



Thunderbolt™ Technology

Brett Branch
Thunderbolt Platform
Enabling Manager



Agenda

- Technology Recap
 - Protocol Overview
 - Connector and Cable Overview
- System Overview
 - Technology Block Overview
 - Silicon Block Overview
 - Device Block Overview
- Industry Status
 - PCs
 - Cables
 - Devices

Thunderbolt™ Technology Overview

Transformational high-speed, dual-protocol, PC I/O delivering **performance, simplicity, and flexibility**

Leading Performance in PC I/O

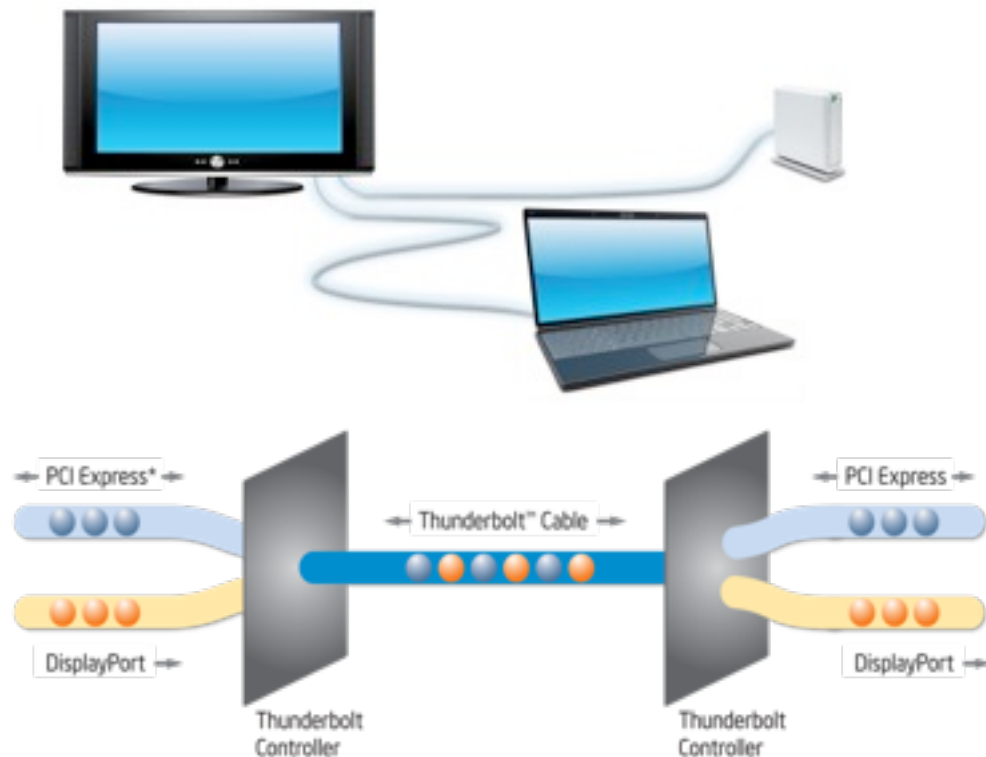
- Faster speed and multi-tasking with bidirectional, dual-channel, 10 Gbps per channel

Simple

- Connect to more devices with data and display on ONE cable

Flexible

- Add more devices simply with daisy chaining
- Enables PCIe expansion outside of the PC chassis



Fastest Connection to Your PC Experience[†]

