THE DEVELOPMENT OF THE USB STANDARD

An Interoperability Case Study

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In 1994, Intel teamed up with several other companies to create the Universal Serial Bus (USB) as an industry standard to improve hardware interface interoperability. Hardware interfaces are the ports, plugs, cables or electronic signals carried from a computer to a peripheral device or network.

The standard was developed in response to the problems caused by the use of many different types of cable to transfer data and power, and to attach peripheral devices to computer hardware. This time-consuming multiplicity meant that devices were often incompatible with users' computer hardware. The USB soon replaced a wide variety of ports. It has since become an accepted universal standard to attach many peripheral devices, such as keyboards, printers and mobile devices, to computer hardware.

BEFORE THE STANDARD

Before the USB became standard, users needed multiple hardware interfaces to connect computing devices and for data transfer and charging. Every accessory had its own connection configuration and hardware requirement, which was often specific to a particular device.[1] This resulted in computers having various cable ports and products having various cables, often making them incompatible.[2]

This meant that certain types of computer hardware and peripheral devices could not be connected with each other. Naturally, this was a big headache for consumers. They had to check carefully that their accessories were compatible with their hardware or buy a port extension.

Even if the cable and cable ports were compatible, each device communicated differently with the computer hardware. To get around that problem, the user had to install separate software. As they added more devices, the computer might become slower and occasionally crash.

THE IMPACT OF MULTIPLE STANDARDS

In short, before standardisation consumers had a tough job choosing interoperable devices and cables. Computer hardware manufacturers had to choose which ports and connections to include in their hardware. Physical space, user functionality and licensing fees tended to limit the number of ports offered. The lack of standards weakened competition between computer hardware providers.

Consumers who had invested in peripherals supported by one manufacturer were wary of buying hardware from another maker if their peripheral devices were not compatible. As a result, they were "locked in" to a degree to the original supplier. Furthermore, the existence of multiple standards lessened competition for peripherals since consumers tended to choose accessories compatible with their computers. Moreover, manufacturers were unwilling to invest in devices using standards which had only limited take-up.

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[1] Arc Technica, *A brief history of USB, what it replaced, and what has failed to replace it*, August 2014 - https://arstechnica.com/gadgets/2014/08/a-brief-history-of-usb-what-it-replaced-and-what-has-failed-to-replace-it/

[2] Kensington, *The Evolution of USB: What the New WSB-IF Specifications Mean for Users*, October 2020 - https://www.kensington.com/en-gb/News-Index---Blogs--Press-Center/Docking--Connectivity-Blog/the-evolution-of-usb-what-the-new-usb-if-specifications-mean-for-users/

