Contents

Foreword

In the previous century, most computers used for scientific and technical programming consisted of one or more general-purpose processors, often called CPUs, each capable of carrying out a diversity of tasks from payroll processing through engineering and scientific calculations. These processors were able to perform arithmetic operations, move data in memory, and branch from one operation to another, all with high efficiency. They served as the computational motor for desktop and personal computers, as well as laptops. Their ability to handle a wide variety of workloads made them equally suitable for word processing, computing an approximation of the value of pi, searching and accessing documents on the web, playing back an audio file, and maintaining many different kinds of data. The evolution of computer processors is a tale of the need for speed: In a drive to build systems that are able to perform more operations on data in any given time, the computer hardware manufacturers have designed increasingly complex processors. The components of a typical CPU include the arithmetic logic unit (ALU), which performs simple arithmetic and logical operations, the control unit (CU), which manages the various components of the computer and gives instructions to the ALU, and cache, the high-speed memory that is used to store a program's instructions and data on which it operates. Most computers today have several levels of cache, from a small amount of very fast memory to larger amounts of slower memory.

Application developers and users are continuously demanding more compute power, whether their goal is to be able to model objects more realistically, analyze more data in a shorter time, or for faster high-resolution displays. The growth in compute power has enabled, for example, significant advances in the ability of weather forecasters to predict our weather for days, even weeks, in the future and for auto manufacturers to produce fuel-efficient vehicles. In order to meet that demand, the computer vendors were able to shrink the size of the different features of a processor in order to configure more transistors, the tiny devices that are actually responsible for performing calculations. But as they got smaller and more densely packed, they also got hotter and hotter. At some point, it became clear that a new approach was needed if faster processing speeds were to be obtained.