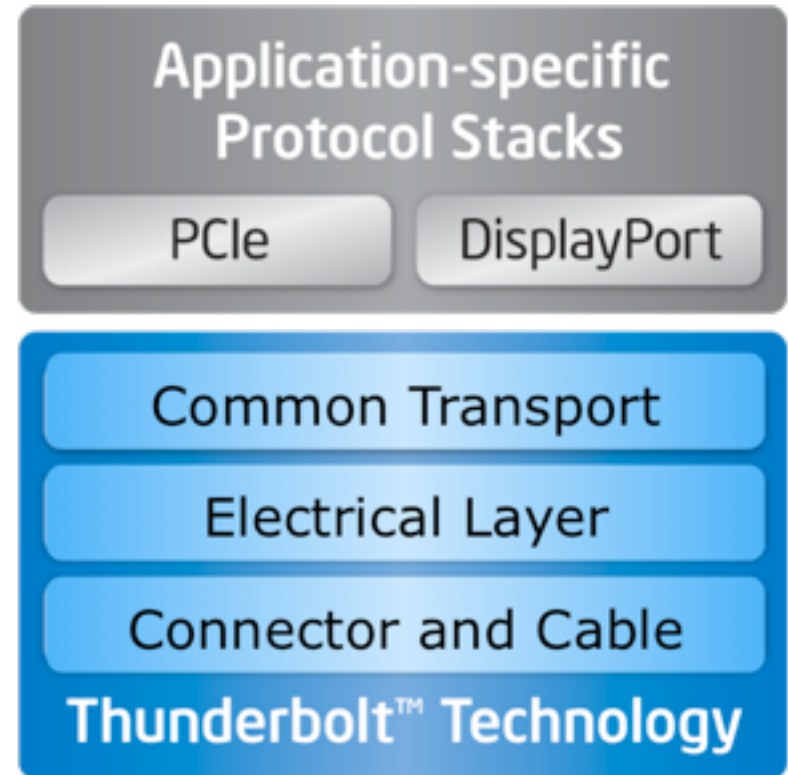
vary depending on the specific hardware and software used. For more information go to <http://www.intel.com/technology/io/thunderbolt/index.htm>



*Other names and brands may be claimed as the property of

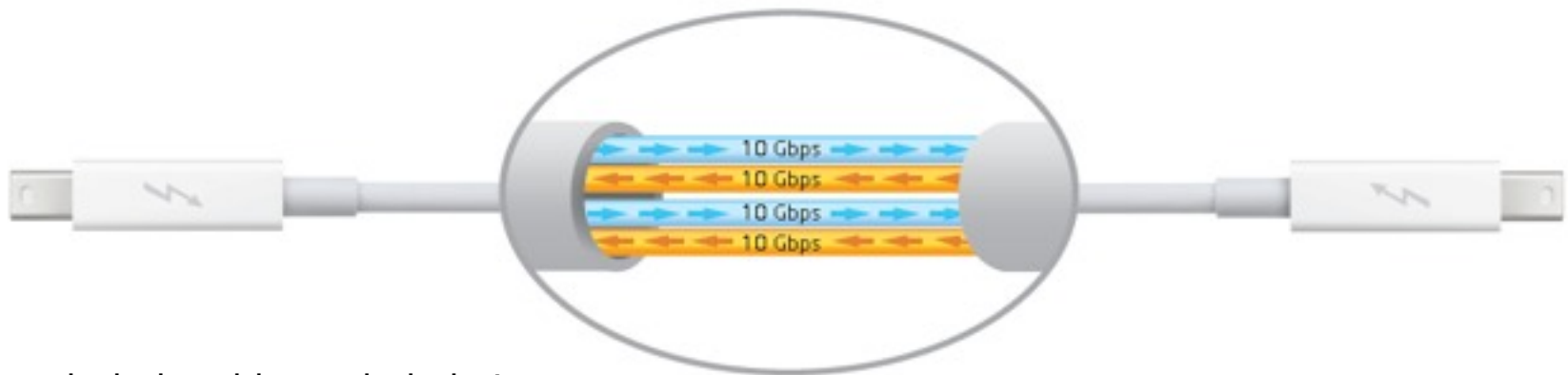
Protocol Overview

- Transparent Tunneling of PCI Express* / DisplayPort*
- Common electrical interface
- Common Thunderbolt™ transport
- Connection managed by silicon / firmware



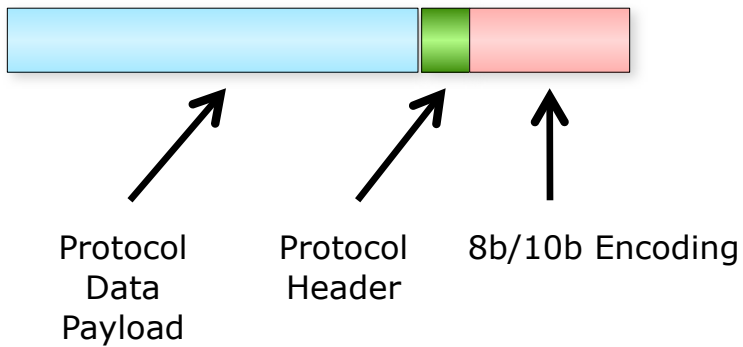
Thunderbolt™ Connector and

- 2x channels per cable – 10Gbps bidirectional per channel
- Active cables (circuitry in cable ends) enables cable length of up to 3m
 - Connection setup logic
 - Power logic
 - Clock/Data recovery circuitry
- Thunderbolt™ receptacle compatible with Mini DP (but is a new part)
- Silicon detects if native DisplayPort* or Thunderbolt when plugged in



