# THUNDERBOLT™

Driving 4K Workflows with Thunderbolt™ 2

Thunderbolt™ 2 helps the media and entertainment industry meet the massive data demands of fully digital workflows. High performance and broad compatibility help deliver time and cost savings, from image acquisition through post production.

As media and entertainment production workflows move to all-digital content from beginning to end, they face a common dilemma: the massive amounts of data created in 4K filmmaking overwhelm all but the most advanced environments. To handle the demands of post-production data management in an all-digital world, the industry is increasingly turning to Thunderbolt for solutions.

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By Gary Adcock, Studio37 Inc.
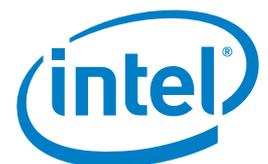
CHALLENGE

The RAW or Native camera data files at the beginning of a typical 4K workflow can include both High Frame Rate (HFR) and High Dynamic Range (HDR) imagery. Capture of elevated frame rates and extended dynamic range can result in data challenges that include the following:

- **Large data loads on set and in post production** can overwhelm the capabilities of transfer technologies, with cumbersome Native camera files that often exceed the recording capabilities of film.

- **Massive data movement requirements from the moment of acquisition** often increase dramatically throughout the production process and into final post production and finishing.

SOLUTION

Thunderbolt technology, developed by Intel, is a flexible, high-bandwidth I/O solution with the ability to daisy-chain multiple devices within a single workflow. Originally brought to market in 2011 with bandwidth of 10 gigabits per second (Gbps) the latest-generation Thunderbolt™ 2 builds further on the capabilities of its predecessor:

- **Bandwidth** up to 20 Gbps
- **Support** for the DisplayPort* 1.2 protocol

Thunderbolt 2 products make it possible for video professionals to display and transfer 4K content simultaneously, dramatically improving post-production workflows.

THUNDERBOLT™ 2 KEEPS UP WITH SATURDAY NIGHT LIVE

Saturday Night Live (SNL) has an extremely challenging production environment. Tasked with producing multiple short film clips within a 72-hour work schedule, the production faces some of the tightest time constraints and demands in the industry. Fast turnaround time is critical, and Thunderbolt is used both in the field and in the studio.

"On our lightning-fast delivery schedules at the SNL film unit, we embrace any technology that will help us move faster. The introduction of Thunderbolt into our workflow has allowed us to move our data 12 times faster than before, which makes a huge difference. Thunderbolt buys us more time in post, which allows us to accomplish MORE in the same time frame. Lots of people say 'every second counts,' but in our case, it's literally down to the last second every Saturday night at 11:30 p.m."

Alex Buono | Director of Photography, SNL Film Unit

A Natural Enabler for 4K Workflows

Thunderbolt enables 4K workflows in a number of unique ways. Offering enhanced performance with innovative design, Thunderbolt combines PCI Express* (PCIe*) and DisplayPort I/O protocols onto a single, highly efficient cable connection that offers a bidirectional bandwidth of 20 Gbps, as shown in Figure 1.
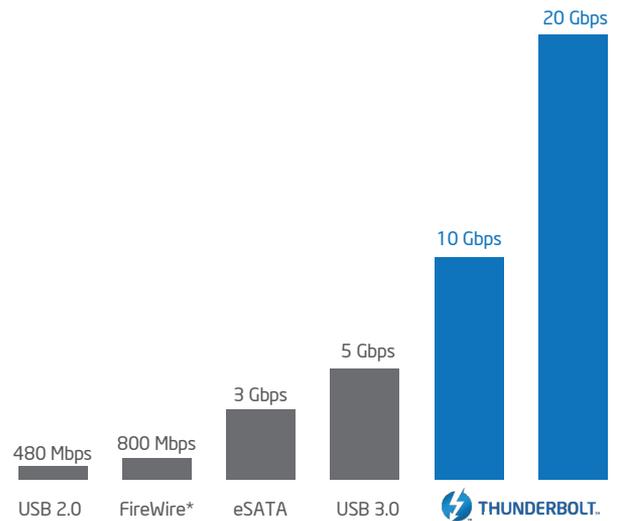

Figure 1. Bandwidth provided by selected connection technologies.

