

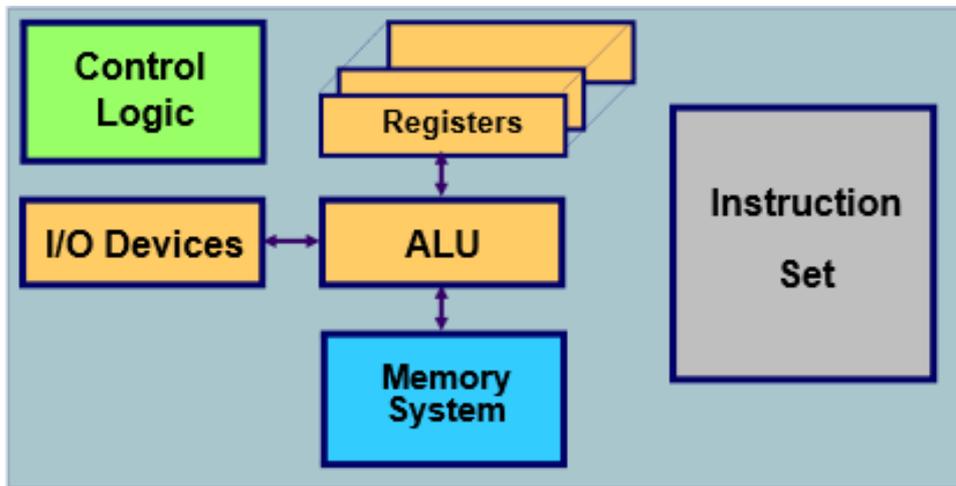
Lecture 1

Objective:

1. Computer Architecture
2. Many Definitions for CA
3. Typical Architecture Attributes
4. Computer Organization
5. Definition of a Computer
6. A Computer System
7. Basic Principles of Computers
8. Why von Neumann Architecture?
9. Central Processing Unit (CPU)
10. CPU Internal Structure
11. Registers
12. Machine Instructions
13. What is program
14. Function of control unit

Computer Architecture

- Computer architecture refers to those attributes of a computer system that are visible to programmers, or have a direct impact on the logical execution of programs.

**Many Definitions for CA:**

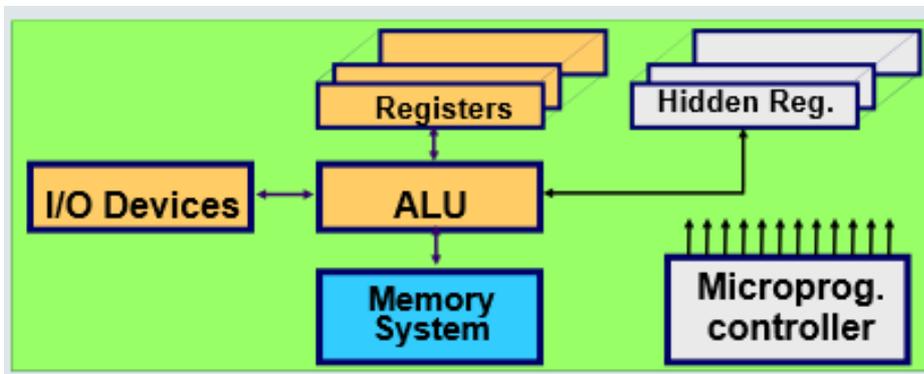
- "The science and art of selecting and interconnecting hardware components to create computers that meet functional, performance and cost goals."
- "The theory behind the design of a computer."
- "The conceptual design and fundamental operational structure of a computer system."
- "The arrangement of computer components and their relationships."

Typical Architecture Attributes:

- The instruction set.
- Data representation methods.
- The basic hardware units in the CPU.
- Functions of the main components.
- Instruction execution.
- Memory organization.
- I/O mechanisms.
- The ways in which the main components are interconnected.

Computer Organization

- Computer organization refers to the operational units and their interconnections that realize the architectural specifications.



- Ex. Multiplication function:
 - Architectural issue: having a multiply instruction or not.
 - Organization issue: a special multiply unit or repeated use of the add unit to perform multiplication.