Thunderbolt cable exploded view of dual channel data streams

Thunderbolt™ Protocol Tunneling



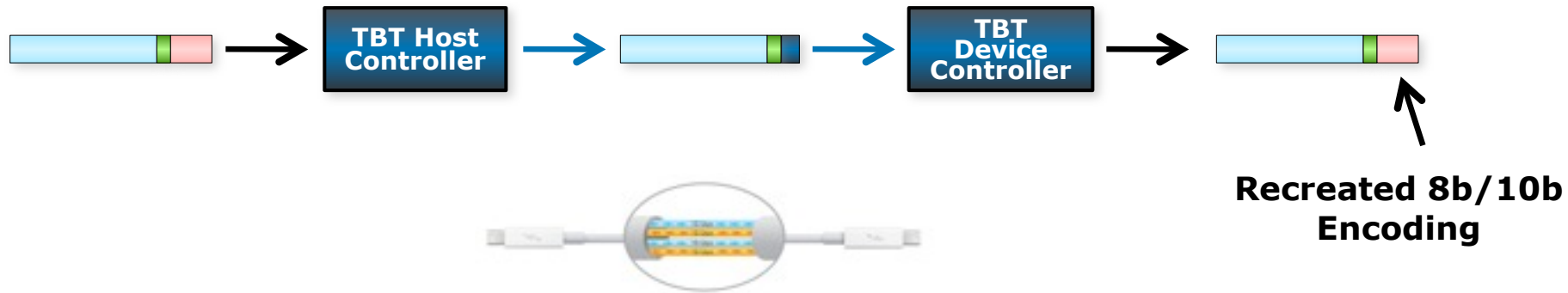
Thunderbolt™ Protocol Tunneling

Mapping a protocol to the Thunderbolt transport:



Flash Memory Summit Thunderbolt™ Protocol Tunneling

End-to-End

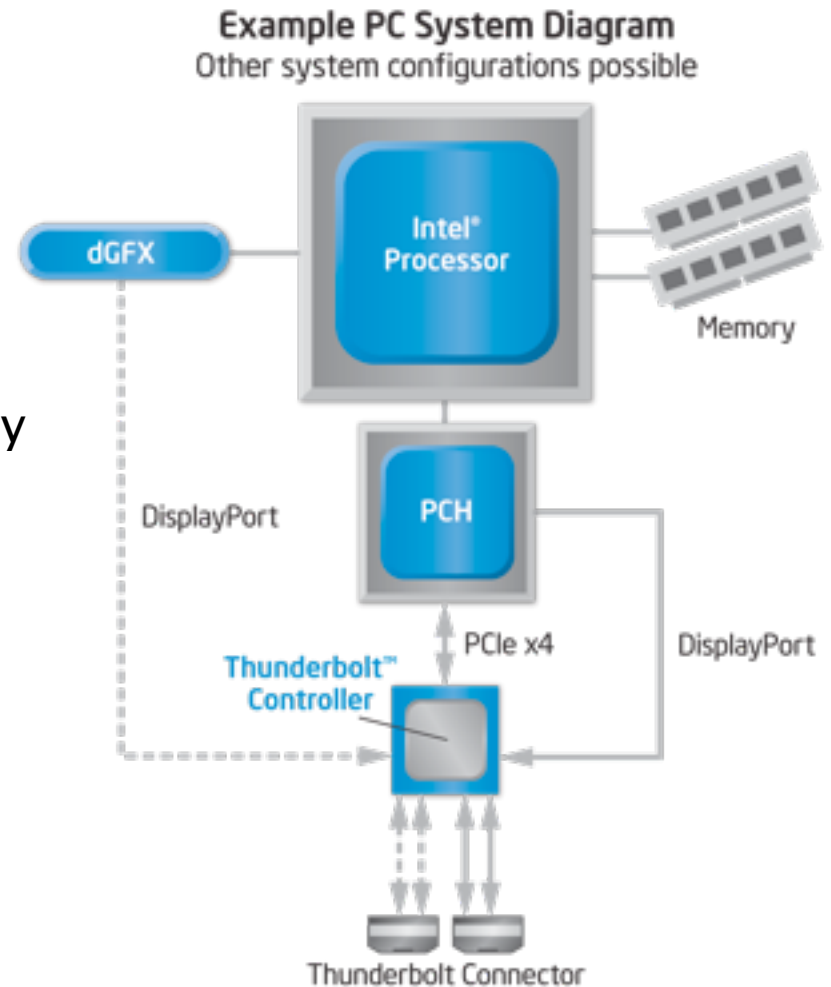


Underlying Protocol(s) | Thunderbolt Protocol | Underlying Protocol(s)

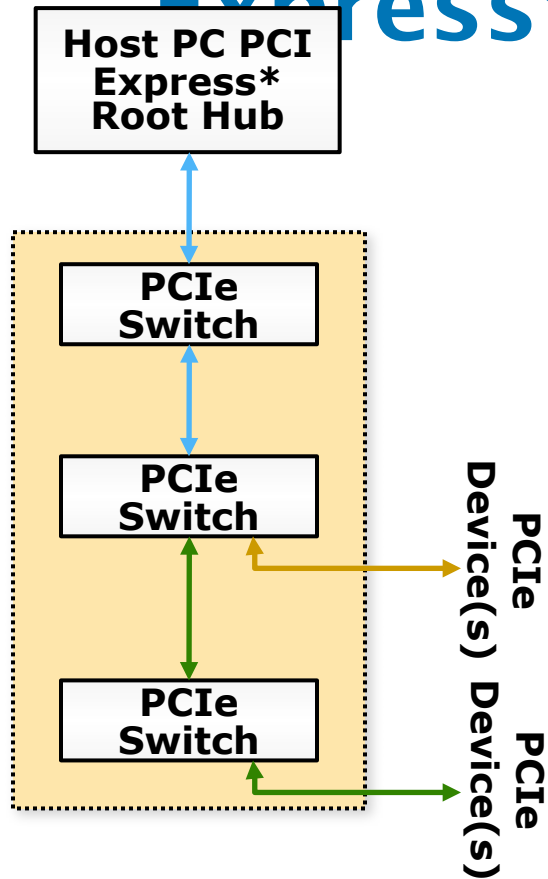
- Underlying protocol untouched, 8b/10b encoding removed
- Thunderbolt™ header used for path routing
 - 10.3125Gbps signaling @ 66/64: 10Gbps of real data throughput
- Underlying electrical encoding replaced at endpoint

Technology Architecture

- 10Gbps per channel, bidirectional performance
- PCI Express* and DisplayPort* protocols
- Thunderbolt™ ports compatible with standard DisplayPort
- Small connector with 12W power delivery
 - Devices can be bus or self A/C powered, 8.5 watts bus power available to power device
 - Bus powered devices can only be plugged into self A/C powered devices, or directly to host
- Daisy chain topologies



