

## THUNDERBOLT - LIGHT PEAK

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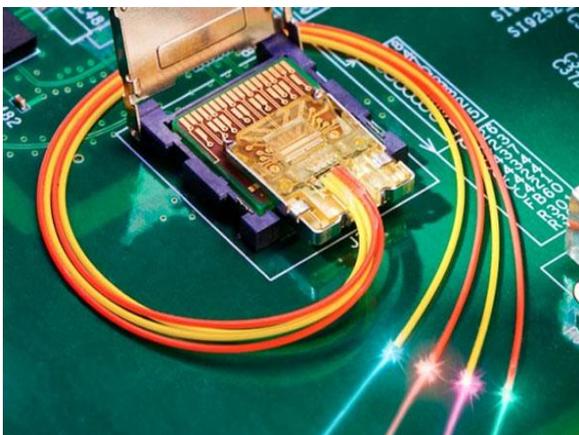
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### Abstract

**Thunderbolt** (originally under the code name **Light Peak**) is an interface for connecting peripheral devices to a computer via an expansion bus. Thunderbolt technology is a new, high-speed, dual-protocol I/O technology designed for performance, simplicity, and flexibility. Thunderbolt essentially combines PCI Express and Display Port into a new serial data interface that can be carried over longer and less costly cables. Thunderbolt driver chips fold the data from these two sources together, and split them back apart again for consumption within the devices. The interface was originally designed to use flexible optical fiber cables, but a version using conventional copper wiring was also developed to furnish the desired 10 Gb/s bandwidth at lower cost.

Developed by Intel and brought to market with technical collaboration from Apple in late February 2011 by introducing its new line of MacBook Pro laptop computers and announced the technology's commercial name would be Thunderbolt, with these machines being the first to feature the new I/O technology.



### Introduction

Intel introduced Light Peak at the 2009 Intel Developer Forum (IDF), using a prototype Mac Pro motherboard to run two 1080p video streams plus LAN and storage devices over a single 30-meter optical cable with modified USB ends. The system was driven by a prototype PCI Express card, with two optical buses powering four ports. At the show, Intel claimed that Light Peak-equipped systems would begin to appear in 2010.

On 4 May 2010, in Brussels, Intel demonstrated a laptop with a Light Peak connector, indicating that the technology had shrunk to small enough to fit inside such a device, and had the laptop send two simultaneous HD video streams down the connection, indicating that at least some fraction of the software/firmware stacks and protocols were functional. At the same demonstration, Intel officials said they expected hardware manufacturing to begin around the end of 2010.

In September 2010, some early commercial prototypes from manufacturers were demonstrated at Intel Developer Forum 2010.

### Description

Thunderbolt is based on the Mini Display Port connector developed by Apple. This is electrically identical to "normal" DisplayPort connectors, but uses a smaller connector that is more suitable for use on laptops and other consumer devices. It is expected that Thunderbolt's use of this connector will drive wider acceptance.

Because the PCI bus does not carry video data, it is unclear whether a standalone PCI card could offer a Thunderbolt port. The Intel

Thunderbolt Technology Brief does not give a conclusive answer.

Thunderbolt can be implemented on graphics cards, which have access to DisplayPort data and PCI express connectivity, or on the motherboard of new devices, such as the MacBook Pro.

Thunderbolt controllers on the host and peripherals fold the PCI and DisplayPort data together and unfold them after they exit the cable. Thunderbolt is bi-directional, which often requires sophisticated reflection and cross-talk suppression techniques, such as used in 10GB Ethernet.