The Thunderbolt protocol allows users to daisy chain up to six devices and/or displays per port. Because Thunderbolt uses PCIe, it offers interoperability with a broad range of data-transfer protocols, including Fibre Channel, SAS, eSATA, FireWire*, USB, and the various types of wired Ethernet. With simple connectivity to existing infrastructure, customers can make a gradual transition to Thunderbolt, upgrading equipment as desired.

Thunderbolt 2 is currently available across all Apple Mac* product lines, and increasingly available on other PCs and workstations from manufacturers such as ASUS, Dell, HP, Lenovo, and others. One noteworthy capability of computers enabled with Thunderbolt 2 is that they can network together at 10 Gbps speeds. This connectivity provides an excellent solution for professionals who use mobile workstations in the field to quickly share files with a tower or an all-in-one workstation in the office.

Networking based on Thunderbolt works across platforms, simplifying file sharing among computers running Mac OS* and Microsoft Windows*. In addition, a robust ecosystem of Thunderbolt devices—including storage, displays, docks, and media capture equipment—help round out a comprehensive set of offerings that support today's most demanding workflows. And Thunderbolt cables, including optical cables up to 60 meters in length, work with both Thunderbolt and Thunderbolt 2, enhancing flexibility.

Why Thunderbolt™ 2 Matters for 4K Production

The value of Thunderbolt devices for managing data effectively begins at the point of acquisition, as 4K productions create massive amounts of original camera data, which needs to be acquired, monitored, evaluated, and archived. The dramatic increase in data sizes makes the move from HD to 4K significantly more complex than the earlier transition from SD to HD formats.

It's not uncommon for as much as 6 terabytes (TB) of original RAW data per camera to be generated in a single day of 4K production. Maintaining the integrity of that information requires duplication of the original camera data onto multiple, separate volumes of storage, allowing for distribution of the camera originals, client review copies, and editorial and finishing versions. This process tends to dramatically escalate overall data requirements.

Bandwidth Requirements of Common Video Resolutions

Bandwidth required per resolution based on Gbps, at 24 bpp/60 Hz, not including encoding / header overhead
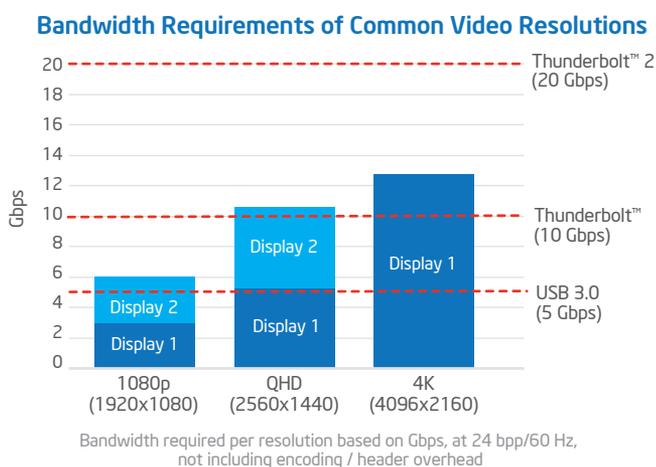
Figure 2. When it comes to displaying video at the most demanding levels, Thunderbolt™ 2 is the clear choice.

With blazingly fast bandwidth speeds up to 20 Gbps, Thunderbolt 2 uniquely fills the need for I/O connectivity that is capable of handling immense amounts of data in a timely manner. Moreover, Thunderbolt 2 devices provide simplicity and mobility that greatly facilitate the ability of video professionals to literally take their studios into the field, completing workflow tasks on the set and in real time that could previously be done only within a post-production facility. This is a key advantage, as the ability to properly review footage and begin edits on location can often save costly reshoots and other delays.

