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Intel IT Explores Thunderbolt™ 3 Technology Benefits

With a focus on employee's requirements for universality, ease-of-use, and future-readiness, Intel IT tested and is now deploying Thunderbolt™ 3 technology docks across our enterprise

Based on our testing, Thunderbolt™ 3 technology docks are in full deployment at Intel and serve as our plan-of-record docking solution.

Executive Summary

Facing a complex environment of docking solutions, some of which do not meet the needs of our new workplace transformation requirements, Intel IT conducted multiple rounds of Thunderbolt™ 3 technology testing. The results of these tests indicate that Thunderbolt 3 technology benefits Intel employees as well as Intel IT in the following ways:

- **Simplification.** We can reduce the total number of different dock models in the environment. Fewer solutions to support will result in lower support costs.
- **Support for collaboration spaces.** Thunderbolt 3 technology-based docks work with Thunderbolt 3 technology- or USB-C*-based PCs and Macs*, can charge as well as dock, and are easy to set up. This combination of features makes Thunderbolt 3 technology a good solution for all employees enjoying Intel's "free address" open floor design workspaces.
- **Future-readiness.** Thunderbolt 3 technology can be used in future use cases, such as connecting 4K displays and providing an external graphics unit for added graphics power without increasing PC weight.

Based on our positive testing results, Thunderbolt 3 technology docks are now being deployed at Intel as our plan-of-record docking solution.

Thunderbolt™ 3 Technology Dock Benefits for Intel IT



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Port Simplification

One port for charging, USB*, PCI Express*, and other Thunderbolt™ 3 devices



Charge and Dock

OS independent for Intel's "free address" open floor design workspaces



Future-readiness

Connection for future use cases such as 4K displays and external graphics unit

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Acronyms

PoC proof of concept

TCO total cost of ownership

Business Challenge

Intel's office workers are highly mobile and are primarily equipped with laptops or notebooks, most of which have limited display and USB* connections. But many use cases require employees to use two displays as well as a USB-based keyboard, mouse, and headset—mandating the use of a dock. A dock allows a single cable from the notebook or PC to enable an entire fleet of peripherals ready to run from that one cable. This solution enables employees to easily connect their notebook to multiple displays (including 4K models), an external keyboard and mouse, USB devices, and more, all while charging their notebooks over that same cable. Intel IT observes that nearly all of Intel's office workers are using some sort of docking technology during their daily work.

Reducing Environment Complexity and Total Cost of Ownership

In our current environment, Intel's employees can choose between three dock solutions:

- **Mechanical dock.** These docks rely on a mechanical interface (not a driver) that is usually OEM- and device-specific (for example, a workstation and a notebook from the same OEM have different docks, and some models do not have any mechanical dock solution).
- **Docks based on another driver technology.** These docks typically use a USB or USB-C* connection and require one or more drivers (such as DisplayLink* virtual graphics card software) for full functionality, including multi-monitor support. Often, such devices are touted as universal docks. Those that utilize a chip and drivers to compress and decompress the video stream have an impact on the host system performance and may also affect the performance of non-display devices connected to the dock. For example, if most of the dock's bandwidth is consumed by output to displays, then there may not be enough bandwidth left for full USB device performance.

With docks that do not rely on compression of the video signal, display bandwidth is limited, thereby precluding support for configurations like desktops with dual 4K/60 Hz monitors.

- **Docks based on Thunderbolt™ technology.** Intel IT now supports Thunderbolt 3 technology through the USB-C interface. Currently, we have about 27,000 active Thunderbolt 3 technology docks in our environment across three generations of PCs.

Each of these docking solutions has its advantages and disadvantages. In our experience, mechanical docks are quite stable. While they may have occasional mechanical failures, they tend not to experience many software-based issues. However, the wide variety of proprietary interconnections translates to higher support costs because there are so many different types that must be tracked and managed. Also, as OEMs design thinner PCs, there are fewer options for mechanical docking solutions.