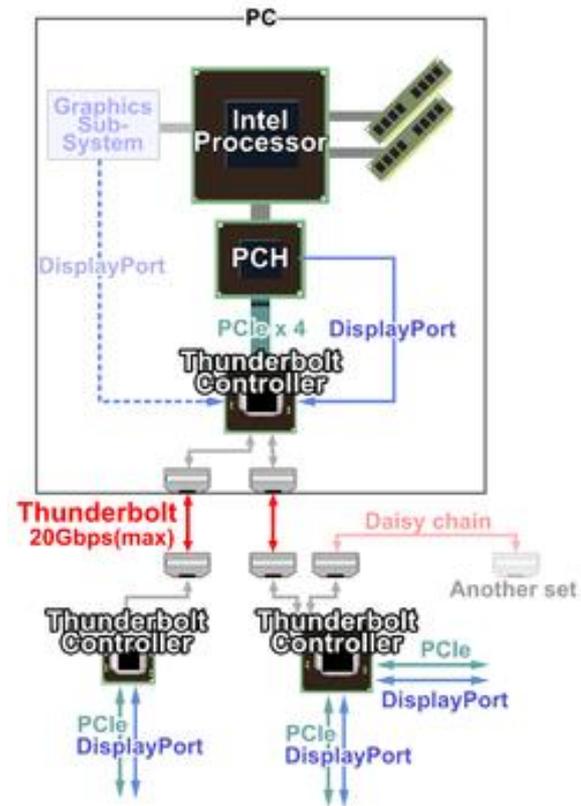
### Advantages over Copper vs. optical

Originally conceived as an optical technology, Thunderbolt switched to electrical connections to reduce costs and to supply power.

In 2009, Intel officials said the company was "working on bundling the optical fibre with copper wire so Light Peak can be used to power devices plugged into the PC". In 2010, Intel said the original intent was "to have one single connector technology" that would allow "electrical USB 3.0 [...] and piggyback on USB 3.0 or 4.0 DC power.

Initial Thunderbolt implementations would be based on copper wires. Intel and industry partners are still developing optical Thunderbolt hardware and cables. The optical fiber cables are to run "tens of meters" but will not supply power, at least not initially.

They are to have two 62.5-micron-wide fibers to transport an infrared signal up to 100 metres (330 ft). The conversion of electrical signal to optical will be embedded into the cable itself, allowing the current display port socket to be future compatible, but eventually Intel hopes for a purely optical transceiver assembly embedded in the PC.



### Performance

At 10 Gbps, Thunderbolt technology gives you great responsiveness with high-speed data and display transfers in each direction—at the same time. With a single cable, connecting a PC to multiple devices is simple, making it easy to get and see what you want, when you want it. Thunderbolt technology gives you incredible flexibility; high performance expansion is just a cable away for new and novel uses, now and in the future.

With the 10 Gbps performance of Thunderbolt products you can:

- Transfer a full-length HD movie in less than 30 seconds.
- Backup 1 year of continuous MP3 playback in just over 10 minutes.

### What is Thunderbolt technology and how does it work?

Developed by Intel (under the code name **Light Peak**), and brought to market with technical collaboration from Apple.

Thunderbolt technology has following characteristics:



- Dual-channel 10 Gbps per port.
- Bi-directional.
- Dual-protocol (PCI Express\* and Display Port\*).
- Compatible with existing Display Port devices.
- Daisy-chained devices.
- Electrical or optical cables.
- Low latency with highly accurate time synchronization.
- Uses native protocol software drivers.
- Power over cable for bus-powered devices.

## Conclusions

- Thunderbolt technology enables using the thinnest and lightest laptops and connecting to the extra power and performance of other devices when needed, using a single cable.
- Several innovative companies have announced Thunderbolt enabled products, or plans to support Thunderbolt in upcoming products including Apple Inc.
- Data transfers for backup, sharing, and editing are tremendously accelerated using Thunderbolt products, significantly reducing times to complete these tasks.
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- The advantage is that the Thunderbolt Light Peak Connector would have support for high-speed data transmission, even faster than the USB3 technology.
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## References

- [1] Intel Corporation, "Light Peak Technology," <http://www.intel.com/go/lightpeak/index.htm>.
- [2] Intel Corporation, "Silicon Photonics Technology", <http://www.intel.com/go/sp/>.
- [3] T. Blackwell, K. Chang, H.T. Kung and D. Lin, "Credit-Based Flow Control for ATM Networks", IEEE Network, 1995.
- [4] L. M. Ni and P.K. McKinley, "A Survey of Wormhole Routing Techniques in Direct Networks," IEEE Computer, 1993.
- [5] Microsoft Corporation, "NDIS Miniport Drivers," <http://msdn.microsoft.com/enus/library/ff565949%28VS.85%29.aspx>.
- [6] M. Heydemann, "Cayley Graphs and Interconnection Networks," in Graph Symmetry: Algebraic Methods and Applications, pp. 167-224, 1997.
- [7] M. D. Wagh and O. Guzide, "Mapping Cycles and Trees on Wraparound Butterfly Graphs," SIAM Journal on Computing, Volume 35, Issue 3, pp. 741-765, 2005.
- [8] J. Hamilton, "An Architecture for Modular Datacenters," 3rd Biennial Conference on Innovative Data Systems Research (CIDR), 2007.