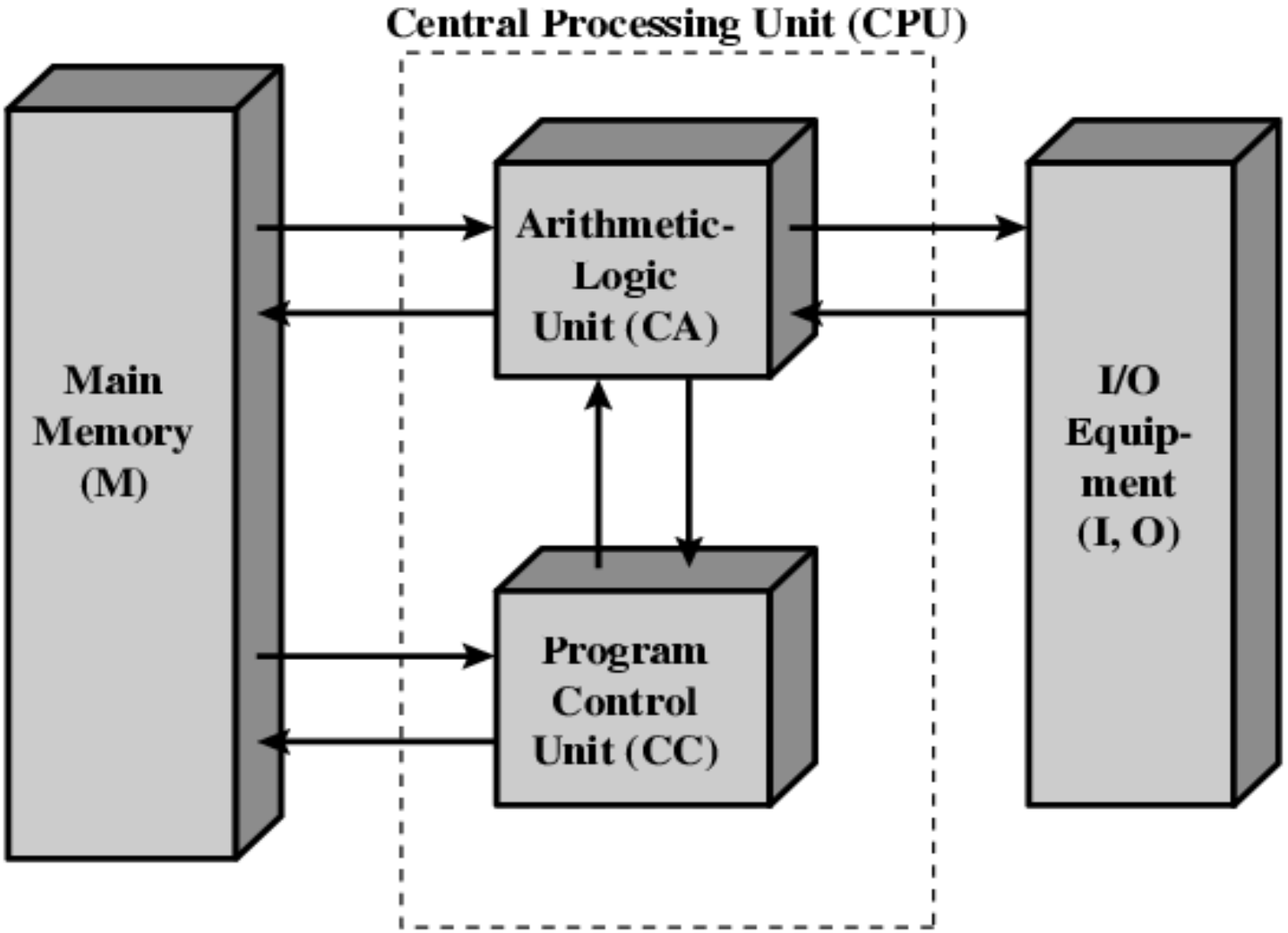
Computer Architecture
CH1: Introduction

Salahaddin University – Erbil
College of Engineering
Department of Electrical Engineering
Prepared by: Diary R. Sulaiman

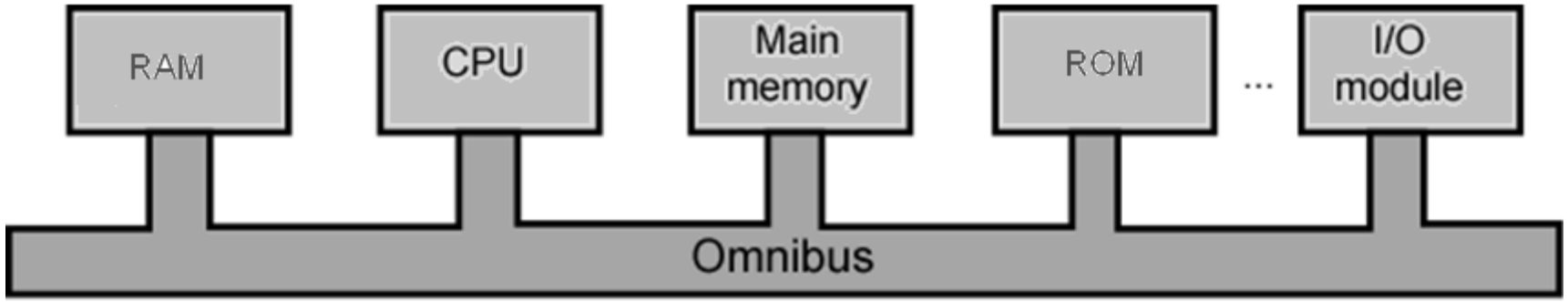
Outline

-von Neumann machine,
- Architecture, Organization,
- Structure, Function, and
- All Computer Functions??

