Introduction to Computer Organization

BSCS-4th

Dated: Sep Week-1

Instructor’s Introduction

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Course Book

- **‘Computer Organization and Architecture’ by William Stallings (9th Edition or up)**

- Reference Books:
- ‘The Intel Microprocessors’ by Barry B. Brey (8th edition)

Course Outline (CO & AL)

- Introduction to computer organization.
- Processor, memory, IO and their interconnection,
- Data Representation: Signed and Unsigned numbers, (algorithms for signed and unsigned number multiplication)
- Function of Computer, Instruction Execution Cycle and interrupts, CPU performance
- Memory Addressing Modes (Real mode Memory Addressing, Protected mode memory addressing, Paging)
- Memory Hierarchy, Cache (Mapping functions, writing policies, Replacement algorithms)
- Instruction Pipelining (technique, pipeline performance, pipeline hazards),
- Practice of assembly language programming, and Data addressing modes.

Marks Distribution

- **Assignments & Lab Reports**: The assignments will be submitted as desired by the instructor. The labs will be conducted as required for the course.

- **Pre- Requisite**: None

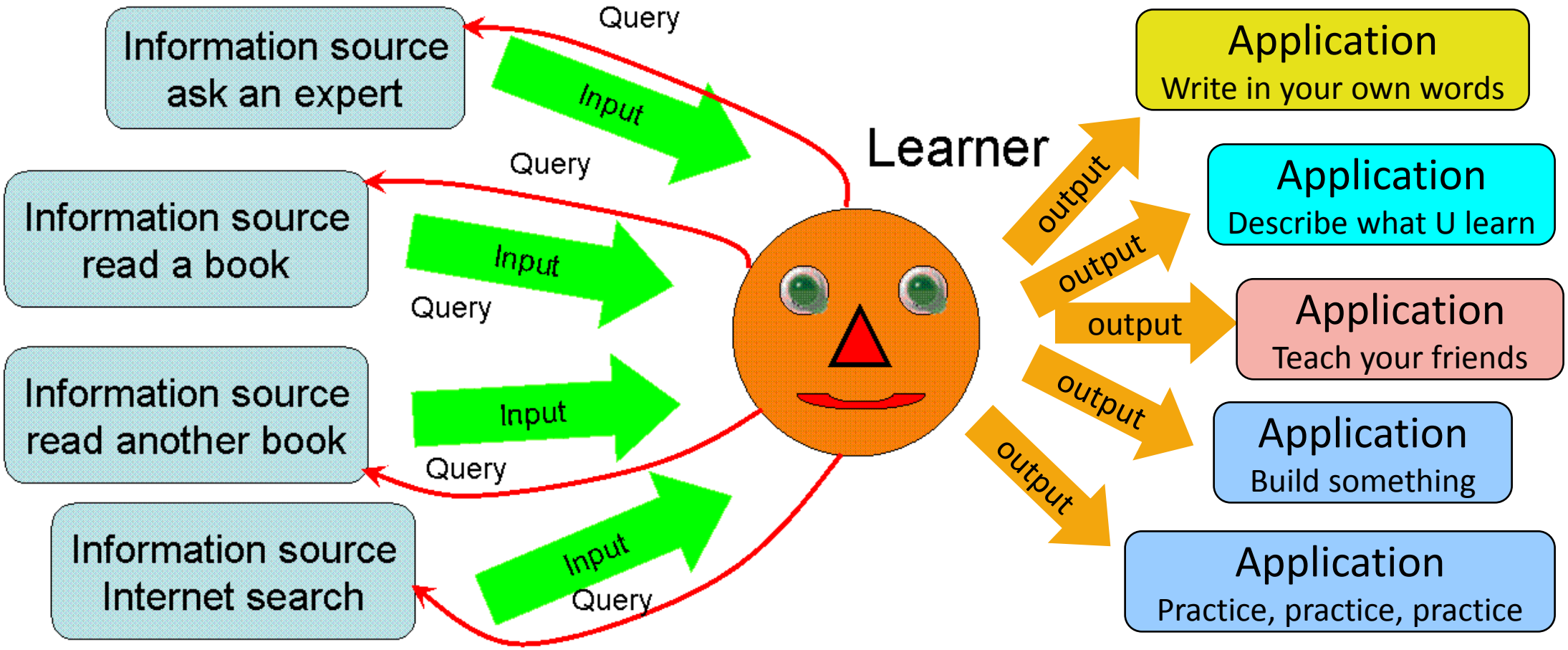
- **Grading Policy:**
- Internal assessment: 20%
- Mid Term Exam : 30%
- Labs Work : 16% (absolute marks)
- End Semester Exam : 50%

Note: Labs will be conducted on Lab Days as per time table.