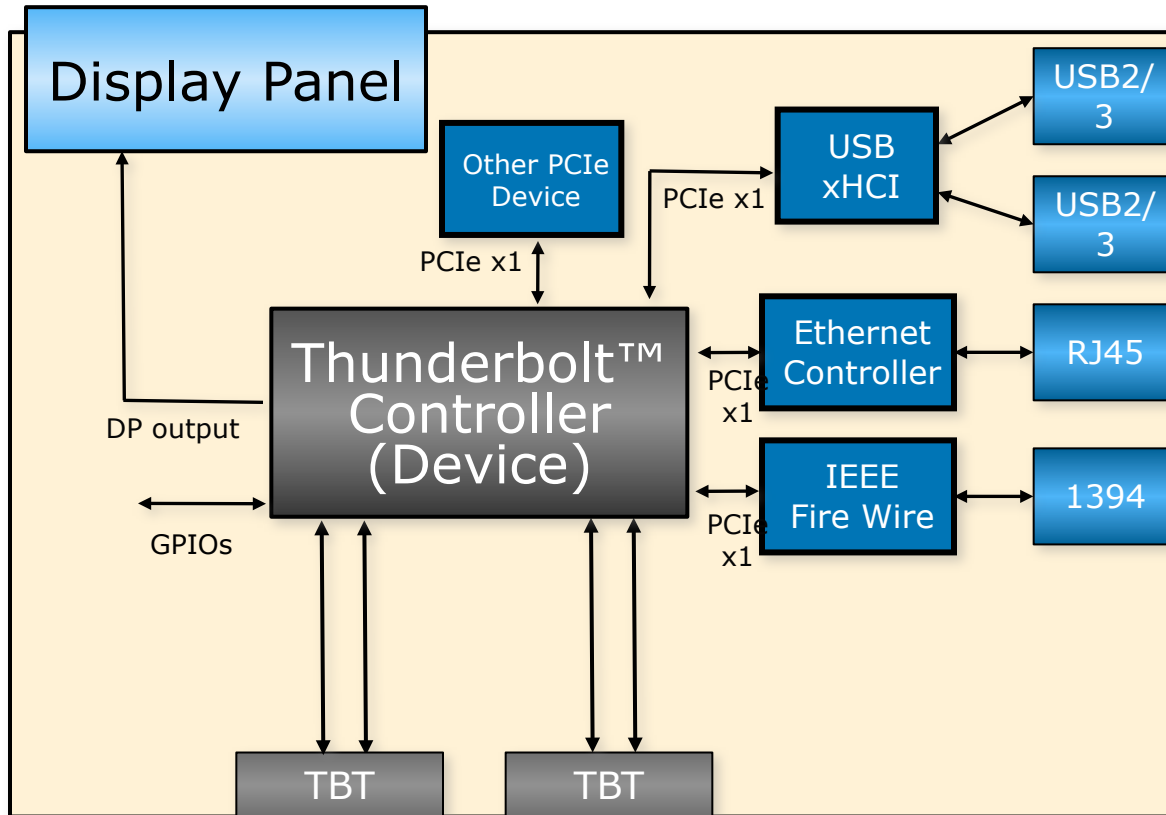
What the OS Sees – PCI Express*



Thunderbolt™
Domain

Example Thunderbolt™

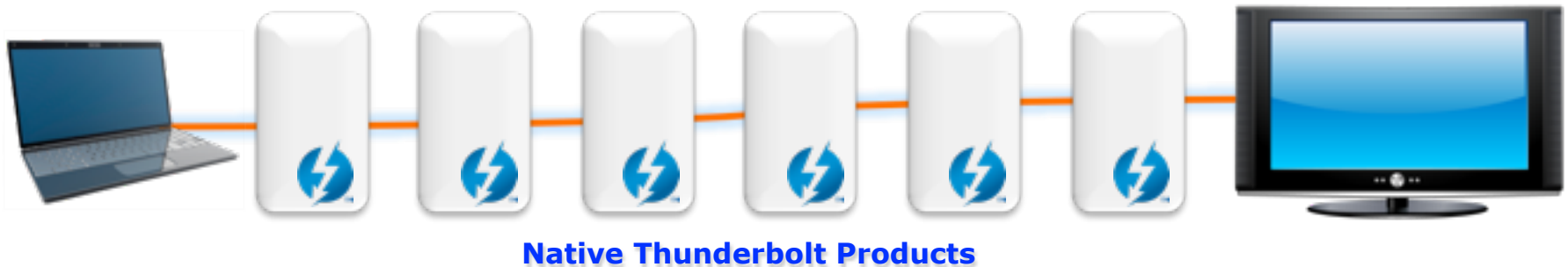
A single connection for DisplayPort*, and PCI Express*