Structure of von Neumann machine



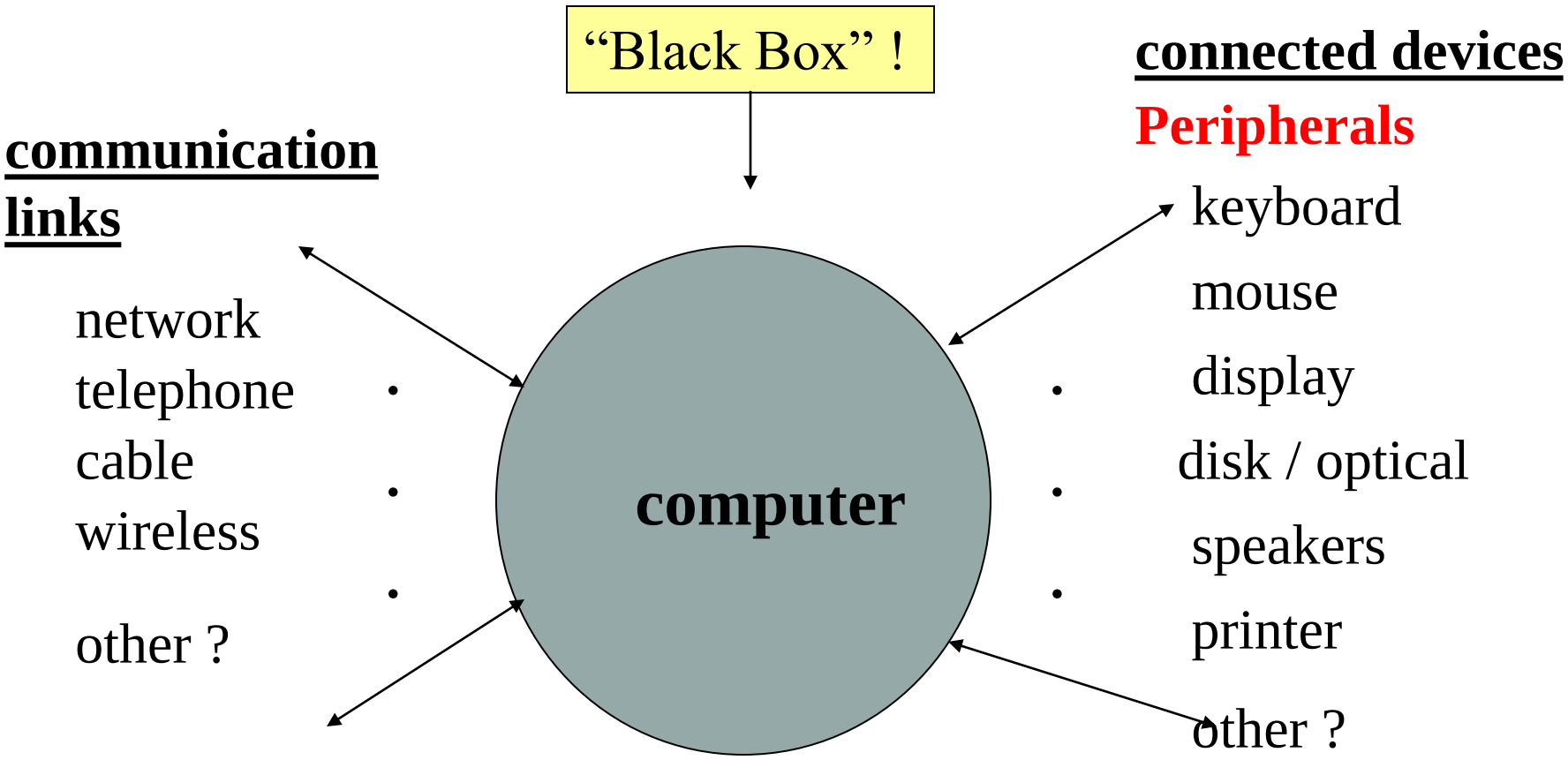
Structure of von Neumann machine



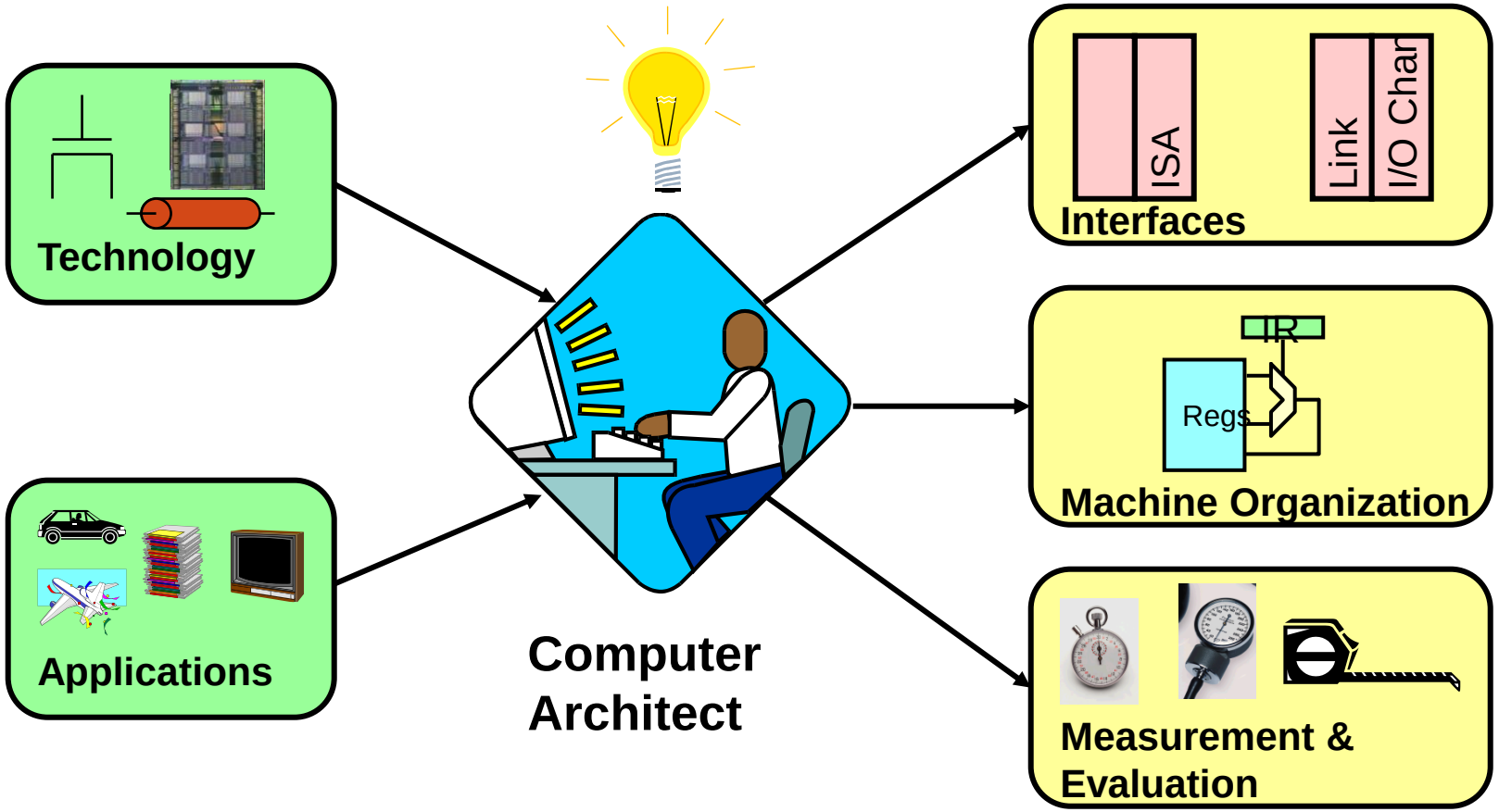
von Neumann Architecture

- Program is stored in memory along with data.
- Programs and data are indistinguishable.
- Uses a single processor.
- Sequential carrying out of instructions.

Computer Architecture & Organization ?



What is Computer Architecture?



