Thunderbolt™ 3 Brings External NVMe Storage to Client Computers

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Agenda

- Thunderbolt Overview
- Broad Market Adoption
- Thunderbolt storage benefits for key segments
- Wrap Up
COMPACT THUNDERBOLT™ 3 SSD STORAGE AS FAST AS INTERNAL SSDs

https://www.youtube.com/watch?v=nNjgzS6vlpQ
What is USB-C?

**USB-C is a connector and cable**
- Small and flippable
- USB 2.0 data (only requirement)
- Video, charging, alternate modes (optional)

More than 10 configurations available
5 examples shown below

<table>
<thead>
<tr>
<th>Configuration</th>
<th>USB 2.0</th>
<th>USB 3.0</th>
<th>USB 3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP over USB-C</td>
<td>480 Mb/s</td>
<td>5 Gb/s</td>
<td>10 Gb/s</td>
</tr>
<tr>
<td>x4 lanes DP + USB 2.0</td>
<td></td>
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<tr>
<td>DP Multi-Function</td>
<td></td>
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<tr>
<td>x2 lanes DP + USB 3.1</td>
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</tbody>
</table>

What is Thunderbolt 3?

**TBT3 supports all USB-C configurations**
- 40Gb/s (supports DP, USB, and PCIe)
- 2 video streams, up to x8 lanes DP 1.2
- USB 3.1 (10Gb/s), up to PCIe Gen 3 x4
- Supports Native USB and DisplayPort

**Universal** for PC/Mac, cables, devices
The USB-C that does it all

Does it All

- One Port
- One Cable
- One Brand
How **Thunderbolt Protocol** Works

DisplayPort and PCIe are **tunneled** over a **40Gb/s bi-directional** Link.

**PCI Express** and **DisplayPort** transported between Thunderbolt™ controllers over a **Thunderbolt cable**.

Thunderbolt 3 controllers have integrated **USB 3.1 (10Gb/s) XHCI host controller** to support USB - not a device side controller.
Envision a World with Thunderbolt™ 3 Everywhere

“Intel plans to drive large-scale mainstream adoption of Thunderbolt by integrating Thunderbolt 3 into future Intel CPUs, and by releasing the Thunderbolt Protocol specification to the industry next year”

Thunderbolt 3 Windows OS support
- Windows inbox driver support
- RS3 Native, RTD3 & UCSI support
- Native OS security
Integration expected to push Thunderbolt™ 3 computer volumes into the hundreds of millions over the next 2-3 years.
Thunderbolt™ 3 Ecosystem Snapshot

Certified Thunderbolt™ 3 Devices

- Adapters (81)
- Networking (15)
- Display (7)
- AV / Other (17)
- Docks (79)
- PCI Expansion (30)
- Card Reader, Hub (4)
- Storage (110)
- eGfx (32)
Thunderbolt 3 vs. USB 3.1 Portable NVMe SSD

Thunderbolt 3 offers 3-6x more performance for small cost adder.

We expect the cost of PCIe NVMe based SSDs to become comparable with SATA SSDs in future.

Standard 15W of bus power for larger capacity drives.
Thunderbolt™ 3 Storage Benefits for Key Segments

<table>
<thead>
<tr>
<th>Segment</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td>Speed: Speed up to 2,850MB/s (PCIe Gen 3x4)</td>
</tr>
<tr>
<td>Media</td>
<td>Capacity: Standard 15W of bus power for larger capacity drives</td>
</tr>
<tr>
<td></td>
<td>Thunderbolt SSDs offer real-time extension to capacity limited PC</td>
</tr>
<tr>
<td>Gaming</td>
<td>Compatibility: Hundreds of millions of Thunderbolt™ 3 PCs in the next 2-3 years</td>
</tr>
<tr>
<td></td>
<td>Pro level quality - due to required host, device, and cable cert</td>
</tr>
<tr>
<td>On the Go</td>
<td>Cost: USB PD controllers and 40Gb/s cable costs continue to drop</td>
</tr>
<tr>
<td></td>
<td>Small cost adder when compared to the SSD cost</td>
</tr>
</tbody>
</table>

Based on Intel Internal Projections
Thunderbolt™ 3 to 10GbE adapter ~$100 may accelerate 10GbE transition

Mainstream 10GbE for thin-and-light laptops can drive client and data center refresh for faster SSDs
Media Creation

Portable, desktop, compact flash, and NAS storage innovation is happening on Thunderbolt™ 3 and PCIe

Manage large photo library created by widely available 4K phone cameras

Quickly ingest and edit multi-stream uncompressed HD and 4K video
Gaming

Keep entire gaming library on Thunderbolt™ 3 external SSD

Expand capacity of PC or Mac with Thunderbolt 3 external SSD, while maintaining the same performance as an internal SSD.

Record game play in 4K then post to Twitch or YouTube
On the Go

Offer lower bin SSDs focused at mainstream segment, offering 3x SATA performance (1,500MB/s)

Drive brand awareness for your SSDs in mainstream channels

Convenient small form factor
Next Steps

- Become a Thunderbolt developer
  - Contact Shailendra Sinha at Intel shailendra.sinha@intel.com

- Work with existing Thunderbolt 3 ODM to improve time to market
  https://thunderbolttechnology.net/tech/odms

- Collaborate with industry on optimal M.2 configurations
  - Performance up to PCIe Gen 3 x 4 and Bus Power up to 15W
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