How to Study This Course

- The point is learning, and learning requires effort, no shortcut here.
- Never ever limit yourself to a single source of information, use multiple sources.
- Approach each of your sources with specific questions in mind, with the goal of finding answers to those questions.
- Apply that information, don’t let it remain idle in your brain, this is how you construct your own understanding.
- The final step is to establish a ‘Feedback loop’, enabling the learner to self-correct errors in understanding.
- Practice, practice and practice until you get it done, coz nothing is impossible in this world.

Approach to Learning



Rules of Class

- Always get in the class in time.
- Concentrate on what is being taught in class.
- Don’t involve in talking or using mobiles.
- I will include ‘class behaviour’ marks for every individual.
- Ask questions by first raising your hand and then delivering words.
- Do not pass comments in the class.
- Always make notes for your own benefit.
- Teachers decision will be final in every aspect. No late Quiz etc.

Difference between Organization & Architecture

- **Computer Architecture** refers to those attributes of a system visible to a machine language programmer.

- Architectural attributes include the instruction set, the number of bits used to represent various data types, I/O mechanisms, and techniques for addressing memory.

- It is difficult to design an Operating System well without the knowledge of the underlying architecture.

Notes

- **Architecture** is the underlying hardware.
- **Instruction set** is the complete set of all the instructions in machine code that can be recognized and executed by a ‘Central Processing Unit’ (CPU).
- **Data types** e.g. integer, float, double, character.
- Moreover a 32-bit system uses a 32-bit microprocessor e.g. CPU registers and address buses or data buses are of that width.
- Whereas a 64-bit system manipulates 64 bits at a time.
- **Techniques for addressing memory** like direct addressing, indirect addressing, paging etc.

Difference between Organization & Architecture

- **Computer Organization** refers to the operational units and their interconnections that realize the architecture.

- Organizational attributes include hardware details such as control signals, interfaces between the computer and peripherals, and the memory technology used.

- Organization changes with changing technology whereas architecture is abstract/higher level.

Notes

- **Computer organization** refers to the interconnections between the operational units that form the architecture.
- **Control signals** tell the computer's memory, ALU unit and I/O devices how to respond to a program's instructions. Such signals are generated by a 'Control Unit' (CU).
- **Interface** means how external devices connect and communicate with the computer system. This interface is provided by a 'port' on a compute system.
- **Memory technology** such as cache memory, RAM, magnetic disk etc. This is called a 'memory hierarchy'. Data is organized in this hierarchy.

Notes

- The **technology** is constantly changing, based on business demands and advancements in industry.
- **Organizational attributes** adapts to these changes by restricting components e.g. splitting the cache into two, one for instruction and one for data. Or adding or removing components e.g. adding another level of cache to improve performance.
- **Architectural component** models represent high level designs. Pentium-4 CPU was introduced in 2000. Intel introduced ‘core’ technology in 2006. So the change in architecture is gradual and it remains the same for quite some time.

Difference between Organization & Architecture

- For Example-1:

- It is an ‘architectural’ design issue whether a computer will have a **multiply** instruction.

- However it is an ‘organizational’ issue whether that instruction will be executed by a special multiply unit or repeated additions.

Example-2

- It is an ‘architectural’ design issue whether a computer will have a **add** instruction.

- How to implement an adder is part of computer ‘organization’. Meaning it could be a ‘serial adder’, or ‘carry look ahead adder’ or ‘ripple adder’.

Example-3

- For example, both Intel and AMD processors have the same X86 architecture.
- But how the two companies implement that architecture (their computer organization) is usually very different.
- The same programs run *correctly* on both, because the architecture (instruction set and hardware components) is the same.
- But the programs on both machines may run at different speeds, because the organization are different.
- Different organization means their ‘realization of architecture is different’ from one another.

Final Note

- ‘Computer Architecture’ can be considered as an agreement between Hardware and Software people.

- That is, what all feature is being provided by the hardware manufacturer that the software programmer can run on this machine.

