Introduction

Computer Architecture and Computer Organisation

INFO 2603
Platform Technologies

Week 1: 02-Sept-2019

Course Introduction

Main Areas:

- Computer Architecture
- Computer Networks
- Operating Systems

100% Coursework: Practical Lab Exams and Written Exams

Computer Architecture vs Computer Organisation

Computer Architecture describes architectural attributes that impact on the logical execution of a program.

Computer Organisation describes operational units and interconnections that implement an architectural specification. (Affects price and performance)

Computer Architecture

Examples of architectural attributes:

- Instruction set

- Number of bits used for representing data types (numbers, characters)

- Input/Output mechanisms

- Techniques for addressing memory

Computer Organisation

Examples of organisational attributes:

- Control signals
- Interfaces between the computer and peripherals
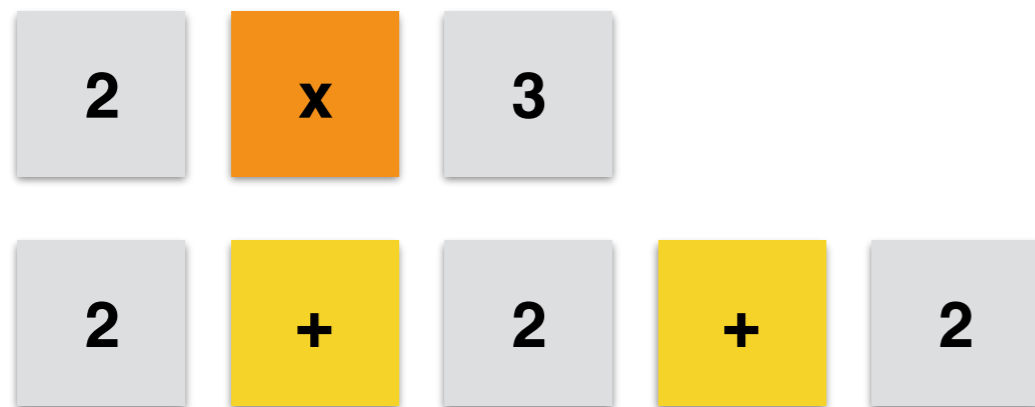- Memory technology used

Example

Architectural design issue:

- whether a computer will have a multiply instruction.

Organisational design issue:

- whether the multiply instruction is implemented by a special multiply unit or repeated use of the add unit.

**Frequency of use
Speed of both approaches
Cost and physical size of multiply unit**

| 2 | x | 3 |

| 2 | + | 2 | + | 2 |

Same result

Distinction

Many computer manufacturers offer a family of computer models, all with the same architecture but differences in organisation. (Different price and performance).

Hardware Review

- Tremendous variety of computers available based on:
  - Cost
  - Performance
  - Size
  - Application
- List some examples:
  - Brands
    - HP
    - Apple
    - Dell
    - Asus
    - Toshiba
    - Lenovo
  - Types:
    - Desktop
    - Laptop
    - Tablet
    - Smart phone
    -

Hardware Review

- Brands
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- Types:
  - Desktop
  - Laptop
  - Tablet
  - Smart phone
  - Server
  - Super computer
  - Embedded Systems (Pi)
  - Wearables

