Computer Organization and Architecture I

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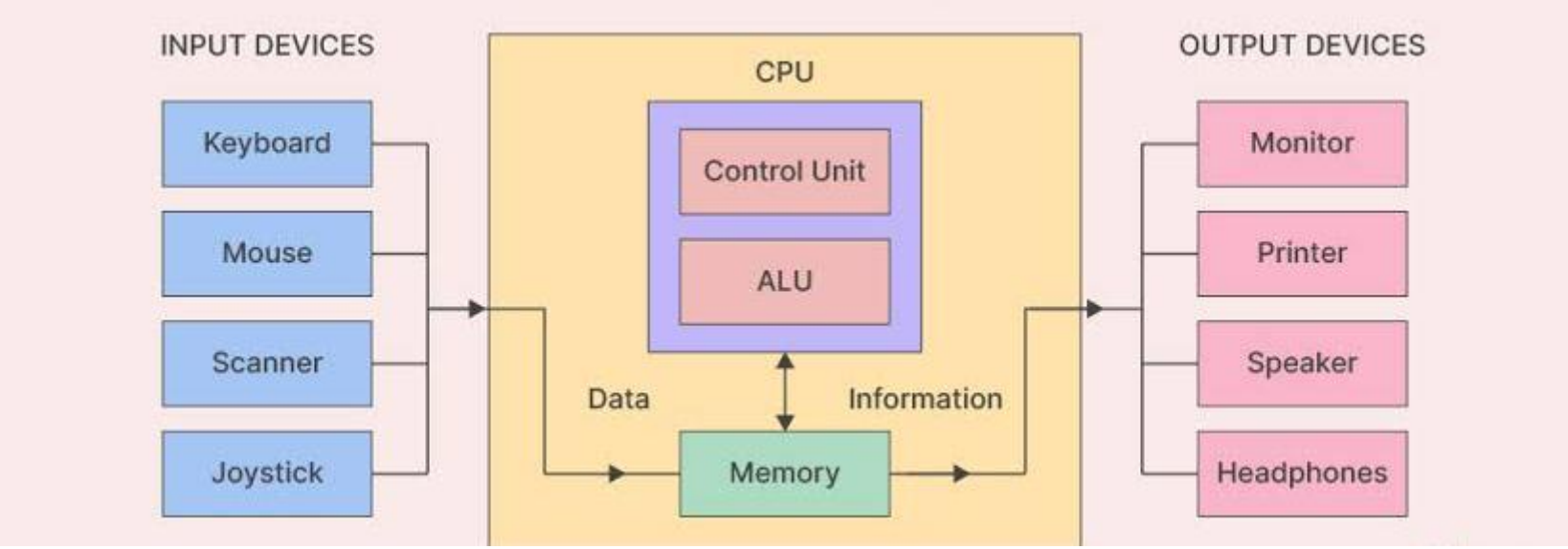


UNIT I - 3

UNIT 1: Introduction

- Learning Outcomes

1. Differentiate between computer organization and computer architecture
2. Discuss the evolution of computers in 5 generations
3. Describe the von Neumann architecture

Computer Architecture

- Computer Architecture refers to those attributes of a system that have a direct impact on
  - the logical execution of a program. Examples:
  - the instruction set
  - the number of bits used to represent various data types
  - I/O mechanisms
  - Addressing techniques
- Architecture is those attributes visible to the programmer

