20CS2009
Computer Organization & Architecture

Course Objectives

1. learn about the working of the processor and main memory
2. understand various concepts of the arithmetic unit and error correction
3. about the working of control unit.

Course Outcomes

1. explain the function of the central processing unit

2. develop algorithms for error correction in memory modules (main and cache memory)

3. describe various input and output modules for the central processing unit

4. demonstrate standard addressing modes for logical and physical memory addressing

5. summarize various stages of instruction pipelining in the processor.

6. explore various ways to implement the micro instruction sequencing and execution

Syllabus

Module 1: Introduction to Computer Architecture

Introduction of computer organization and architecture, A top-level view of computer function and interconnection

Module 2: Introduction to Internal Memory Technology

Design of Direct mapped cache in the virtual lab, Introduction to interrupts, Multiple interrupts, Introduction to cache memory, Elements of cache design, Internal Memory, Semiconductor memory, Error correction, Advance DRAM.

Module 3: Input / Output Modules and Scheduling

Design of memory unit in the virtual lab. Introduction to external devices, Input / Output modules, programmed I/O, Interrupt driven I/O, Direct memory access, I/O channels and processors, introduction to process scheduling.

Module 4: Computer Arithmetic and Instruction Set

Design of Arithmetic and Logic Unit in virtual lab.Computer arithmetic, Integer representation and arithmetic, Floating point representation and arithmetic, types of operands and operations (Intel x86 and ARM processor), Addressing modes and formats.

Module 5: Processor Structure and Functions

Design of registers and counter in virtual lab. Instruction sets, Processor organization, Register organization, Characteristics and functions, Addressing modes, Processor structure and function, Instruction pipelining.

Syllabus

Module 6: Control Unit and Micro Programmed Control

Control unit operation, Control of the processor, Hardwired implementation, Micro-program control, Micro instruction sequencing, Micro instruction execution

Text Books:

William Stallings, “Computer Organization and Architecture: Designing for Performance”, Pearson Education, 11th edition, 2019, ISBN: 978-0-13-499719-3. John P.Hayes, “Computer Organization and Architecture”, McGraw Hill, 3rd edition, 2002, ISBN: 0070273553.

Reference Books:

- John L.Hennessy, David A.Patterson, “Computer Architecture: A Quantitative Approach”,
- Morgan Kaufmann, 5th edition, 2012, ISBN: 978-0-12-383872-8 3. Andrew S. Tanenbaum, Todd Austin, “Structured Computer Organization”, Prentice Hall, 6th edition, 2013, ISBN-10: 0132916525.
- Douglas E. Comer, “Essentials of Computer Architecture”, Addison -Wesely, 1st edition, 2005, ISBN-10: 0131491792

Why should I learn Computer Architecture?

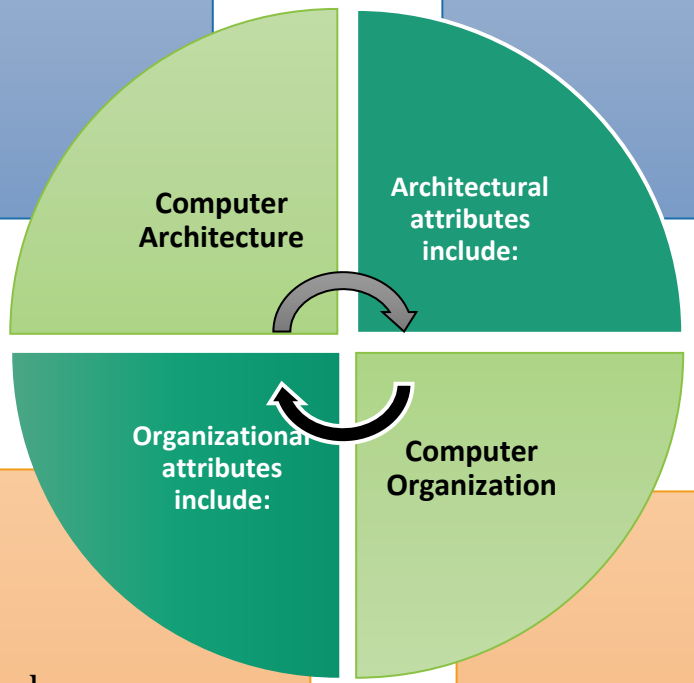
- Will get the idea about main physical components of a computer
- Functional Units of a system
- Memory Operations (Storage and Retrieval of data)
- Instruction Execution
- How we can achieve performance in CPU
- Control Operation (when, where and what need to be executed)

