Introduction to Computer Science and Engineering

CSN-101

Introduction to Computer Structure : CPU, 8805 Assembly Language

Prof. Partha Pratim Roy
Associate professor, CSE Department
Indian Institute of Technology Roorkee

Introduction: Computer Structure

- **Computer is a fast electronic calculating machine that**
  - ✓ Accepts digitized input information
  - ✓ Processes the information according to a list of internally stored instructions
  - ✓ Produces the results as an output information.
  - ✓ The instruction is called a computer program and internal storage is called memory.
- List of instructions are called programs & internal storage is called computer memory

History

- The first documented computer architecture was in the correspondence between Charles Babbage and Ada Lovelace, describing the analytical engine.
- When building the computer Z1 in 1936, Konrad Zuse described in two patent applications for his future projects that machine instructions could be stored in the same storage used for data, i.e., the stored program concept.
- Computer architecture prototypes were physically built in the form of a transistor transistor logic (TTL) computer—such as the prototypes of the 6800 and the PA-RISC—tested, and tweaked, before committing to the final hardware form.

Types of computers

- **Personal computers**: - This is the most common type found in homes, schools, Business offices etc.,
- **Note book computers**: - These are compact and portable versions of PC, supports all features of Personal computer.
- **Work stations**: - These have high resolution input/output (I/O) graphics capability, but with same dimensions as that of desktop computer.
- **Enterprise systems** (mainframe system): - These are used for business data processing in medium to large corporations that require much more computing power and storage capacity than work stations.
- **Super computers**: - These are used for large scale numerical calculations required in the applications like weather forecasting, simulation, Aircraft design etc.

CPU introduction

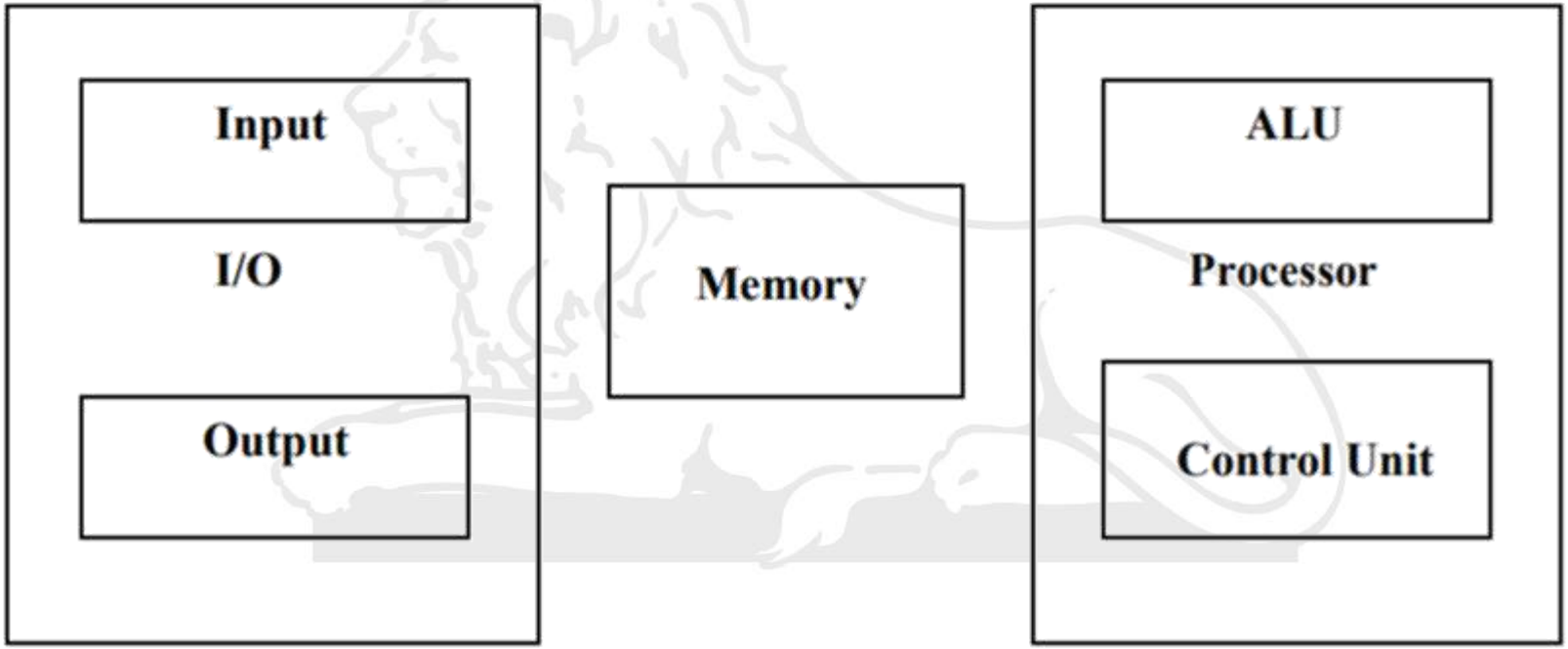
- The central processing unit (CPU) is the portion of a computer system that carries out the instructions of a computer program.
- To perform the basic arithmetical, logical, and input and output operations of the system.
- It acts as the BRAIN OF COMPUTER.
- Early CPUs were custom-designed as a part of a larger, sometimes one-of-a-kind, computer.
- The IC has allowed increasingly complex CPUs to be designed and manufactured to tolerances on the order of nanometres.