Computer Organization

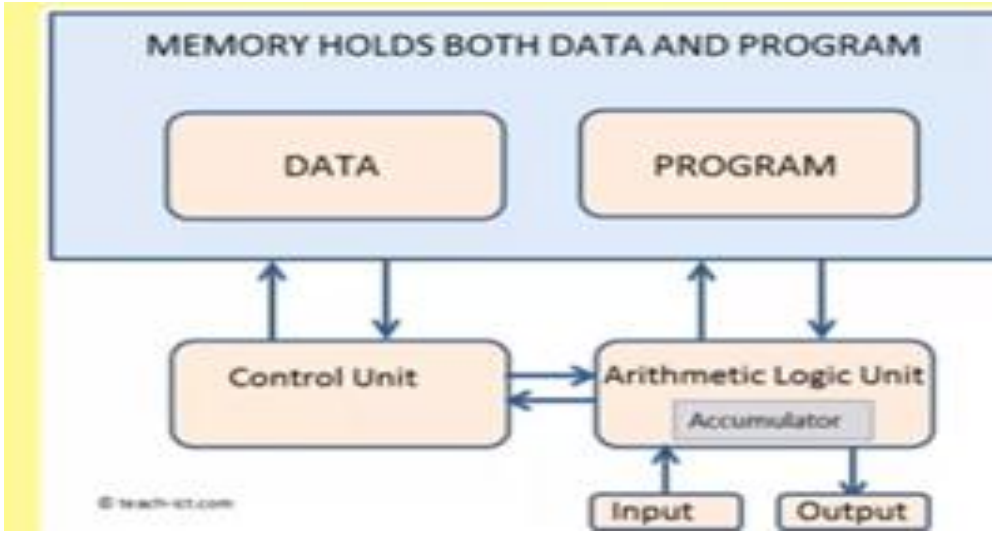
- Computer Organization refers to the operational units and their interconnections that realize the architectural specifications. Examples are things that are transparent to the programmer:
  - control signals
  - interfaces between computer and peripherals
  - the memory technology being used
- Organization is how features are implemented
  - Control signals, interfaces, memory technology.
  - e.g. Is there a hardware multiply unit or is it done by repeated addition?

Generations of Computers

Generations	1	2	3	4	5
Technology	Vacuum Tubes	Transistors	Integrated circuit IC	Large scale integration LSI	Very large scale integration (VLSI) and Ulta large scale integration
Size	Huge	large	smaller	Mini computer	PC
Memory			larger	Several MB	Gigabytes
Processing speed	In milliseconds	In micro seconds	In nanoseconds	10 times faster	Very fast
Storage	Magnetic tapes	Removable disk	Magnetic disk	Magnetic disk and optical disk	Tera bytes: hard disks and solid state disks SSD
Programming	Machine language	High level	High level	High level	High level, Artificial intelligence

Von Neumann Architecture

- Von Neumann architecture is based on the stored-program computer concept, where instruction data and program data are stored in the same memory.
- This design is still used in most computers produced today.



Von Neumann Layout

- Consisted of
- Control Unit: decoding instructions and controlling data flow
- Arithmetic Logic Unit: Calculations and Logical operations
- Bus: wires that carry data around the computer
- Registers: memory locations with specific purposes.

UNIT 1 REVIEW QUESTIONS

1. Define the following terms
   i. Computer Organization
   ii. Computer Architecture
2. State two differences between computer architecture and computer organization.
3. State the key features of third generation computers
4. Describe the evolution of transistor technology from 1st generation to 5th generation computers.
5. Describe the key features of the von Neumann architecture
6. Modern computers are based on the von Neumann architecture. Describe the components of this architecture.

UNIT 2: The CPU

- Learning outcomes

1. Describe the general overview of a computer system
2. Explain the purpose of the CPU
3. Explain the meaning and functions of cpu components
    i. ALU
    ii. Control unit
    iii. Registers
    iv. Cache
    v. buses