Non-Thunderbolt technology docks may not always charge laptops, requiring users to use a separate charging plug connected to the PC. Our experience has also shown that non-Thunderbolt technology docks have more compatibility issues with Microsoft Windows* feature updates compared to Thunderbolt technology docks and thus require more maintenance—raising total cost of ownership (TCO). Mac* support for non-Thunderbolt technology docks can also be problematic. Using a Thunderbolt technology dock, we have found that most PCs will charge regardless of the dock manufacturer.¹

To save time, money, and resources, we need to standardize on a common dock across Intel's PC fleet. The chosen dock must have low support overhead. For that reason, we have selected Thunderbolt technology docks as the plan-of-record docking technology.

Supporting Workplace Transformation and Optimal User Experience

As part of Intel's workplace transformation efforts, many buildings offer "free-address" floor designs (also called "hoteling"), where there are no assigned spaces—people simply sit down and are ready to work with little or no setup. While this open floor design is great for collaboration, it does pose some technical challenges for Intel IT. For example, because mechanical docks are designed specifically for a particular physical device, they do not support this work scenario. Intel employees have different use cases that are best supported by different laptop and notebook designs; unless we want to impede employee productivity by deploying a single PC model for everyone, mechanical docks are not an option for collaborative spaces.

¹ Workstation laptops with high power demands are an exception; they always require an external power supply.

And while both Thunderbolt technology and other single-cable docks serve in collaborative spaces, the fact that non-Thunderbolt technology docks can't be relied on to charge all PC models is a serious disadvantage.

User experience is also a consideration for our choice of docking solution. In the Intel delivery model, docks are usually shipped directly to the user. The dock connections

must be simple enough for the majority of users to set up the dock themselves with little to no support from IT.

To support all work environments, ranging from a standard office cubicle to the manufacturing cleanroom to an open floor design, we need a universal, simple dock that meets all employees' needs.

A Closer Look at Thunderbolt™ 3 Technology

Before Thunderbolt™ technology was introduced by Intel, connecting multiple displays required either a desktop cluttered with a spaghetti of specialized cables (see Figure 1) or a large, clunky mechanical dock, which required thicker, heavier notebooks.

The Thunderbolt™ interface arrived in 2011, supporting the connection of several peripherals using a single cable. Initially, Thunderbolt technology's bandwidth was 10 Gb/s and it used the same physical connector as Mini DisplayPort*. Thunderbolt™ 2 technology doubled the performance of the connection to 20 Gb/s, utilizing the same connector and cable solution. Then, in 2015, the Thunderbolt™ 3 protocol doubled the solution's bandwidth from 20 Gb/s to 40 Gb/s. Thunderbolt 3 technology also added host compatibility with all USB* devices using an integrated USB host controller, expanding the interfaces supported over a single cable. In addition, Thunderbolt 3 technology uses a USB-C* connector instead of the Mini DisplayPort connector. This new connector is ideal for new, thinner notebooks and offers ease-of-use improvements that enable flippable, reversible cables.

The top benefits of Thunderbolt 3 technology are as follows:

- **Versatility.** The Thunderbolt 3 connector supports a wide range of communication protocols—legacy and modern—including Thunderbolt technology, DisplayPort, various flavors of USB, and PCI Express* (PCIe*) over Thunderbolt controllers.
- **Performance.** With bandwidth up to 40 Gb/s, Thunderbolt 3 technology is designed to handle the expected avalanche of connected devices. For example, the average number of connected devices per person in 2010 was 1.84. By 2020, that number is expected to increase to 6.58.²
- **Universality.** The goal of Thunderbolt 3 technology is interoperability across different computer and peripheral suppliers with consistent performance and reliability. Intel supports an industry-wide certification program that involves electrical and functional testing to help ensure high quality and interoperability across the Thunderbolt 3 technology ecosystem.
- **Daisy chain.** Thunderbolt™ devices can be connected to each other, rather than running the cable all the way to the PC or dock. A common use case is for Thunderbolt technology-based monitors to be connected to each other.
- **Peer-to-peer networking.** Very easy and fast way to transfer big images from one PC to another. A common use case is provisioning of systems and another use case is backup disk drives.