Hardware Review

- Computers are complex systems.
- Easier to understand using:
  - Hierarchical nature of computer systems
  - Interrelated subsystems
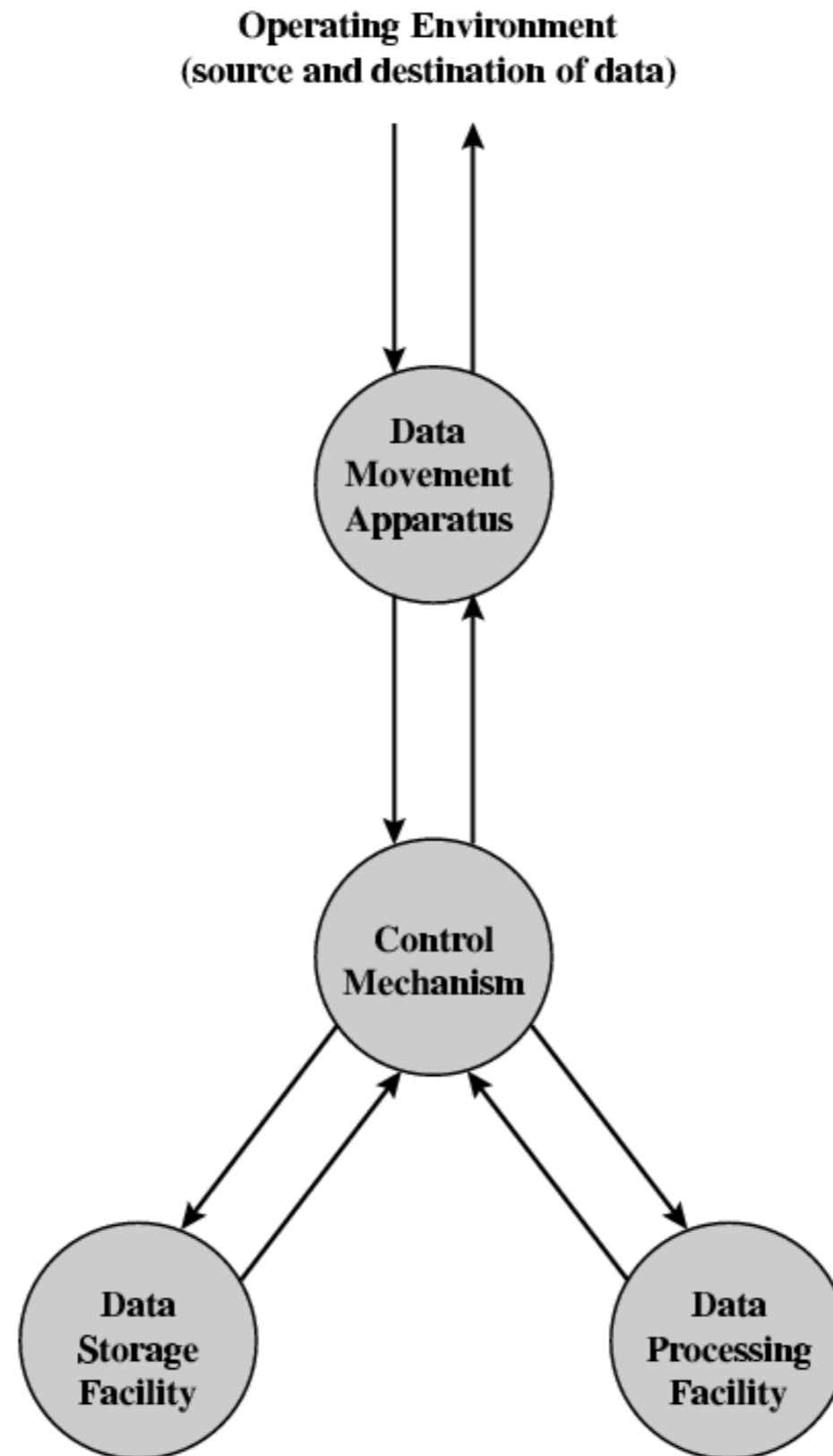 - Drill down to elementary subsystems

Computer 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

Basic Computer Functions

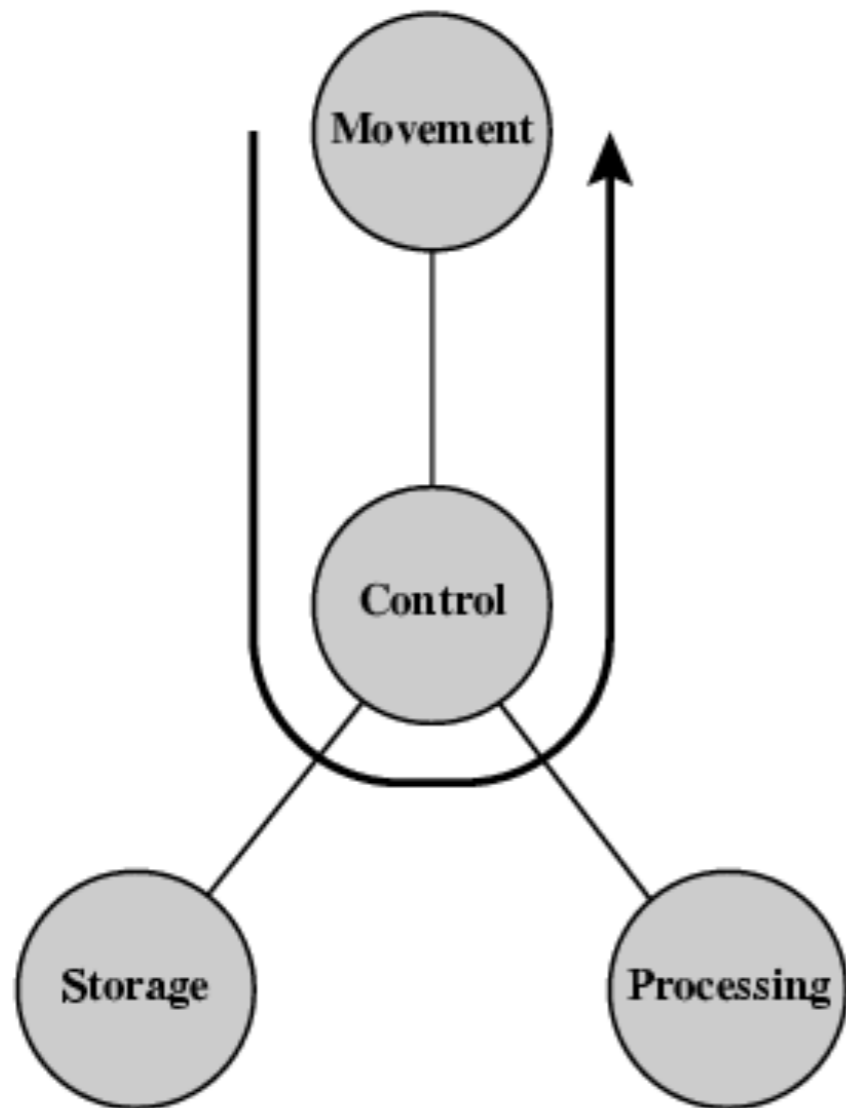All computer functions can be classified as :

