



Evolution of Microprocessors

Second Stage

Microprocessor

Computer Engineering Department

Lecture No. 1

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Introduction to Microprocessors and Their Evolution

A **microprocessor** is the central processing unit (CPU) of a computer system implemented on a single integrated circuit (IC). It is often referred to as the *brain* of the computer because it performs arithmetic and logic operations, controls data flow, and executes instructions stored in memory. In essence, a microprocessor fetches, decodes, and executes instructions sequentially, enabling programmable computing across a wide range of electronic devices from personal computers to embedded systems and smartphones.

Evolution of Microprocessor

The evolution of microprocessors can be traced through several generations, each characterized by advances in technology, architecture, and performance:

The beginning

Intel **4004** was the first commercially **available single-chip microprocessor** in history as in figure 1. It was a 4-bit CPU designed for usage in **calculators**, designed for "embedded applications". Clocked at 740 KHz, the 4004 executed up to 92,000 single word instructions per second, could access 4 KB of program memory and 640 bytes of RAM.

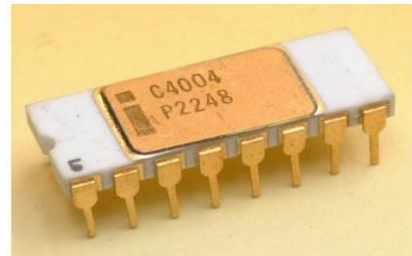
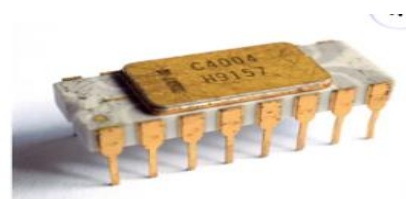


Figure 1. Intel's first 4004 microprocessor

Many other companies also introduced 4-bit microprocessor such as Rockwell international, Toshiba, Zilog and Motorola



TOSHIBA



First Generation (1971)

The microprocessors that were introduced from 1971 to 1973 were referred to as the first generation systems. First-generation microprocessors processed their instructions serially i.e., they fetched the instruction, decoded it, and then executed it. When the instruction was completed, the microprocessor updated the instruction pointer and fetched the next instruction, performing this sequential drill for each instruction in turn.

- ✓ The Intel 4004 was followed in 1972 by the Intel 8008, the world's first 8-bit microprocessor. The 8008 is not an extension of the 4004 design, but the culmination of a separate design project at Intel, arising from a contract with Computer Terminals Corporation of San Antonio TX, for a chip they were designing.
- ✓ There were other microprocessors in the market during the same period:
 - Rockwell International's PPS-4 (4 bits)
 - National Semiconductor's IMP-16 (16 bits) They were low cost, slow speed and low output currents. They were not compatible with TTL.

Limitations of first generation microprocessors is small memory size, slow speed and instruction set

- **Second Generation (1974)**

By the late 1970s, enough transistors were available on the IC in the second generation of microprocessor sophistication. The second generation marked the beginning of very efficient 8 bit microprocessors. Some of the popular processors were:

- i. Intel's 8080 ii. Motorola's 6800 and 6809 iii. Zilog's Z80.

The distinction between the first and second generation devices was primarily the use of newer semiconductor technology to fabricate the chips. This new technology resulted in instruction increasing, execution speed, and higher chip densities. They were manufactured using NMOS technology. It is TTL compatible.

Intel's experience with the 8008 provided a tremendous source of ideas on how to improve on the microprocessor. Starting in the middle of 1972, these ideas were used to define the Intel 8080 microprocessor. The improvements in the 8080 included more instructions, a 64-KB address space, 256 I/O ports, 16-bit arithmetic instructions, and vectored interrupts. The designers of the 8080 included some of the key individuals responsible for the 4004 and 8008. The first 8080 ran at 2 MHz and was rated at 0.64 millions of instructions per second (MIPS). Unlike the 4004 and 8008, the 8080 was quickly adopted by designers and incorporated into numerous products.

INTEL, introduced 8085 which was an updated version of 8080 last 8-bit processor. The main advantages of 8085 were its internal clock generator, internal system controller and higher clock frequency. This higher level of component integration reduced the 8085's cost and increased its usefulness. Intel has managed to sell well over 100 million copies of the 8085 microprocessor, its most successful 8-bit, general-purpose microprocessor.

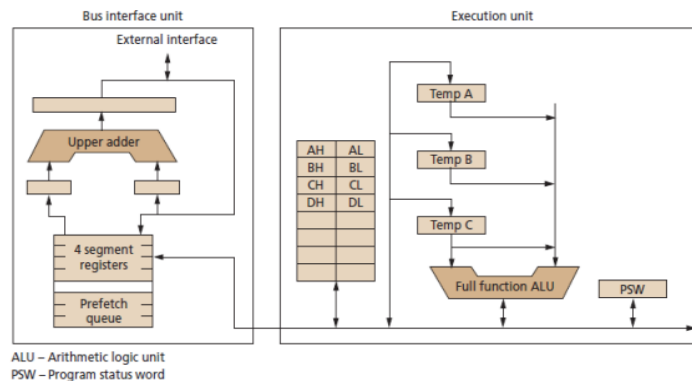
- **Third Generation (1979)**

The third generation, introduced in 1979, was represented by Intel's 8086 and the Zilog Z8000, which were 16 bit processors with minicomputer like performance. The third generation came about as IC transistor counts approached 250,000. Motorola's MC68020, for example, incorporated an on chip cache for the first time and the depth of the pipeline increased to five or

more stages. This generation of microprocessors was different from the previous ones in that all major workstation manufacturers began developing their own RISC-based microprocessor architectures.