Computer Architecture

Computer Organization

- Attributes of a system visible to the programmer
- Have a direct impact on the logical execution of a program

- Instruction set, number of bits used to represent various data types, I/O mechanisms, techniques for addressing memory



- Hardware details transparent to the programmer, control signals, interfaces between the computer and peripherals, memory technology used

- The operational units and their interconnections that realize the architectural specifications

Difference between Organization and Architecture

Computer Architecture :

Refers to those **attributes of a system visible** to a programmer or, put another way, those **attributes** that have a direct **impact on the logical execution** of a program

- A term that is often used interchangeably with computer architecture is **Instruction set architecture(ISA)**.
- **defines** instruction formats, instruction opcodes, registers, instruction and data memory; the effect of executed instructions on the registers and memory; and an algorithm for controlling instruction execution

Computer Organization

- Refers to the **operational units and their interconnections** that realize the architectural specifications.

Example:

Architecture : whether my computer will have multiply instruction or not.

Organization: Multiply instruction is going to implemented by special unit or repeat addition method

Structure and Function

Structure: The way in which the **components are interrelated.**

Function: The **operation of each individual component** as part of the structure.

Both the structure and functioning of a computer are more important and required one in computer architecture.

Four basic functions that a computer can perform:

- **Data processing**
- **Data storage**
- **Data movement**
- **Control**

Four basic functions that a computer can perform

Data processing

- Data may take a wide variety of forms and the range of processing requirements is broad

Data storage

- Short-term
- Long-term

Data movement

- Input-output (I/O) - when data are received from or delivered to a device (peripheral) that is directly connected to the computer
- Data communications – when data are moved over longer distances, to or from a remote device

Control

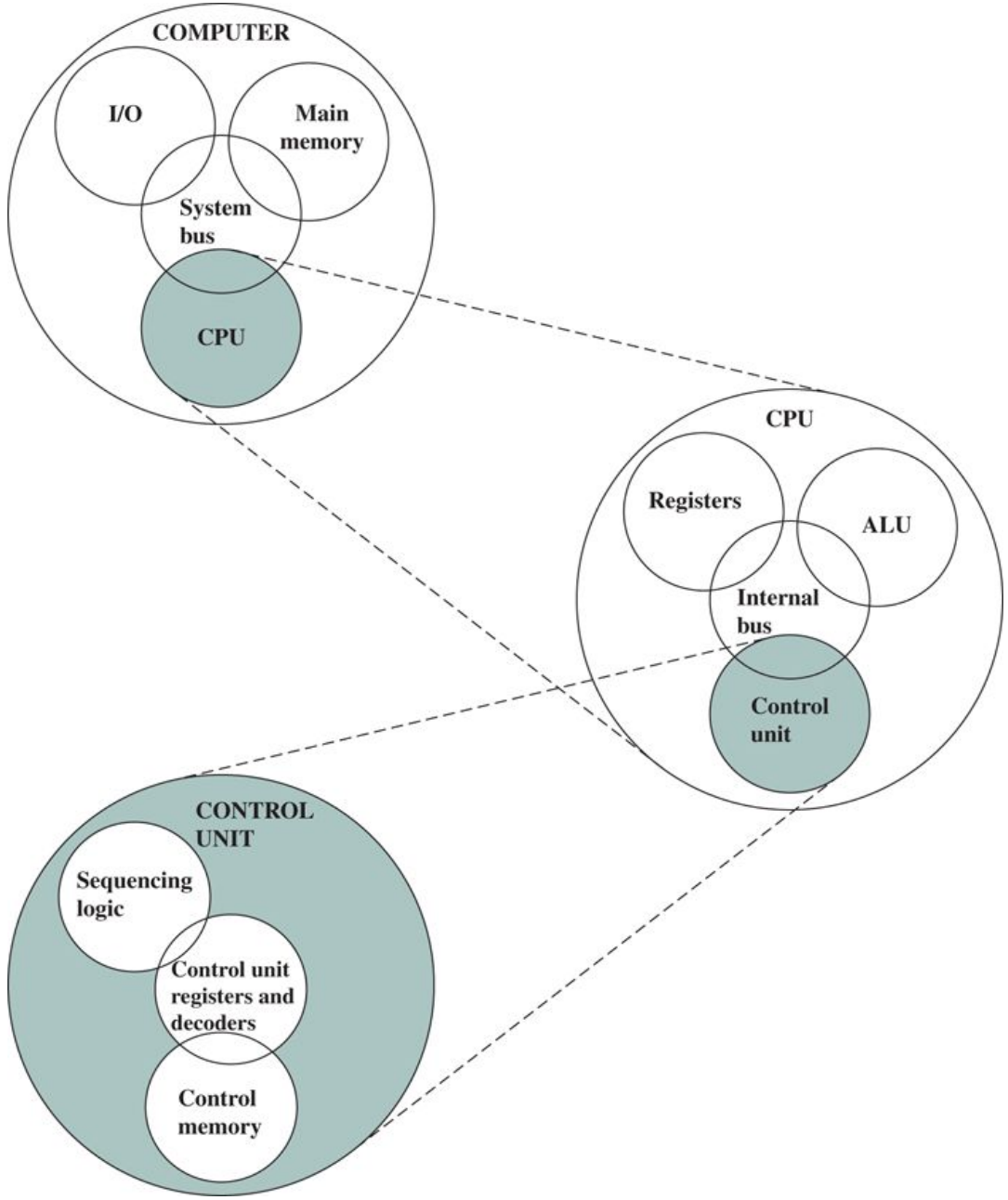
- A control unit manages the computer's resources and orchestrates the performance of its functional parts in response to instructions