‣ Data processing
‣ Data storage
‣ Data movement
‣ Control

Functional View

Operating Environment
(source and destination of data)

Data Movement Apparatus

Control Mechanism

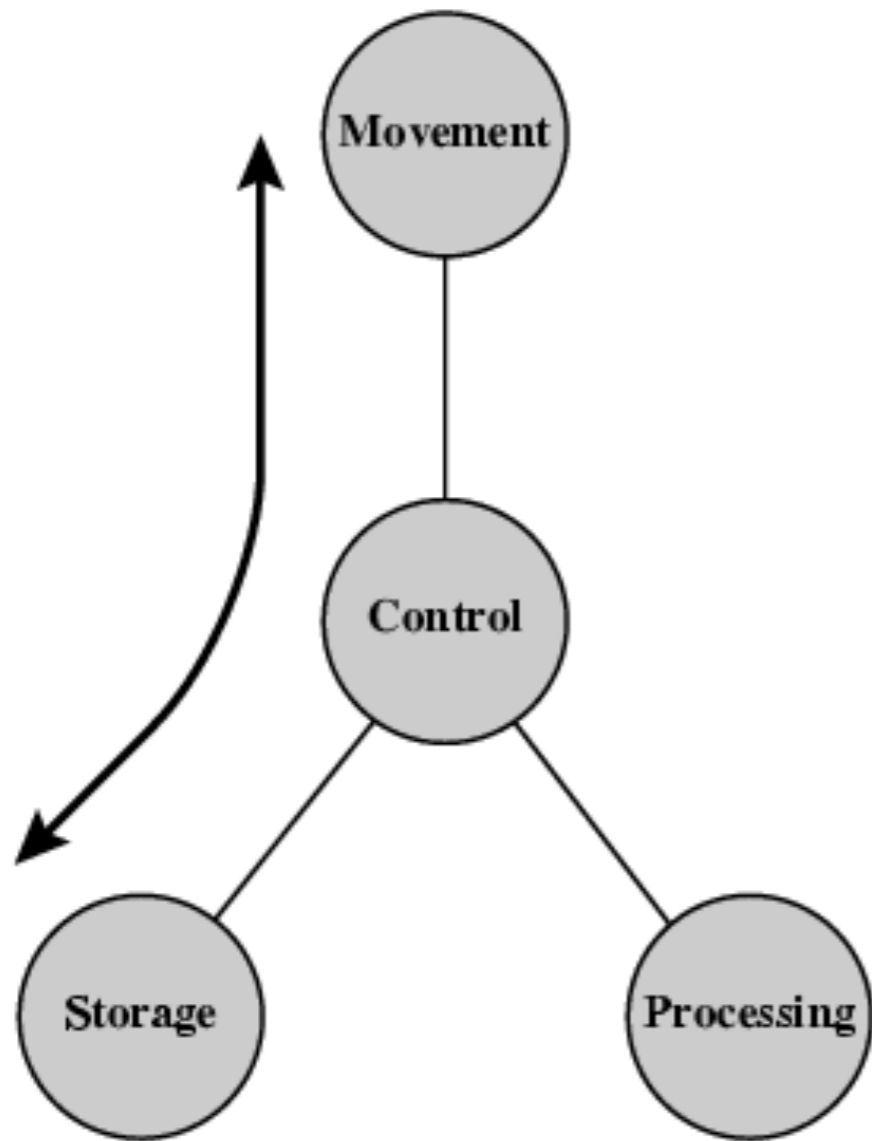Data Storage Facility

Data Processing Facility
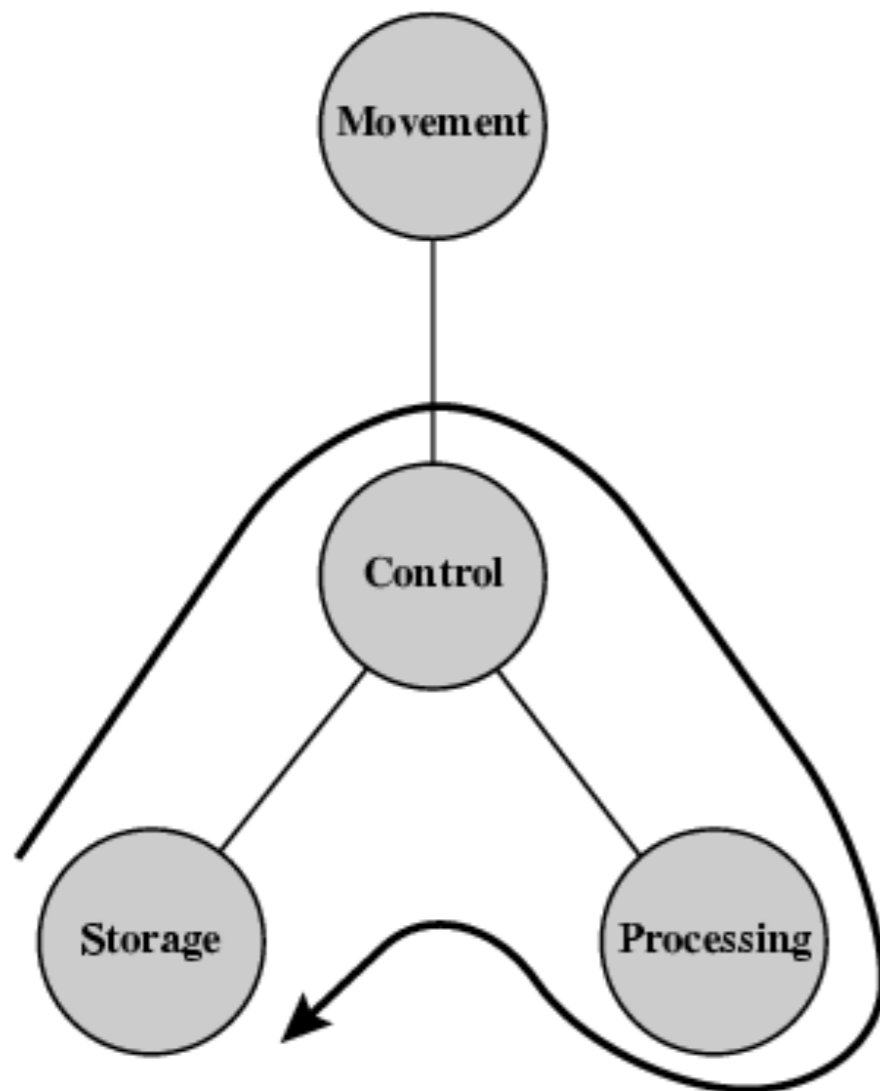
Operations (a) Data movement

- Between computer and outside world
  - Direct connection: Peripherals (input/output devices)