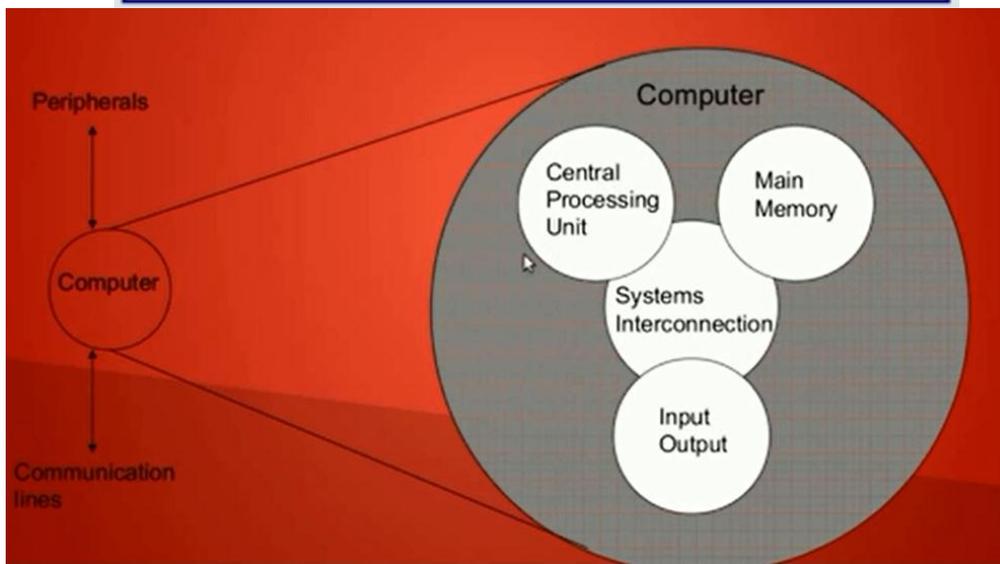
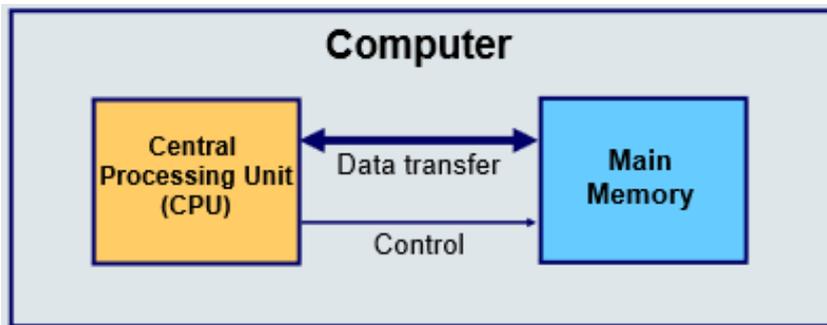
Structure & Function

- Structure is the way in which components relate to each other
- Function is the operation of individual components as part of the structure

- All computer functions are:
 - Data processing
 - Data storage
 - Data movement
 - Control

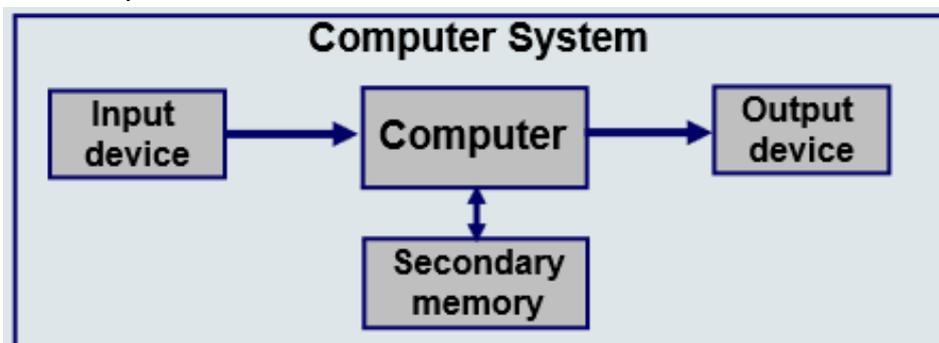
Definition of a Computer

□ A computer is a data processing machine which is operated automatically under the control of a list of instructions stored in its main memory.



