

1. INTRODUCTION

As computers grow and evolve, so do the tools for inputting information into computers. Ports are holes in computers where one can connect various external devices such as mice, keyboards, and USB devices to add extra functions to computers. As time has passed, ports have become more advanced, and more functional across a wider array of devices.

2. OVERVIEW

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 PCIe bus does not carry video data, it is unclear whether a standalone PCIe card could offer a Thunderbolt port. The Intel Thunderbolt Technology Brief does not give a conclusive answer. Intel disclosed documentation where video stream is sent to a dual-thunderbolt controller, with the video stream being only sent to one of the Thunderbolt Port, giving the assumption that video stream is not mandatory on Thunderbolt implementation.

Thunderbolt can be implemented on PCIe, 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 PCIe and DisplayPort data together and unfold them after they exit the cable. Thunderbolt is interoperable with [DisplayPort] 1.2 compatible devices. When connected to a DisplayPort compatible device the Thunderbolt port can provide a native DisplayPort signal with 4 lanes of output data at no more than 5.4 Gbit/s per lane. When connected to a Thunderbolt device the per-lane data rate becomes 10 Gbit/s and the 4 lanes are configured as 2 channels with each bidirectional 10 Gbit/s channel comprising one lane of input and one lane of output. Thunderbolt essentially combines PCI Express and DisplayPort into a new serial data interface that can be carried over longer and less costly cables. Because PCI Express is widely supported by device vendors and built into most of Intel's modern chipsets, Thunderbolt can be added to existing products with relative ease.

Thunderbolt driver chips fold the data from these two sources together, and split them back apart again for consumption within the devices. This makes the system backward compatible with existing DisplayPort hardware upstream of the driver. The interface was originally intended to run on an optical physical layer using components and flexible optical fiber cabling developed by Intel partners and at Intel's Silicon Photonics lab. The Intel technology at the time was marketed under the name Light Peak, today (2011) referred to as Silicon Photonics Link. However, it turned out that conventional copper wiring could furnish the desired 10 Gbit/s Thunderbolt bandwidth per channel at lower cost. Later versions of Thunderbolt are still planned to introduce an optical physical layer based on Intel silicon photonics technology.

3. A BRIEF ABOUT PORT

There are many different types of ports, each with its own purpose. A USB (Universal Service Bus) port provides a standard for connecting devices that are more optional to computer use, such as scanners and cameras. Similarly, a USB 2 port is a new, high speed version of USB, and allows quicker transfer of data, with up to 480Mbits/sec. A parallel port is an older kind of port that came before USB and uses a 25-pin connector to connect peripherals such as printers to the computer. It is used with devices that need relatively high bandwidth. Similarly, a serial port is a serial communication physical interface through which information transfers in or out one bit at a time. Throughout most of the history of computers, data transferred through serial ports included devices such as terminals or modems. Mice, keyboards, and other peripheral devices also connected in this way. This technology has also been primarily replaced

Game or Joystick ports are traditional connectors for video game input devices, such as joysticks, on PCs. The game port is usually integrated with a PC I/O or sound card, or as an on-board feature of some motherboards. Recently, USB has become an alternate means of connecting game input devices to computers. The PS/2 port is the current means of connecting a keyboard and a mouse to a computer. Its name comes from the IBM Personal System/2 series of computers, with which it was introduced in 1987. A monitor port is connected to the computer's video card and is used to connect the monitor to the computer in order to display data. Lastly, a