  - Longer distances: Data communication channels

Operations (b) Storage

- Data storage
  - Temporary e.g. RAM
  - Long-term e.g. files
  - Read function
  - Write function

Operation (c) Processing from/to storage

- Data processing on locally stored data

Operation (d) Processing from storage to I/O
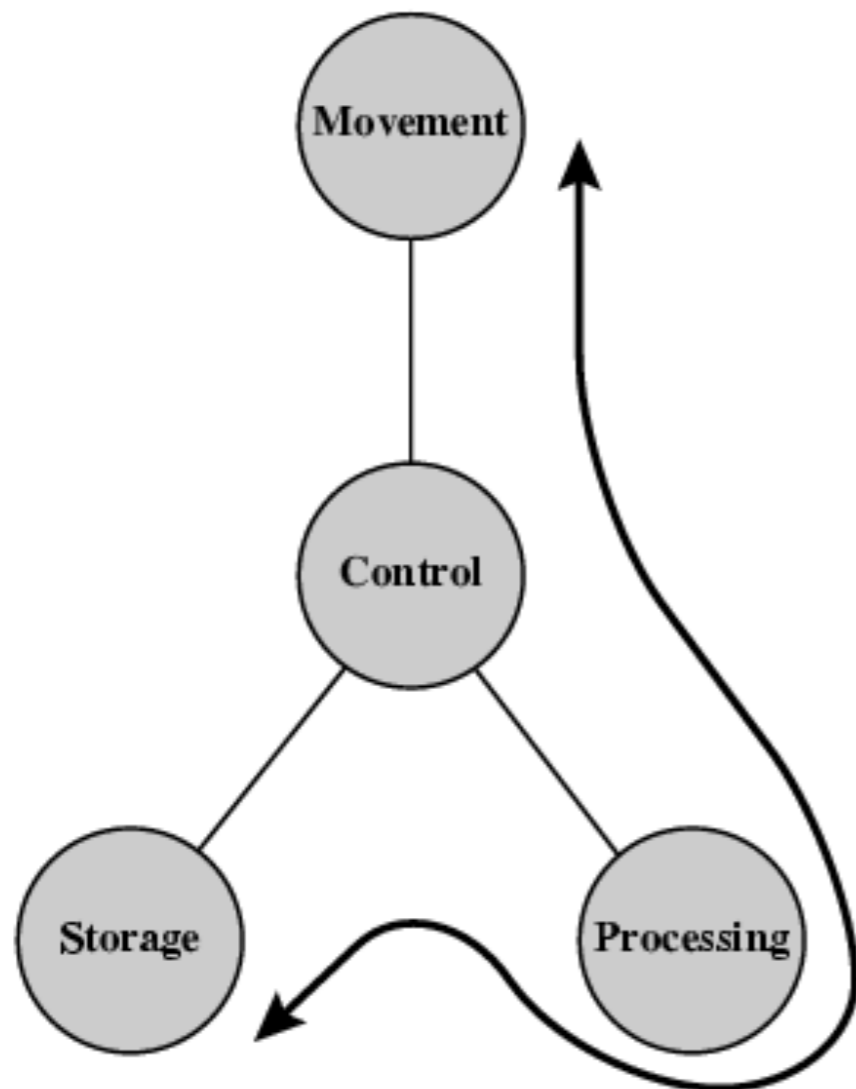
- Processing being done on data moving en route between local storage and the external environment

