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Basic overview of Thunderbolt Port (Interface)

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Abstract: Personal computers can be connected to peripheral devices using ports. Each port has an address of itself that is specific to it and is only accessed when called by the CPU. Different types of ports have different data carrying capacities. The fastest port available on present day PCs is the thunderbolt port. This review paper is dedicated to the understanding of the history, structure, uses and other aspects of the thunderbolt interface. The working and compatibilities have been thoroughly discussed.

Keywords: PCI e , DMI, SCSI, PCH, Thunderbolt, Intel.

I. Introduction

Thunderbolt was developed by Intel. It was Commercially introduced on Apple's 2011 MacBook Pro, using the same Apple-developed Connector as Mini Display Port, which is Electrically identical to Display Port, but uses a smaller, non-locking connector [1]. Though the Thunderbolt trademark was registered by Apple, full rights belong to Intel which subsequently led to the transfer of the registration from Apple to Intel. Thunderbolt controllers multiplex one or more individual data lanes from connected PCIe and Display Port devices for transmission via one duplex Thunderbolt lane, then de-multiplex them for consumption by PCIe and Display Port devices on the other end. A single Thunderbolt port supports up to six Thunderbolt devices via hubs.

II. History

Intel introduced Light Peak at the 2009 Intel Developer Forum (IDF) [2] using a prototype Mac Pro logic board 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. The technology was presented as having an initial speed of 10 Gbit/s over plastic optical cables, and promising a final speed of 100 Gbit/s in the future. At the show, Intel claimed that Light Peak-equipped systems would begin to appear in 2010. A YouTube video simultaneously published by Intel also showed Light Peak interfacing with HD cameras, laptops, docking stations, and HD monitors. Jason Ziller, Head of the Intel Optical I/O Program Office also demonstrated the internal components of the technology under a microscope and the sending of data through an oscilloscope.

III. Security

Since Thunderbolt extends the PCI Express bus, which is the main expansion bus in current systems, it allows very low level access to the system. PCI devices need to have unlimited access to memory, and may thus compromise security. This issue exists with many high-speed expansion buses, including PC Card, ExpressCard and FireWire.[3] An Intel Thunderbolt attacker could, for example, maliciously configure a Thunderbolt device. On connecting to a computer, the device, through its direct and unimpeded access to system memory and other devices, would be able to bypass almost all security measures of the OS and have the ability to read encryption keys or install malware

IV. Thunderbolt 2

In April 2013, Intel announced plans for the Thunderbolt™ controller, an important advancement in I/O technology. Doubling the bandwidth to run at 20 Gbs, Thunderbolt technology enables simultaneous 4K video file transfer and display for eye-popping video and data capability. The result is great news for an industry on the cusp of widespread adoption of 4K video technologies.

V. Key Features

- Dual-channel 10Gbps per port[4]
- Bi-directional
- Dual-protocol (PCI Express and DisplayPort)
- Compatible with existing DisplayPort 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

VI. Copper Vs Optical

Originally conceived as an optical technology, Intel switched to electrical connections to reduce costs and to supply up to 10 W of power to connected devices. In 2009, Intel officials said the company was "working on bundling the optical fiber 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 Piggy back on USB 3.0 or 4.0 DC power [5]. Light Peak aimed to make great strides in consumer-ready optical technology, by then having achieved "[connectors rated] for 7,000 insertions, which matches or exceeds other PC connections,cables [that were tied] in multiple knots to make sure it didn't break and the loss is acceptable" and "you can almost get two people pulling on it at once and it won't break the fibre," predicting that "Light Peak cables will be no more expensive than HDMI." In January 2011, Intel's David Perlmutter told Computerworld that initial Thunderbolt implementations would be based on copper wires [6]. "The copper came out very good, surprisingly better than what we thought," he said.A major advantage of copper is the ability to carry power. The final Thunderbolt standard specifies 10 W DC on every port.

See comparison section below:

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 MDP connector to be forward compatible, but eventually Intel hopes for a purely optical transceiver assembly embedded in the PC [4]. The first such optical Thunderbolt cable was introduced by Sumitomo Electric Industries in January 2013.