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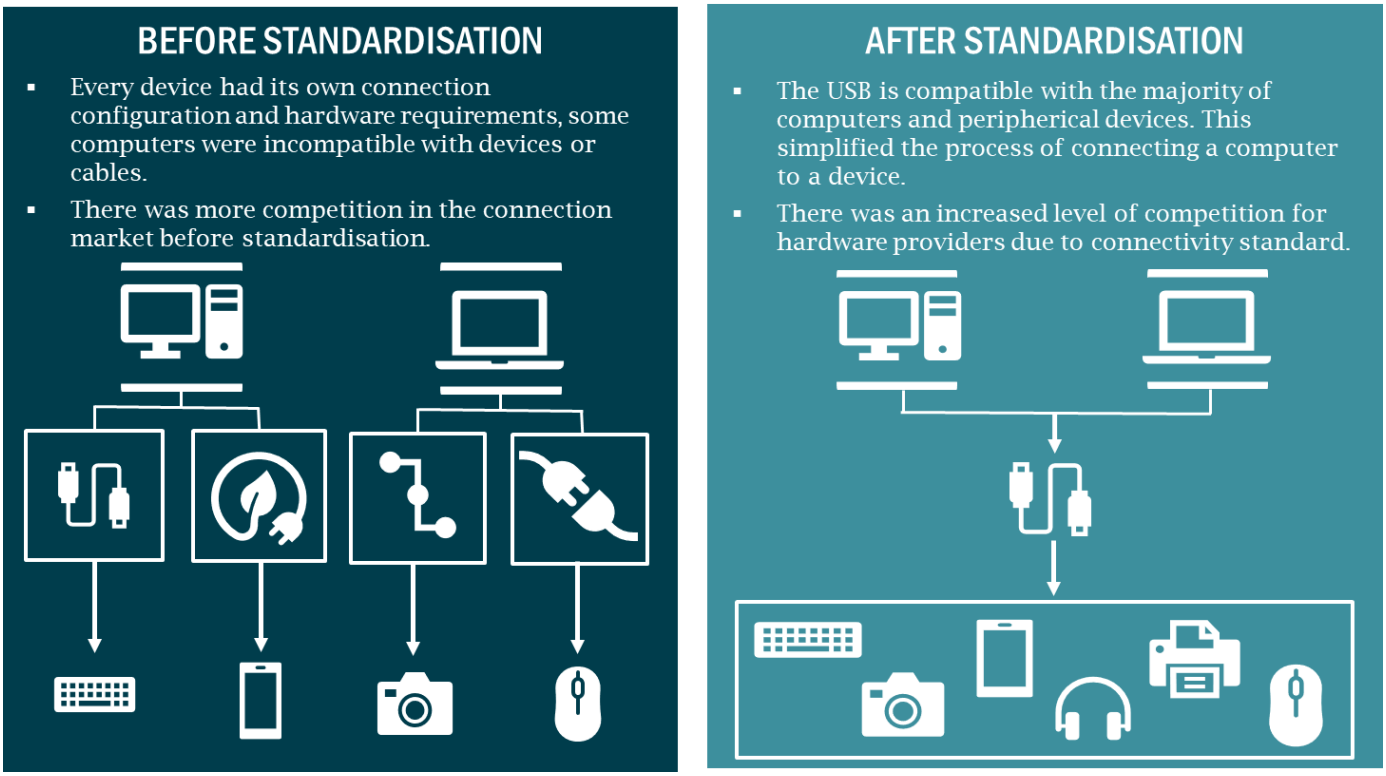
FIGURE 1 PROCESS OF CONNECTING COMPUTER HARDWARE TO PERIPHERAL DEVICES



Source: Frontier Economics

WHAT LED TO THE STANDARD

The development of the USB was an example of private companies collaborating to set standards that benefited the whole industry. Intel took the initiative in 1992 with the aim of simplifying computer connectivity. The first USB was designed to be small and cheap. It worked by acting as a translator for the different communication methods of peripheral devices. By enabling computers to process requests from multiple competing accessories, a large number of devices could be used at the same time.

Intel was granted a patent for the USB technology in 1997. However, patents can be problematic for companies trying to establish standards. That's because they are designed to give the patent holder control of how the new technology is used - or even to exclude other companies from using it. A tight grip over the patent, or high licensing fees, would have prevented the USB's widespread adoption.

Intel, then, needed to involve more firms if it wanted companies and consumers to trust the USB.[3] The group of companies developing the standard had to be small enough to respond quickly to change, but large enough to be representative of the entire industry. This led to Intel to set up the "USB Promoter Group". There were six members initially - Apple, Hewlett-Packard, LSI, Compaq, IBM and Microsoft – but Apple later quit because it was producing FireWire, a USB rival.

To overcome the barriers to industry collaboration, Intel assigned its patent to a "patent pool". In such a pool, the associated rights are aggregated among multiple patent holders and each one is allocated a share

[3] European Patent office, *A truly universal connection*, January 2017- https://www.epo.org/news-events/events/european-inventor/finalists/2013/bhatt/feature.html

of the licensing fees. The arrangement meant that participants in the pool were free to create products that supported the USB standard.

Patent pools are often used for standardisation because common standards rely on complementary technology created by competing firms. The main advantage is increased efficiency. The creation of a patent pool acknowledges that collaborating rivals are more likely than a standalone company to produce a universal standard.

To spur the development and use of USB technology, the initial promoters set up a support group of more than 700 companies. This "Implementers Forum" (USB-IF) was tasked with encouraging a wide range of firms, not just computer manufacturers and software providers, to adopt the USB.[4] The diverse membership of the group was vital to the USB's adoption and continuous development.