CPU introduction

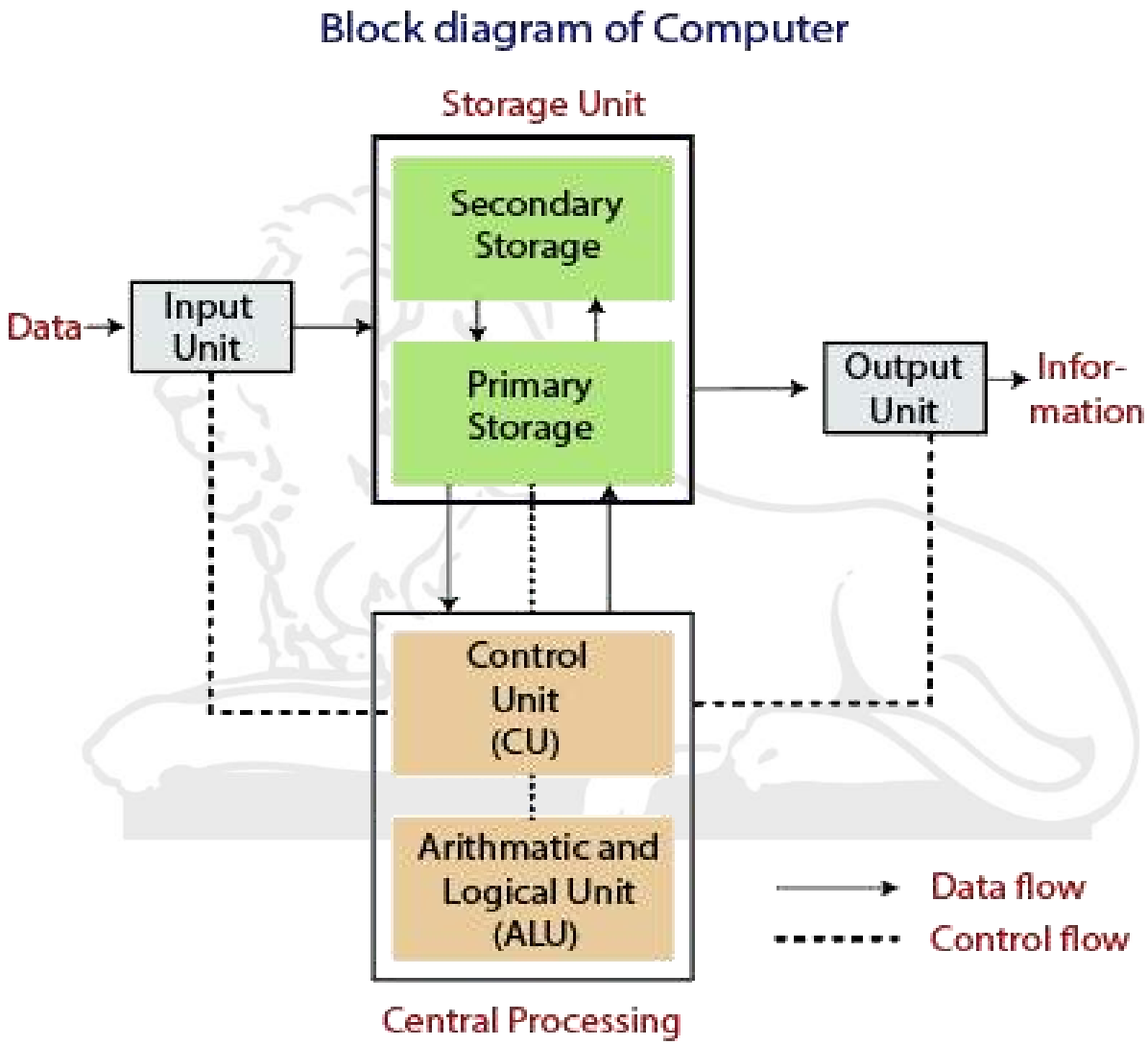
- However, this method of designing custom CPUs for a particular application has largely given way to the development of mass-produced processors.
- This standardization began in the era of discrete transistor mainframes and minicomputers and has rapidly accelerated with the popularization of the integrated circuits (IC).
- Both the miniaturization and standardization of CPUs have increased the presence of digital devices in modern life far beyond the limited application of dedicated computing machines.
- Modern microprocessors appear in everything from automobiles to cellphones and children's toys.