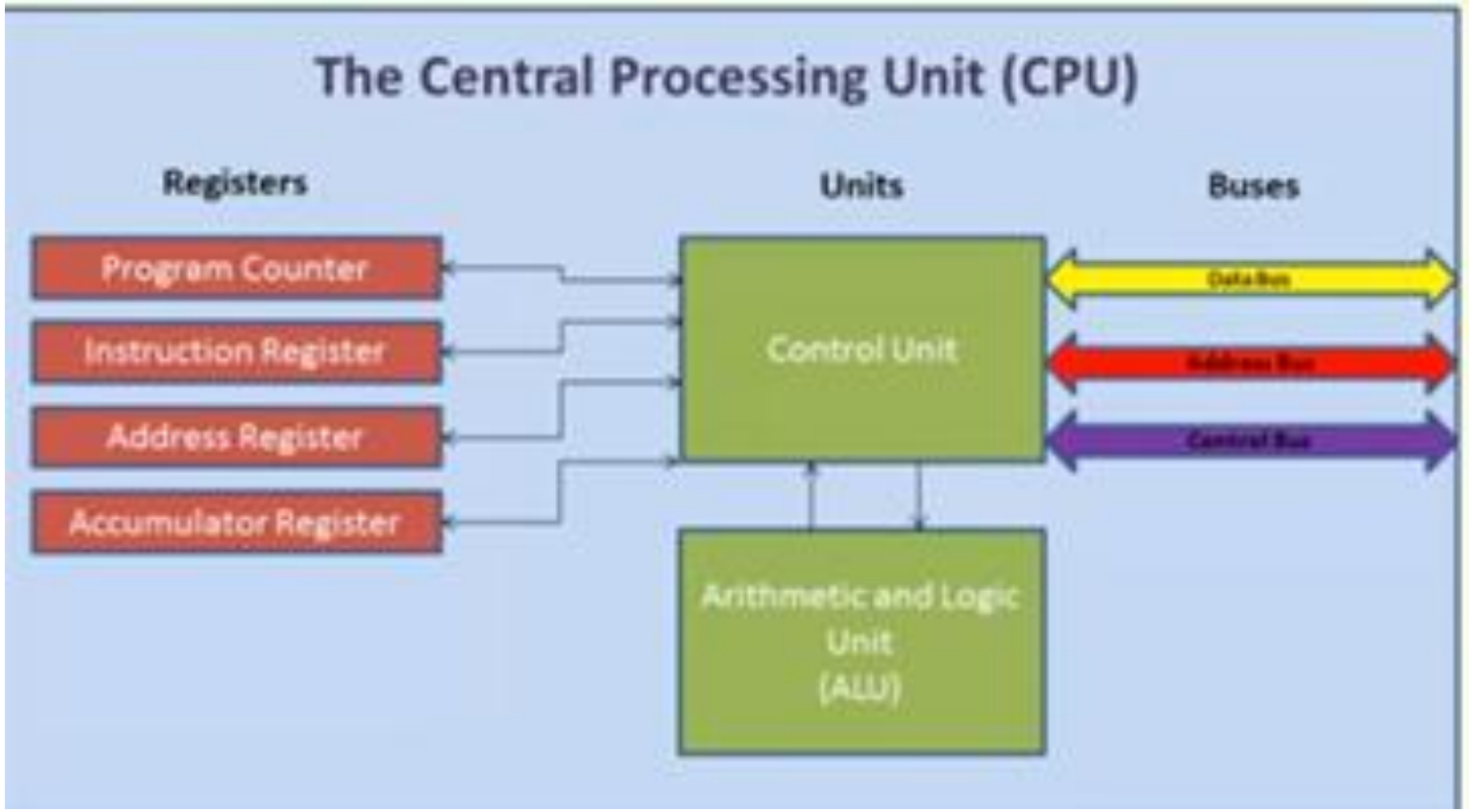
Purpose of CPU

- The cpu fetches instructions from memory (RAM), it decodes the instructions and then executes those instructions. The instructions are provided by the computer program.
- The cpu is made up of billions of transistors combined to make logic gates to process data and instructions.

Clock speed

- The cpu has clock speed:
- Clock speed is a tiny quartz crystal inside the CPU chip. The CPU can only do something when the clock ticks. During each tick the cpu can process instructions.
- Clock speed is measured in herts.
  - Megahertz(MHz)=1 million herts
  - Gigaherts(GH
  - z)=1 billion herts
- Modern processors can process at a speed of 3GHz

Inside the CPU



THE UNITS

- Arithmetic Logic Unit: carries out arithmetic and logical operations in the computer
- Control unit: responsible for decoding the instructions and send out signals to control how data moves round the parts of the CPU and memory to execute these instructions.
- Registers: are memory locations inside the CPU that have specific purposes and can be accessed very fast unlike RAM which is outside the CPU.
- Registers hold data and instructions being used by the computer now.

Types of Registers

- MAR: Memory address register
- MDR: memory data register
- Accumulator: stores the outcome of a calculation
- Program counter PC: stores next instruction
- Current instruction register (CIR): stores instructions being used now

CACHE

- Data and programs currently in use are stored in the RAM
- But RAM is comparatively slow when compared to the speed at which registers work.
- As a result a bottle neck can arise which can slow down the computer.
- Cache is a small amount of very fast memory built into the CPU
- It is used to store instructions or data either frequently used or about to be used.

