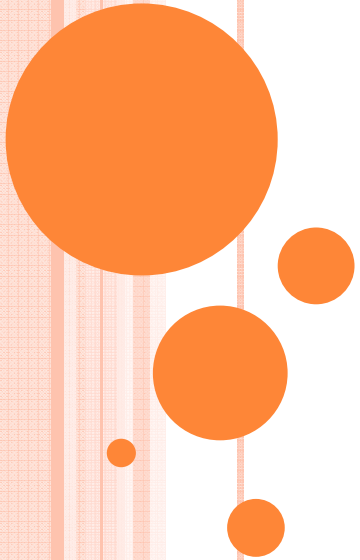
COMPUTER ORGANIZATION AND ARCHITECTURE (CS-205)



COURSE OBJECTIVES:

- A student should grasp the basic concepts of computer architecture and organization, and understand the key skills of constructing cost-effective computer systems.
- A student should learn how to quantitatively evaluate different designs and organizations, and provide quantitative arguments in evaluating different designs.
- A student should be able to articulate design issues in the development of processor or other components that satisfy design requirements and objectives.

WHY STUDY THIS COURSE?

- Design better computer system, including system software such as compilers, operating systems, and device drivers.
- Optimize program behavior.
- Evaluate (benchmark) computer system performance.
- Understand time, space, and price tradeoffs.

COURSE OUTCOMES (CO):

- To gain an in depth understanding of the various types of Processor

Organization,

- Understanding how the timing & control signal is generated by the processor for the execution of an instruction.
- To be capable of analyzing and understanding the performance of any computer with different types of memory present along with their organization.
- To know how the processor takes data from the memory devices, how the I/O devices are interlinked with the processor using I/O processor or interfaces.

Computer Architecture

- Just as buildings, each computer has a visible structure, referred to as its architecture.
- Computer architecture deals with the functional behaviour of a computer system as viewed by a programmer.
- It includes the information formats, the instruction set architecture (ISA), and the techniques for addressing memory of a computer system.
- It is concerned with the specification of various modules, such as processors and memories structuring them together into a computer system.
- In computer science and engineering computer architecture is the practical art of selecting and interconnecting hardware components to *create computers that meet functional, performance and cost goals* and the formal modeling of those systems.

COMPUTER ORGANIZATION

- Computer organization deals with structural relationships that are not visible to the programmer (like clock frequency or the size of physical memory)
- It is concerned with the way the hardware components operate and the way they are connected together to form the computer system.
- It includes the high-level aspects of a design, such as the memory system, the bus structure, and the design of the internal CPU (where arithmetic, logic, branching and data transfers are implemented).

COMPUTER ARCHITECTURE *VS* ORGANIZATION

- Computer architecture
  - Logical aspects of system as seen by the programmer. E.g., instruction sets, instruction formats, data types, addressing modes.
  - Computer architecture explains what a computer should do.
  - Computer architecture is designed first.
- Computer organization
  - Physical aspects of computer systems. E.g., circuit design, control signals, memory types.
  - Computer organization explains how a computer works.
  - Computer organization is started after finalizing computer architecture.

- The primary function of a digital computer is to process data input to it to produce results that can be better used in a specific application environment.

- The functional blocks in a computer are of four types:

  1. Central Processing Unit
  2. Memory
  3. Input Unit
  4. Output Unit

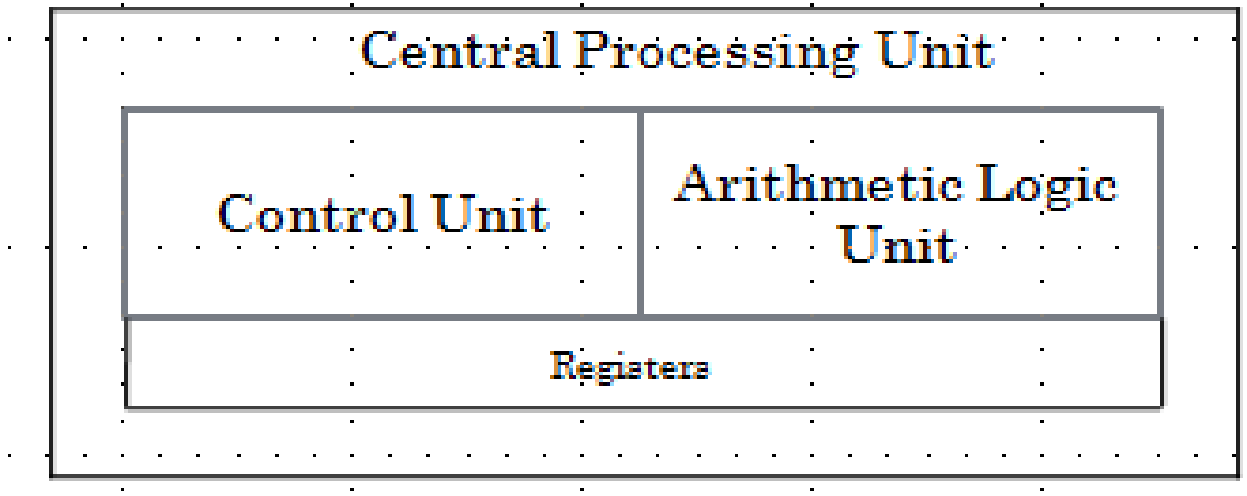
Central Processing Unit (CPU)

- The CPU or the microprocessor (or simply processor) is referred as the brain of a computer system.
- CPU consists of three main subsystems, the Control Unit (CU), the Arithmetic Logic Unit (ALU), and the Registers.
- Speed of the computer system is defined by the architecture of the processor being used.

CPU

- The Central Processing Unit (CPU a.k.a. Processor) is the chip which acts as a control center for all operations. It executes instructions (a program) which are contained in the memory section.
- Basic operations involve
  - the transfer of data between itself and the memory section
  - manipulation of data in the memory section or stored internally
  - the transfer of data between itself and input/output devices
- The CPU is said to be the **brains** of any computer system. It provides all the timing and control signals necessary to transfer data from one point to another in the system.

Central Processing Unit (CPU) (Condt…)



ARITHMETIC LOGIC UNIT

- The ALU contains electronic circuits necessary to perform arithmetic and logical operations.
- The arithmetic operations are ADD, SUBSTRACT, MULTIPLY, DIVIDE, etc.
- The logical operations include COMPARE, SHIFT, ROTATE, AND, OR, etc
- The control unit analyses each instruction in the program and sends the relevant signals to all other units – ALU, Memory, Input unit and Output unit

Control Unit

- It is responsible for directing and coordinating most of the computer system activities.
- It does not execute instructions by itself. It tells other parts of the computer system what to do.
- It determines the movement of electronic signals between the main memory and arithmetic logic unit as well as the control signals between the CPU and input/output devices.

CONTROL UNIT(CONDT…)

- The internal communication inside a computer that transforms raw data into useful information is called **processing.**
- To perform this transformation, the computer uses two components- processor and memory
- The program is fed into the computer through the input unit and stored in the memory
- To execute the program, the instructions have to be fetched from memory one by one which is done by control unit
- Then the control unit decodes the instruction.