A Computer System

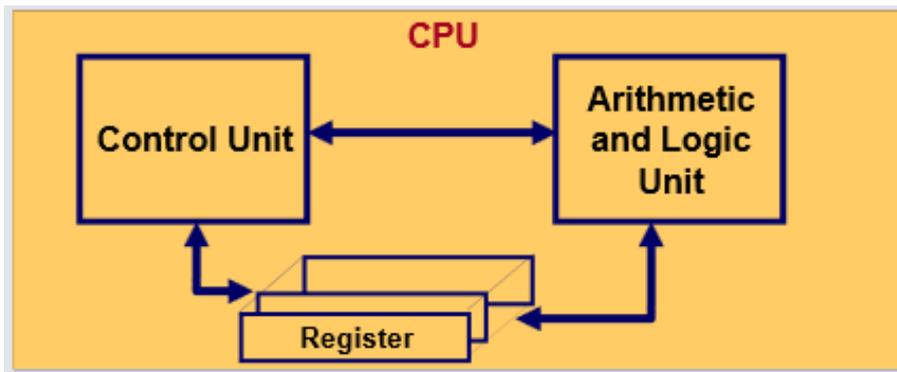
□ A computer system consists of a computer and its peripherals.
 □ Computer peripherals include input devices, output devices, and secondary memories.



Central Processing Unit (CPU)

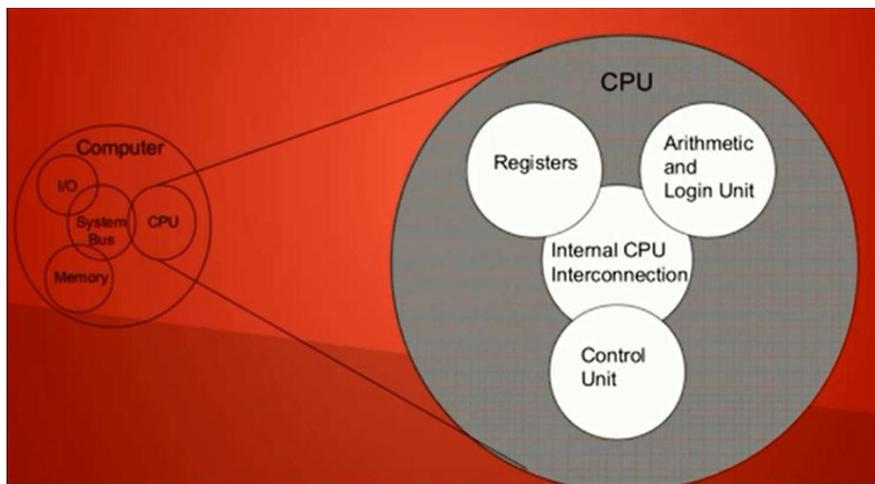
The Central Processing Unit (CPU), also called processor, includes two main units:

- A program control unit, and
- An Arithmetic and Logic Unit (ALU).



- The primary function of a CPU is to execute the instructions stored in the main memory.
- An instruction tells the CPU to perform one of its basic operations.
- The CPU includes also a set of registers, which are temporary storage devices used to hold control information, key data, and intermediate results.
- It includes also an internal bus infrastructure, which provides data movement paths among the control unit, ALU, and registers.
- The CU is the one which interprets (decodes) the instruction to be executed and "tells" the other components what to do.

CPU Internal Structure



Registers

- CPU must have some working space (temporary storage).
- These storage units are called registers.
- They are the top level component in the memory hierarchy.
- Number and function of the registers vary between different computers.
- Register organization is one of the major design decisions.

☒ Register Organization

- The registers serve two main functions:
 - User-Visible Registers: used by machine or assembly language programmers to minimize memory access.
 - General-purpose registers
 - Data registers
 - Address registers
 - Condition code registers
 - Control and Status Registers: used by the control unit to control the operation of the CPU, and by the operating system to control the execution of programs.

Machine Instructions

- The CPU can only execute machine code in binary format, called machine instructions.
- A machine instruction specifies the following information:
 - What has to be done (the operation code)
 - To whom the operation applies (source operands)
 - Where does the result go (destination operand)
 - How to continue after the operation is finished (next instruction address).
- Machine instructions are of four types:
 - Arithmetic and logic operations.
 - Data transfer between memory and CPU registers.
 - Program control (conditional branches, etc.).
 - I/O transfer.

What is program:

- A sequence of steps.
- For each step, an arithmetic or logical operation is done.
- For each operation, a different set of control signals is needed.