Principal Elements of a Computer System

Peripherals

Computer

Communication lines

Computer

Central Processing Unit

Main Memory

Systems Interconnection
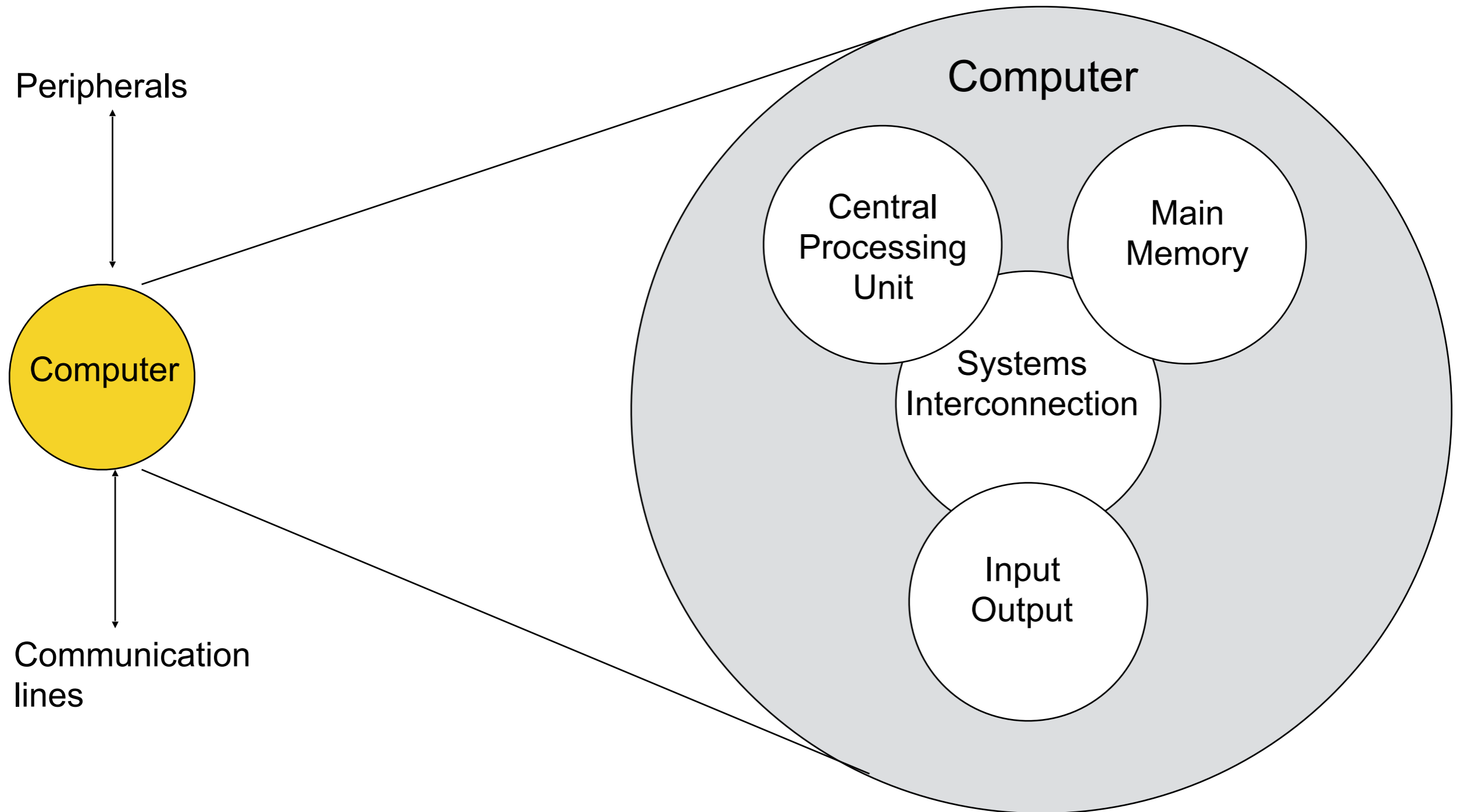
Input Output

Principal Elements of a Computer System

- **Central Processing Unit (CPU)** - Processor
  - Controls the operation of the computer
  - Performs data processing functions
- **Main Memory:** stores data
- **Input/Output (I/O)** Subsystem
  - Moves data between the computer and its external environment
- **System Interconnection**
  - Mechanism for communication among CPU, main memory and I/O