² Statista, "Number of network-connected devices per person around the world from 2003 to 2020," [statista.com/statistics/678739/forecast-on-connected-devices-per-person/](https://www.statista.com/statistics/678739/forecast-on-connected-devices-per-person/)

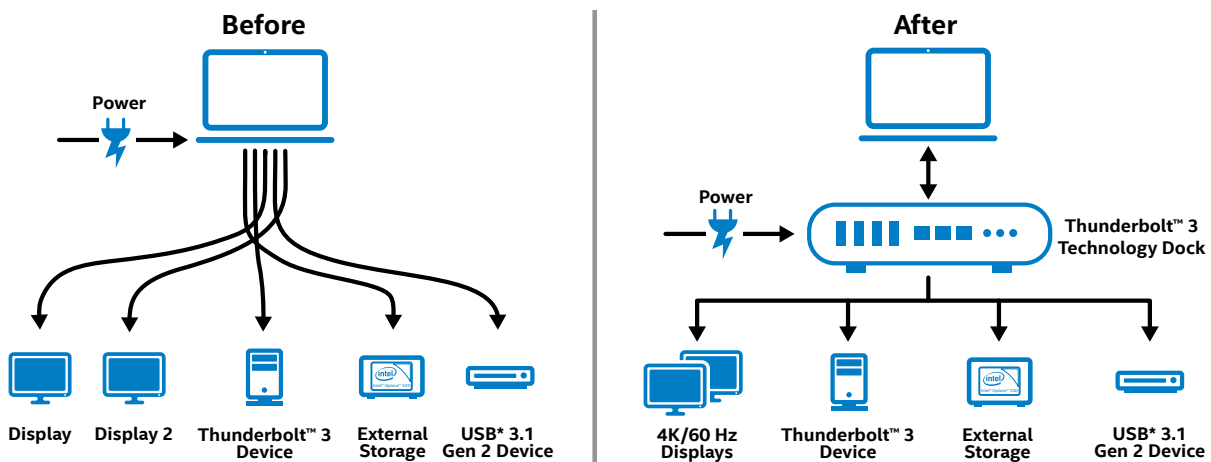


Figure 1. A Thunderbolt™ 3 technology docking solution reduces legacy cable clutter and provides a single, high-performance point of connection for many peripherals while also providing power to the PC.

Thunderbolt™ 3 Technology: Our Testing and Results

To meet our needs for a common, universal, and simple docking solution, Intel IT has been working to confirm that Thunderbolt 3 technology delivers benefits across three areas:

- **The path to simplification.** Thunderbolt 3 technology will allow us to reduce the total number of different dock models in the environment. As a result, we will have fewer sub-populations of docking solutions to maintain and validate, reducing TCO.
- **Support for free address use cases.** Intel is committed to creating a modern working environment, and Intel IT has an important role to play in supporting these efforts. Thunderbolt 3 technology is one of only a few solutions that will work for this use case in our environment, as well as working for other use cases, such as stations needing to support 4K/60 Hz displays. Moreover, the Thunderbolt 3 technology docks are easy for users to set up.
- **Future-readiness.** Thunderbolt 3 technology will scale beyond what it does today and brings some very interesting new use cases into reality. For example, the possibility of added graphics capability with an external graphics unit could give users a lighter PC for remote use but provide added graphics power when docked. In this case, the weight of the PC could go from six pounds to just three or four pounds. This could both improve the user experience and lower costs. Thunderbolt technology can also be used to support dual 4K/60 Hz monitors (unlike USB-C docks). While the majority of Intel employees do not currently use 4K monitors, it is highly possible that as monitors are refreshed, new monitors may be 4K and will require Thunderbolt technology's high bandwidth.

Typically, when we introduce new technology into our environment, we perform market evaluation, followed by lab testing by our engineers. Then, if the testing goes well, we conduct one or more proofs of concept (PoCs), followed by production deployment. This is the general process we followed when making Thunderbolt 3 technology our plan-of-record docking solution.

Lab Testing and Early PoC

IT engineers configured our prototype docks with two- and three-display laptop configurations, complete with attached keyboard, mouse, and audio to mimic what we commonly see at Intel employees' desks. We emphasized the element of *repeatability* at this stage. Could we remove notebooks and return them, over and over, and realize identical user experiences? Across all lab tests, we experienced no significant issues with performance or repeatability.