Technology Constraints

- Yearly improvement
  - Semiconductor technology
    - 60% more devices per chip (doubles every 1.5 years)
    - 15% faster devices (doubles every 5 years)
  - Magnetic Disks
    - 60% increase in density
  - Circuit boards
    - 5% increase in wire density

Changing Technology leads to Changing Architecture

- 1970s (CISC mainframes)
  - multi-chip CPUs
  - semiconductor memory very expensive
  - microcoded control
  - complex instruction sets (good code density)
- 1980s (RISC micros)
  - single-chip CPUs, on-chip RAM feasible
  - simple, hard-wired control
  - simple instruction sets
  - small on-chip caches
- 1990s (fast clocks)
  - lots of transistors
  - complex control-instruction-level parallelism
- 2000s
- even more transistors
  - BIG SHIFT Here!!!
    - Parallelism is focus
    - Power now critical
- 2020s (???)

The Intel Microprocessor Evolution

Microprocessor	Year introduced	No. of Transistors
8008	1972	3000
8080	1974	4500
8085	1976	6500
8086	1978	29,000
8088	1979	29,000
80286	1982	130,000
80386	1985	275,000
80486	1989	1.2 million
Pentium	1992	3.1 million
Pentium Pro	1995	5.5 million
Pentium III	1999	9.5 million
Pentium 4	2000	42 million
Intel Core i7-3612QE	2.10GHz -	1.40 Billion 22nm Transistors April ??, 2012
Intel Core i7-3612QM	2.10GHz -	1.40 Billion 22nm Transistors April ??, 2012

2021…….

Computer Architecture & Organization

- ***Architecture:***
- 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.
- Basic data representation methods.
- I/O mechanisms.
- The basic units in the CPU.
- Functions of the major components.
- Instruction execution.

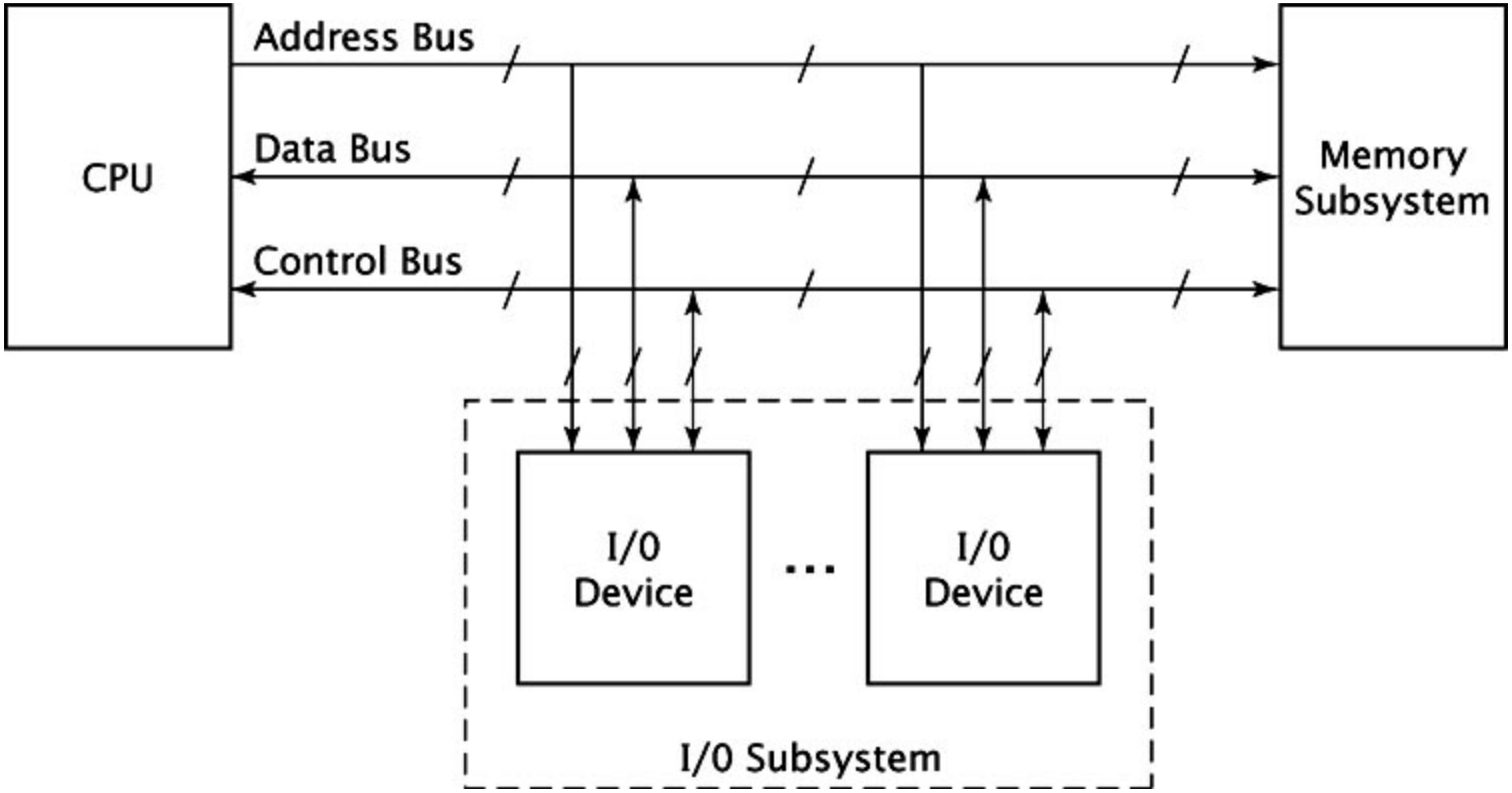
Computer Organization

- ***Organization:***

is how features are implemented.

- Control signals,
- interfaces,
- memory technology.

Computer Organization



Why Study Computer Architecture

- To be a ***professional in any field of computing*** today, you not regard the computer as just a ***black box*** that executes programs by magic.
- You should understand a ***computer system's functional components***, their ***characteristics***, their ***performance***, and their ***interactions***.
- You need to understand computer architecture in order to ***build a program*** so that it runs more ***efficiently*** on a machine.
- When selecting a system to use, you should be able to ***understand the tradeoff among various components***, such as CPU clock speed vs. memory size.

Structure & Function

various models components:

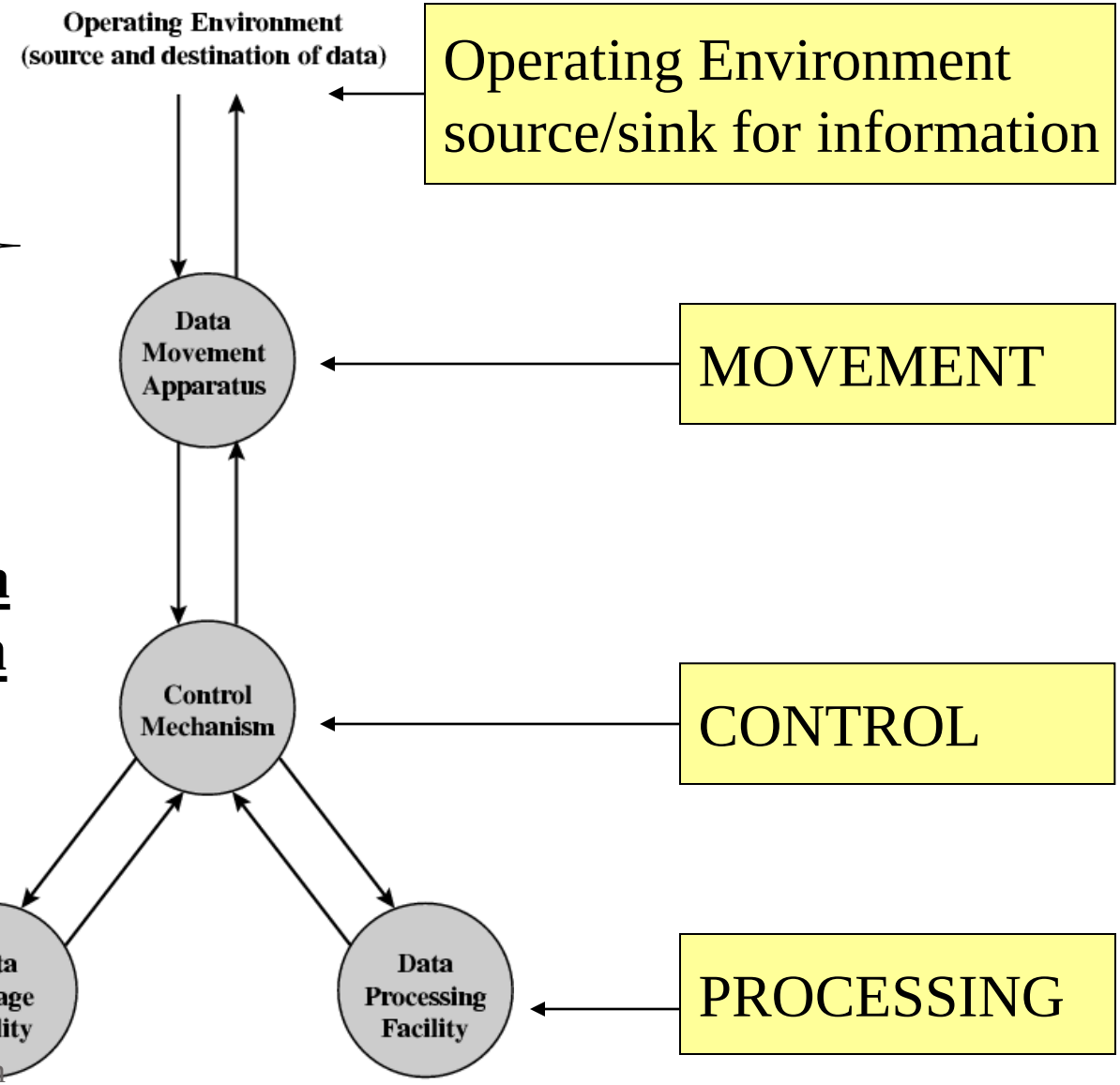
- ***Structure*:** is the way in which components relate to each other, or
  - How components relate to each other

- ***Function:*** is the operation of individual components as part of the structure.

Function

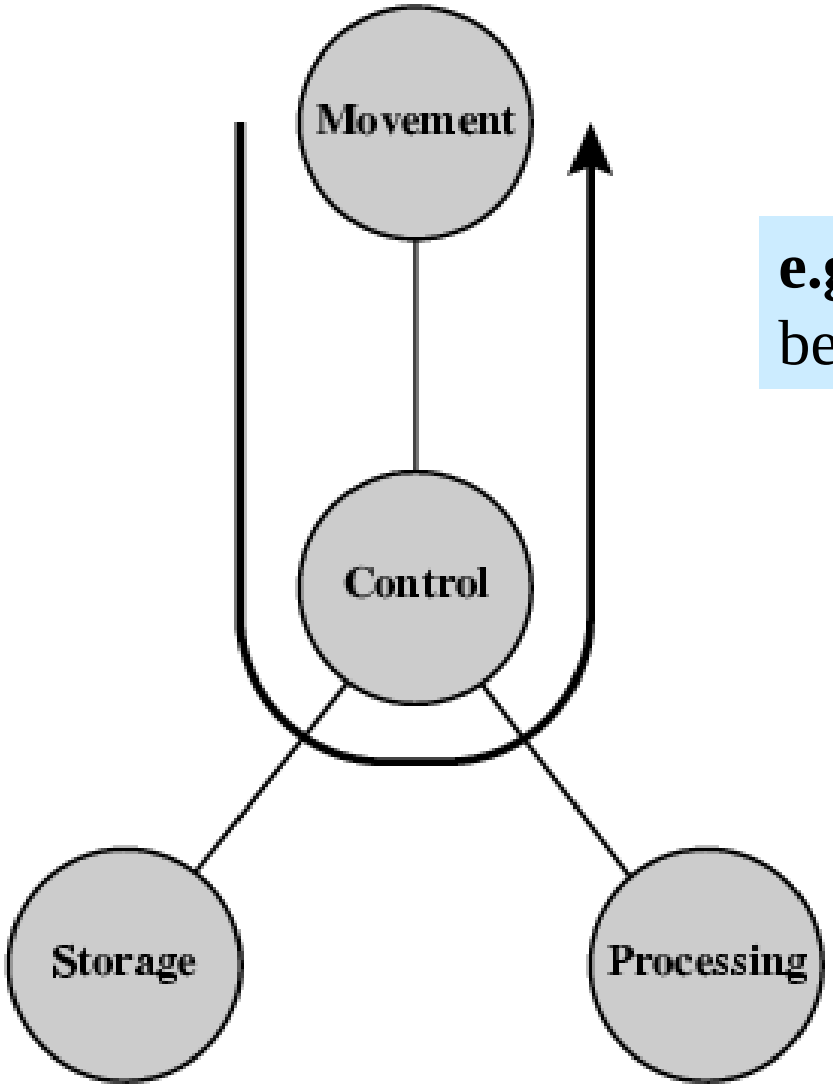
- ***All computer functions are*:**
  - Data processing
  - Data storage
  - Data movement
  - Control