Principal Elements of the CPU

Computer

I/O

System Bus

CPU

Memory

CPU

Registers

Arithmetic and Logic Unit

Internal CPU Interconnection
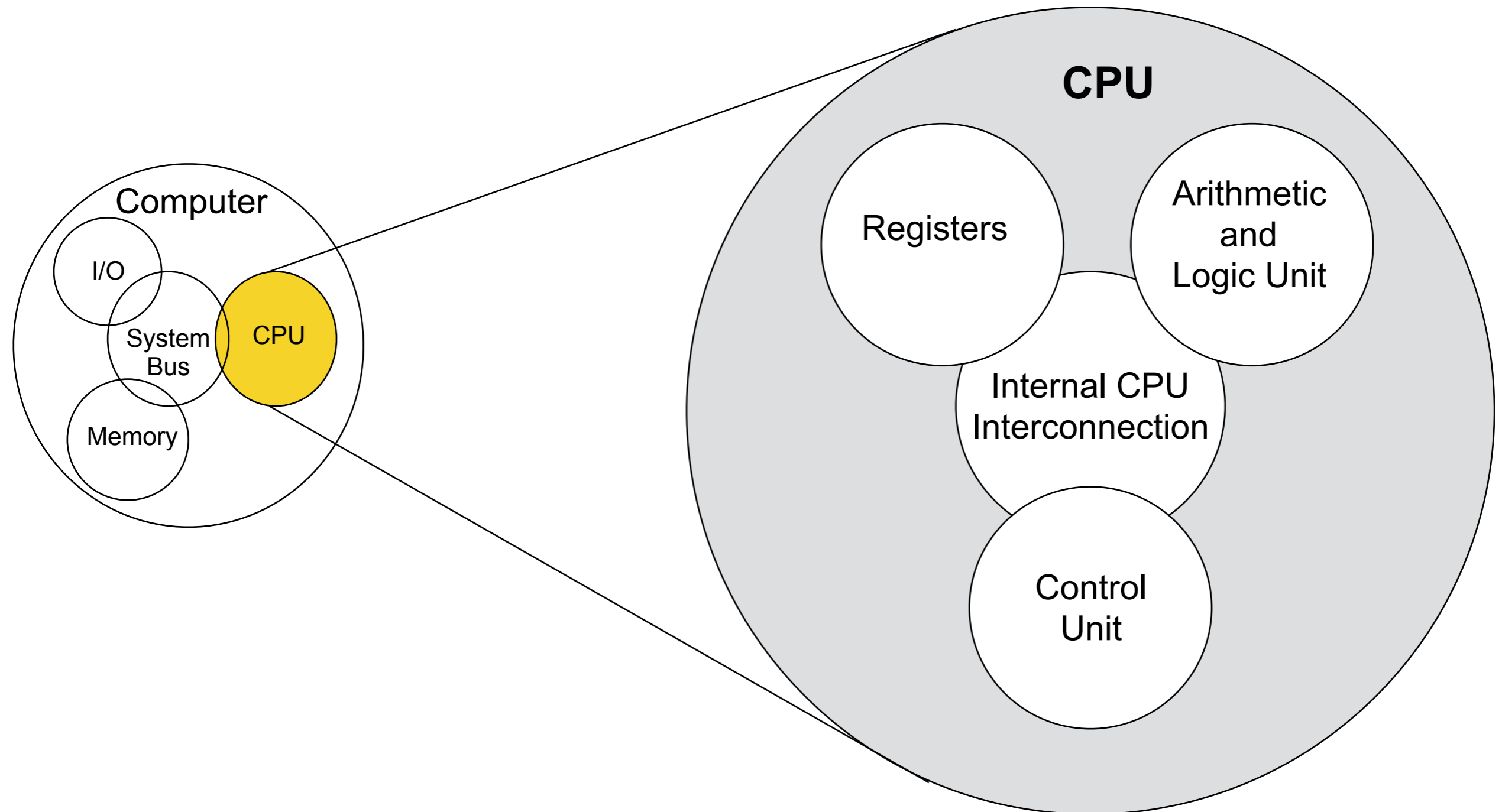
Control Unit

CPU Structural Components

- **Control Unit (CU)**
  - Controls the operation of the CPU
- **Arithmetic and Logic Unit (ALU)**
  - Performs the computer's data processing functions
- **Registers**
  - Provide storage internal to the CPU
- **CPU Interconnection**
  - Mechanism for communication among the CU, ALU and registers