- In short, whatever instructions you use to talk to Hardware can be considered as a part of computer Architecture. (e.g. instruction set).

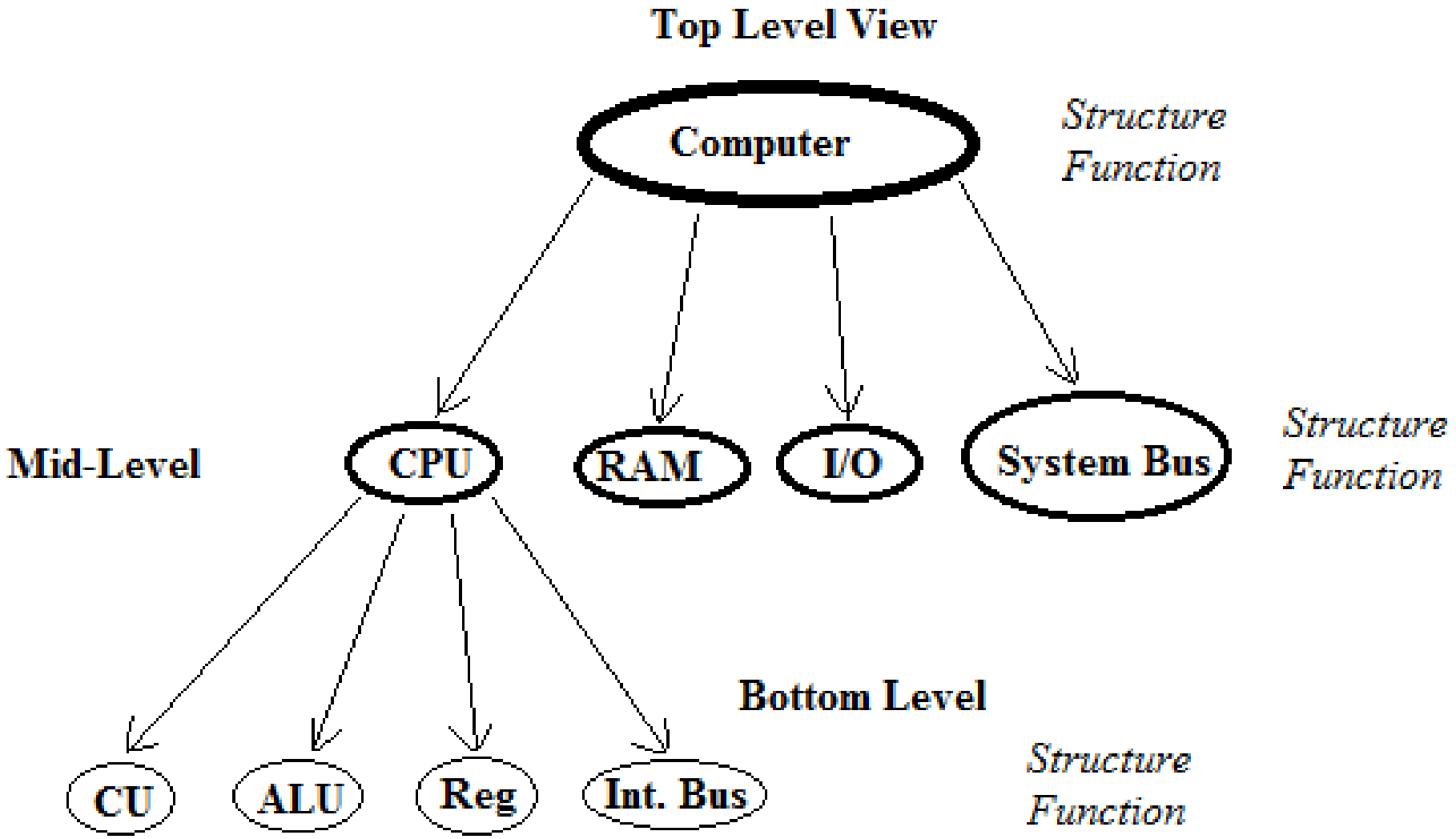
Computer : A Hierarchical System

Computer -> CPU -> Control Unit

- A ‘computer’ is a complex ‘hierarchical system’, whose major components are processor, memory and I/O.
- A hierarchical system has different levels, and at each level, the system consists of a set of components and their relationships.
- In ‘top-down’ approach, we begin with a top view and decompose the system into its sub-parts.
- The behaviour at each level depends only on a simplified working of the system at the next lower level. And at each level the designer deals with structure and function.
- Structure is the way in which the components are inter-related.
- Function is the operation of each individual component as part of the structure.

