

# Introduction to Microprocessors

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2. History and evolution
3. Architecture of a typical microprocessor
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# Overview of microprocessors

- A **microprocessor** is an integrated circuit (IC) that performs the functions of a central processing unit (CPU) in a computer. It processes instructions from software and executes tasks using arithmetic, logic, control, and input/output operations.
- **Key Components of a Microprocessor:**
  - Arithmetic Logic Unit (ALU): Performs mathematical and logical operations.
  - Control Unit (CU): Directs operations within the processor by interpreting instructions from programs.
  - Registers: Small, fast storage locations for temporary data and instructions.
  - Cache Memory: Stores frequently accessed data to improve processing speed.
  - Bus System: Transfers data between the microprocessor and other components (data, address, and control buses).

# Overview of microprocessors

- **Types of Microprocessors:**
  - CISC (Complex Instruction Set Computing): Supports a wide variety of instructions. Example: Intel x86 processors.
  - RISC (Reduced Instruction Set Computing): Uses a smaller set of simple instructions for faster performance. Example: ARM processors.
  - DSP (Digital Signal Processors): Specialized for processing real-time signals such as audio or video.
  - Multicore Processors: Combine multiple processing units (cores) in a single chip to increase performance.
- **A microprocessor operates in a continuous cycle known as the fetch-decode-execute cycle:**
  - Fetch: The control unit gets the next instruction from memory.
  - Decode: The instruction is decoded to understand what action is required.
  - Execute: The ALU performs the required operation.

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# History and Evolution

## 1st Generation (1971–1973): 4-bit Microprocessors

- Notable Chip: Intel 4004
  - Year: 1971
  - Bit Size: 4-bit
  - Transistors: ~2,300
  - Clock Speed: 740 KHz
  - Technology: PMOS
  - Use: Basic calculators and simple embedded systems
- Significance:
  - First commercially available microprocessor
  - Designed for a Japanese calculator company (Busicom)
  - Could perform simple arithmetic and logic operations

# History and Evolution

## 2nd Generation (1974–1978): 8-bit Microprocessors

- Notable Chips:
  - Intel 8080 (1974)
  - Intel 8085 (1976)
  - Motorola 6800, Zilog Z80
- Improvements:
  - Higher clock speed (~1 MHz)
  - More instructions and addressing modes
  - Used NMOS technology
  - Supported interrupts and I/O
- Applications:
  - Early computers (like the Altair 8800)

# History and Evolution

## 3rd Generation (1978–1982): 16-bit Microprocessors

- Notable Chips:
  - Intel 8086 (1978) – the basis of x86 architecture
  - Intel 80186, 80286
  - Motorola 68000
- Key Features:
  - Addressing of more memory (up to 1 MB and beyond)
  - Segment-based memory management (Intel)
  - Faster execution with pipeliningUsed in IBM PCs (8088 variant)

# History and Evolution

## 4th Generation (1982–1990): 32-bit Microprocessors

- Notable Chips:
  - Intel 80386 (1985)
  - Intel 80486 (1989)
  - Motorola 68020/68030
- Advancements:
  - 32-bit internal and external data bus
  - On-chip cache memory
  - Pipelining and integrated FPU (80486)
  - Virtual memory and multitasking support

# History and Evolution

## 5th Generation (1990s):

- Superscalar & Early 64-bit
- Notable Chips:
  - Intel Pentium (1993)
  - AMD K5, K6
  - PowerPC, MIPS, SPARC
- Key Innovations:
  - Superscalar architecture: multiple instructions per clock
  - MMX technology (for multimedia)
  - Integrated L2 cache in some models
  - Introduction of parallel instruction pipelines

# History and Evolution

## 6th Generation (2000s): 64-bit, Multi-Core

- Notable Chips:
  - Intel Core, Pentium 4, Athlon 64, PowerPC G5
- Milestones:
  - 64-bit processing becomes standard
  - Multicore processors emerge (dual-core, quad-core, etc.)
  - Enhanced power management
  - Introduction of virtualization support

# History and Evolution

## Modern Era (2010–Present): Multicore, AI, Mobile, ARM

- Key Players:
  - Intel Core i3/i5/i7/i9, AMD Ryzen, Apple M1/M2/M3
  - ARM Cortex-A, Qualcomm Snapdragon, Apple Silicon
- Technologies:
  - 7nm and 5nm fabrication nodes
  - 10+ core processors (desktop/server)
  - Integrated GPUs
  - AI accelerators and neural engines
  - Ultra-low-power mobile processors
  - System-on-Chip (SoC) integration
- Trends:
  - Mobile & Edge computing (phones, tablets, IoT)
  - Parallel computing & GPUs for AI
  - Custom microarchitectures (e.g., Apple's ARM-based M-series)
  - Green computing and thermal efficiency

# Architecture of a Typical Microprocessor

## Arithmetic and Logic Unit (ALU)

- Function: Performs all arithmetic operations (add, subtract, multiply, divide) and logical operations (AND, OR, NOT, XOR).
- Importance: It's the heart of the processor for computation.
- Subcomponents: Accumulators (temporary registers for operations) Flags (carry, zero, sign, overflow indicators)

## Control Unit (CU)

- Function: Directs the operation of the processor.
- Tasks:
  - Decodes instructions fetched from memory.
  - Coordinates between ALU, memory, and I/O devices.
  - Generates control signals to manage data flow.
- Instruction Decoder: Part of CU that translates binary instructions into control signals.