Structure - The Control Unit
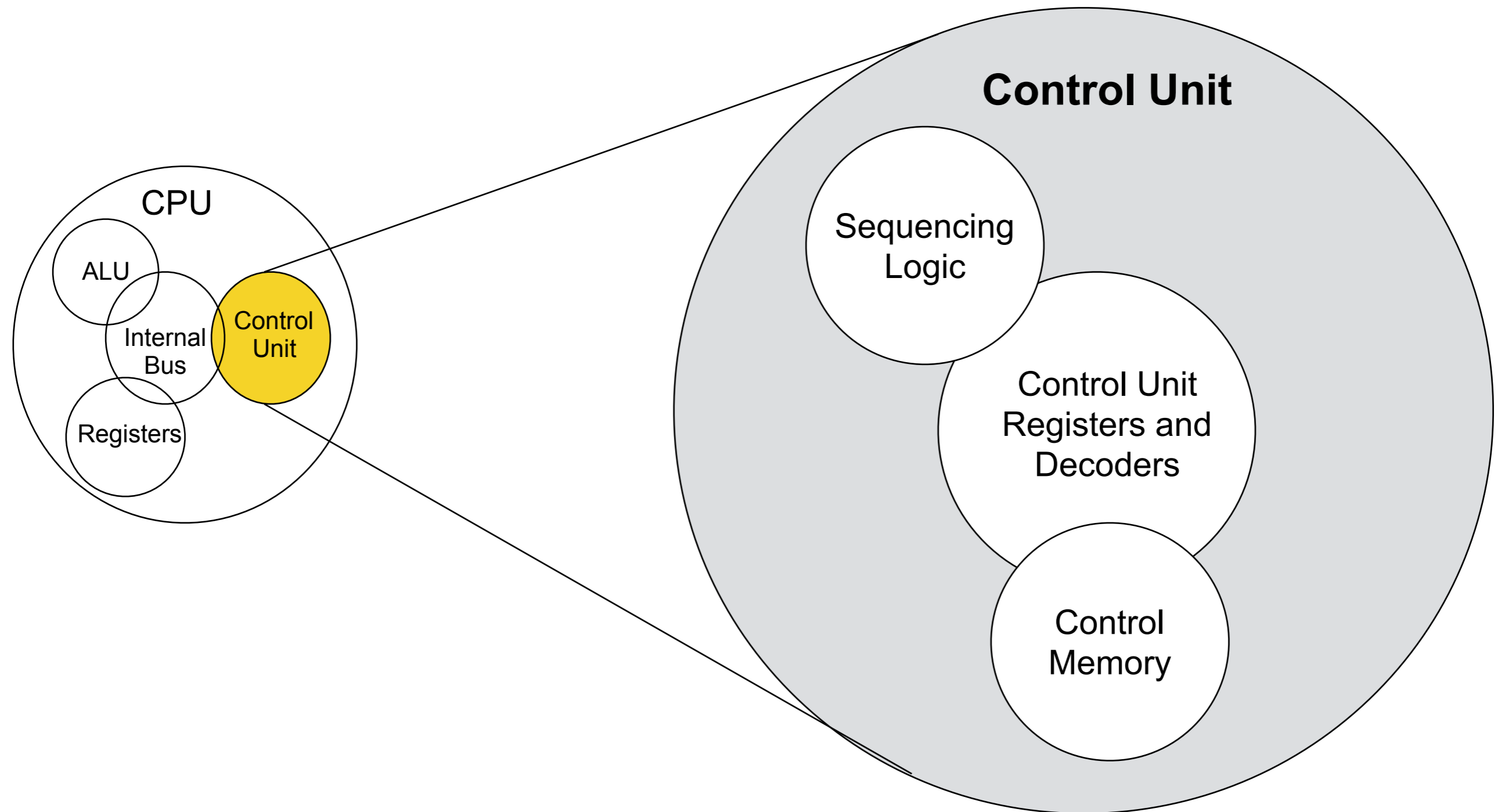
Structure - The Control Unit (CU)

- One common implementation approach:
  - Microprogrammed Implementation: The CU operates by executing microinstructions that define its functionality.

First Generation: Vacuum Tubes

- ENIAC: Electronic Numerical Integrator And Computer
  - Built in response to war (World War II) 1943
  - Calculate range and trajectory firing tables
  - Ballistics equations (vs solved by hand = days)
  - 5000 additions per second;
  - Decimal machine (rather than binary: Why?)
  - Finished in 1946 (too late for use in war)
- General purpose: reused to determine feasibility of hydrogen bomb

# First Generation: ENIAC

**1946
Public Unveiling**

http://www.computerhistory.org/timeline/computers

Numeration Systems

```
System:      Hash Marks                Roman   Decimal   Binary
-------      ----------                -----   -------   ------
Zero         n/a                        n/a      0         0
One          |                          I        1         1
Two          ||                         II       2         10
Three        |||                        III      3         11
Four         ||||                       IV       4         100
Five         /|||/                      V        5         101
Six          /|||/ |                    VI       6         110
Seven        /|||/ ||                   VII      7         111
Eight        /|||/ |||                  VIII     8         1000
Nine         /|||/ ||||                 IX       9         1001
Ten          /|||/ /|||/                X        10        1010
Eleven       /|||/ /|||/ |              XI       11        1011
Twelve       /|||/ /|||/ ||             XII      12        1100
Thirteen     /|||/ /|||/ |||            XIII     13        1101
Fourteen     /|||/ /|||/ ||||           XIV      14        1110
Fifteen      /|||/ /|||/ /|||/          XV       15        1111
Sixteen      /|||/ /|||/ /|||/ |        XVI      16        10000
Seventeen    /|||/ /|||/ /|||/ ||       XVII     17        10001
Eighteen     /|||/ /|||/ /|||/ |||      XVIII    18        10010
Nineteen     /|||/ /|||/ /|||/ ||||     XIX      19        10011
Twenty       /|||/ /|||/ /|||/ /|||/    XX       20        10100
```

https://www.allaboutcircuits.com/textbook/digital/chpt-1/decimal-versus-binary-numeration/

von Neumann Machine

- John von Neumann: mathematician and physicist.
  - ENIAC consultant 1945
  - Proposed that a program could be represented in a form suitable for storage in memory alongside the data.
    - Computers then get instructions by reading them from memory: stored-program concept