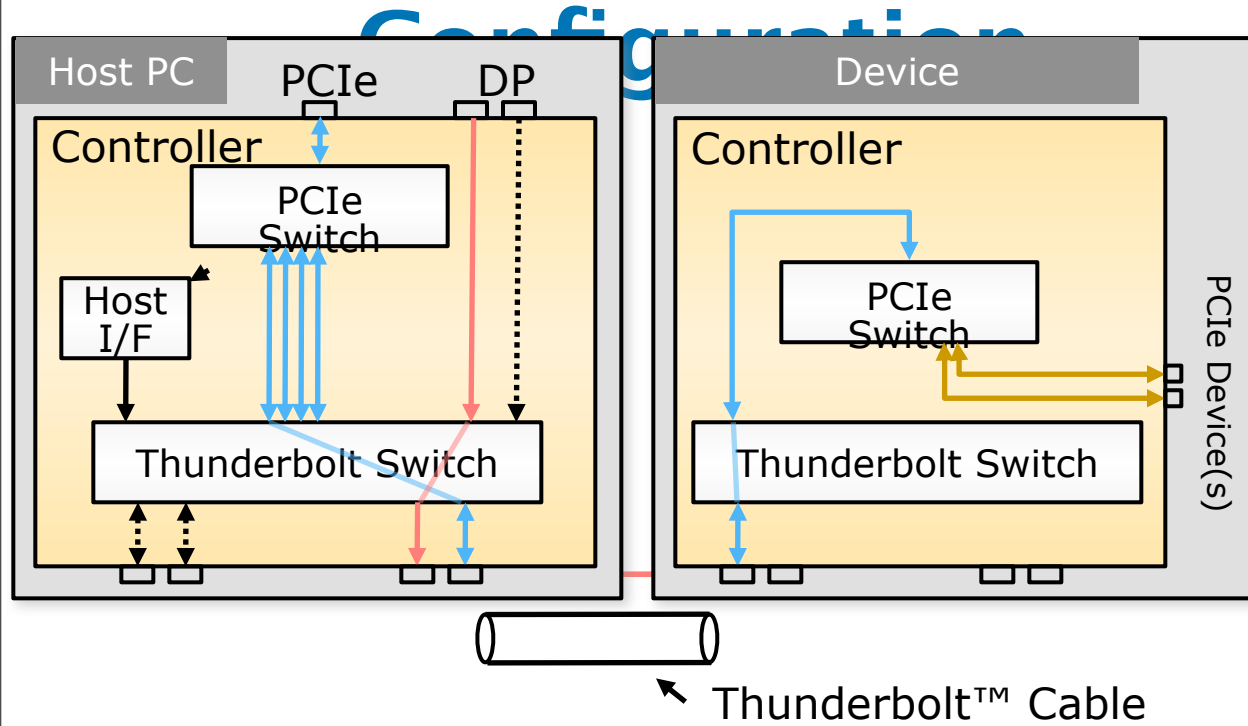
Daisy Chaining and Native

Multiple Thunderbolt™ devices can be connected to a single Thunderbolt connector on a PC

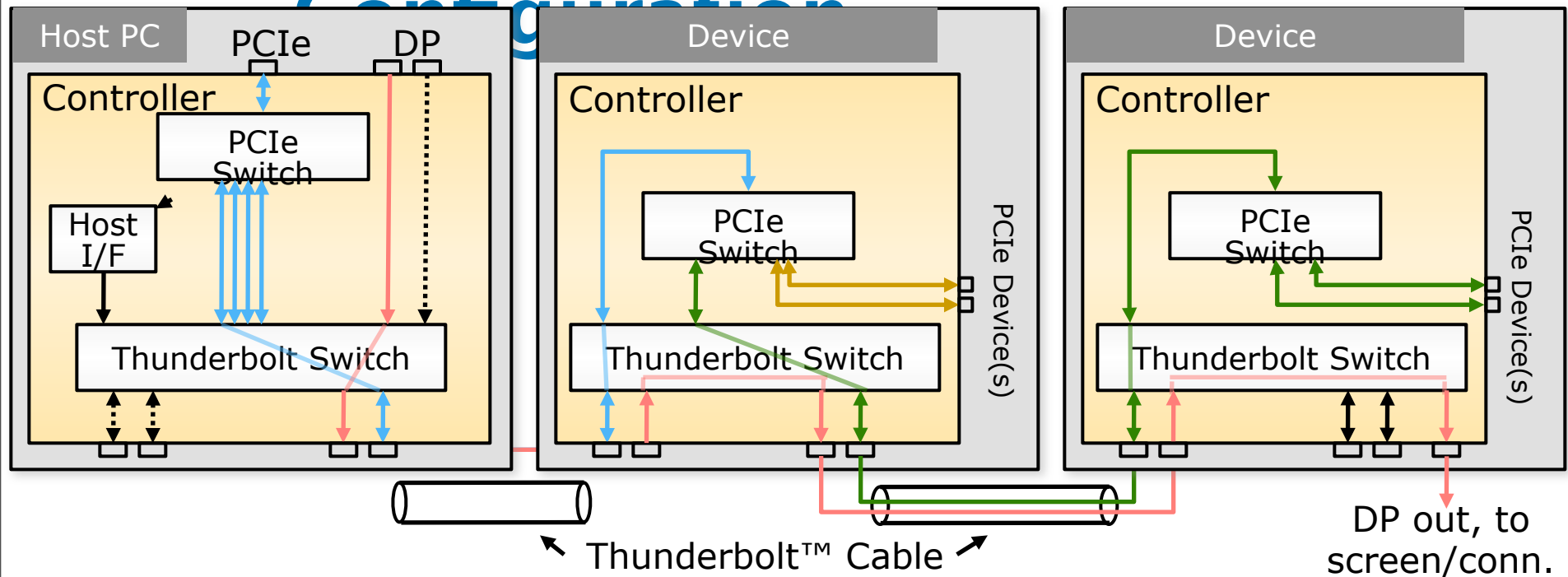
- A native DisplayPort*(DP++) display can be connected at the end of the daisy chain¹
- Downstream TBT ports behave as a PC extension
- Daisy-chained device ports support either Thunderbolt or DisplayPort



