



For immediate release

Tech Magazines exclusive contribution

Title –

“Thunderbolt – a striking history”

Subtitle –

Intel’s Thunderbolt interface has had a somewhat rocky uptake but has now established itself as the premium interface protocol for studio professionals, gamers, crypto-miners and more recently mainstream consumers.

Featuring 40Gbps data throughput, daisy chaining and the ability to connect 8K monitors through one cable, Thunderbolt 4 has emerged as the preferred standard for high-speed data transfer.

Bunbury, Western Australia, 22 September 2021

Thunderbolt 4 is now widely available across Apple devices and computers, newer PC's and as an add-on to existing PC's.

Thunderbolt 4 has replaced the previous Thunderbolt 3, which for high end Apple and PC users has been the standard for high-speed data transfer for around half a dozen years.

Arriving at Thunderbolt

Thunderbolt was created by Intel working with Apple.

Thunderbolt combined PCIe, DisplayPort, and power as an all-in-one standard, allowing fast data transfers, fast display support and charging - all available in a single cable.

But prior to Intel releasing Thunderbolt 4 as the world's premium interface protocol, there existed a general acceptance in the market of varieties of the USB protocol.

The now dominant USB-C was the result of a combined effort from multiple computer and peripheral manufacturers. Co-ordinated by Intel, the USB-C connector went from a 2013 concept to a 2014 specification rolled out across almost all technology devices.

The USB-C connector was based around the existing USB 2.0 Micro-B connector but included the reversibility of Apple's Lighting connector. The new standard was driven by the decreasing thickness of laptop computers and the physical real estate occupied by USB Type-A connectors.

Earlier USB Protocols and Connectors

USB Type-A, or USB Standard-A, is the original design for the USB standard and uses a flat rectangular shape.

On a typical USB cable, the Type A connector male connector is the end that goes into a host, like a laptop computer.

Different USB versions including USB 1.1, USB 2.0 and USB 3.0 share the same USB Type-A design. That means a Type-A connector is always compatible with a Type-A port even if the device and host use different USB versions.

For example, a USB 3.0 external hard drive also works with a USB 2.0 port, and vice versa.

Similarly, small devices such as a mouse, keyboard or network adapter that have hard-wired USB cables commonly use Type-A connectors. That's also true for peripherals without cables, such as a thumb drive.

USB 3.0's connectors and ports have more pins than USB 2.0. This enables faster speeds and higher power output. However, these pins are organized in a way that doesn't prevent them from physically working with the previous USB versions.

There were also smaller Type-A plugs and connectors. These included Mini Type-A and Micro Type-A, but these connectors had limited take up.

Interestingly Intel has continued its development of USB with USB4.

Like Thunderbolt 4, USB4 will connect to both Thunderbolt 3 and 4 and is also backwardly compatible with earlier USB-C devices.

Indeed, USB4 is very similar to Thunderbolt 4, bar a few exceptions but has been completely overshadowed by Thunderbolt 4. It is likely only a matter of time before Intel simply drops the USB name.

Thunderbolt and Apple

Working closely with Apple, Intel released the first version of Thunderbolt on Apple's MacBook Pro in 2011.

Thunderbolt and later Thunderbolt 2 used a Display Port connector which was incompatible with USB varieties that dominated PC computers.

Originally invented by Intel's Silicon Photonics group, the technology was originally slated to run through optical fibres. It was known within Intel as Light Peak.

Alongside Apple, Intel found they could achieve similar data throughput at significantly lower cost by using traditional copper wires.

The trademark "Thunderbolt" was registered by Apple who later ceded the name to Intel who still held the technology's intellectual rights.



Figure 1 A Thunderbolt 2GB external Solid State Drive

Thunderbolt – a slow road travelled

For some time, the only major technology house to use Thunderbolt or it's evolved, Thunderbolt 2 was Apple.

That meant there wasn't the same proliferation of Thunderbolt products as there was for USB 3.0 and later, USB-C products. As is often the case with technologies championed by Apple, the relatively high cost for Thunderbolt peripherals and accessories was a major hurdle in growing the market for Thunderbolt.