Initially, however, there was a reluctance to rely solely on the USB as a connector. It was not until the late 1990s that computer companies began to use it more widely. By 2011, seven billion USB-equipped devices were produced globally.[5] The USB has evolved over the years. There have been many different versions, with varying connection speeds and types of cables. However, the port has remained a constant for most peripheral devices, including mice, keyboards and printers. In 2019, manufacturers worldwide churned out USB devices valued at $31 billion.[6]

COMPETING STANDARDS MAY HAVE SPURRED INNOVATION

The first version of the USB in 1996 transferred data at a speed of 1.56Mbps. With the 2019 version the speed had reached 40,000Mbps. Each iteration down the years has also improved the power transfer rate and provided additional functionality.

Competing connection and port technologies may have acted as a spur to the continued enhancement of the USB. Apple in particular established a number of standards for use on its own hardware and devices that it licensed to third parties. Notably, FireWire, developed in the late 1990s, offered much faster speeds (400Mbps) than the USB available at the time. And, unlike the USB, FireWire was able to transfer data in both directions simultaneously.

As FireWire gained market share in high-end storage products and video equipment, USB developers responded in 2000 by launching the USB 2.0. This nominally boasted better maximum performance (480Mbps) than FireWire, though it performed less well in some tests.[7] Ultimately, the USB's widespread compatibility and low licence fees limited demand for FireWire. By 2003, Apple was using the USB in combination with FireWire on its own hardware, and by 2005 it had withdrawn FireWire 400.

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[4] USB-IF, About USB-IF - https://www.usb.org/about

[5] European Patent office, *A truly universal connection*, January 2017 - https://www.epo.org/news-events/events/european-inventor/finalists/2013/bhatt/feature.html

[6] Business wire, *Global USB Devices Market Forecast to 2027*, April 2021- https://www.businesswire.com/news/home/20210406005601/en/Global-USB-Devices-Market-Forecast-to-2027---Surging-Adoption-of-USB-Type-C-in-Medical-Industry-Presents-Opportunities---ResearchAndMarkets.com

[7] Daniel Knight, *Why FireWire Failed- but Thunderbolt won't*, May 2011 - https://lowendmac.com/2011/why-firewire-failed-and-thunderbolt-wont/

HOW THE STANDARD IMPROVED OUTCOMES

Cable standardisation has made life more convenient. Instead of wasting time hunting for compatible peripheral devices, consumers can choose any accessory with a USB connection and know it will be compatible. And they have a galaxy of suppliers to choose from.

The wide membership of the USB-IF has maintained pressure to keep improving the standard, benefiting both consumers and developers of new software and hardware. It is, of course, difficult to know how port and connection technology would have evolved without the USB. Wired or wireless technologies might have developed more rapidly if companies had not been married to the standard; the spread of wireless chargers and data transfer may have been held back.

On the other hand, standardisation has ensured that manufacturers can take a clear view of how their products will be connected with computers, reducing the risks inherent in designing new devices. This has led to a wave of innovation. The standardised port has enabled greater connectivity with Wi-Fi adapters, optical drives, Ethernet ports and mobile network dongles.

By making users' existing accessories compatible with any new hardware, the standardised USB port means fewer electronic devices are discarded, reducing waste. This lowers demand for raw materials and cuts CO2 emissions from the production of accessories and cables.

CONCLUSION

The conclusions to be drawn from the development of the common USB standard are broadly positive.

First, there have been clear benefits for consumers. By making it easier to attach peripheral devices and transfer data, the USB has led to efficiency gains for consumers - and also for developers.

Second, the standard has intensified competition in computer hardware and peripherals. Suppliers have a wider pool of potential customers, while consumers are less likely to be locked in to a specific standard.

Third, the common standard has brought environmental benefits. There are positive externalities from the USB, including reductions in electronic waste, the use of resources and CO2 emissions.

Fourth, the patent pool has enabled disparate suppliers to coalesce around an agreed standard. Without the patent pool, it would arguably have been much harder for suppliers to settle on a standard. The USB paved the way for competing companies to collaborate on innovations.

Fifth, the standard has not led to ossification. The USB continues to develop as a standard, supported by its industry bodies. Cooperation within the industry was an essential factor. Many firms collaborated to ensure the USB was fit for purpose. However, it is at least possible that competing standards would also have driven innovation.

Sixth, a degree of competition around the standard persists that is likely to incentivise innovation. The competition comes from innovative technologies developed by major companies, including Apple and Intel, as well as from alternatives to the USB such as wireless connectivity and charging.

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