Figure Next Slide ->

Hierarchical System: Block Diagram



Four basic ‘Functions’ of a Computer

- Function is the operation of each individual component as part of the structure.
- Four basic functions that a computer system can perform are:

1) Data processing 2) Data storage 3) Data movement 4) Control

1) The computer must be able to process data. The data may take a wide variety of forms and the range of processing requirements is broad. Process of items of data to produce meaningful information.
2) It is also essential that a computer must store data. Files of data are stored on the computer for subsequent retrieval and update.

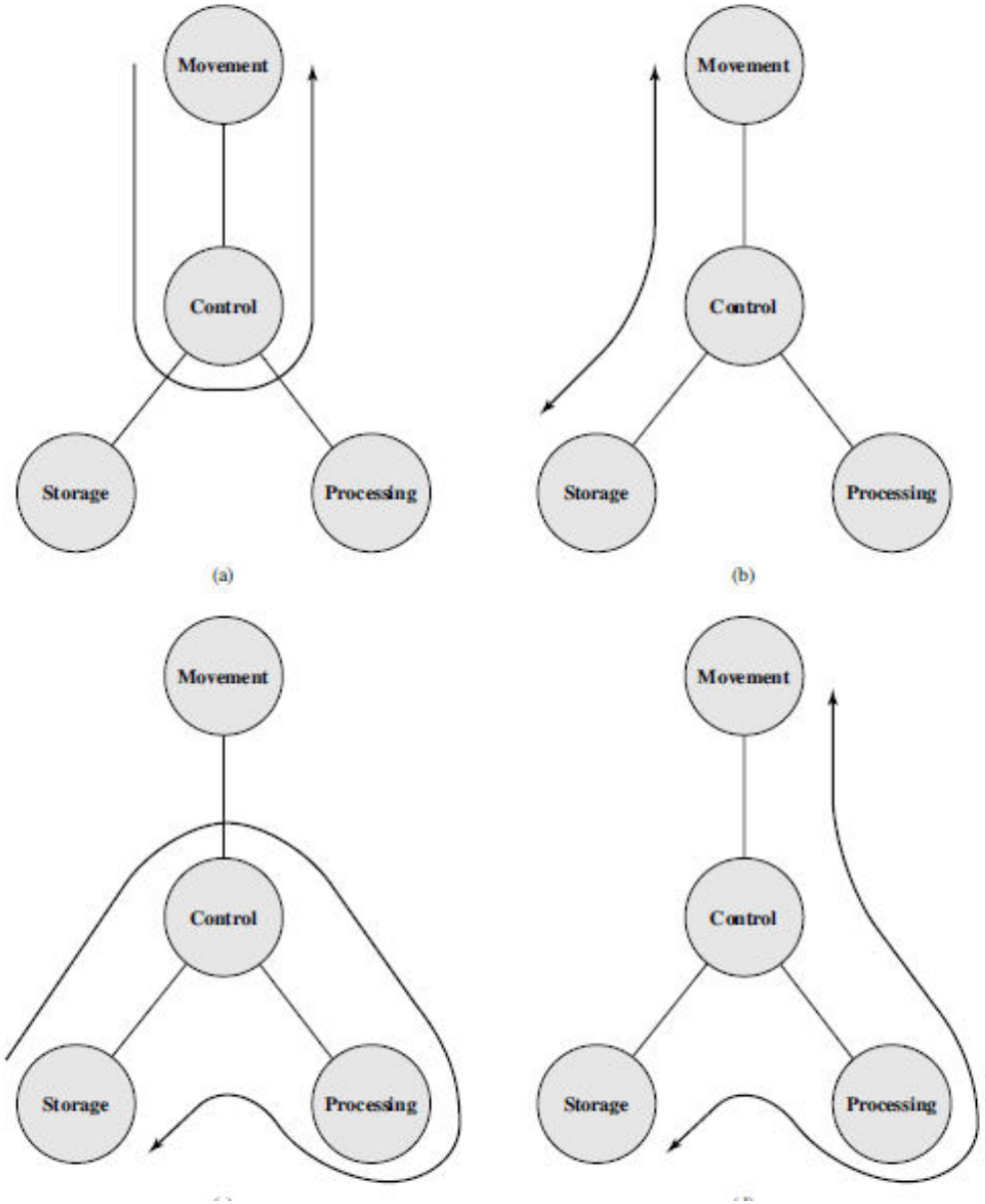
Four basic ‘Functions’

3) The computer must be able to move data between itself and the outside world and connects to devices that serve as either sources or destinations of data.