Next, we performed limited beta testing across a 25-user sample base working in real-world office conditions. Generally, we and the users were pleased. However, we learned an important lesson: drivers matter. Some of the 25 testers used relatively old laptops from various OEMs. On one hand, this proved that our docks worked with various systems—even non-Windows-based PCs. On the other hand, outdated drivers and firmware did cause some functionality issues. Updating drivers and firmware remedied the problems, but this indicated a possible need for preemptive updating by IT before broad dock deployment.

Wider Adoption

Following our 25-user test, we rolled out Thunderbolt 3 technology docks (produced by an OEM that designed its products to our reference design specifications) to a wider audience of several hundred. After weeks of regular use, we conducted a survey. As we'd hoped, the majority of the responses were positive and yielded comments such as these:

- "Better monitor support—full high-definition and 4K external on dual displays—whereas my old dock was just high-definition external. Fewer crashes by far. Fewer USB and audio problems."
- "More stable, didn't experience any blue screens or hangs on dock/undock compared to other OEM dock."
- "My OEM dock would have complete loss of devices—network and display drop out at least once a day. Efforts to update every driver and uninstall/re-install many programs were in vain. This new dock completely fixed the issue. I hate to give it back because it works better than my OEM dock."
- "I really like that I can finally drive three screens and power with just a single Thunderbolt technology dock."
- "Better connectivity, especially with display ports, which I need to support IT monitors."

Not surprisingly, the driver and firmware concerns encountered in the 25-user tests remained. Some users were unable to interact with some peripherals, slow system response, or other erratic behavior. Again, driver and firmware updates corrected most of these issues.

**"I really like that I can finally drive three screens
and power with just a single Thunderbolt
technology dock."**

Lessons Learned

Thunderbolt 3 technology is in full production deployment. To date, we have deployed more than 27,000 Thunderbolt 3 technology-based docks across three generations of PCs, and the feature is now standard on all laptops and workstations purchased by Intel IT.

After extensive evaluation of Thunderbolt 3 technology, we see several benefits from the new docking solution:

- **Lower environment complexity.** Cross-platform docking means that Thunderbolt 3 technology-based docks can remain in service wherever and whenever needed within the workplace. Over time, we expect OEM drivers to become more homogeneous, further improving ease of use and a seamless user experience.
- **Simplified management.** Intel designs its docking solutions to the Thunderbolt 3 technology standard, so there is significantly reduced risk of design variances causing unforeseen incompatibilities.
- **Native Windows support.** Windows 10 now integrates native Thunderbolt 3 technology support, further improving workplace compatibility, reducing management complexity, and simplifying deployment.
- **Thinner PCs.** With each successive notebook generation, PCs become thinner as legacy USB and other ports give way to the smaller USB-C interface that carries the Thunderbolt 3 protocol and other common PC protocols.
- **More capability.** With Thunderbolt 3 technology docks, users can utilize dual 4K/60 Hz monitors and still provide bandwidth for USB or Thunderbolt 3 technology peripheral devices. Additionally, our tests prove that docks based on Thunderbolt technology can be more reliable for charging than non-Thunderbolt technology, USB-C alternatives.

Conclusion

These rewarding deployment experiences have reaffirmed Intel's commitment to standardizing on Thunderbolt 3 technology. Based on our research, this solution meets Intel IT's needs while paving the way for future growth, and we will continue to share it across Intel's workforce.

Thunderbolt 3 technology is not a perfect solution and does incur some added maintenance costs (particularly around driver and firmware updating) beyond those of mechanical docks. However, all dock technologies require firmware updates from time to time, regardless of connection method. Overall, the benefits to Intel IT of adopting Thunderbolt 3 ports and docking solutions have significantly outweighed any minor shortcomings, most or all of which are shared with traditional USB docking options.

Our priority is to make this the docking technology used by Intel because of its simplified connectivity and universality. In doing so, we will **lower IT costs, reduce SKU sprawl** (and the associated support complexity), **improve worker productivity**, and make Intel's work environments better prepared to embrace the computing needs of tomorrow.

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