Top Down View of a Computer:

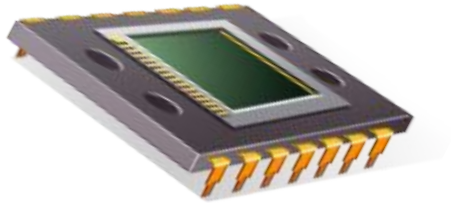
Single Processor System

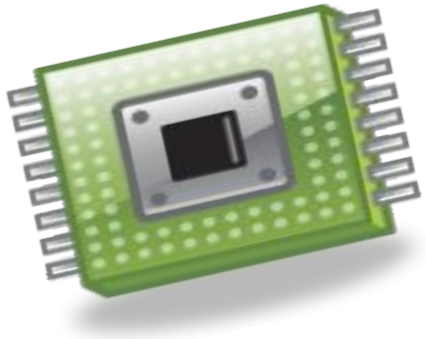
Major Components are :

- CPU – controls the operation of the computer and performs its data processing functions
- Main Memory – stores data
- I/O – moves data between the computer and its external environment
- System Interconnection – some mechanism that provides for communication among CPU, main memory, and I/O
  - A common **example** of system interconnection is by means of a **system bus.**



CPU Major structural components





- **Control Unit**

  Controls the operation of the CPU and hence the computer

- **Arithmetic and Logic Unit (ALU)**

  Performs the computer's data processing function

- **Registers**

  Provide storage internal to the CPU

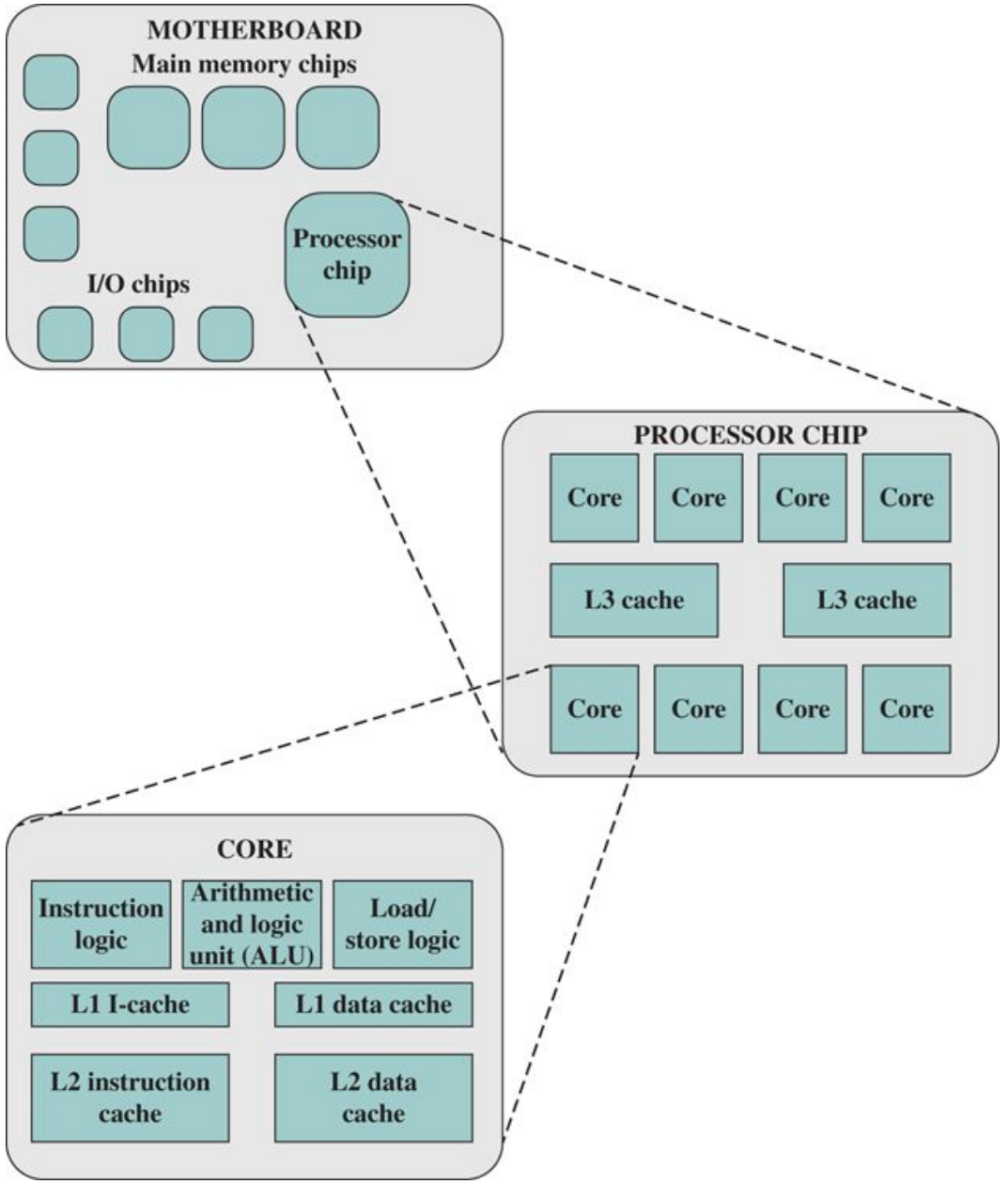
- **CPU Interconnection**

  Some mechanism that provides for communication among the control unit, ALU, and registers

View of Multicore Computer:

Multi Core Processor

- **Central processing unit (CPU):**
  - That portion of a computer that **fetches and executes** instructions.
  - It consists of an **ALU, a control unit, and registers.**
  - In a **system with a single processing unit**, it is often simply referred to as a **processor**.
- **Core:**
  - An **individual processing unit** on a processor chip.
  - **A core may be equivalent in functionality to a CPU on a single-CPU system.**
  - **Specialized processing units** are also referred to as **cores**
- **Multicore Processor**
  - **A physical piece of silicon containing one or more cores.**
  - The processor is the computer component that interprets and executes instructions.
  - If a **processor contains multiple cores,** it is referred to as a **multicore processor** (may referred simply as processor also).



- A **chip** is a single piece of semiconducting material, typically silicon, upon which electronic circuits and logic gates are fabricated.The resulting product is **referred to as an integrated circuit .**
- The motherboard contains a slot or socket for the processor chip, which typically contains multiple individual cores, in what is **known as a multicore processor.**

Functional elements of a core are:

- **Instruction logic:** This includes the tasks involved in fetching instructions, and decoding each instruction to determine the instruction operation and the memory locations of any operands.
- **Arithmetic and logic unit (ALU):** Performs the operation specified by an instruction.
- **Load/store logic:** Manages the transfer of data to and from main memory via cache.

IAS / Von–Neumann:

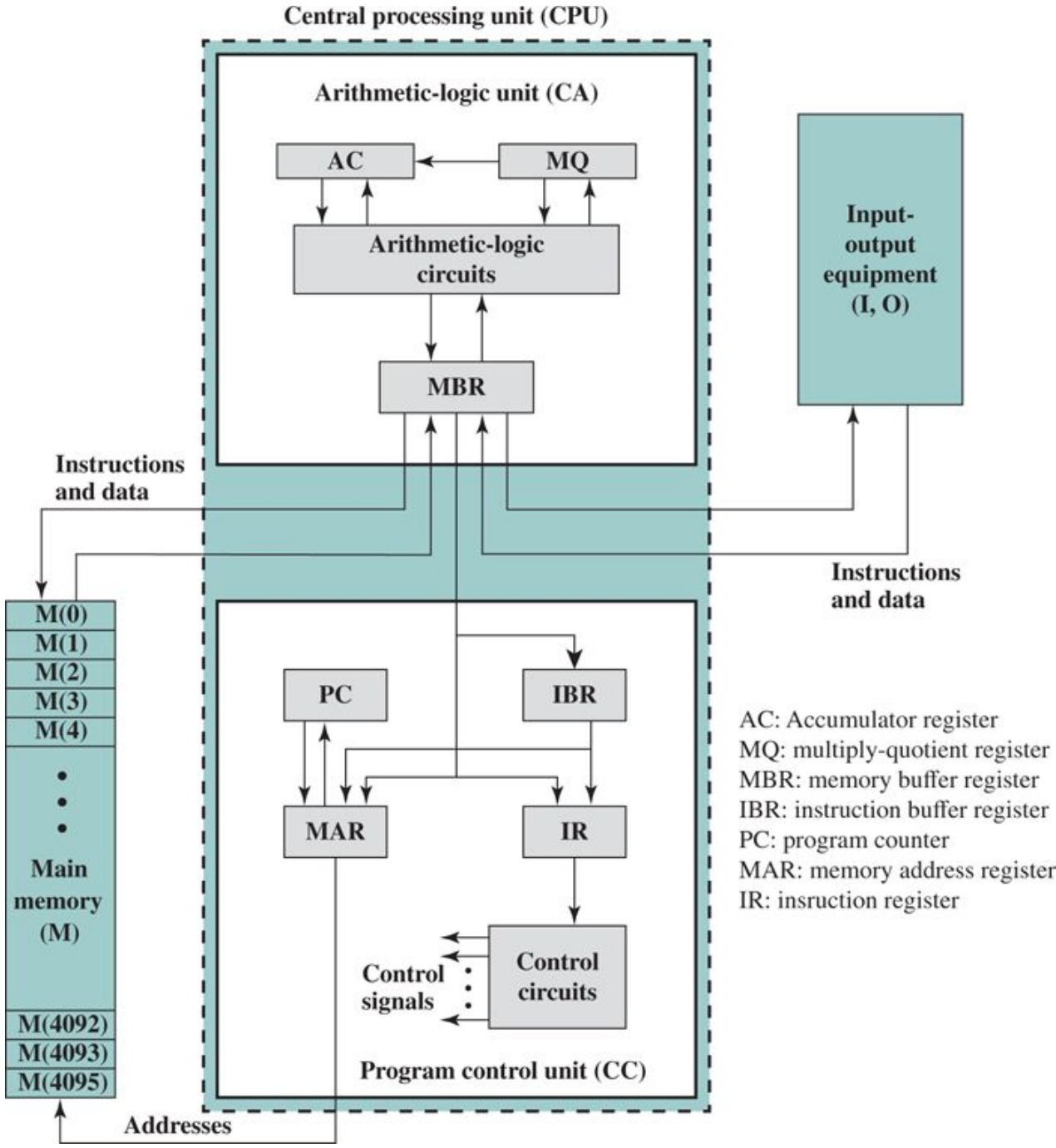
- ***Von-neumann*** designed a new stored-program computer in 1946 with support from his colleagues at Institute for Advanced Studies(IAS), Princeton,New Jersey.
- The computer is today known as ***IAS computer***.
- Most of the computers **still use the stored program concept** of Von-neumann.

IAS computer works on following principles:

- **Same memory is used** to store both the program and data.
- The **program is executed in written sequence**.
- A program can **modify itself when computer executes the program**.

IAS Structure

- **A main memory** , which stores both data and instructions
- An **arithmetic and logic unit (ALU)** capable of operating on binary data
- A **control unit** , which interprets the instructions in memory and causes them to be executed
- **Input–output (I/O)** equipment operated by the control unit



- **Memory buffer register (MBR):** Contains a word to be stored in memory or sent to the I/O unit, or is used to receive a word from memory or from the I/O unit.
- **Memory address register (MAR):** Specifies the address in memory of the word to be written from or read into the MBR.
- **Instruction register (IR):** Contains the 8-bit opcode instruction being executed.
- **Instruction buffer register (IBR):** Employed to hold temporarily the right-hand instruction from a word in memory.
- **Program counter (PC):** Contains the address of the next instruction pair to be fetched from memory.
- **Accumulator (AC) and multiplier quotient (MQ):** Employed to hold temporarily operands and results of ALU operations.