Released at the end of 2008, USB 3.0 incorporated SuperSpeed (SS) data transfer up to 5 gigabits per second (Gbps). Utilising full-duplex transfers so that data can transfer in both directions simultaneously, allowed USB 3.0 about a 20x bandwidth increase over USB 2.0.

At the time the huge advantage for USB 3.0 acceptance was the backward compatibility with USB 2.0 devices. Simply, your new computers would still work with your old USB 2.0 peripherals.

USB 3.1 Gen 2 was announced in 2013, raising transfer speeds 10 Gbps. This was the same speed that Apple was touting with Thunderbolt. However, this latest Intel technology used a new connector, referred to as a USB Type-C or more simply USB-C.

The low cost of USB peripherals plus the increasingly faster versions of USB didn't help the uptake of Thunderbolt.

However, Apple and Intel changed the connector on their newly released Thunderbolt 3 at the end of 2015.

They changed it to a compatible USB-C connector.

The game has changed

With Thunderbolt 3 and the introduction of a USB-C compatible connector the connectivity game was to change quickly.

Now, any computer user could use just one computer port to attain 40Gbps data throughput, fast charging, connection to DisplayPort monitors, PCIe plus maintain all their existing USB-C peripherals.

Thunderbolt 3 allowed for daisy chaining of up to 6 Thunderbolt devices on a single port. The same port could also connect to a Thunderbolt hub or docking station that could connect even more devices and peripherals, with just a single cable back to the host computer.

The advent of Thunderbolt 3

Here's how Thunderbolt 3 is different from its predecessors -

- The Mini DisplayPort connection type was changed to a USB-C type connection
- All Thunderbolt 3 cables will work as USB-C cables
- Not all USB-C cables will work as Thunderbolt 3 cables
- Thunderbolt 3 has a top data transfer speed of 40Gbps as long as the cable is $\leq 0.5\text{m}$
- For longer cables, Thunderbolt 3 supports passive mode cables (cheaper) that have a top speed of 20Gbps, and active mode cables (more expensive) that retain the 40Gbps speed
- Thunderbolt 3 is backwardly compatible with earlier versions of Thunderbolt, but due to the new port type, adapters are required to use legacy Thunderbolt devices
- Any USB-C device plugged into a Thunderbolt 3 port will function normally.

- Thunderbolt devices use discrete Thunderbolt chips to function, and as such they will not function if plugged into a USB-C port

Then in 2020, the further evolved Thunderbolt 4 was released.

So what is Thunderbolt 4?

Thunderbolt 4 is the latest generation of Intel's premium connectivity interface.

It is fully compatible with Thunderbolt 3 and USB4. It is backwardly compatible with all USB-C versions.

Evolving from Intel and Apple's existing Thunderbolt 3 specification, Thunderbolt 4 complements and builds on the existing USB-C, 3.2 and 2.0 architectures. The result is that you can plug a USB-C cable into a Thunderbolt 4 port and it will operate normally as USB-C. The socket remains the same as that which has been used for several recent versions of USB, most popularly known as USB-C.

With an increase in the speed of hardware and ever-increasing demands of professionals, gamers, and users of processing intensive software, there has been a corresponding significantly higher data performance required to maintain peak performance.

Thunderbolt 4 is that major update catering for that extra hardware and software demand. So popular is Thunderbolt 4 that all major computer and device manufacturers are beginning to incorporate Thunderbolt 4 into their higher end products.

For example Apple's latest iPad has USB-C but the 2021 iPad Pro boasts Thunderbolt 4. Aimed at studio professionals the iPad 4 is their top-end tablet and gets the nod as the world's first mobile device to have Thunderbolt 4.

And yes, this was the game changer.

However, Thunderbolt 4 raises the maximum bandwidth to 40Gbps and enables multiple simultaneous data and display protocols. Thunderbolt 4 can dynamically share a single high-speed link with multiple end devices, so that the priority task or process is allocated the bulk of bandwidth.

As mentioned earlier, Intel's USB Type-C connector had become an almost default

interface for modern computers and devices, so the introduction of Thunderbolt 4 provides for that backward compatibility whilst at the same time allowing users to buy new Thunderbolt hardware without being penalised by different connectors or incompatible protocols.