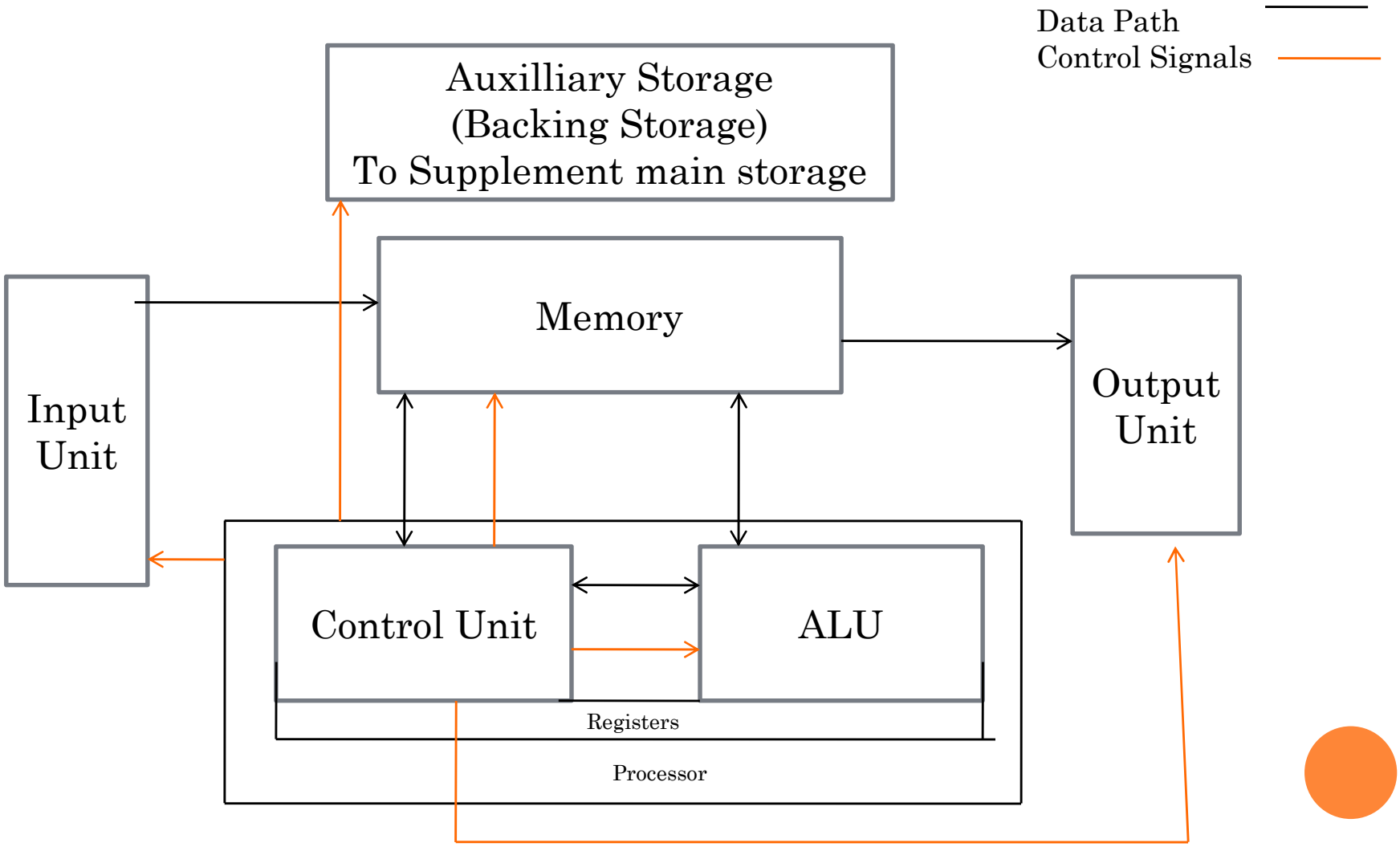
CONTROL UNIT(CONDT…)

- According to instruction, control unit issues signals to other units.
- After instruction is executed, the result of the instruction is stored in memory or stored temporarily in the register, so that this can be used by the next instruction.
- The results of a program are taken out of the computer through the output unit.

CONTROL UNIT(CONDT…)

- To complete an event i.e. processing, control unit repeats a set of four basic operations:
- Fetching is the process of obtaining a program instruction or data item from the memory
- Decoding is the process of translating the instruction into commands the computer can execute.
- Executing is the process of carrying out the commands.
- Storing is the process of writing the result to memory.