Functional Unit

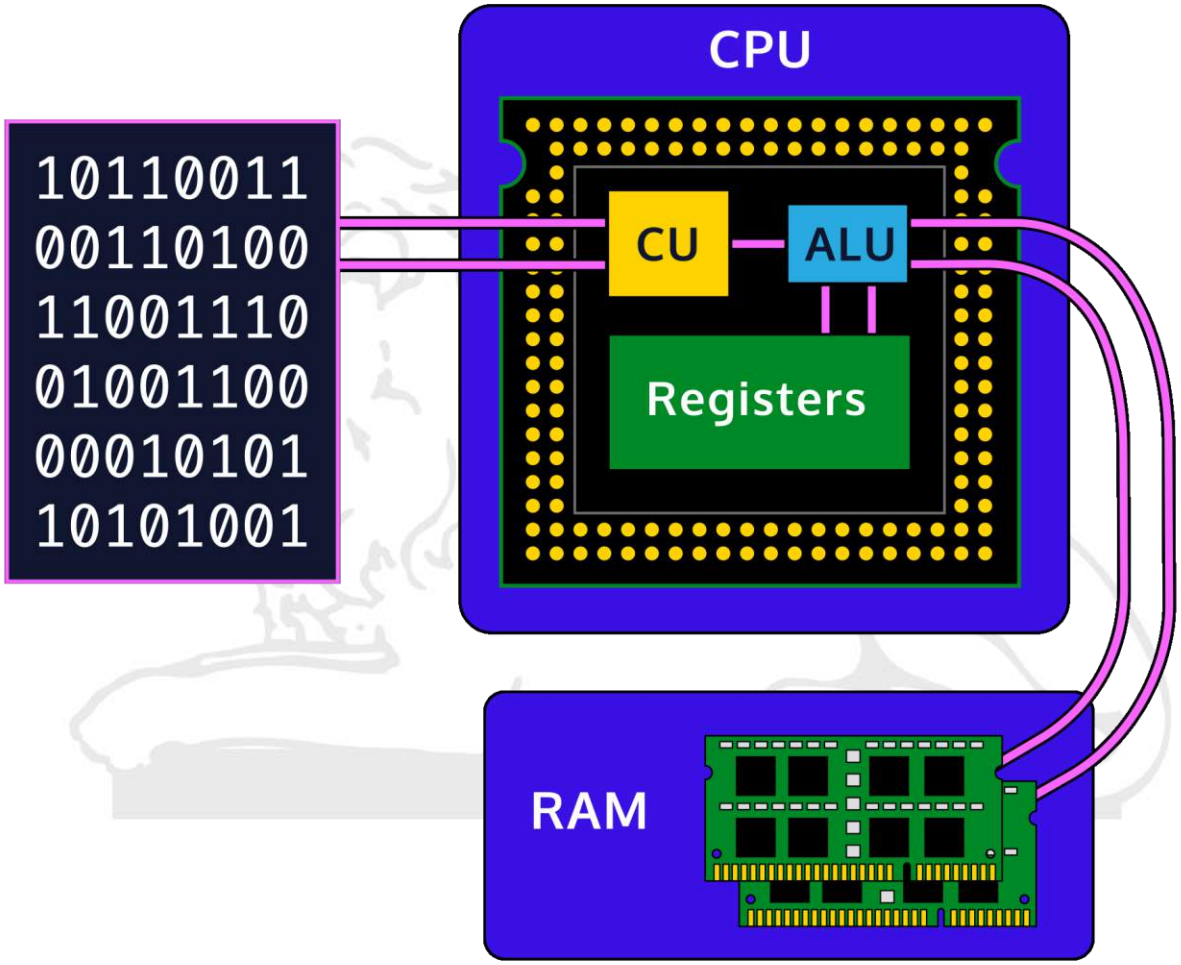
- A computer consists of five functionally independent main parts input, memory, arithmetic logic unit (ALU), and output and control unit.



