Difference between ARM and Intel processors

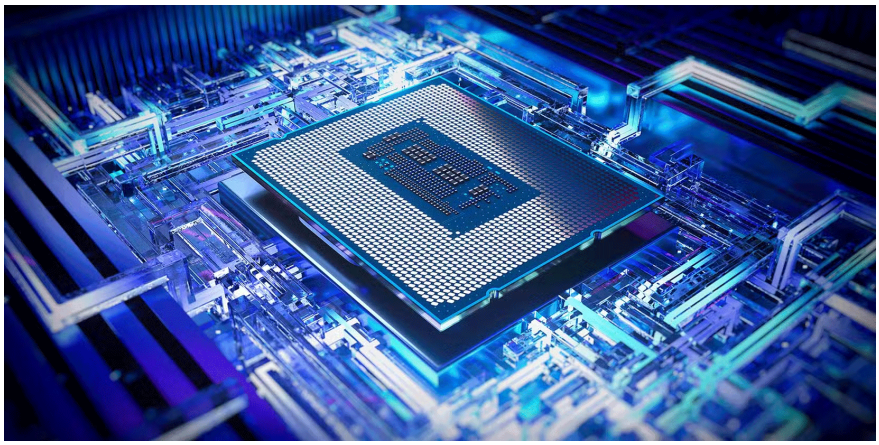
Now, ARM is a direct competitor to Intel. So how exactly are they different and which processor is better?

ARM and Intel are two companies that design microprocessors that are used in most electronic devices today. ARM processors are known for their power efficiency in mobile devices, while Intel is known for its high-performance microprocessors used in personal computers and servers.

However, in recent years, ARM chips have become popular for personal computers, especially laptops. Now, ARM is a direct competitor to Intel. So how exactly are they different and which processor is better?

ARM and Intel are the two technology companies that dominate the digital world.

ARM and Intel are two technology giants that manufacture different types of microprocessors for the electronics market. Both companies have their own ISA (Instruction Set Architecture) that they have exclusive rights to use and license. Intel's ISA is called the x86 architecture, which uses the CISC (Complex Instructions Set Computing) design philosophy. ARM's ISA is the ARM architecture, which uses the RISC (Reduced Instruction Set Computing) design philosophy.



Until recently, Intel designed and manufactured all of its processors in-house, but it has now moved to a foundry model. This allows Intel to expand its manufacturing capacity to third-party foundries like TSMC and gain more advanced manufacturing capabilities, making Intel's more difficult-to-manufacture chip designs possible.

In contrast, ARM partners with companies like Apple and Samsung to design processors using its ARM architecture while using third-party foundries to manufacture the chips. That's why you'll see many ARM-based

smartphone processors, such as Qualcomm Snapdragon, Samsung Exynos, MediaTek Dimensity, and Google Tensor, come from different companies despite being classified as ARM processors.

Now that you understand how both companies work, let's talk about the differences between their processors and how they can affect overall performance.

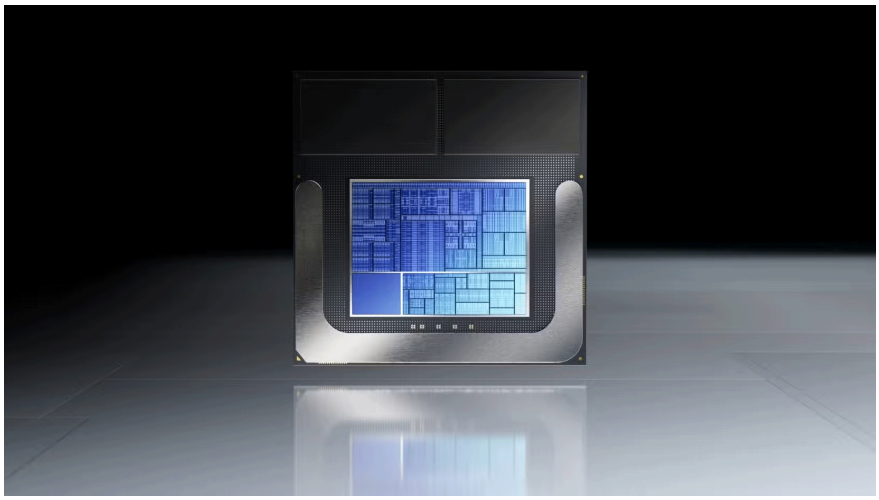
Difference between ARM and Intel processors

Just a few years ago, ARM was primarily seen as a low-power processor used for handheld devices. However, with Apple's Apple Silicon M series of chips and Qualcomm's Snapdragon X Elite processors entering the market, ARM is trying to compete directly with Intel.

So, what is an Intel x86 processor and how is it different from an ARM processor?

1. Instruction Set Architecture (ISA)

As discussed earlier, ARM processors use RISC, while Intel processors use CISC as the design philosophy for their ISA. RISC processors use simpler, fixed-length instructions that execute in a single clock cycle. This simplicity can lead to greater efficiency in terms of power and heat dissipation.



CISC processors, on the other hand, have more complex instructions that can perform multiple operations on a single instruction. This design philosophy emphasizes flexibility and is often used to create extremely complex software at the cost of low power efficiency and higher temperatures.

However, the distinction between RISC and CISC has become blurred over time. For example, modern ARM processors can now combine complex instructions for better performance, while the latest Intel processors use techniques like microcompilation, which breaks down CISC instructions into simpler RISC-like operations for better energy efficiency on simpler tasks.

2. Software compatibility/support

Because the x86 and ARM ISAs are based on two very different design philosophies (RISC and CISC), software created for Intel chips cannot be natively executed on ARM processors, and vice versa. Developing most programs on a specific architecture ensures that consumers will buy the company's processors simply because of the large number of applications available.