Functional View



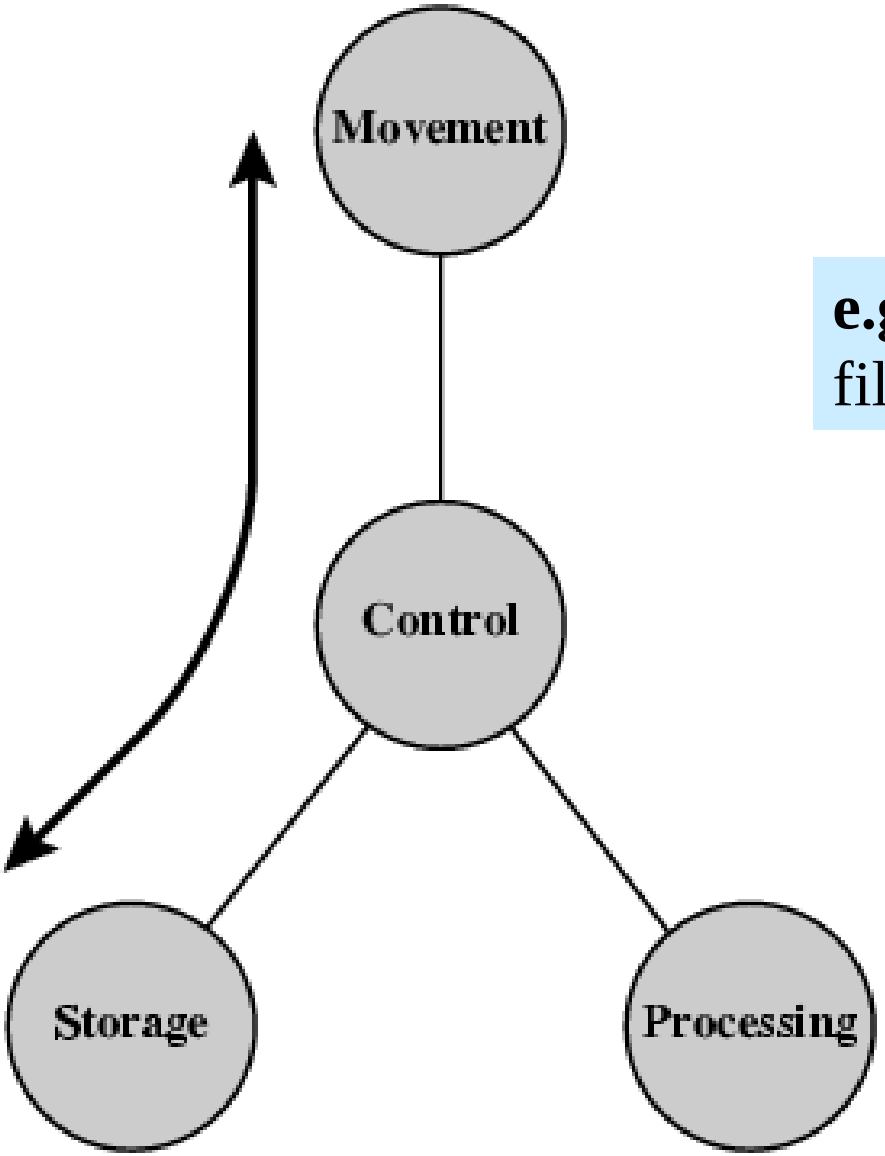
Basic Functions That a Computer can Perform

Operations (a) Data movement



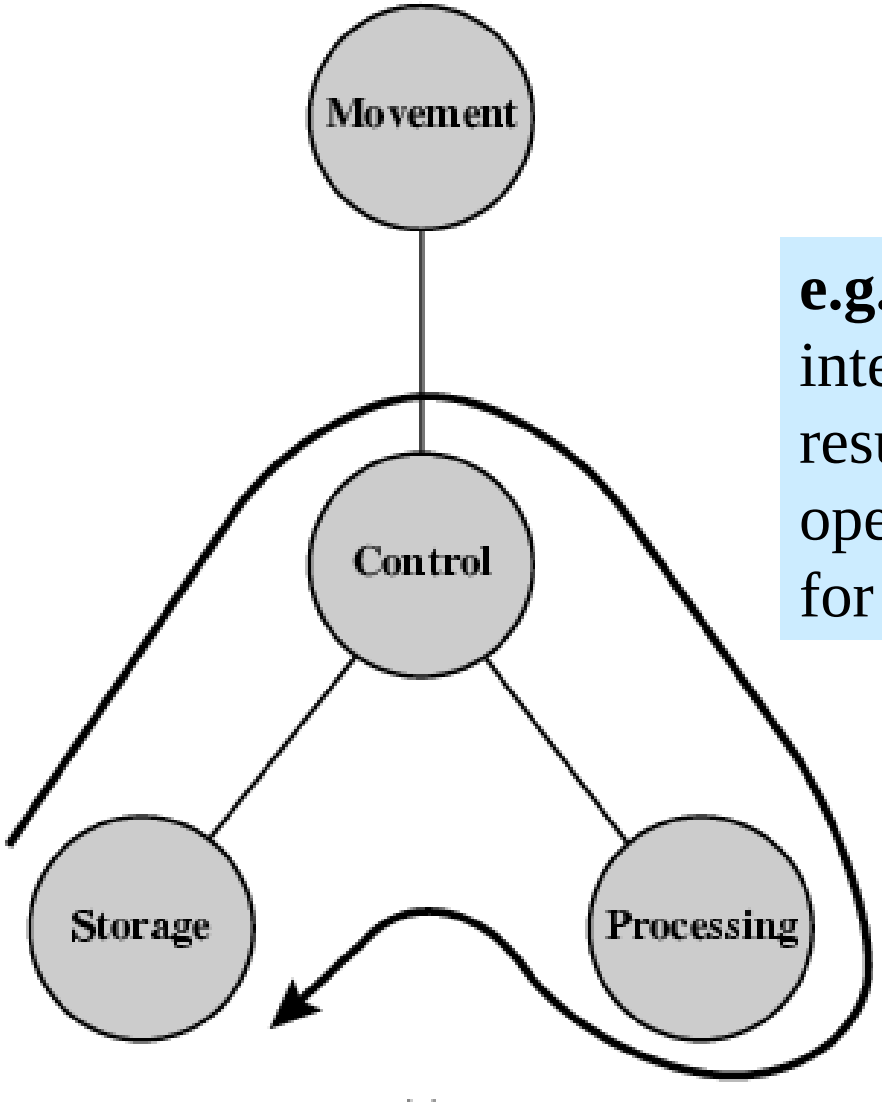
e.g. copy a file between disks

Operations (b) Storage



e.g. load a text file for editing

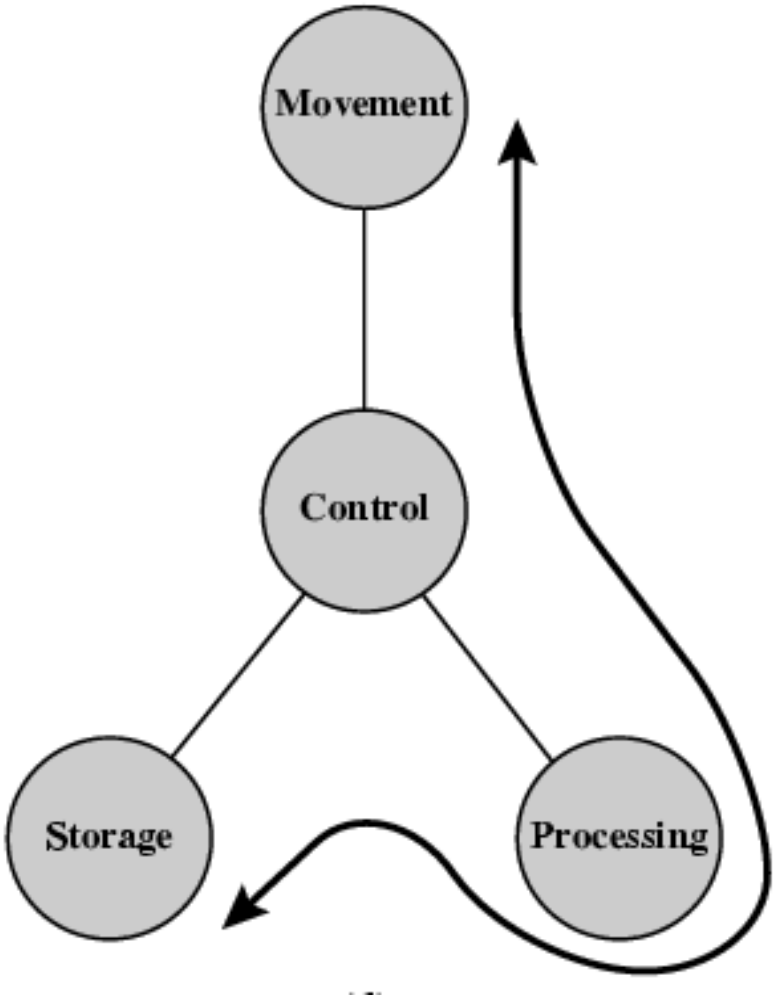
Operation (c) Processing from/to storage