# Architecture of a Typical Microprocessor

- **Registers:** Registers are small, fast storage units within the CPU used to hold data and instructions temporarily.
- **Types:**
  - General Purpose Registers (GPRs): Hold intermediate data (e.g., AX, BX in x86).
  - Special Purpose Registers:
    - Program Counter (PC): Holds the address of the next instruction.
    - Instruction Register (IR): Holds the current instruction.
    - Stack Pointer (SP): Points to the top of the stack.
    - Status Register/Flag Register: Stores the result of operations (e.g., Zero flag, Carry flag).
- **Cache Memory**
  - Function: High-speed memory located inside or close to the processor to store frequently accessed data.
  - Levels:
    - L1 Cache: Fastest, smallest, closest to the core.
    - L2 Cache: Slower than L1 but larger.
    - L3 Cache: Shared among cores in multicore processors.

# Architecture of a Typical Microprocessor

**System Buses:** Buses are pathways that transfer data and signals between microprocessor components and other parts of the computer.

Types:

- Data Bus: Transfers actual data.
- Address Bus: Carries memory addresses.
- Control Bus: Carries control signals like read/write.

**Clock Generator:**

- Provides timing signals to synchronize all operations.
- Measured in MHz or GHz (e.g., 3.2 GHz = 3.2 billion cycles per second).

**Input/Output (I/O) Ports:**

- Allow communication with external devices (keyboard, display, etc.). Mapped I/O and
- Memory-mapped I/O are two common methods for handling I/O operations.

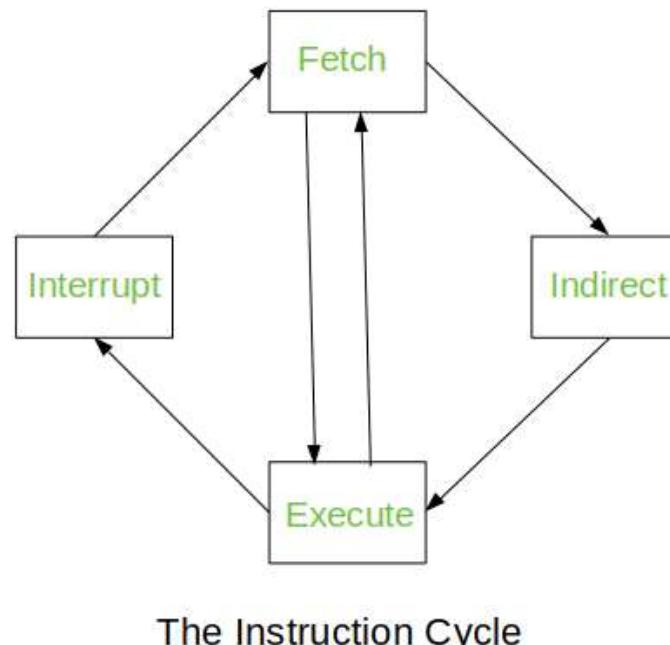
# Microprocessor operations

Microprocessor operations follow a structured cycle known as the Fetch-Decode-Execute cycle, which is the core process by which a microprocessor executes instructions from a program.

- **Fetch:** This is the stage where the microprocessor retrieves the next instruction to be executed from memory.
  - Program Counter (PC): Holds the address of the next instruction.
  - Memory Address Register (MAR): The address from the PC is copied here to access memory.
  - Memory Data Register (MDR): The instruction fetched from memory is temporarily held here.
  - Instruction Register (IR): The fetched instruction is moved here for decoding and execution.
- **Decode:** At this stage, the Control Unit interprets the instruction stored in the Instruction Register.
  - Opcode (operation code) and operands are extracted from the instruction.
  - The control logic interprets what action is to be taken.
  - If needed, it determines the addressing mode (immediate, direct, indirect, etc.).

# Microprocessor operations

- **Execute:** The microprocessor carries out the decoded instruction.
  - Arithmetic/logic operations are performed by the Arithmetic Logic Unit (ALU).
  - Data transfer operations involve moving data between registers or memory.
  - Control operations may involve jumping to a different instruction address.



# Microprocessor vs. Microcontroller

Parameter	Microprocessor	Microcontroller
<b>Definition</b>	Microprocessors can be understood as the heart of a computer system.	Microcontrollers can be understood as the heart of an embedded system.
<b>What is it?</b>	A microprocessor is a processor where the memory and I/O component are connected externally.	A microcontroller is a controlling device wherein the memory and I/O output component are present internally.
<b>Circuit complexity</b>	The circuit is complex due to external connection.	Microcontrollers are present on chip memory. The circuit is less complex.
<b>Memory and I/O components</b>	The memory and I/O components are to be connected externally.	The memory and I/O components are available.

# Microprocessor vs. Microcontroller

<b>Compact system compatibility</b>	Microprocessors can't be used in compact system.	Microcontrollers can be used with a compact system.
<b>Efficiency</b>	Microprocessors are not efficient.	Microcontrollers are efficient.
<b>Zero status flag</b>	Microprocessors have a zero status flag.	Microcontroller doesn't have a zero status flag.
<b>Number of registers</b>	Microprocessors have less number of registers.	Microcontrollers have more number of registers.
<b>Applications</b>	Microprocessors are generally used in personal computers.	Microcontrollers are generally used in washing machines, and air conditioners.



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