With six Thunderbolt™ 2 ports, the new Mac Pro* from Apple provides added flexibility for your 4K content creation workflows.

Thunderbolt 2 in Action

Intel recently completed a 4K production project, for use in demonstrations and by the technology ecosystem, that demonstrates the capabilities and benefits of Thunderbolt 2. As part of the effort to generate compelling 4K content and behind-the-scenes footage, a broad range of devices and protocols were used, which highlight the benefits of Thunderbolt 2 as a non-proprietary means of connectivity.

A Phantom* Flex4K camera, capable of capturing up to 1,000 frames per second for short durations of filming, was used to capture super-slow-motion shots. That content was brought into the Thunderbolt-based offload station using a customized Magma ROBEN-3* Thunderbolt 2 expansion chassis, with a Small-Tree Communications 10GbE PCIe card, a 1.6 TB ioFX* card from Fusion-Io and 3 TB of solid-state drives (SSDs) that were configured in RAID 5 for redundancy.

Innovative Workflows for Image Acquisition and Storage

Demo-content production took advantage of the 20 Gbps of bandwidth provided by Thunderbolt 2 to transfer data to a Promise Pegasus2* R8 RAID array. Its 24 TB of capacity served as the main content "archive" on set, while creating a simultaneous secondary backup to an 8 TB G-Raid* from G-Technology, both daisy-chained to the Magma chassis using Thunderbolt.

The Apple MacBook Pro* with Retina* display being used in production controlled the initial data offload to its internal SSDs. When that approach proved insufficient due to the amount of data being acquired, the on-set team decided to use the ioFX card and its hardware-based error-correcting code (ECC) memory tools. This approach allowed the production team to accelerate workflow redundancy by configuring the software so that any changes or additions made to the ioFX card were automatically copied onto the Pegasus2 R8 and the G-Tech RAID devices.

As a result, immediate and multiple redundant copies of the data were produced. The multiple backups being created nearly in real time provide a compelling proof point for the unique value of Thunderbolt 2 to this type of flexible, accelerated workflow.

HP Z* Workstations with Thunderbolt™ 2 are a great option for 4K productions and come in a variety of form factors including mobile, all-in-one, and tower workstations.

Explore Thunderbolt 2:
www.thunderbolttechnology.net

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Simultaneous Image Display and Transfer

For the behind-the-scenes video, the production used the Blackmagic Design 4K Cinema Camera*, which includes a Thunderbolt 2 port that allowed the crew to control, monitor, and offload 4K video files directly to an HP 15-inch ZBook* mobile workstation, equipped with Thunderbolt 2. The HP ZBook, connected to an HP DreamColor* monitor for viewing high-resolution images as the files were transferred to the Promise Pegasus2 R8 with dual Thunderbolt 2 ports.

Thunderbolt 2 ease of use allowed the production to archive the behind-the-scenes data on the same storage arrays as the demo content footage simply by swapping the Thunderbolt cable connection between the host computers. The distance between the devices was not a factor with the latest Thunderbolt cables from Corning, which come in lengths up to 60 meters.

Simplified Content Distribution and Open, Flexible Workflows

The final demo content was distributed to several companies using G-Tech and LaCie portable drives with Thunderbolt ports, further exemplifying the value of Thunderbolt as a flexible approach. Both companies' drives include USB 3.0 connectivity, making it simple to distribute content to recipients that may have computers unequipped with Thunderbolt ports.

While using an alternate connection—such as USB 3.0 in this case—delivers much slower transfer rates, this flexibility emphasizes the fact that Thunderbolt coexists easily alongside other types of connectivity. Adopting Thunderbolt 2 facilitates open options for production and post-workflows as they were always meant to be: complementary, non-exclusive, and easy to use.

Conclusion

As the industry increasingly moves toward 4K workflows, post-production professionals must adopt approaches and techniques that enable them to manage data efficiently. Thunderbolt is uniquely suited as the I/O connectivity that is capable of handling virtually all aspects of 4K data management, making it a critical component of forward-looking production workflows.

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