Thunderbolt Technology Possibilities:

With Thunderbolt products , performance, simplicity and flexibility all come together.[7] Users can add high-performance features to their PC over a cable, daisy chaining one after another, up to a total of 6 devices, including up to 2 high resolution DisplayPort v1.1a displays. Because Thunderbolt technology delivers two full-bandwidth channels, the user can realize high bandwidth on not only the first device attached, but on downstream devices as well.

Why Thunderbolt Technology Matters:

Data transfers for backup, sharing, and editing are faster with Thunderbolt technology, significantly reducing times to complete these tasks. For time-sensitive data, such as video and audio during creation and playback, data transfers can be critical to the success of the work. Thunderbolt technology was specifically designed with video and audio applications in mind with inherently low latency and highly accurate time synchronization capabilities.Thunderbolt technology is providing rapidly with new innovations and techniques in which our modern devices can work faster.

Model	Channels	Size (mm)	Power (W)	Family	Release Timing	Features
82523EF	4	15 × 15	3.8	Light Ridge	Q4 2010	
82523EFL	4	15 × 15	3.2	Light Ridge	Q4 2010	
L2510	2	15 × 15	???	Eagle Ridge	Q1 2011	
L2310	2	8 × 9	1.85	Eagle Ridge (SFF)	Q1 2011	
L2210	1	5 × 6	0.7	Port Ridge	Q4 2011	Device only
L3510H	4	12 × 12	3.4	Cactus Ridge	Cancelled	
L3510L	4	12 × 12	2.8	Cactus Ridge	Q2 2012	
L3310	2	12 × 12	2.1	Cactus Ridge	Q2 2012	Host only
L4510	4	12 × 12	???	Redwood Ridge	2013	
L4410	2	10 × 10	???	Redwood Ridge	2013	Host only
L5520	4	???	???	Falcon Ridge	Q3 2013	Thunderbolt 2, 20 Gbit/s speed+DP 1.2

Fig. 1. Intel Thunderbolt Controllers

VII. Intel Thunderbolt Technology Architecture

- 10Gbps per channel, bidirectional
- PCIe and Display Port protocols
- Compatible with standard Display Port displays
- Daisy chain topologies
- Low latency, 8ns accuracy time sync across 7 devices

Controller Architecture: A Thunderbolt controller is the building block used to create Thunderbolt products. A Thunderbolt controller contains:

- A high-performance, cross-bar Thunderbolt protocol switch
- One or more Thunderbolt ports
- One or more DisplayPort protocol adapter ports
- A PCI Express switch with one or more PCI Express protocol adapter ports

The external interfaces of a Thunderbolt controller that are connected in a system depend on the application for which the system is designed. Protocol Architecture:Thunderbolt technology is based on a switched fabric architecture with full-duplex links.[8] Unlike bus-based I/O architectures, each Thunderbolt port on a computer is capable of providing the full bandwidth of the link in both directions with no sharing of band- width between ports or between upstream and downstream directions. A Thunderbolt connector is capable of providing two full-duplex channels. Each channel provides bi-directional 10 Gbps of band- width. A Thunderbolt connector on a computer is capable of connecting with a cable to Thunderbolt products or to DisplayPort devices.

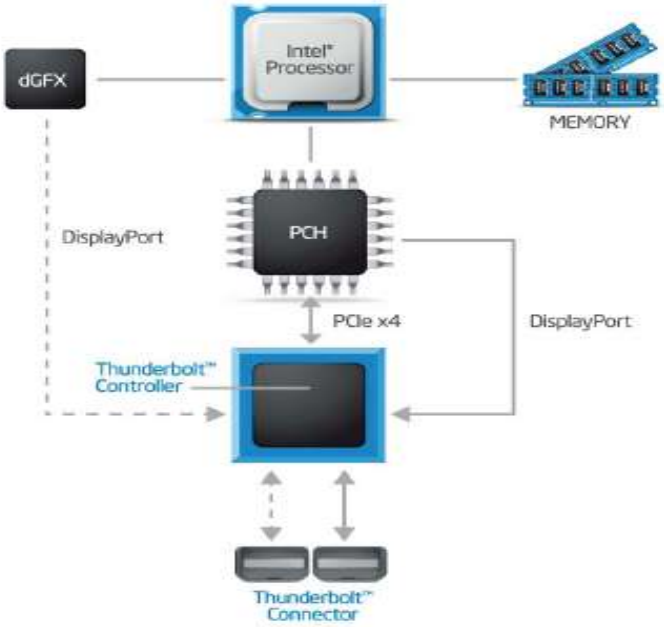

Fig. 2. PC system showing Thunderbolt controller connections.