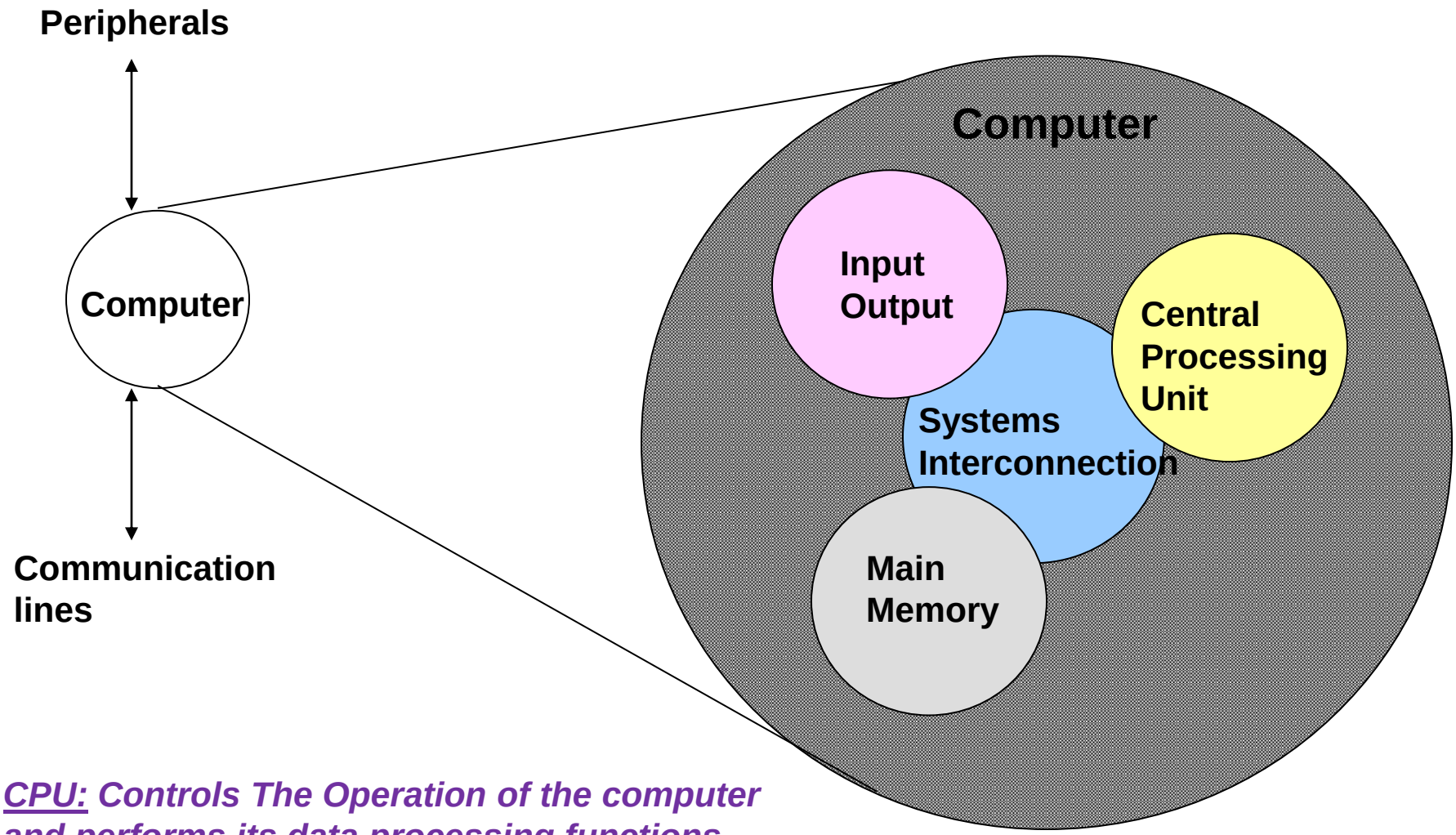
e.g. compute an intermediate result from some operands & save for later use