Memory Hierachy

- Hard disk>RAM>External Cache>Internal cpu cache>Registers

Buses

- A bus is a communication channel through which data can be moved.
- There are many buses in a computer i.e universal serial bus (USB) which can transfer data between computer and external devices.
- **There are three main buses inside the computer:**
- Control bus: carries control signals around the CPU and memory indicating whether the operation is read or write and ensures that the operation happens at the right time.
- Address bus: carries memory address for memory locations to be read or written into. Its is unidirectional only works from cpu to memory
- Data Bus: carries data between CPU and memory. It is bidirectional

UNIT 2 REVIEW QUESTIONS

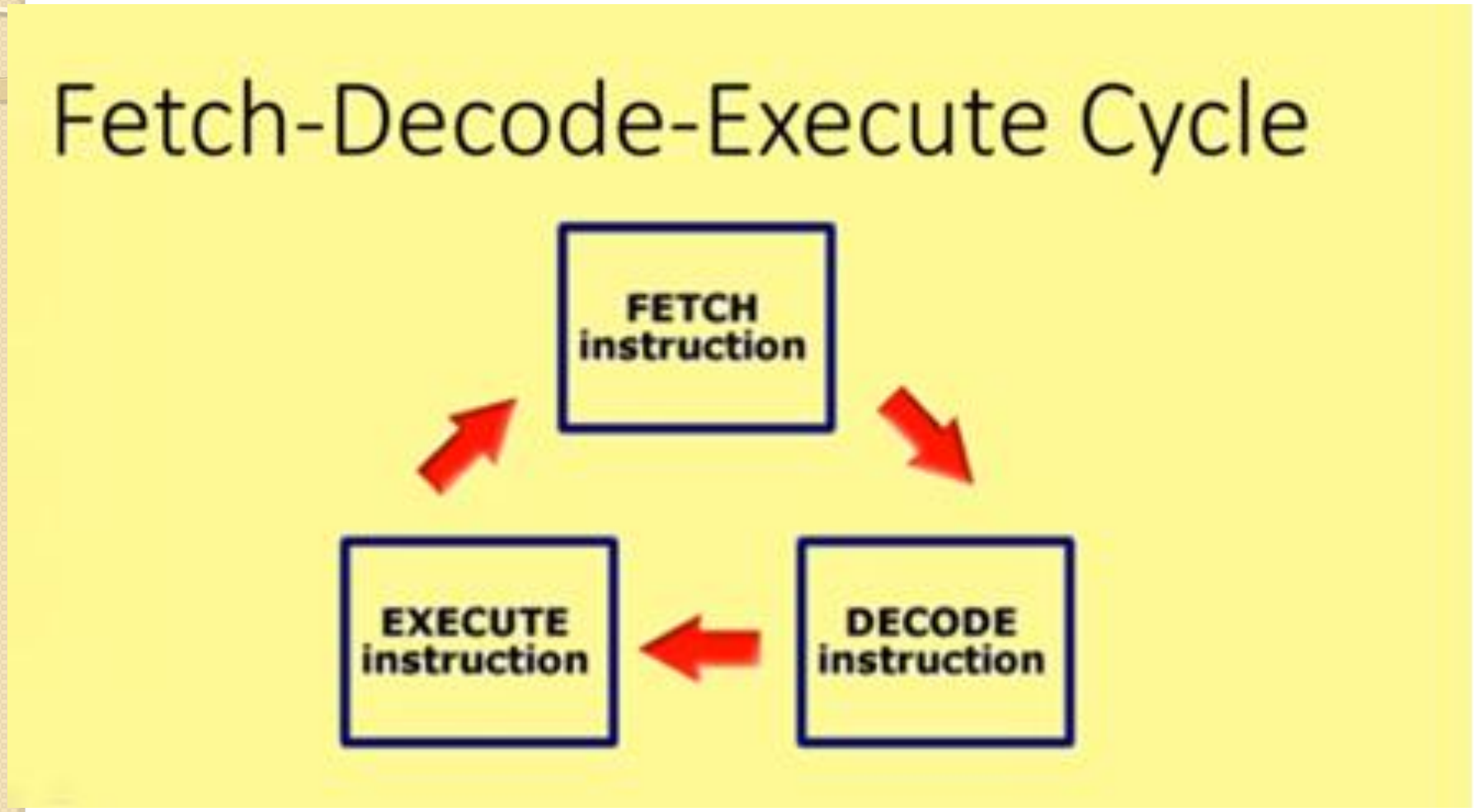
1. Describe the structure of the CPU
2. What is cpu clock speed
3. State three main functions of the CPU
4. Discuss the meaning and the functions of the following units of the CPU
    i. Arithmetic logic unit
    ii. Control unit
    iii. Registers
    iv. Cache
    v. Buses
5. Explain five types of registers
6. Explain three types of buses
7. Differentiate between cache memory and RAM
8. Use a pyramid to highlight the hierarchy of memory in a computer