VIII. How Does Thunderbolt Work?

Systems with Thunderbolt controllers will attached them one of two ways: either it's attached directly to PCI Express links originating from a Sandy or Ivy Bridge-class processor, or it derives connectivity from a Platform Controller Hub's available PCIe. On the desktop, most motherboard vendors will hook up through the PCH in order to avoid monopolizing processor-based lanes, which are generally needed for add-in graphics. Such a configuration does open up the potential for a bottleneck, since the DMI connection between processor and chipset is theoretically good for around 2 GB/s of bi-directional throughput.[9] DisplayPort data routes between the Thunderbolt controller and the PCH's Flexible Display Interface, since that's where display connectors attach.[10] The FDI is its own pathway, specifically reserved for carrying display information, and it does not impact the bandwidth available through DMI 2.0. PCIe

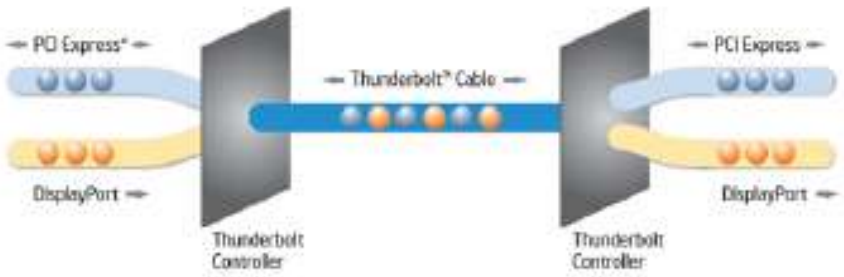

Fig. 3. Working of Thunderbolt

PCIe and DisplayPort signals enter the Thunderbolt controller separately, are multiplexed, travel through a Thunderbolt cable, and are de-multiplexed at the other end. Machines that come armed with Thunderbolt will either include one or two ports, each supporting up to seven chained devices, two of which can be DisplayPort-enabled monitors. So, you end up with the ability to attach [11]

Five devices and two Thunderbolt-based displays:

- Six devices and one Thunderbolt-based display
- Six devices and one display via mini- Display Port adapter
- Five devices, one Thunderbolt-based display, and one display via mini-DisplayPort.