Operation (d)
Processing from storage to I/O

e.g. compute and display a result from some operands

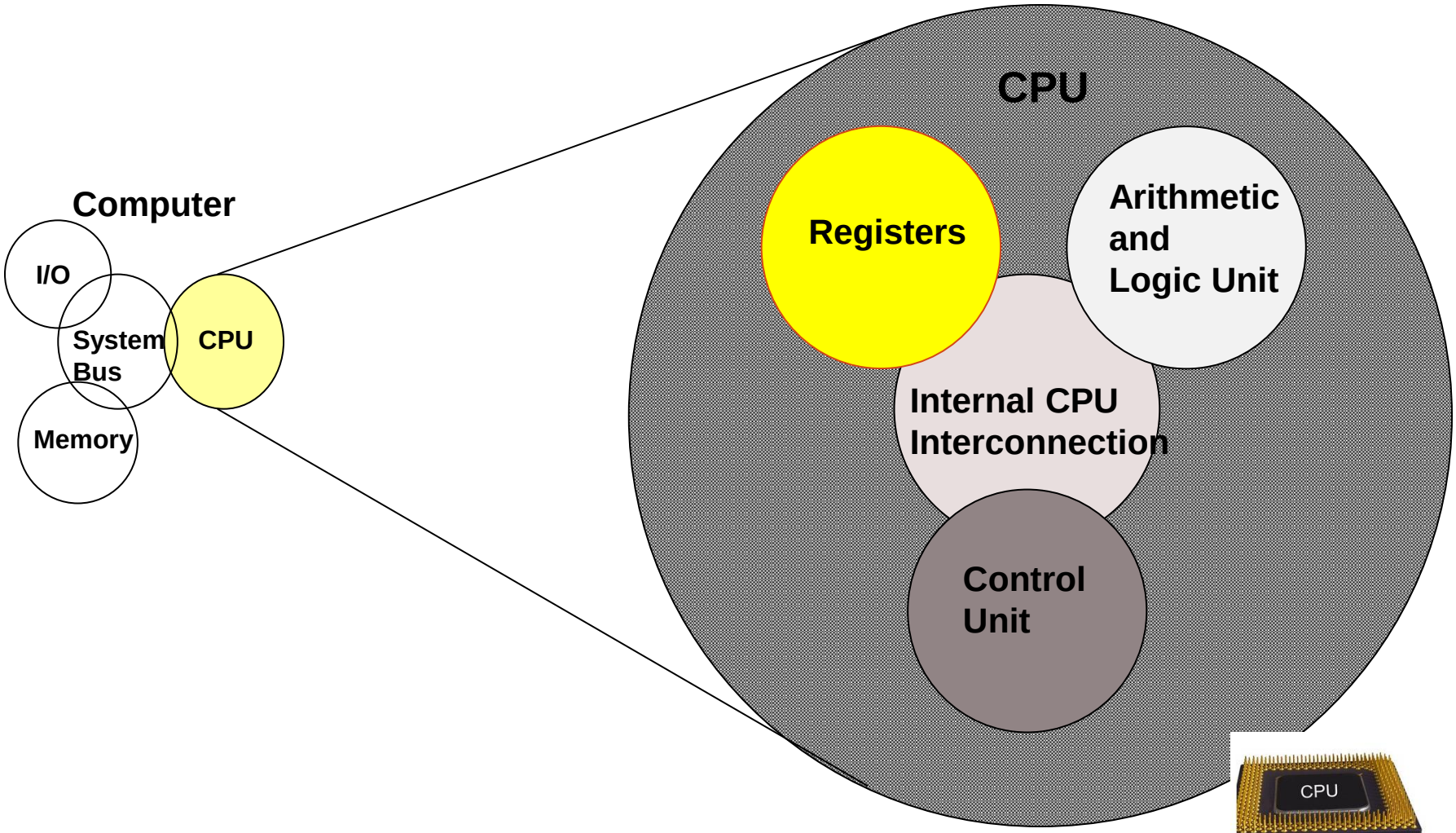


The Computer: Top Level Structure

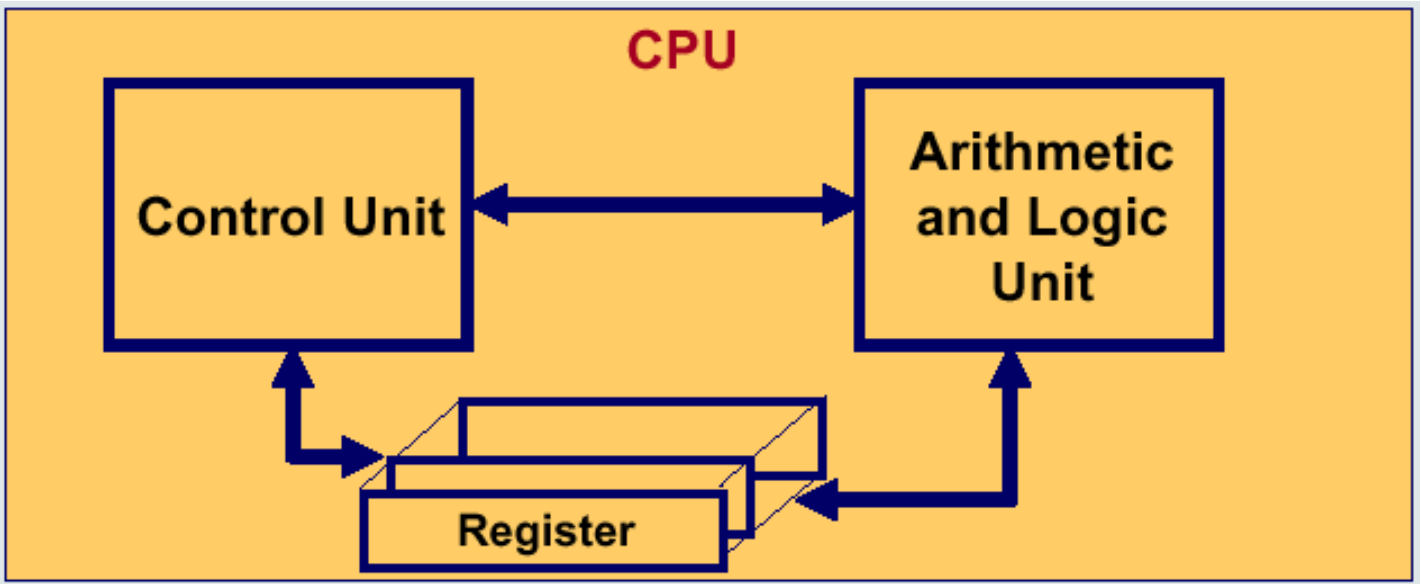


CPU: *Controls The Operation of the computer and performs its data processing functions.*

Structure - The CPU



Structure - The CPU



CPU and instruction execution

The primary function of a CPU, also called processor, is to ***execute the instructions stored in the main memory,*** and it includes three main units:

1. A program control unit, Controls the operation of the CPU and hence the computer by interpreting (decoding) the instruction to be executed and "tells" the other components what to do.

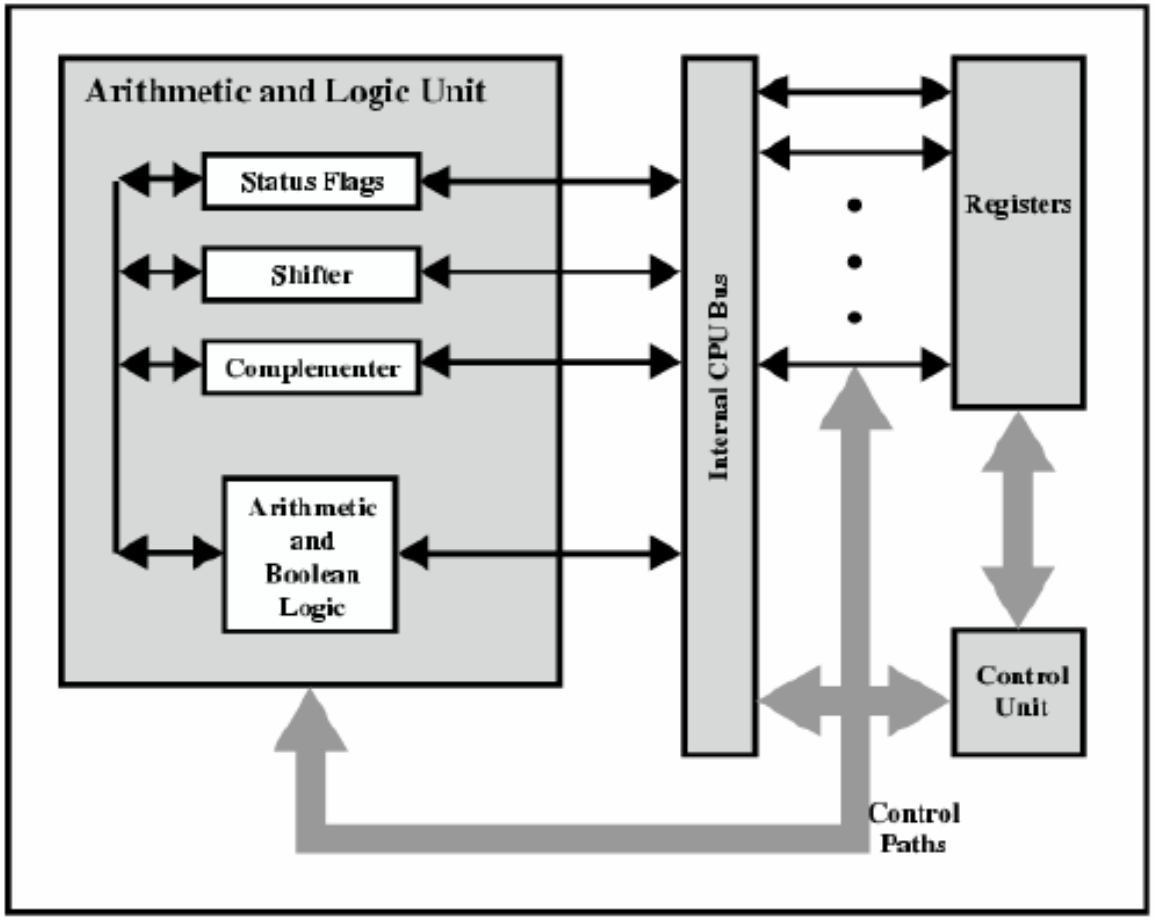
2. An Arithmetic and Logic Unit (ALU), Perform the computer's data processing functions. and