The 8086 microprocessor was structured as a bus interface unit (BIU) and an execution unit (EU) as in figure below. The BIU handled instruction and operand fetches from memory. The BIU fed opcodes to and requested operands from the EU, which performed the instructions. The BIU and EU constituted a simple pipeline, with the BIU fetching instructions concurrently with processing in the EU. The 8086 instituted an unusual form of segmented addressing. Within a segment, addressing was limited to 64 KB. The 8086 had a companion floating-point chip, the 8087. The 8087 introduced Intel's 80-bit floating-point format.

Intel 80186 and 80188 were the improved versions of Intel 8086 and 8088, respectively. In addition to 16-bit CPU, the 80186 and 80188 had programmable peripheral devices integrated on the same package.



Fourth Generation (1981)

As the workstation companies converted from commercial microprocessors to in-house designs, microprocessors entered their fourth generation with designs surpassing a million transistors. This era marked the beginning of 32 bits microprocessors as Intel 80386. Then 80486 is a combination 386 processor a math coprocessor, and a cache memory controller on a single chip.

Motorola introduced 68020/68030. They were fabricated using low-power version of the HMOS technology called HCMOS, but poor performance compared to Intel's own 80286 which was almost four times as fast on typical benchmark tests.

The 68020 became hugely popular in the UNIX super microcomputer market, and many small companies produced desktop-size systems. The MC68030 was introduced next. The continued success led to the MC68040, which included an FPU for better math performance.

A 68050 failed to achieve its performance goals and was not released, and the follow-up MC68060 was released into a market saturated by much faster RISC designs. The 68k family faded from the desktop in the early 1990s. Other large companies designed the 68020 and follow-ons into

embedded equipment. At one point, there were more 68020s in embedded equipment than there were Intel Pentiums in PCs.

Fifth Generation (1995)

Microprocessors in their fifth generation, employed decoupled super scalar processing, and their design soon surpassed 10 million transistors. This age the emphasis is on introducing chips that carry on-chip functionalities and improvements in the speed of memory and I/O devices along with introduction of 64-bit microprocessors.

Intel leads the show here with Pentium, Celeron and very recently dual and quad core processors working with up to 3.5GHz speed. With AMD's introduction of a 64-bit architecture backwards-compatible with x86, x86-64 followed by Intel's near fully compatible 64-bit extensions. With operating systems Windows XP x64, Windows Vista x64, Windows 7 x64, Linux, BSD, and Mac OS X that run 64-bit native, the software is also geared to fully utilize the capabilities of such processors.

What is a Core?

A standard processor has one core (single-core.) Single core processors only process one instruction at a time (although they do use pipelines internally, which allow several instructions to be processed together; however, they are still run one at a time.)

What is a Multi-Core Processor?

A multi-core processor is composed of two or more independent cores, each capable of processing individual instructions. A dual-core processor contains two cores, a quad-core processor contains four cores, and a hexa-core processor contains six cores.

The concept of having **multiple cores on a single processor chip** emerged in the **early 2000s**, as a response to the limitations of increasing clock speeds. **Intel Core Duo (2006)** – part of Intel's "Core" architecture; marked a major leap in efficiency and multi-threaded performance.

Why Multi-Core Was Needed

1. **Clock speed plateau:** Around 2004, CPU frequencies stopped increasing significantly (~3–4 GHz) due to heat/power issues.
2. **Parallel processing demand:** Applications (like multimedia, gaming, and servers) needed more simultaneous processing.
3. **Efficiency:** Multiple slower cores could perform better than one fast core while consuming less power.

Hence, instead of making one core faster, engineers started adding **more cores**.

. Sixth Generation

While the 5th generation focused on parallel processing and early AI, the **6th Generation** is defined by Quantum Computing, Nanotechnology, and Artificial Neural Networks.

- **Defining Features:**
 - **Intelligent Processing:** Moving beyond simple "logic" to machines that mimic human reasoning and learning.
 - **Quantum Bits (Qubits):** Unlike classical bits (0 or 1), qubits use "superposition" to perform millions of calculations simultaneously.
 - **Voice & Natural Language:** True seamless interaction with technology (Natural Language Processing).
- **Goal:** To achieve **Ultra Large Scale Integration (ULSI)** where chips are not just faster, but "smarter" at the atomic level. A Quantum QPU (Quantum Processing Unit) handles the heavy math "heavy lifting."

This refers specifically to Intel's 6th Generation Core Processors (Codename: Skylake), released around 2015, 14nm process technology, support for DDR4 memory, and significantly better integrated graphics (4K support).

Examples: Intel Core i7-6700K, i5-6600U.

As of 2026, we are seeing the "6th Generation" materialize through:

1. **NPU (Neural Processing Units):** Dedicated "brains" inside your phone or laptop specifically for AI.
2. **Chiplet Technology:** Instead of one large chip, processors (like AMD Zen 6) are built like LEGO blocks to be more efficient.

FUTURE OF MICROPROCESSOR