Like Apple's famous tagline - "*it just works*".

The result is that there is 100% compatibility with existing USB-C, USB 3.2, USB 2.0, USB4 and Thunderbolt 3 devices. Thunderbolt 4 can support 3 speeds from 10Gbps through to 40Gbps.

There are also various adapters that allow Thunderbolt 4 to connect to earlier and legacy data storage and video products. It is only recently that high performance 4K, 6K and 8K monitors have started to ship with native Thunderbolt 4 connectors.

The giant step forward is that Thunderbolt allows for dual lane operation whilst maintaining up to 40 Gbps operation over 40 Gbps certified Thunderbolt cables. [HomeKit Australia's 100w 5A Thunderbolt cable](#) includes an e-Marker verification chip within its design so that these Thunderbolt cables truly are "smart" cables.

Thunderbolt 4 also supports the USB PD charging standard. Put simply, M1 MacBooks and MacBook Airs, iPad Pro, a future iPhone, existing Android smartphones and other devices can charge significantly faster over Thunderbolt.

The good news for PC fans is that Intel began the integration in 2019 of Thunderbolt into their CPUs as of their tenth generation Core processors.

Thunderbolt 3 vs Thunderbolt 4

Whilst Thunderbolt 4 may not appear to be different to Thunderbolt 3, it has improved in several key areas.

The first improvement is that minimum PCIe data requirements have increased from 16Gbps to 32Gbps. This means that high-speed external PCIe devices like [HomeKit Australia Thunderbolt Fire SSD drive](#) and external graphics will see significant increases in data transfer rates and performance.

Second, VT-d based DMA protection that forms part of Thunderbolt 4, helps prevent security threats by remapping requests from external devices and checking for proper permissions.

And third, Thunderbolt 4 also adds "Wake from Sleep". Wake from Sleep over Thunderbolt 4 allows a Mac, iPad or PC to resume processing with peripherals that are connected through a Thunderbolt 4 docking station.

Thunderbolt 4 also doubles its video support for dual 4K displays at 60Hz or one 8K display at 30Hz. It still transfers data at 40Gbps like Thunderbolt 3 but with the doubled PCIe bandwidth. External GPU users can expect the same sort of increase.

One of the great advantages of Thunderbolt 4 is its ability to offer three powered out ports on devices like docking stations. This has been a major issue for power users with USB-C.

How does Thunderbolt work?

Thunderbolt combines PCI Express and Mini DisplayPort into a combined serial data interface.

- Thunderbolt 1 implementations had two channels, each with a transfer speed of 10 Gbps, resulting in an aggregate single directional bandwidth of 20 Gbps.
- Thunderbolt 2 used link aggregation to combine the two 10 Gbit/s channels into a single bi-directional 20 Gbps channel.
- Thunderbolt 3 changed to a compatible USB-C connector and has one 40 Gbps channel. With the older Thunderbolt standards, the cable was active, meaning the cable itself is a device that requires power to operate (which is why most Thunderbolt 1 or 2 devices would require an external power source in order to function.) This made Thunderbolt a much more expensive solution, as the cable could cost many times the price of a competing USB-C cable.

Thunderbolt 1 & 2 used a Mini DisplayPort connector prior to Thunderbolt 3 adopting the USB-C compatible connector.

Thunderbolt 4 continues to use the same connector, offering high-speed storage, high-res monitors, and [Thunderbolt docking stations](#) or [Thunderbolt hubs](#). Thunderbolt 4 can daisy chain up to six connected devices.



Figure 2 One side of a Thunderbolt docking station that also houses 2 x NVMe SSD's

Whilst USB4 transfers data from 20-40Gbps, Thunderbolt 4 is firmly 40Gbps.

We are seeing many new Apple products feature Thunderbolt 4, including the latest iPad Pro. Many PC laptops are now shipping with Thunderbolt 4, especially those based around 11th generation Intel Core CPU's.

If you click on the attached photo there's a great compatibility chart provided by [Intel](#).