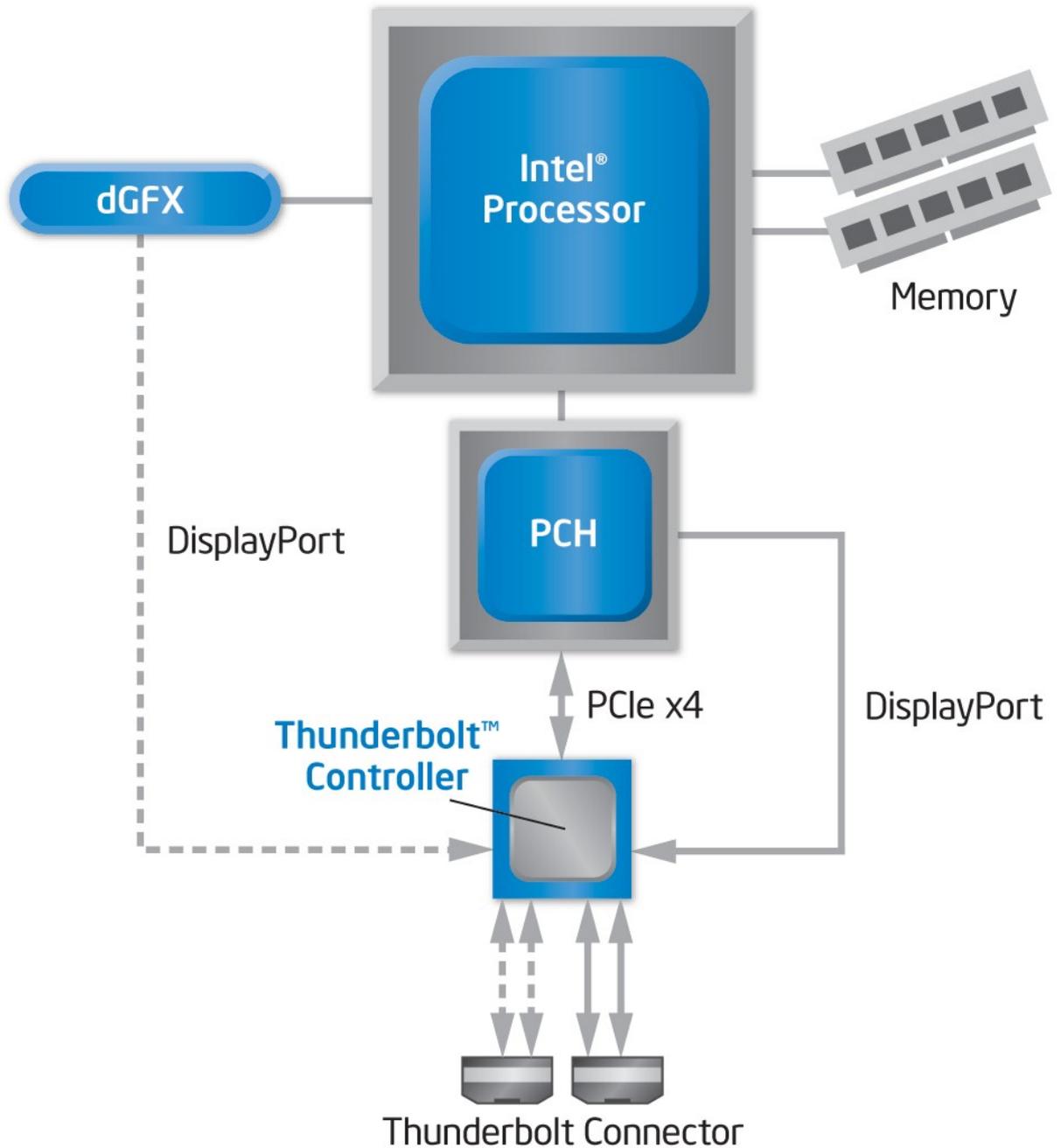
FireWire, or IEEE 1394 port is a serial bus interface standard created by Apple in competition with USB 2, offering high-speed communications between computer and peripheral device. Its advantage over other types of ports is its lower cost and simplified, more adaptable cabling system. It has been adopted as the High Definition Audio-Video Network Alliance standard connection interface for audio/visual component communication and control. FireWire is also available in wireless, fiber optic and coaxial versions. USB 3.0 and FireWire together are the newest types of ports, and can be used to connect almost any type of peripheral, since they are both created to be universally usable, and to transfer data at much faster speeds than other ports.

Both FireWire and USB have the potential to replace all other ports because they allow for the connecting of many different devices using the same male and female plug-ins. Since almost all computers come with USB, FireWire, or both, this port could be used to transfer any data from the peripheral to the computer. By simply installing drivers for the devices one connects on one's computer, the computer can easily interpret data coming in from a USB or FireWire port, no matter what the peripheral is. This is different from other ports because, in the past, different peripherals all required different ports in order to be connected and understood by the computer. For example, there is a specific port for a mouse, a specific port for a keyboard, and a specific port for a monitor.

There are many new peripheral devices that use USB ports to mimic the functions of well-known peripherals that use legacy ports. For example, there are many mouse peripherals that now connect through USB ports. There are also many keyboards that connect through the USB port. Wireless keyboards almost always use a receiver plugged into a USB slot because it is much less complicated than it would be using a wireless device with a serial port. The same is true for monitors, game input devices, and even speakers. There are USB and FireWire adapters available that allow the connection of devices that connect through serial, parallel, and other many other legacy ports. By becoming a universal standard for peripheral connection, USB and FireWire have gained the ability to eventually replace all other ports.

