

Introduction to Microprocessors

Dr. M Krishnam Raju

Assistant Professor

Electronics & Communication Engineering

Content

1. Overview of microprocessors
2. History and evolution
3. Architecture of a typical microprocessor
4. Microprocessor operations: Fetch, Decode, and Execute
5. Microprocessor vs. Microcontroller

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.

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).

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.

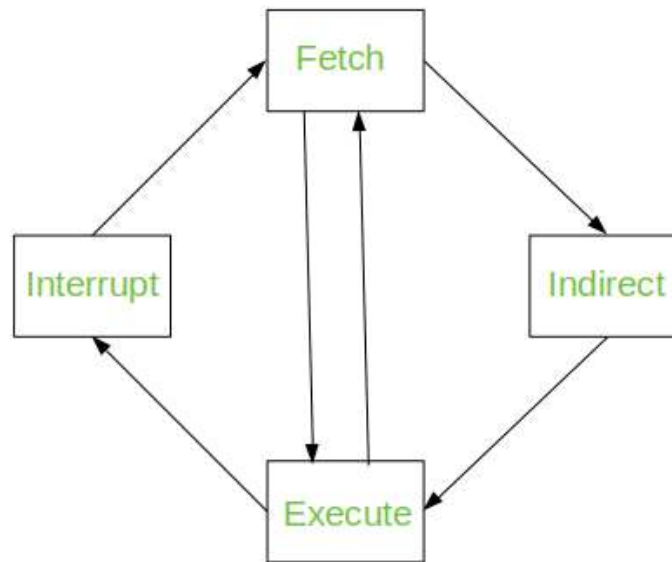
Microprocessor operations

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.



The Instruction Cycle

Microprocessor vs. Microcontroller

Parameter	Microprocessor	Microcontroller
Definition	Microprocessors can be understood as the heart of a computer system.	Microcontrollers can be understood as the heart of an embedded system.
What is it?	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.
Circuit complexity	The circuit is complex due to external connection.	Microcontrollers are present on chip memory. The circuit is less complex.
Memory and I/O components	The memory and I/O components are to be connected externally.	The memory and I/O components are available.

Microprocessor vs. Microcontroller

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

Parul[®]
University

NAAC
GRADE **A++**



<https://paruluniversity.ac.in/>