Data flow between CPU, memory and I/O devices



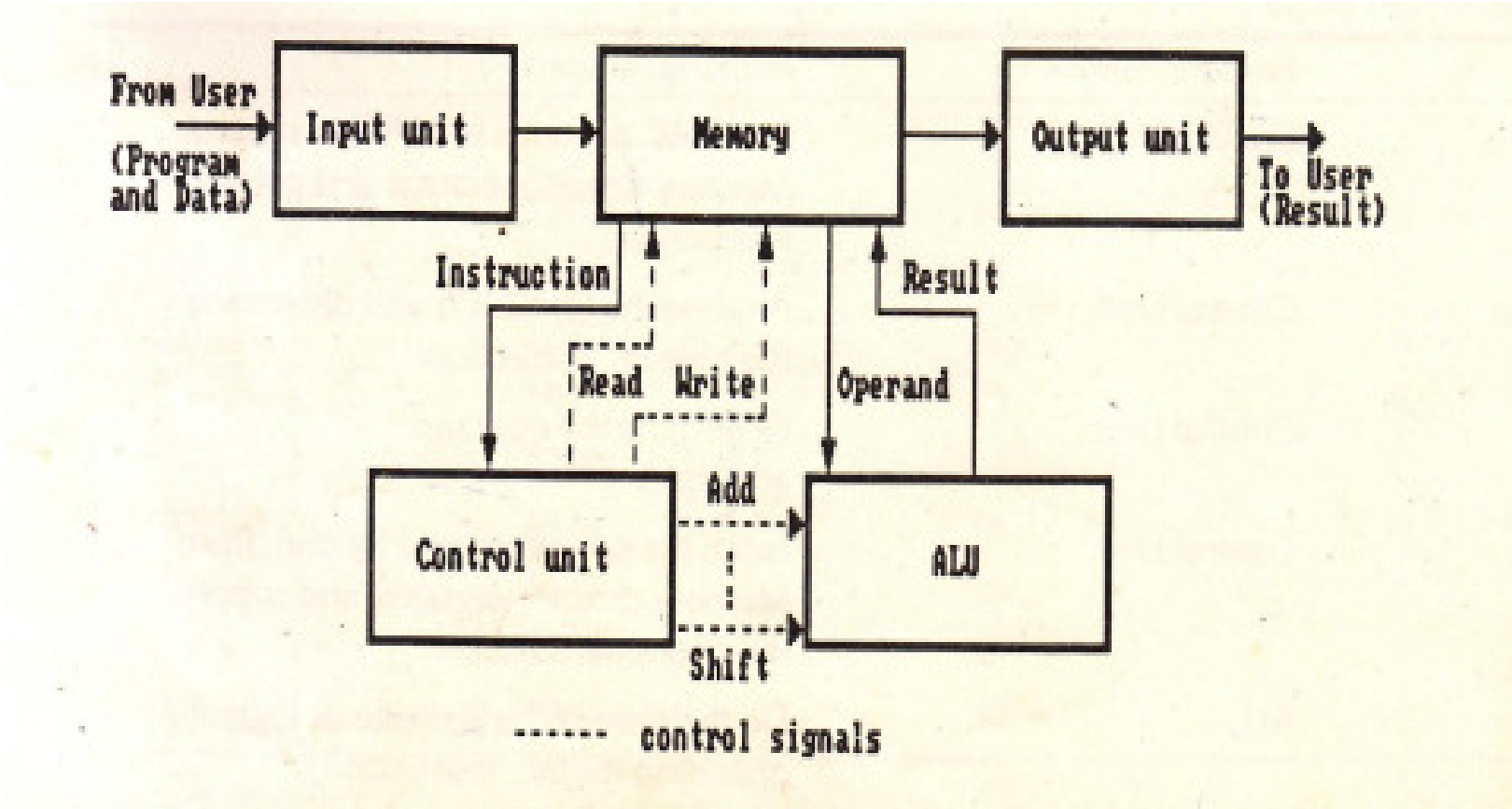
COMMUNICATION INSIDE A COMPUTER..

- A computer program consists of both instructions and data. The program is fed into the computer through the input unit and stored in the memory.
- In order to execute the program, the instructions have to be fetched from memory one by one.
- This fetching of instructions is done by the control unit.
- After an instruction is fetched, the control unit decodes the instruction.
- According to the instruction, the control unit issues control signals to other units.

COMMUNICATION INSIDE A COMPUTER..