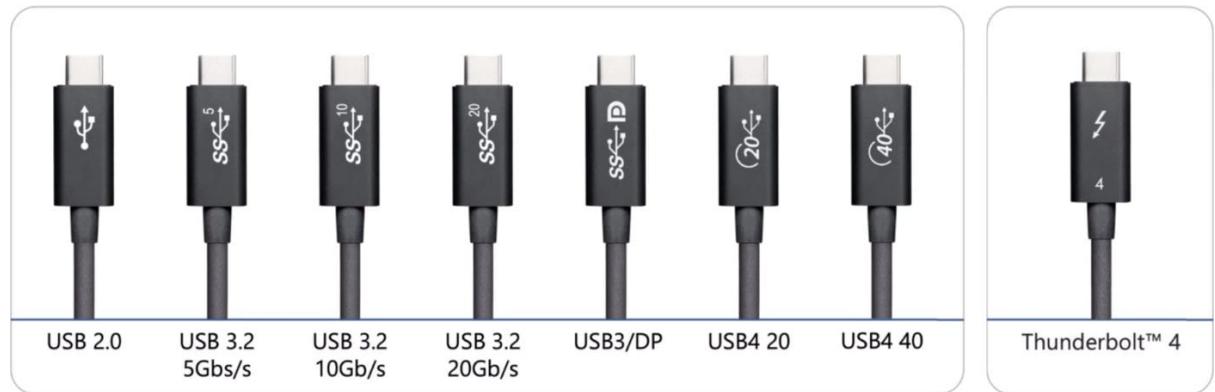


Figure 3 All of these USB connectors will work with Thunderbolt 4

Thunderbolt for gamers

Thunderbolt 4 especially offered new and improved opportunities for gamers and their setups.

First, a multi-port [Thunderbolt docking station](#) can connect via a Thunderbolt 4 cable to a single Thunderbolt 4 port on your Mac, laptop, iPad Pro or PC. A Thunderbolt 4 docking station will increase the number of devices you can connect to your Thunderbolt equipped gaming setup.

Gamers might connect a high-end 60Hz monitor, gaming keyboard, a gaming mouse and a Thunderbolt SSD external drive to the docking station. The Thunderbolt docking station then only requires a single Thunderbolt 4 cable that plugs into your computer or gaming device.

Thunderbolt 4 docking stations increase the number of Thunderbolt 4 ports available, plus typically add additional ports for USB-C, USB, DisplayPort, audio, memory cards and ethernet.

Gamers also have access to the huge advantage offered by ultra-premium Thunderbolt 4 data storage. Thunderbolt 4 transfers data at 40Gbps, so it is easy to connect high performance data storage like the Thunderbolt external SSD's or a gaming monitor.

The bonus with Thunderbolt 4 is this bandwidth works in both directions so the outgoing video signal doesn't conflict with incoming data from other devices or peripherals such as Thunderbolt SSD drive.

Plus, gamers can use a Thunderbolt docking station to keep their gaming space organised.

Using Thunderbolt 4, gamers can add an external video capture device for streaming. Thunderbolt 4 allows for video capture gameplay in full 4K at 60Hz or in 1080p at 240Hz. By using a dedicated video capture unit for gameplay, Thunderbolt 4 frees up valuable system resources

So Thunderbolt 4 allows gamers to play games at higher settings whilst retaining excellent video quality.

Thunderbolt 4 also allows the connection of an external GPU. The external GPU is used to improve graphics performance on the gaming computer and to also speed data mining for the cryptocurrency flock.

Beware the Thunderbolt premium

Thunderbolt products are often made in the same factory yet the prices from OEM recipients can vary greatly.

For example, this is exactly the case with Thunderbolt products from the major Thunderbolt suppliers Orico and HomeKit Australia.

Thunderbolt products from both suppliers are mostly built on the same production line and both suppliers sell only high-quality Thunderbolt product.

However, the price of Orico product can be double or even triple the price of HomeKit Australia Thunderbolt products.