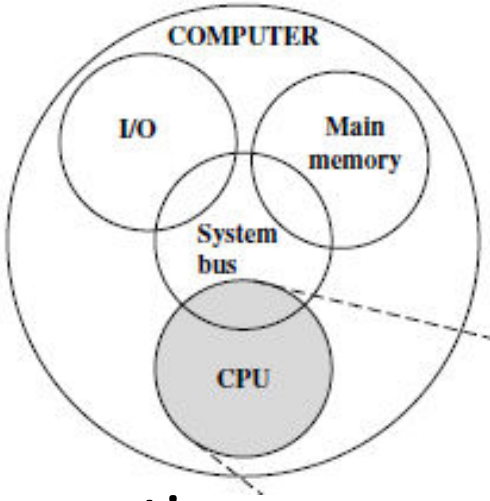
- When data are received from or delivered to a device that is directly connected to the computer, the process is known as **Input/Output (I/O)**, and the device is referred to as **Peripheral.**

4) Finally, there must be control of these three functions. This control is exercised by the individual(s) who provide the computer with instructions.

Possible Computer Operations



Internal Structure of the Computer

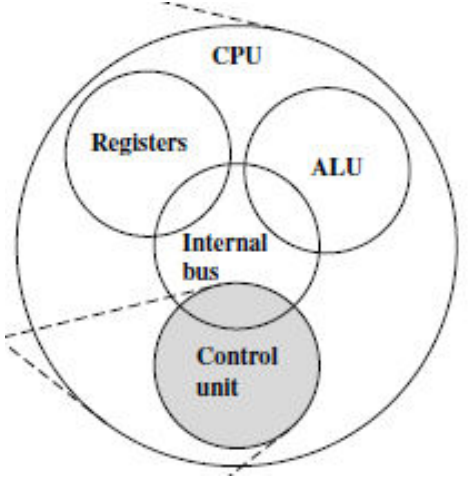


- A computer has four main components: Their Functions are:

1) CPU 2) Main memory 3) I/O 4) System interconnections

1) **Central Processing Unit (CPU)** controls the operation of the computer and performs its data processing functions as 'processor'.
2) **Main memory** stores bulk of data as RAM.
3) **I/O** moves data between the computer and its external environment.
4) **System interconnections** provides for communication among CPU, main memory and I/O by means of a 'system bus'.

Structural Components of a Processor



CPU is the component that executes a program by performing arithmetic and logical operations on data.

- The main structural components of a processor or a CPU are:

1) Control unit 2) ALU 3) Registers 4) CPU interconnections

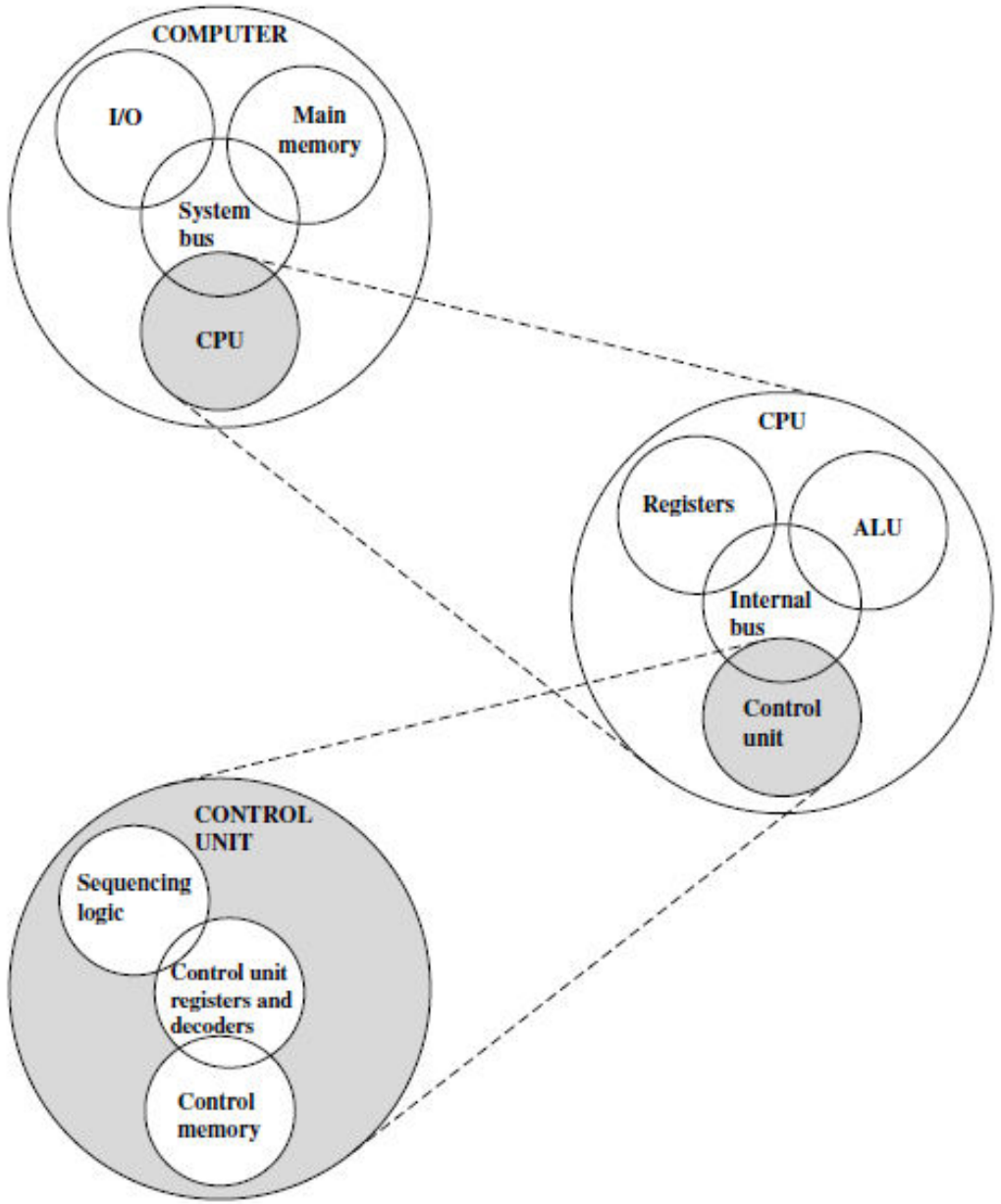
1. **Control unit** controls the operation of the CPU and hence the computer. It tells the computer's memory, ALU and I/O, how to respond to a program's instructions.
2. **Arithmetic and Logic Unit (ALU)** performs the computer's data processing functions.
3. **Registers** provide storage internal to the CPU.
4. **CPU interconnections** provide for communication among the control unit, ALU and registers by means of an 'internal bus'.

Control Unit

- Within the CPU, a **control unit** manages the computers resources and orchestrates the performance of its functional parts in response to those instructions.

- The computer can function as a data storage device with data transferred from the external environment to computer storage (as Read) and vice versa (write).

The Computer: Top-Level Structure



Assignment No. 01 (Due Next Week)

Q1. What is the distinction between computer organization and computer architecture?

Q2. What is the difference between computer ‘structure and function’?

Q3. What are the four main ‘functions of a computer’?

Q4. Define the internal ‘structure of a computer’.

Q5. List and briefly define the main structural ‘components of a processor’.

The End

Components and Working of Control Unit (CU) Morris Page 231, Page 137

- See book figure.
- design of control unit in computer architecture (google)
- https://www.studytonight.com/computer-architecture/design-of-control-unit.php
- http://nptel.ac.in/courses/106103068/20
- https://en.wikipedia.org/wiki/Control_unit
- http://whatis.techtarget.com/definition/clock-speed
- control signals in computer architecture (google)

design of arithmetic logic unit Morris Page 117 and page 164

- http://www.explainthatstuff.com/howtransistorswork.html
- How do transistors work in calculators and computers? ALU Logic
- And or operations in weather and logic gates
- The transistor is the primary building block of all microchips,
- including your CPU, and is what creates the binary 0's and 1's (bits)
- your computer uses to communicate and deal with Boolean logic.
- When placed in different configurations, transistors form logic gates,
- which can be combined into arrays called half adders that can also be
- combined into full adders. [ALU]