

The Modern Computer

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Supplemental Reading for CPUs

CPU cache and overclocking

In this reading, you will learn about the various levels of cache for central processing units (CPUs) and how a CPU processes and executes instructions. Additionally, you will learn about overclocking CPUs to maximize processing speeds. IT Support professionals may use this information when purchasing, allocating, and/or configuring high-performance servers.

Cache

You may already be familiar with the term “cache”. In computer jargon, cache (pronounced “cash”) refers to a small amount of recently used data that is stored either on hardware or in software. The first time data is accessed, both the initial request for the data and the reply containing the data pass through multiple points on their journey. Depending on several variables, these points might include I/O devices, motherboard busses, RAM, cables, hard drives, applications, networks, the internet, cloud platforms, and more. If a computer needed to use these full paths everytime it tried to access data, the entire transaction could take a relatively long time. Cache speeds up this process by holding a local copy of the most recently accessed data in temporary storage.

CPU cache

CPUs use a system of cache storage to help them quickly access data. A CPU cache is normally stored inside each core of the CPU. Older computers might store CPU cache in a transistor chip that is attached to the motherboard, along with a high-speed bus connecting the chip to the CPU.

CPU levels of cache

There are three levels of CPU cache memory:

- **Level 3 cache:** L3 cache is the largest and slowest of CPU cache. However, it is often twice as fast as RAM. L3 is the first CPU cache location to store data after it is transferred from RAM. L3 cache is often shared by all of the cores in a single CPU.
- **Level 2 cache:** L2 cache holds less data than L3 cache, but it has faster access speeds. L2 holds a copy of the most recently accessed data that is not currently in use by the CPU. Each CPU core normally has its own L2 cache.
- **Level 1 cache:** L1 cache is the fastest and smallest of the three CPU cache levels. L1 holds the data currently in use by the CPU. Each CPU core usually has its own L1 cache.

Overclocking a cpu

Overclocking a CPU sets it to run at a higher CPU clock frequency rate than the manufacturer’s original specifications. For example, if a processor is labeled as having a 3.2 GHz base frequency rate, it may be possible to overclock the CPU to run at 3.5 GHz. Achieving a higher CPU clock frequency rate means the CPU can process a higher volume of instructions per nanosecond, resulting in faster performance. A computer user might want to overclock their CPU to improve sluggish speeds when performing processor-intensive tasks, like video editing or gaming.

Overclocking a CPU’s frequency involves three variables:

- The base CPU clock frequency, often measured in GHz.
- The core frequency, which is calculated by multiplying the base frequency by the CPU core multipliers.
- The core voltage, which needs to be increased in small increments to meet the increasing power demand of the CPU during the overclocking process.

Warnings on overclocking

Overclocking the CPU can damage the computer if not configured properly. Operating a CPU at a higher speed can overheat the CPU and surrounding hardware, which can cause the computer system to fail. Additionally, overclocking the CPU can shorten the overall lifespan of the computer and void the computer’s warranty. It is better to avoid overclocking the CPU and instead purchase the appropriate CPU speed necessary to meet computing demands.

How to overclock a CPU safely

As an IT Support professional, you may be asked to overclock a CPU. There are steps you should follow to do this as safely as possible. Always make sure that the requestor understands the risks of overclocking before agreeing to perform this procedure.

1. **Check if overclocking is supported:** First, make sure the CPU is a model that is unlocked for overclocking. Not all CPUs can support overclocking, including most laptop CPUs. Check the CPU manufacturer’s documentation to determine if overclocking is possible for the CPU model. Both Intel and AMD provide overclocking guides and tools for supported CPU models (see below for links to these guides). Additionally, check the documentation for the computer’s motherboard model to ensure that it can support an overclocked CPU.
2. **Clean the inside of the computer:** Turn off and unplug the computer. While wearing an anti-static wristband, open the computer and use compressed air to remove any dust build-up that has accumulated. It is especially important to remove any dust from around the CPU, fans, and intake vents.
3. **Ensure an appropriate CPU cooler is installed (critical):** If the computer has a stock CPU cooler, it is most likely insufficient for cooling an overclocked CPU. Replace the stock CPU cooler with an advanced cooling system, like a liquid cooling system.
4. **Follow the manufacturer’s instructions for overclocking the CPU:** Using the detailed instructions from the manufacturer (see below for links to Intel and AMD’s guides):
 - a. Use benchmarking software to establish a baseline for the normal performance of the computer.
 - b. Set each CPU core multiplier to the value of the lowest multiplier using either the manufacturer’s overclocking software (recommended) or the BIOS. Then reboot the computer.
 - c. Increase each CPU core multiplier by 1 to increase the CPU frequency.
 - d. Test each increase for stability using the testing utility provided by the manufacturer.
 - Fix any problems flagged by the testing tools, especially temperature alerts. If the system becomes too unstable, roll back to the last frequency that produced a stable performance and stop overclocking the CPU.
 - If the voltage appears to become insufficient to support the new frequency, increase the voltage by 0.05V. Do not increase the voltage above 1.4V without specialized cooling hardware.
 - If the computer freezes or crashes, it has either become completely unstable or the CPU is not getting enough voltage to support the overclocked frequency. Use the BIOS to return to the last stable frequency or increase the voltage in 0.01V increments until stable.
 - e. If stable, reboot the computer before attempting the next increase.

Resources for more information

- **Intel: Overclocking: Maximize Your Performance** - Intel’s all-inclusive guide to overclocking CPU, RAM, and motherboard. The site also provides utility tools for fine-tuning overclock performance and lists Intel CPU models that support overclocking.
- **AMD: AMD Ryzen™ Master Utility for Overclocking Control** - AMD’s toolkit for overclocking Ryzen processors. Note that overclocking support for non-Ryzen models is no longer recommended by AMD.
- **AMD: Ryzen™ Processor Overclocked Memory Compatibility List** - List of AMD Ryzen CPU models that support overclocking.
- **AMD: How to Overclock Your AMD Ryzen CPU** - Instructions for overclocking AMD Ryzen CPUs from PC Magazine.

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