INTEL CPU EVOLUTION

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This paper presents the history of the development of Intel central processing units. Several facts from the company's history and the technology of microprocessor production are also considered in it. The chronology of the paper goes through different stages of processor development, ranging from primitive microchips to ultra-modern processors.

A central processing unit (CPU), also called a central processor or just a processor, is an electronic circuitry that executes instructions comprising a computer program. It is the technical characteristics of the processor that users pay attention to when choosing a computer or server, because the higher the performance is required, the more powerful it should be [1].

Before analyzing the development of central processing units, mention should be made about the development of computers in general. The first CPUs appeared in the 1940s. Computers required a big number of processors to function. They existed in a limited number, primarily were housed in big corporations and government agencies. Such computers were the size of a fairly large room. At the same time, Intel released a large amount of energy, and its performance left much to be desired. However, already in the 1950s, transistors began to be used in the design of processors. Due to their use, engineers managed to achieve a higher speed of the chips, as well as reduce their power consumption, and increase reliability. During the next ten years, the technology of manufacturing IC (integrated circuits) started to develop, which made it possible to create microchips with transistors located on them.

1971 is remarkable as the year of the first microprocessors. The first single-chip microprocessor is the 4-bit Intel 4004. Intel was on the way to its glory. Its founders, Robert Noyce, Gordon Moore, and Andrew Grove, spent a lot of time on the development processing. The Italian physicist Federico Fagin joined the Intel engineering team a year before the release of the first processor. He had extensive experience in computer logic design and silicon gate MOS (metal-oxide-semiconductor) technologies. Thanks to Federico Fagin Intel engineers managed to combine all the microcircuits into one chip. In the early 70s, the company released the first 8-bit central processor Intel 8008. In terms of technical characteristics, the 8008 microprocessors matched the previous version. One of the first microprocessor-based computer systems was the Sac State 8008 project. It was intended for processing and storing medical records. In the mid of 70s, Intel released an improved version the 8-bit Intel 8080 microprocessor. Due to the high performance the processor functioned successfully. Based on the Intel 8080, MITS (Micro Instrumentation and Telemetry Systems) released the Altair-8800 microcomputer. Despite the modest characteristics, it gained unprecedented popularity. The main event after the release of 8080 was the dismissal of Federico Fagin. The Italian did not agree with the internal policy of the company and decided to leave the company. Later, Intel released the first 16-bit 8086 microprocessor. Its development took more than two years. To increase sales of 8086, Intel released 8088 processor. Only the width of the bus has decreased, from 16 bits to 8 bits. This change allowed the processor to work with 8-bit support chips. The next step of the processor development resulted in Intel 80186. The 80286 processor introduced a protected mode with 24-bit addressing, which allowed to use up to 16 MB memory. The Intel 80386 processor appeared in the 80s and introduced an improved mode with 4 GB of RAM. This processors set is built on a register computing model [2].

Microprocessors based on the stack computing model were developed at the same time. Over the years, microprocessors have developed many different architectures. Many of them are still used today. The fifth-generation processor, based on the layout of Vinod Dham, was developed and codenamed P5. Vinod Dham is an engineer and entrepreneur. He is known as the "Father of the Pentium Processor" for his contributions to the development of the Intel Pentium microprocessor. In 1993, the CPU went into production under the name Pentium. Intel managed to improve the technologies that the company used in its products. Their novelty had the ability to cope with two tasks at once. However, users were not fully able to use this processor, because it was necessary to have a special motherboard for it. However, after the release of the next Pentium, the situation became completely different. Thanks to high technologies, chips from Intel have become very popular. They were widely used in the world for a long time. Intel made a great move into the professional and high-end server processor market with the release of the Pentium II and Xeon. But the company lacked an entry-level processor aimed at the huge sector of the PC market. Later,

Intel filled this gap by releasing the Celeron processor with significantly lower performance and a reasonable price. Intel releases the Pentium III a year after the release of Celeron. The new technologies were based on four calculations, which increased the efficiency of processing 3D images, streaming video and other multimedia tasks compared to the Pentium II. Intel later released the Pentium III Coppermine. The Coppermine had improvements that resulted in a huge performance improvement over the first Pentium III. Due to its highly efficient design, the Pentium III was very popular. But instead of improving this version, Intel focused on increasing the clock speed, and they stopped introducing an extremely long pipeline architecture in the Pentium 4 to achieve this goal. It was absolutely necessary to increase the clock speed considerably to be more successful. Intel envisioned that this could be achieved with Prescott core. Prescott core was the first chip of the latest technological achievements. But Prescott core presented only a marginal performance boost, which was significantly inferior to processors of other companies [3].

The next stage of the development was the x86-64 instruction sets, which were added to the processors. In 2005, the Intel Pentium D rolled off the assembly lines and received two crystals on one substrate. The development of processors was divided into two stages after introducing the "Tick-tock" technology by Intel. “Tick” meant a decrease in the technological process of the current architecture, and “Tock” meant the release of the new architecture of the same technical process. The eighth-generation “Intel Core” architecture was also presented, which had two cores on one chip. The company prioritized efficiency and increase concerning processor cores. One of the most important steps in the history was the release of the new microarchitecture "Sandy Bridge" of a new 32 nm process technology. For ordinary users, the company released a series of processors under the “Intel Core i7” brand, which supported four memory channels with the frequency of 1600 MHz. These processors could enhance the indicated frequencies using the Turbo Boost 2.0 technology. At the same time, there were some enthusiasts, who bought special versions with the “K” postfix, which had an unlocked multiplier. This multiplier made it possible to increase the frequency from 3700 MHz to 5000 MHz with air cooling. In 2015, the sixth generation of "Skylake" was developed on the new LGA1151 socket using a 14 nm process technology. Significant changes were made in the architecture, and the speed of the ring bus that connected the processor cores was doubled. Two years later, "Kaby Lake" was developed according to the same 14+ nm process technology (plus shows an update aimed at the internal layout) including an increase in the edges of transistors and the distance between them, due to which the frequency increased by a couple of hundred MHz and kept in the boost at around 4.5 GHz. The eighth generation of "Coffee Lake" appeared in the same year, running on the new Z370 chipset. Traditionally, the technical process remains unchanged and it is still the same 14++ nm. The second plus appeared due to the optimization of the semiconductors of the crystal, which improved in thermal and frequency performance, although the technological process remained the same. At that time, for ordinary people, the company presented six-core processors operating at a frequency of 4.7 GHz in boost. “Comet Lake” line was developed in 2020. This is the latest generation of the 14++ nm process technology, which is already pretty tired and has recently offered only an increase in the number of cores without noticeable improvements in the architecture. The performance per cycle has not changed for the third generation, and all the progress has been in building up the cores [4].

In conclusion, it can be stated that now the rapid technological growth of processor development has been stopped. The rapid change in technical processes has grown into optimization and multi-core growth without major architecture changes. Being successful in this business for many years, Intel stopped making any noticeable changes and re-released processors under new names, starting with long-lived sockets that remained relevant for several years and did not require a motherboard change. Since 2009, all of the following sockets have been relevant for no more than three years. The offer to re-release processors without changes, but requiring a replacement socket and the purchase of new motherboards, only annoyed customers. Later, the company began to correct the mistakes of the previous years. At present, Intel produces its most advanced chips using the 10 nm process technology. However, by the beginning of 2023, the company promises to use to super-modern 3 nm chips.

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