Function of control unit:

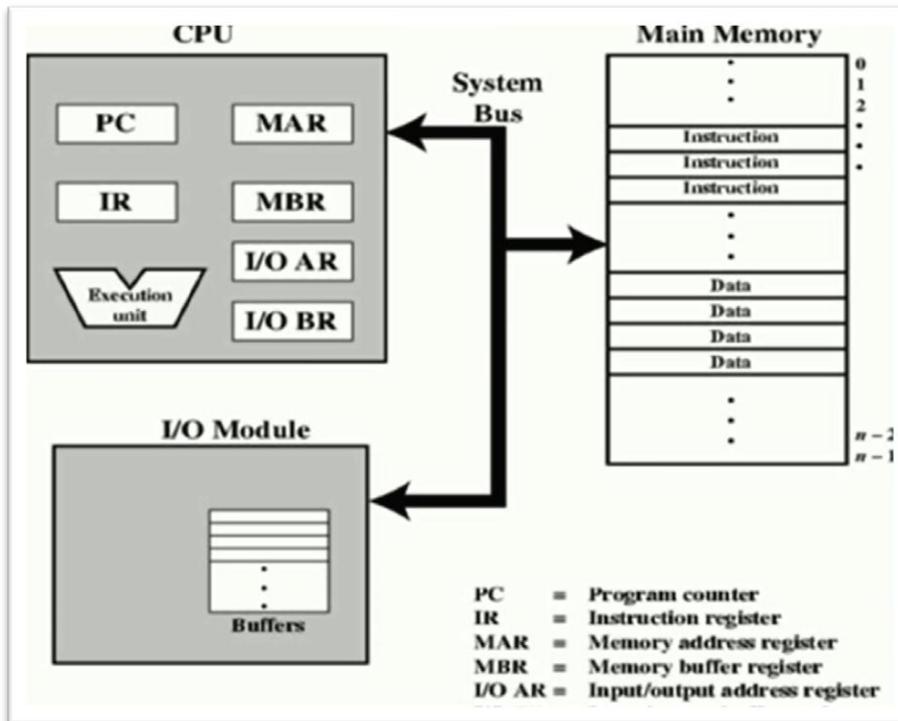
- For each operation a unique code is provided.
E.g. ADD, MOVE
- A hardware segment accepts the code and issue the control signals.
- We have a computer!

Components:

- The control unit and the arithmetic and logic unit constitute the central processing unit.

- Data and instruction need to get into the system and results out. Input/output.
- Temporary storage of code and results is needed. Main memory

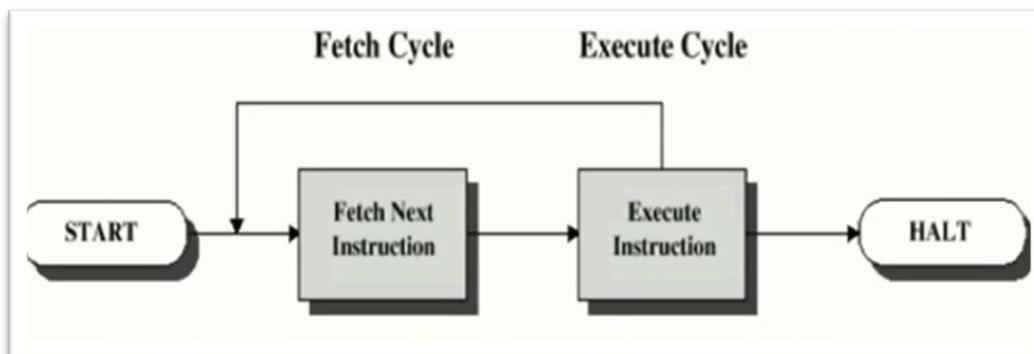
Computer components:



Instruction cycle:

Two steps:

- Fetch
- Execute



Fetch cycle:

- Program counter (PC) holds address of next instruction to fetch.
- Processor fetches instruction from memory location pointed to by PC.
- Increment PC
- Instruction loaded into instruction register (IR).
- Processor interpreters instruction and perform required actions.

Execute Cycle

- Processor-memory
 - data transfer between CPU and main memory
- Processor I/O
 - Data transfer between CPU and I/O module
- Data processing
 - Some arithmetic or logical operation on data
- Control
 - Alteration of sequence of operations
 - e.g. jump
- Combination of above

Example of Program Execution