von Neumann Architecture
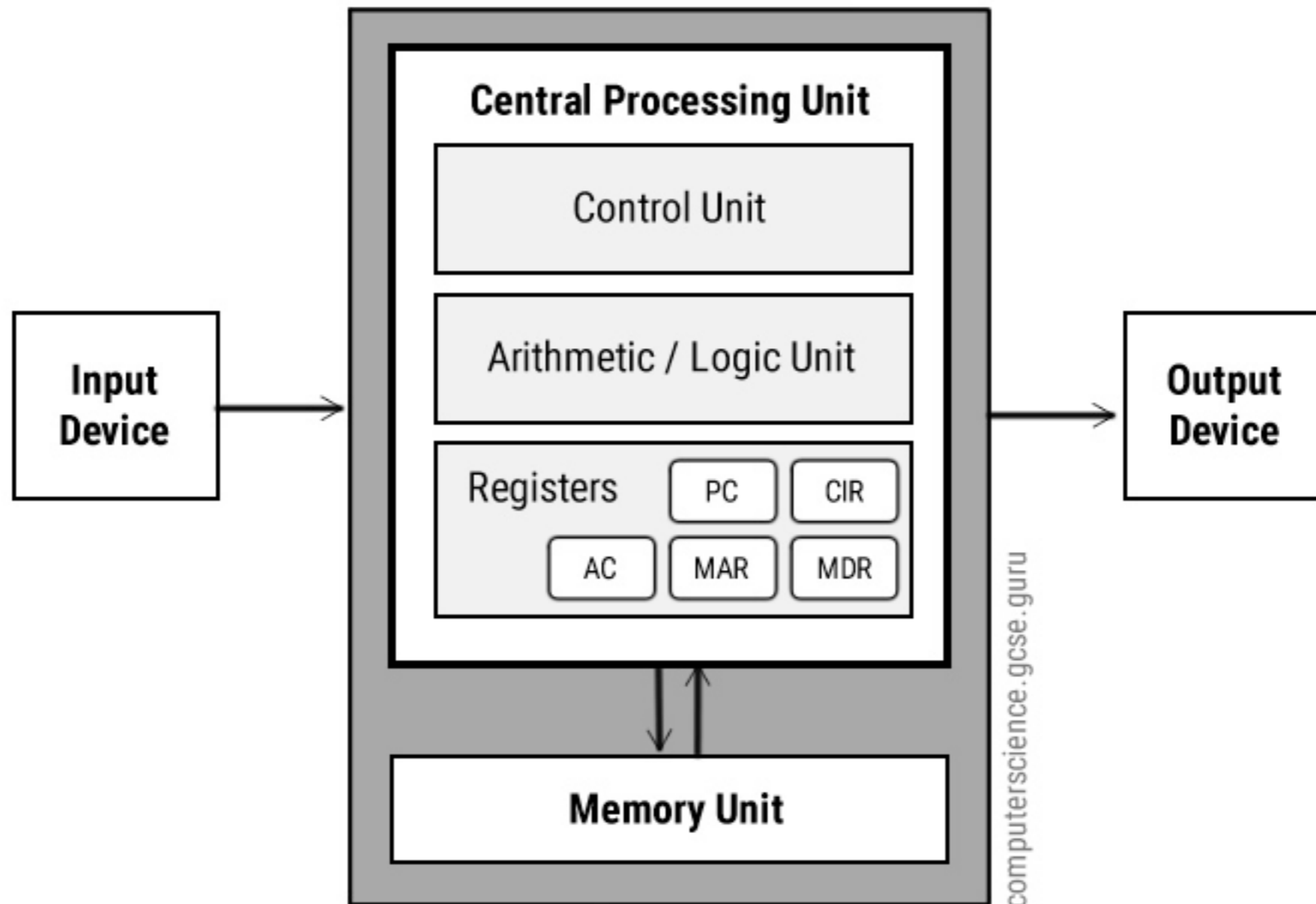
von Neumann Architecture: Registers

MAR	Memory Address Register	Holds the memory location of data that needs to be accessed
MDR	Memory Data Register	Holds data that is being transferred to or from memory
AC	Accumulator	Where intermediate arithmetic and logic results are stored
PC	Program Counter	Contains the address of the next instruction to be executed
CIR	Current Instruction Register	Contains the current instruction during processing

- Registers are high speed storage areas.

von Neumann Architecture

- Three Key Concepts
  - Data and instructions are stored in a single read-write memory
  - The contents of this memory are addressable by location (irrespective of the type of data stored there)
  - Execution occurs in a sequential fashion from one instruction to the next.

Computer Components: Hardwired Program

- Small set of basic logic components that can
  - be combined in various ways to store binary data
  - perform arithmetic and logical operations.
- The configuration is a form of programming using hardware: **hardwired program**

Computer Components: Software Program

- A general purpose configuration of arithmetic and logic functions.

- The control signals applied can be changed!

- A new sequence of codes results in new functionality: Software

Reading

- Chapter 1: Computer Organisation and Architecture

- http://www.computerhistory.org/timeline/computers/

- Chapter 1: Understanding Operating Systems, 8th edition, Ana McIver McHoe and Ida M. Flynn