6. PROTOCOLS IN THUNDERBOLT

Example PC System Diagram Other system configurations possible

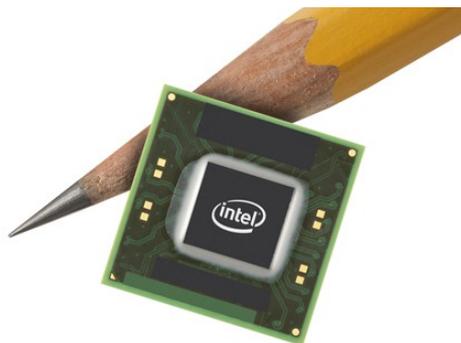


A Thunderbolt controller is the building block used to create Thunderbolt products. A Thunderbolt controller contains:

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

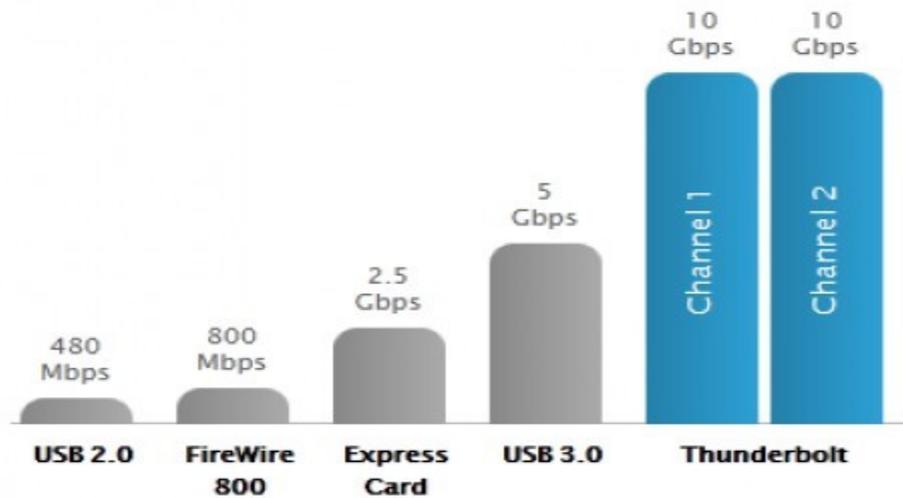
The external interfaces of a Thunderbolt controller that are connected in a system depend on the application for which the system is designed. An example implementation of a host-side Thunderbolt controller is shown in Figure 4. Host side

Thunderbolt controllers have one or more Display Port input interfaces, a PCI Express interface along with one or more Thunderbolt technology interface. By integrating all the features necessary to implement Thunderbolt into a single chip, the host-side controller enables system vendors to easily incorporate Thunderbolt technology into their designs. Thunderbolt technology leverages the native PCI Express and Display Port device drivers available in many operating systems today. This native software support means no extra software development is required to use a Thunderbolt technology enabled product.



8. COMPARISON OF DIFFERENT I/O

High-Speed I/O Performance



From the above graph, it is clear that thunderbolt keeps a big advance in the speed considering the all existing display technology like, USB, firewire express card and HDMI and Esata etc. Thunderbolt provides double the speed of latest USB.3.0 which offers a 5gbps speed in papers but actual performance is very less than that Thunderbolt practical demonstration shows the data transfer of the speed of 750MBps to 850MBps, and can stream up to 8 simultaneous streaming of HD videos, where any of other existing technology offers a maximum of 1 HD streaming at a time, Thunderbolt can also support simultaneous 4 Full HD 1080p streams.

By going for the optical version of Thunderbolt it is possible to achieve a speed of 100Gbps speed, which is more than enough to have external PCIe devices, like external Graphic cards and External RAM, which is very useful for Hard core gamers and to whom who want to boost their office PC for their work and gaming.

9. THUNDERBOLT TECHNOLOGY POSSIBILITIES

With Thunderbolt products, performance, simplicity and flexibility all come together. Users can add high-performance features to their PC over a cable, daisy chaining one after another, up to a total of 7 devices, 1 or 2 of which can be high-

resolution DisplayPort v1.1a displays (depending on the controller configuration in the host PC). 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.

Users can always connect to their other non-Thunderbolt products at the end of a daisy chain by using Thunderbolt technology adapters (e.g., to connect to native PCI Express devices like eSata, Firewire). These adapters can be easily built using a Thunderbolt controller with off-the-shelf PCIExpress-to-“other technology” controllers. System designers taking advantage of Thunderbolt technology can pursue ever thinner and lighter system designs, using fewer connectors while still achieving high performance between their products and external devices. With Thunderbolt technology, workstation-level performance feature expansion can be packaged as standalone accessories, and is only a cable away. And by leveraging the inherently tight timing synchronization (within 8ns across 7 hops downstream from a host) and low latencies of Thunderbolt technology, broadcast-quality media can be produced using Thunderbolt products.

10. CONCLUSION

Thunderbolt technology brings a new balance of performance, simplicity and flexibility to end users and product designers alike. As the fastest PC I/O technology, leveraging two key technologies (PCI Express and Display Port) on one shared high-performance transport, Thunderbolt technology opens doors to entirely new system and product designs.

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.

11. REFERENCES

- www.intel.com/technologies/thunderbolt
 - www.apple.com/thunderbolttechnology
 - www.wikipedia.com/thunderbolt
 - www.howstuffwork.com
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