UNIT 3: Fetch-decode-execute cycle

- Learning Outcome

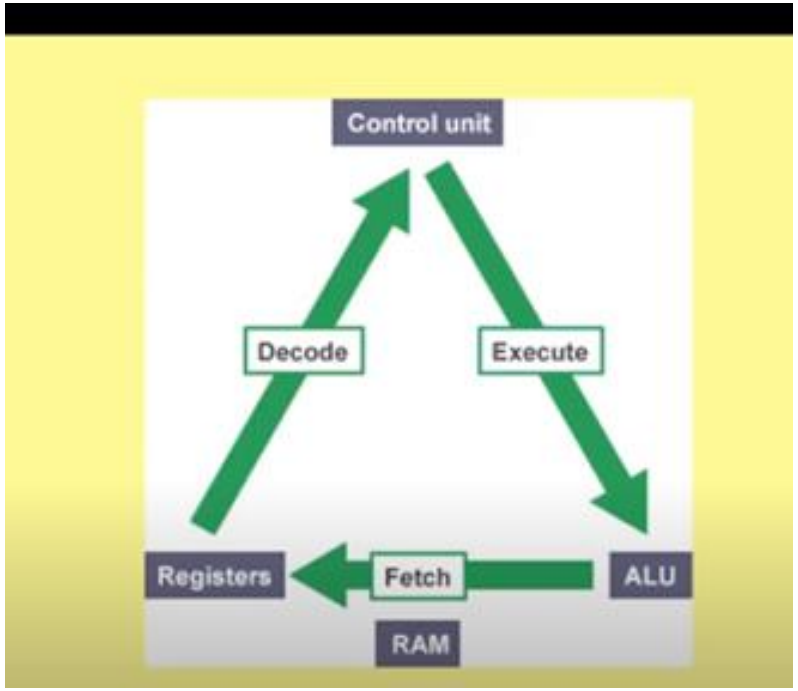
1. Understand the meaning of Fetch-decode-execute cycle
2. Describe the steps of
    i. Fetch
    ii. Decode
    iii. Execute
3. Understand CPU performance metrics

FETCH DECODE CYCLE



FETCH, DECODE EXECUTE CYCLE

- Fetch decode execute cycle is the process where the processor is continuously fetching new instructions from the memory, decoding them then executing them.
- FETCH: The instruction is moved from memory to CPU
- DECODE: The instruction is understood by the CPU
- EXECUTE: The instruction is carried out.



FETCH process

- The address of the instruction to be fetched is moved from program counter (PC) and moved to the memory address register (MAR)
- The instruction is transferred from memory to the MDR (Memory data register)
- Next the instruction in the MDR is copied into the CIR (current instruction register)
- The PC (program counter) is then incremented by 1

DECODE process

- The control unit reads the content of the CIR
- It checks that this is a valid instruction
- If the instruction is not valid, the program crushes
- EXECUTE PROCESS
- The instruction is carried out by the cpu
- This process may use the accumulator and the ALU and may fetch additional data from memory.

CPU Performance

- Factors that determine CPU Performance
  - Clock speed
  - Number of cores
  - Cache memory
  - Size of RAM
  - GPU (graphical processing unit)

UNIT 3 REVIEW QUESTIONS

- Explain using an illustration what you understand by fetch-decode-execute cycle of the cpu
- Describe the steps in the:
  - Fetch process
  - Decode Process
  - Execute process
- Discuss in details the factors that determine the performance of the CPU.