Block Diagram of CPU



CPU Functioning



Components of CPU

- Control Unit (CU)
- Arithmetic Logic Unit (AU)
- A Number of Registers

Information Handled by a instructions

- Information Handled by a Computer Instructions/machine instructions
  - ✓ Govern the transfer of information within a computer as well as between the computer and its I/O devices
  - ✓ Specify the arithmetic and logic operations to be performed
  - ✓ Program
  - ✓ Data
  - ✓ Used as operands by the instructions
  - ✓ Source program
  - ✓ Encoded in binary code 0 and 1

Input Unit

- **The source program/high level language program/coded information/simply data is fed to a computer through input devices.**
  - ✓ Keyboard is a most common type.
  - ✓ Whenever a key is pressed, one corresponding word or number is translated into its equivalent binary code over a cable & fed either to memory or processor.
  - ✓ Joysticks, trackballs, mouse, scanners etc are other input devices.

Memory Unit

- **Its function into store programs and data. It is basically to two types**
  - ✓ **Primary memory** : - It is associated with the processor and operates at the electronics speeds. Programs must be stored in this memory while they are being executed.
  - ✓ **Secondary memory** : - It is used where large amounts of data & programs have to be stored, particularly information that is accessed infrequently.
  - ✓ Examples: - Magnetic disks & tapes, optical disks (i.e. CD-ROM's), floppies etc.

Arithmetic and Logic Unit (ALU)

- Most of the computer operators are executed in ALU of the processor like addition, subtraction, division, multiplication, etc.
- The operands are brought into the ALU from memory and stored in high speed storage elements called register.
- Then according to the instructions the operation is performed in the required sequence.
- Arithmetic and Logic Unit consists of a complicated set of logic circuits and accumulators.
- It is mainly responsible for: Calculation Logical comparison and decision

Control Unit (CU)

- Control Unit controls operations of other parts of CPU as well as all parts of the computer by sending a control signal, e.g.
- Control sequence of instruction to be executed control flow of data among all parts of the computer
- Interpret instructions
- Regulate the timing of processor
- Send control single to and receive control single from peripheral devices

Register

- Register is a special memory used by the CPU for temporarily storing data during execution of the instruction
- **Instruction Decoder:** It is a device that interprets the instruction to be executed.
- **Program Counter (PC):** It holds the address of the next instruction to be executed.
- **Instruction Register (IR):** It holds the instruction being executed.
- **Process Status Register:** It holds “processor bit" about operation done by ALU.

Accumulator (ACC)

- It stores intermediate and final results of the calculation. It's the main working area of ALU. General Purpose Register, It can be used to store any temporary information during the execution of the instruction. Memory Address Register (MAR) It holds to address the data word to be accessed.
- Memory Data Register (MDR) It holds the data word when it is transferred to and from the main memory. Address Decoder It interprets the address in the MAR and selects the appropriate cell in the main memory to be accessed.

Motherboard

- A motherboard is the physical arrangement in a computer that contains the computer's basic circuitry and components.
- On the typical motherboard, the circuitry is imprinted or affixed to the surface of a firm planar surface and is usually manufactured in a single step.
- The microprocessor (Optionally), coprocessors, Memory, BIOS, Expansion slots, Interconnecting circuitry, Additional components can be added to a motherboard through its expansion slots.

Microprocessor

- A microprocessor is a computer processor on a microchip. It's sometimes called a logic chip. It is the "engine" that goes into motion when you turn the computer on.
- A microprocessor is designed to perform arithmetic and logic operations that make use of small number-holding areas called registers.
- Typical microprocessor operations include adding, subtracting, comparing two numbers, and fetching numbers from one area to another.