You also want to avoid retailers selling items such as counterfeit cables promoted or labelled as Thunderbolt cables. Whilst the Thunderbolt symbol and a number like “4” are not a guarantee that a cable is a genuine Thunderbolt cable, genuine cables are typically thicker and heavier than a USB-C 100w cable.

In the example below, the genuine Thunderbolt 4 cable from HomeKit Australia carries the manufacturer details, a Thunderbolt strike symbol and a “4” to identify it is certified as Thunderbolt 4. This cable is double or triple the weight of a comparable USB-C cable and has a diameter of 6mm. These cables also employ premium e-marker chips in each connector adding further smarts to the cable.



Figure 4 A genuine, certified Thunderbolt 4 cable

A counterfeit cable will simply not deliver Thunderbolt performance and in most situations your host device or computer should tell you that you are not accessing Thunderbolt.

Thunderbolt and SSD

Today computer and device users are replacing traditional hard drives and even USB storage with the much faster Solid State Drive (SSD) options that abound the internet marketplaces.

Thunderbolt is often associated with m.2 NVMe SSD's that resemble a common RAM DIMM. They fit into special slots in devices like Thunderbolt enclosures and Thunderbolt docking stations.

NVMe SSD's access a computer's motherboard via PCIe if installed internally or externally via Thunderbolt 4. The blazing speeds of Thunderbolt NVMe SSD drives are at least three times faster than traditional SATA interfaces.

The faster (and more expensive) the SSD becomes, the closer the Thunderbolt data storage devices will get to the quoted 40Gbps throughput that is possible with Thunderbolt 4.

For the first time, Thunderbolt has allowed for external data storage devices with comparable throughputs to upgrades that traditionally needed to be installed internally in a computer.

The future?

Thunderbolt 5 is slated to be released sometime in 2022.

Look for further speed and application improvements, plus it is rumoured that Thunderbolt 5 cable length will progress beyond the technical 2 metre limit available to Thunderbolt 4 users.

Presently, most cable manufacturers limit their Thunderbolt 4 cables to a maximum 1.8 metres to ensure there is no degradation of data throughput.

Conclusion

Since the inclusion of a USB-C compatible connector in 2015, Thunderbolt has quickly become the go-to connectivity interface for high-end and processing intensive computing tasks.

Backed by Apple, and initially targeting their professional users, Thunderbolt connectors are now becoming the standard connector interface across a wide variety of computers and devices.

The rise of cryptocurrency mining has been a further boon to Thunderbolt, with users demanding the fastest data connectivity interface, having maxxed out their internal storage.

Today the blazing speeds and wide variety of devices that can be connected, has made Thunderbolt 4 the new connectivity standard.

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HomeKit Australia is an online retailer following a “factory direct” procurement policy. This ensures products are offered to consumers at highly competitive pricing.

Products include HomeKit Australia SSD's, Thunderbolt SSD drives, hubs, Solid State Drive products, hubs, specialist Apple HomeKit products, GaN (Gallium Nitride) AC chargers, wireless chargers, Apple MagSafe charging and Apple Watch products. Items are available for desktop and laptop computers plus both Apple and Android phones and devices. HomeKit Australia products ship from Australia to USA, Canada, UK, Singapore, Australia and New Zealand.

The HomeKit Australia website is at <https://homekitaustralia.com.au>

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Keith Palmer is a long-time developer of high-end data storage products in Australia and multiple winner of MacWorld Awards.

Starting out with building SCSI hard drives for the Apple Macintosh market and the many studios and professionals in video production, music and photography, Keith's company partnered with Seagate Technology and SyQuest Technology to build industry leading and award-winning data storage products.

The hard drives evolved into FireWire data storage and then into USB.

Now Keith is enjoying working with Solid State Drives, especially those connected with Intel's and Apple's Thunderbolt 4 interface.

Keith's company [HomeKit Australia](#) have now produced their own range of NVMe SSD's plus SATA III 2.5" SSD's and associated [Thunderbolt SSD](#) products.

Robin Belford is a Chartered Engineer whose first computer was an original 1984 Apple Macintosh. Robin has been working with and around computer technologies ever since.

HomeKit Australia delivers to USA, UK, Canada, Singapore, New Zealand and Australia.