- After an instruction is executed, the result of the instruction is stored in memory or stored temporarily in the control unit or ALU, so that this can be used by the next instruction.
- The results of a program are taken out of the computer through the output unit.
- The control unit, ALU and registers are collectively known as Central Processing Unit (CPU)

COMMUNICATION INSIDE A COMPUTER

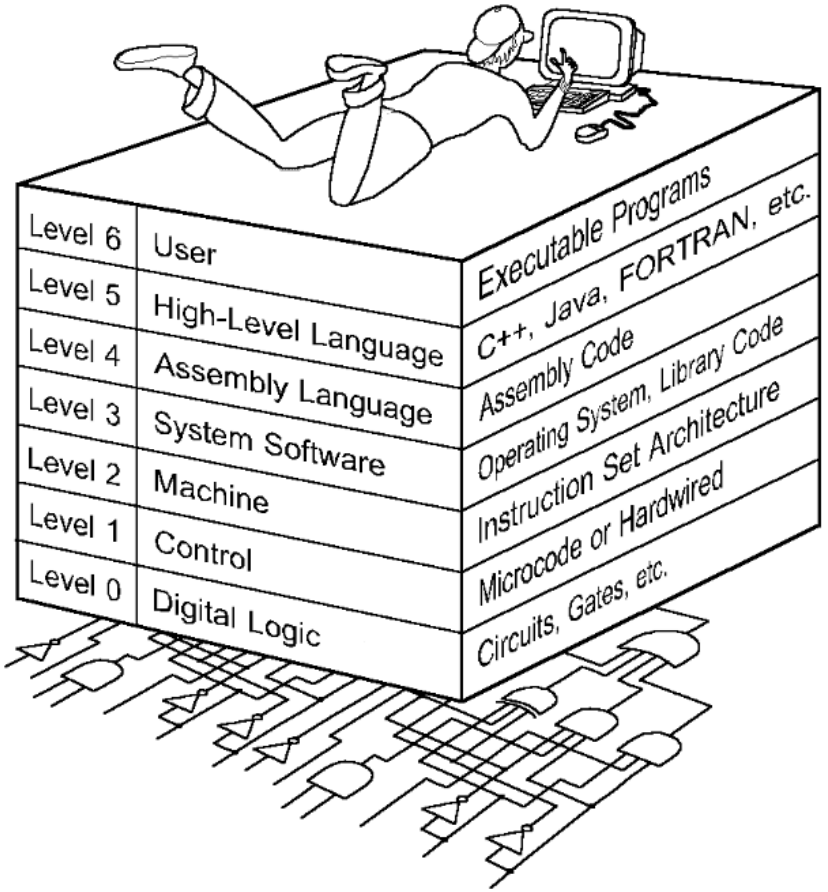


THE COMPUTER LEVEL HIERARCHY

- Writing complex programs requires a “divide and conquer” approach, where each program module solves a smaller problem.
- Complex computer systems employ a similar technique through a series of virtual machine layers.
- Computer Level Hierarchy is the combination of different levels that connects the computer with the user and that makes the use of the computer.
- It also describes how the computational activities are performed on the computer and it shows all the elements used in different levels of system.

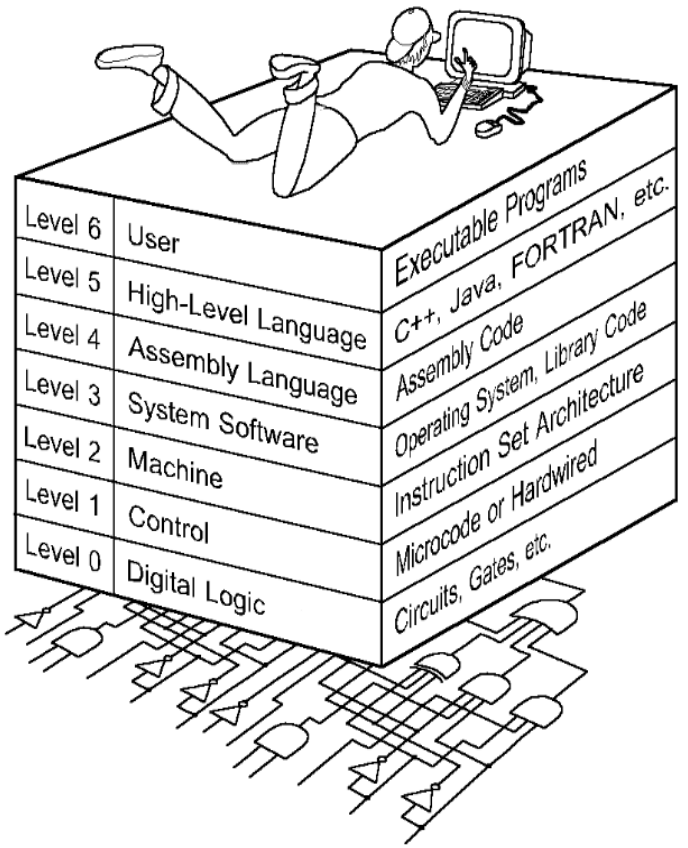
THE COMPUTER LEVEL HIERARCHY

- Each virtual machine layer is an abstraction of the level below it.
- The machines at each level execute their own particular instructions, calling upon machines at lower levels to perform tasks as required.
- Computer circuits ultimately carry out the work.