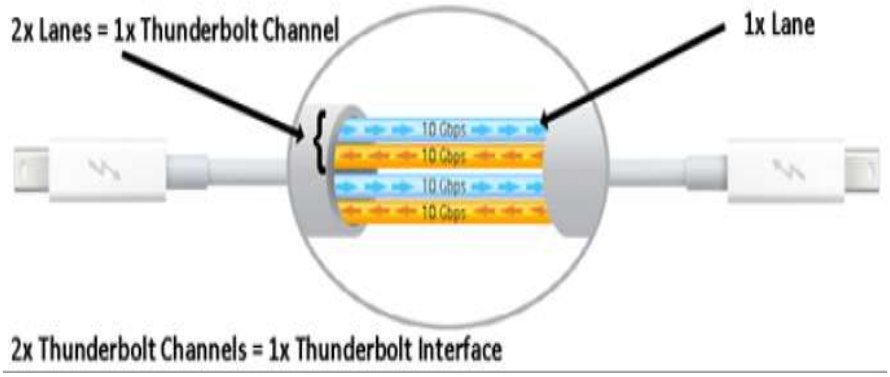

Fig.4. Interface between port and thunderbolt channel

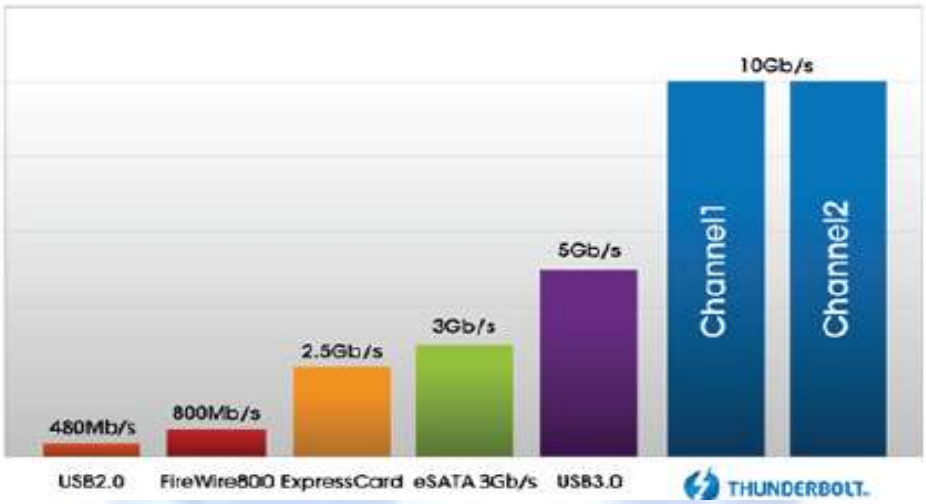

Fig. 5. Speed Comparison of various devices

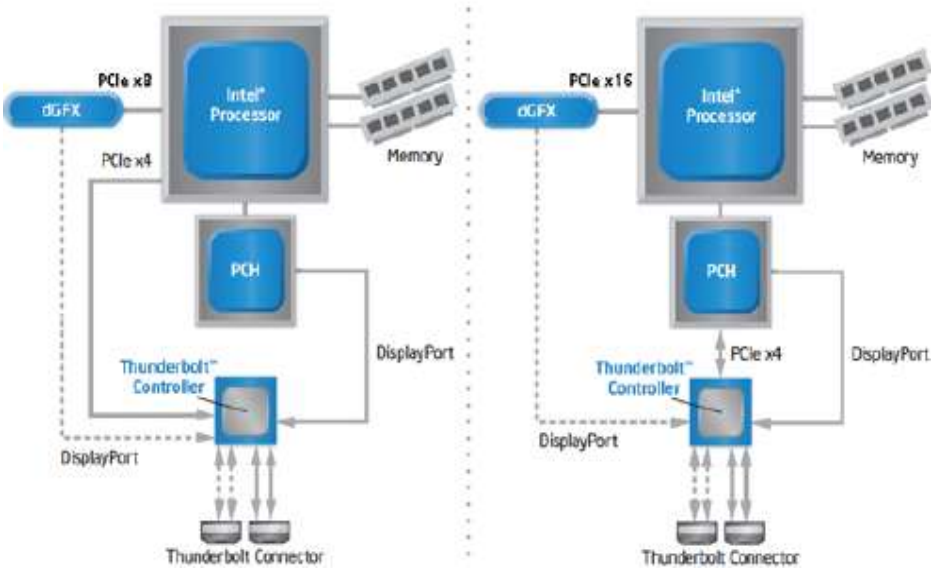

Fig. 6. Ways to interface thunderbolt controller on host system

IX. Uses For The Thunderbolt Port

- Video Capture & Playback- One of the few things holding back the current Mac lineup is the absence of internal PCI Express slots, which are pretty much required to do HD video capture and playback from Anything more than FireBase Camcorders.[12]
- SCSI
- H264 Compression-Thunderbolt could make our H.264 encoding faster yet, so it is good to see someone jump on this bandwagon.
- Super Fast Graphics
- Burn in Flash
- ProAudio-high sample rates through single Thunderbolt I/O port.
- iOS syncing-to speed up syncing large movie and TV show files, podcasts or photo libraries.
- One Port For All-It creates simple single port for all the ports on computer leaving the problem of using other ports.
- Shared Processing-Thunderbolt has become low cost method for sharing information.

X. Conclusion

As discussed in the paper these proposed systems will be very effective for solving several situations where the other technologies would not be able to succeed.Thunderbolt is slowly becoming a fast mode of channel of transferring the data form one source to another with effective use of optical cables that has enhanced the usage of multimedia devices. Not only it has better transfer speed but the advancement in technology will benefit its way in more and more computers.

XI. Acknowledgement

I would like to thank our respected professor who gave us the opportunity to work on a review paper and under his guidance I was able to write this review paper. I would also like to thank my friends who helped in choosing this topic.

XII. References

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