Example Daisy Chain Configuration



Example Daisy Chain Configuration



- PCI Express* devices behind Thunderbolt™ controllers appear logically as behind PCIe switches
- Displayport* connection across Thunderbolt is transparent to the system and is treated as a replacement for a DP cable
- Drivers require little modification to account for hot plug/unplug events
- Host I/F is used by HW to implement connection management

PC Industry Support

PCs



Acer Aspire S5 Apple iMac Apple MacBook Air Apple MacBook Pro



Apple Mac Mini Asus G55 Asus G75 Gigabyte U2442P



Lenovo Thinkpad S430 Lenovo Thinkpad T430 MSI AIO



Motherboards



ASUS P8Z77-V Premium Thunderbolt ASUS P8Z77-V PRO Thunderbolt Gigabyte GA-Z77MX-D3H Gigabyte Z77X-UP4



Gigabyte Z77X-UP5 TH Intel DZ77-RE-75K MSI Z77A-GD80 Intel NUC

ODMs



Available Devices



Apple Thunderbolt Display

Western Digital MyBook Thunderbolt Duo



Elgato Thunderbolt SSD



Promise Pegasus R6 6TB RAID System

Promise Pegasus R4 4TB RAID System



LaCie Little Big Disk Thunderbolt Series



Blackmagic UltraStudio 3D



LaCie 2big Thunderbolt Series

AJA Io XT



G-Tech G-RAID with Thunderbolt

\$299 and below



Seagate GoFlex Desk Thunderbolt Adapter

Seagate GoFlex Thunderbolt™ Adapter



Blackmagic Intensity Extreme



Blackmagic Intensity Shuttle



LaCie eSATA Hub



Sonnet ExpressCard 34 Thunderbolt™ Adapter



Matrox MXO2 Thunderbolt™ Adapter

Broad Device Industry Support



Thunderbolt Cables

- **Thunderbolt cable manufacturers**

- Cables available in various lengths / colors
 - .1m to 3m for electrical cables
 - 10m to 20m for optical cables (Q4'12)



- **Retail cables**

- Available now
- Various brands
- Multiple distribution outlets



- **Lower priced cables coming in Q4'12...**

“...Lintes is pleased to announce new lower cost Thunderbolt cables...based on next generation components, these new cables will enable lower cable prices to the industry...”

“By driving to lower cost Thunderbolt cable solutions, Sumitomo is actively working with Thunderbolt device vendors to get cables included in the box.”

*Other names and brands may be claimed as the property of others.



Thunderbolt™ Technology Enabling

- Register with the Thunderbolt Technology Community at <https://thunderbolttechnology.net/> to get more Thunderbolt™ product, plugfest, developer lab information
- Sign Thunderbolt™ Technology and trademark licenses

Summary

- Transformational high speed, dual-protocol, PC I/O delivering performance, simplicity and flexibility
- New connector which is compatible with DisplayPort*
- Transparent protocol mapping
- Support for daisy chaining

Q&A



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