The Computer Level Hierarchy

- Level 6: The User Level
  - Program execution and user interface level.
  - The level with which we are most familiar.
- Level 5: High-Level Language Level
  - The level with which we interact when we write programs in languages such as C, Pascal, Lisp, and Java.

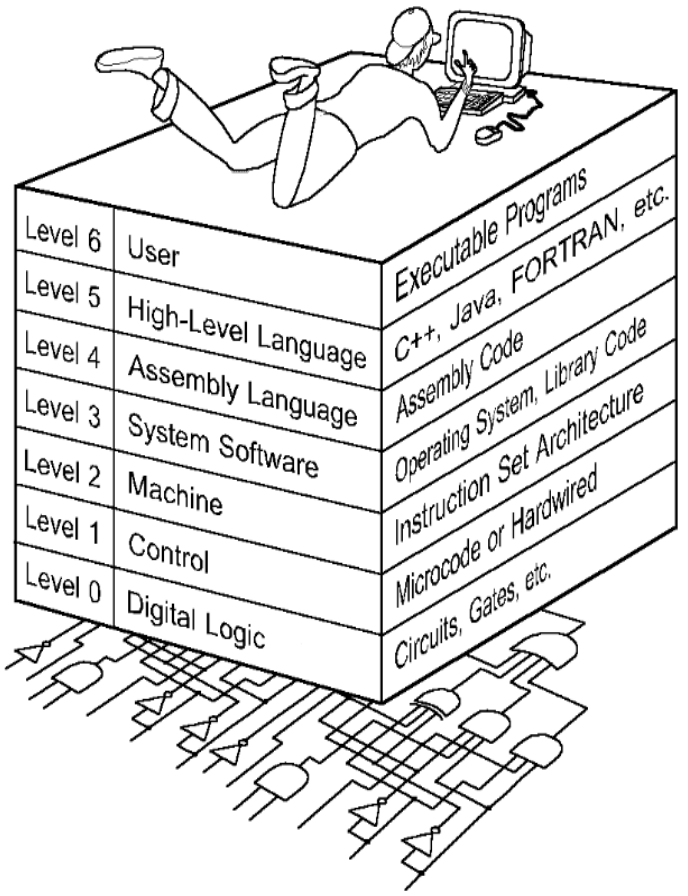


THE COMPUTER LEVEL HIERARCHY

- Level 4: Assembly Language Level
  - The machine understands only the assembly language and hence in order, all the high-level languages are changed in the assembly language. Assembly code is written for it.
- Level 3: System Software Level
  - System software is of various types. System software mainly helps in operating the process and it establishes the connection between hardware and user interface. It may consist operating system, library code, etc.

THE COMPUTER LEVEL HIERARCHY

- Level 2: Machine Level
  - Also known as the Instruction Set Architecture (ISA) Level.
  - Consists of instructions that are particular to the architecture of the machine.
  - Programs written in machine language need no compilers, interpreters, or assemblers.



THE COMPUTER LEVEL HIERARCHY

- Level 1: Control Level
  - A *control unit* decodes and executes instructions and moves data through the system.
  - Control units can be *microprogrammed* or *hardwired*.
  - A microprogram is a program written in a low-level language that is implemented by the hardware.
  - Hardwired control units consist of hardware that directly executes machine instructions.

THE COMPUTER LEVEL HIERARCHY

- Level 0: Digital Logic Level
  - Digital logic is the basis for digital computing and provides a fundamental understanding of how circuits and hardware communicate within a computer.
  - This level is where we find digital circuits (the chips).
  - Digital circuits consist of gates and wires.
  - These components implement the mathematical logic of all other levels.