3. Registers, temporary storage devices used to hold control information, key data, and intermediate results. Number and function of the registers vary between different computers.

CPU includes also an ***internal bus*** infrastructure, which provides data movement paths among the control unit, ALU, and registers.

CPU Internal Structure

"An instruction tells the CPU to perform one of its basic operations"



Register Organization

The registers serve two main functions:

1. User-Visible Registers: used by machine or assembly ***language programmers*** to minimize memory access.

- General-purpose registers
- Data registers
- Address registers
- Condition code registers

2. 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:

1. What has to be done (the operation code)
2. To whom the operation applies (source operands)
3. Where does the result go (destination operand)
4. How to continue after the operation is finished (next instruction

Machine instructions are of four types:

1. Arithmetic and logic operations.
2. Data transfer between memory and CPU registers.
3. Program control (conditional branches, etc.).
4. I/O transfert.

Instruction Set Design

The design of an instruction set is critical to the operations of a computer system. The most important issues are:

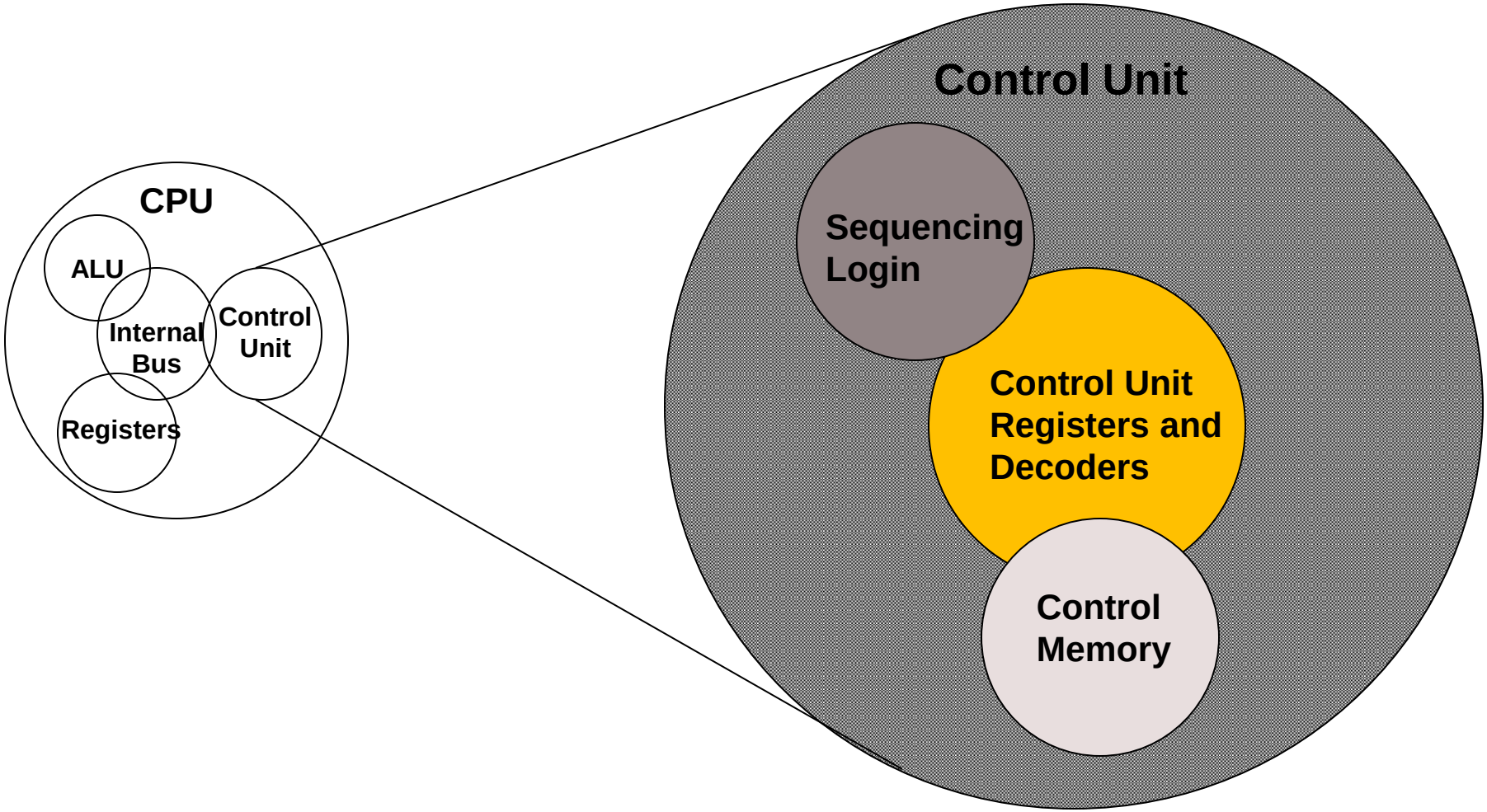
1. Operation repertoire — How many and which operations to provide, and how complex operations should be.
2. Data types — Which data types to be supported.
3. Instruction format — Length, number of addresses, size of various Registers — Number of CPU registers and their use.
4. Addressing — Which modes to be provided.

The issues are highly interrelated and must be considered together.

Machine Cycles

- The execution of an instruction is ***carried out*** in a machine cycle (instruction cycle)
- The CPU executes ***one instruction after the other***, cycle by cycle, repeatedly.
- The machine cycle time (or instruction execution time) of a computer gives an indication of its ***performance (speed).***
- Since different instructions need different time to execute, the ***average instruction execution time*** is used to calculate performance.

Structure - The Control Unit



Summary

A computer executes repeatedly a series of instructions (called programs) stored in its main memory:

- It performs data processing operations specified by the programs.
- It runs the programs automatically, with no need for human intervention.
- It can perform the operations in extremely high speed.
- It can store and manipulate a large amount of data.
- It can communicate with each other and with users in an efficient way.
- It represents program and data in the same way, which leads to flexibility.

End of Chapter 1

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