If you've ever looked for a new desktop CPU, you've probably noticed that your only options are either Intel or AMD processors. This is because most computer programs are designed for x86 processors. Since only Intel and AMD (who own the x86 license) can run these programs natively, they have successfully created a monopoly on the desktop PC processor market.

On the other hand, ARM processors are exclusive to smartphone processors because the smartphone operating system and applications have been specifically programmed to run on ARM chips.

With Apple Silicon and Qualcomm Snapdragon X Elite processors now available in laptops, it seems like ARM chips are making inroads into the PC market as well. However, ARM is currently struggling with software support and compatibility.

Apple's move from Intel processors to Apple Silicon has left many Intel-based apps unusable without the Rosetta 2 emulator. While developers are now trying to catch up in developing Universal apps to run natively on Apple Silicon chips, it will be some time before all apps are natively supported on newer Macs.

Likewise, while the Snapdragon X Elite laptop runs Windows and can run Windows apps, those apps don't run natively on ARM processors. Yes, Windows on ARM is getting better at emulating apps, but in its current state, the performance drops and bugs you'll encounter from emulation are still pretty significant.

3. Performance

While the line between x86 and ARM performance is blurred, Intel processors still outperform ARM processors in specific software categories. This advantage is not due to x86 (which is inherently better for high performance), but rather because many applications are optimized to take advantage of x86's strengths. Workloads that require consistently multi-threaded performance, such as gaming, video editing, CAD, and virtualization, often use x86's advanced scripting and robust ecosystem to maximize the hardware's capabilities.

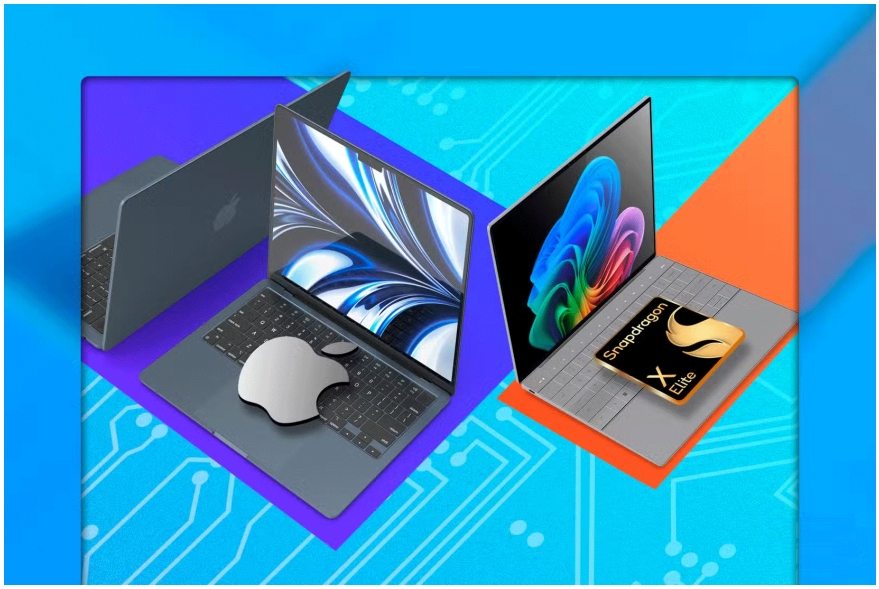
However, with modern ARM processors capable of out-of-order execution and wide instruction pipelines, the performance gap between x86 and ARM is narrowing. Additionally, applications that rely on simpler instructions or prioritize efficiency can easily maximize the capabilities of ARM hardware, delivering excellent performance while still saving power. This makes ARM especially competitive in mobile and power-constrained devices.

As ARM development platforms gain more developer support, more applications will run natively on ARM and developers will be able to optimize for ARM hardware and increase software performance over time.

ARM has demonstrated competitive performance with Apple's M-series chips, outperforming many x86 processors in specific workloads while still maintaining excellent performance. As more developers optimize software performance for ARM hardware, ARM could compete with or even surpass x86 when it comes to performance. Of course, the emphasis here is on 'could,' as Intel chips are improving every year and still lead the way when it comes to running multi-threaded software.

4. Energy efficiency

Because many applications take advantage of x86 hardware, Intel CPUs consume more power to maintain performance. This leads to higher temperatures and shorter battery life on laptops. But like ARM, Intel has found ways to improve on its weaknesses. Modern Intel processors use micro-instruction switching, package sleep states, and integrated RAM into the SoC (System on Chip) and hybrid CPU architectures to make the processor more power efficient.



However, ARM processors still generally offer longer battery life than Intel CPUs because the RISC-based architecture is more power efficient by default.

ARM or Intel processor better?

With ARM-based processors like Apple Silicon and Qualcomm's Snapdragon X Elite showing promising results in terms of raw computing power, heat, and power efficiency, it seems likely that ARM chips will be the future of mobile PC computing. However, this will only be possible if ARM gains more support and developers write and optimize software for the ARM architecture.

If that happens, it doesn't necessarily mean ARM is better than Intel. While ARM processors may have a big advantage in laptops, x86 still offers superior computing power and decades of developer support. As people prioritize performance and high-end computing tasks for their desktops, x86 will likely continue to be the dominant processor for desktops, where battery life isn't an issue and temperatures are easier to control. Additionally, x86 SoCs like Intel's Lunar Lake processors are becoming more and more power-efficient.

So, which processor is better?

Because of the improvements on both sides and the many variables we have to consider when making a judgment, it's hard to give a definitive answer. However, ARM chips are still more power efficient than Intel processors, and Intel chips are generally more efficient than ARM chips. So if you're looking for a laptop with long battery life, you might find an ARM processor better. Conversely, if you're into desktop gaming, you might find an x86 processor from Intel or AMD better.