)</td>
<td>58 (HS)</td>
</tr>
<tr>
<td>Standby Power* [mW]</td>
<td>0.11 (L1.2)</td>
<td>0.11 (L1.2)</td>
<td>0.2 (Hibern8)</td>
</tr>
<tr>
<td>Line Speed [Gbps]</td>
<td>8</td>
<td>5</td>
<td>5.83</td>
</tr>
<tr>
<td>PHY overhead</td>
<td>128/130 (1GB/s)</td>
<td>8/10 (500MB/s)</td>
<td>8/10 (583MB/s)</td>
</tr>
<tr>
<td>MB/mJ* (higher better)</td>
<td>14-18</td>
<td>8-12</td>
<td>8-12</td>
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- PCIe power on par with M-PHY power as mobile interface solution
Architectural Advantages for PCIe Storage in Mobile System

- Given good PCIe PHY power characteristics, there are other advantages
  - Remove Host Controller
  - Engineering synergy
  - Root complex
  - HW Power Management
Summary: What is needed for PCI Express for Mobile?

• **Not** needed
  – Electrical changes
    • Implement existing architecture well (L1.2 sub-states, etc.)

• **Needed**
  – Smaller form factors
    • We have already
      – M.2
      – PCIe BGA for client/compute
    • Work starting in PCI-SIG on smaller BGA for mobile
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Host memory buffer
Replay Memory (RPMB)
Enhanced Power Mgmt
Non-BIOS boot
Namespace WP
Mobile BGA

Data Center to Mobile
Call to Action – Mobile Ecosystem

- Get involved w/ NVM Express and PCI-SIG®
- Consider NVMe/PCIe for your mobile solutions
- SoC vendors allocate PCIe ports for storage

Invest in the future of the storage ecosystem
Thank You