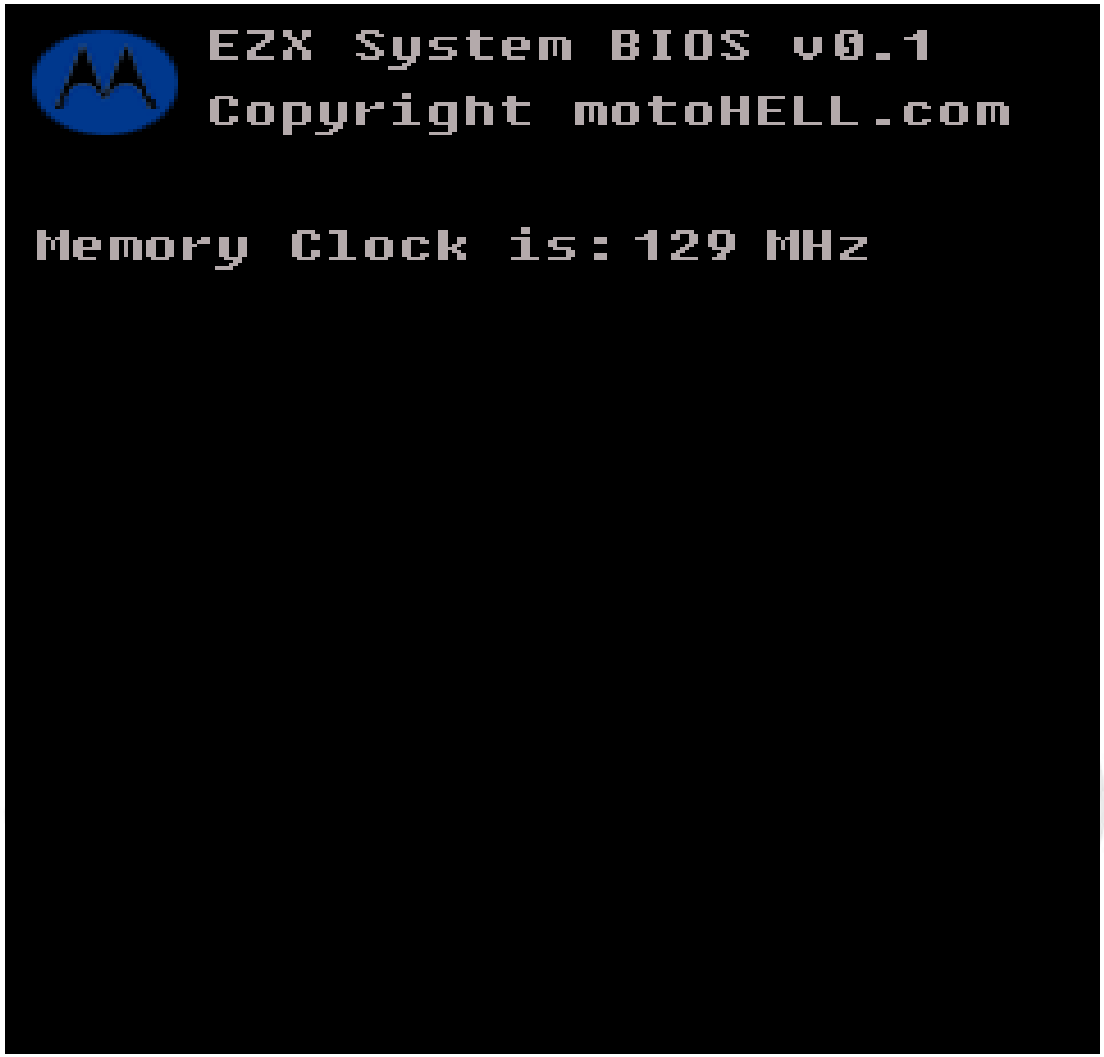
Microchip

- A microchip (sometimes just called a "chip") is a unit of packaged computer circuitry (usually called an integrated circuit)
- That is manufactured from a material such as silicon at a very small scale.
- Microchips are made for program logic (logic or microprocessor chips) and for computer memory

BIOS

- BIOS is an integral part of the computer and comes with it when you bring it home. (In contrast, the operating system can either be preinstalled by the manufacturer or vendor or installed by the user.)
- BIOS is a program that is made accessible to the microprocessor on an erasable programmable read-only memory (EPROM) chip.
- When you turn on the computer, the microprocessor passes control to the BIOS program, which is always located at the same place on EPROM.

BIOS



BIOS GIF

BIOS

- When BIOS boots up (starts up) the computer, it first determines whether all of the attachments are in place and operational and then it loads the operating system (or key parts of it) into the computer's random access memory RAM from the hard disk or diskette drive.
- With BIOS, the operating system and its applications are freed from having to understand exact details (such as hardware addresses) about the attached input/output devices.
- When device details change, only the BIOS program needs to be changed. Sometimes this change can be made during the system setup. In any case, neither the operating system nor any applications you use need to be changed.

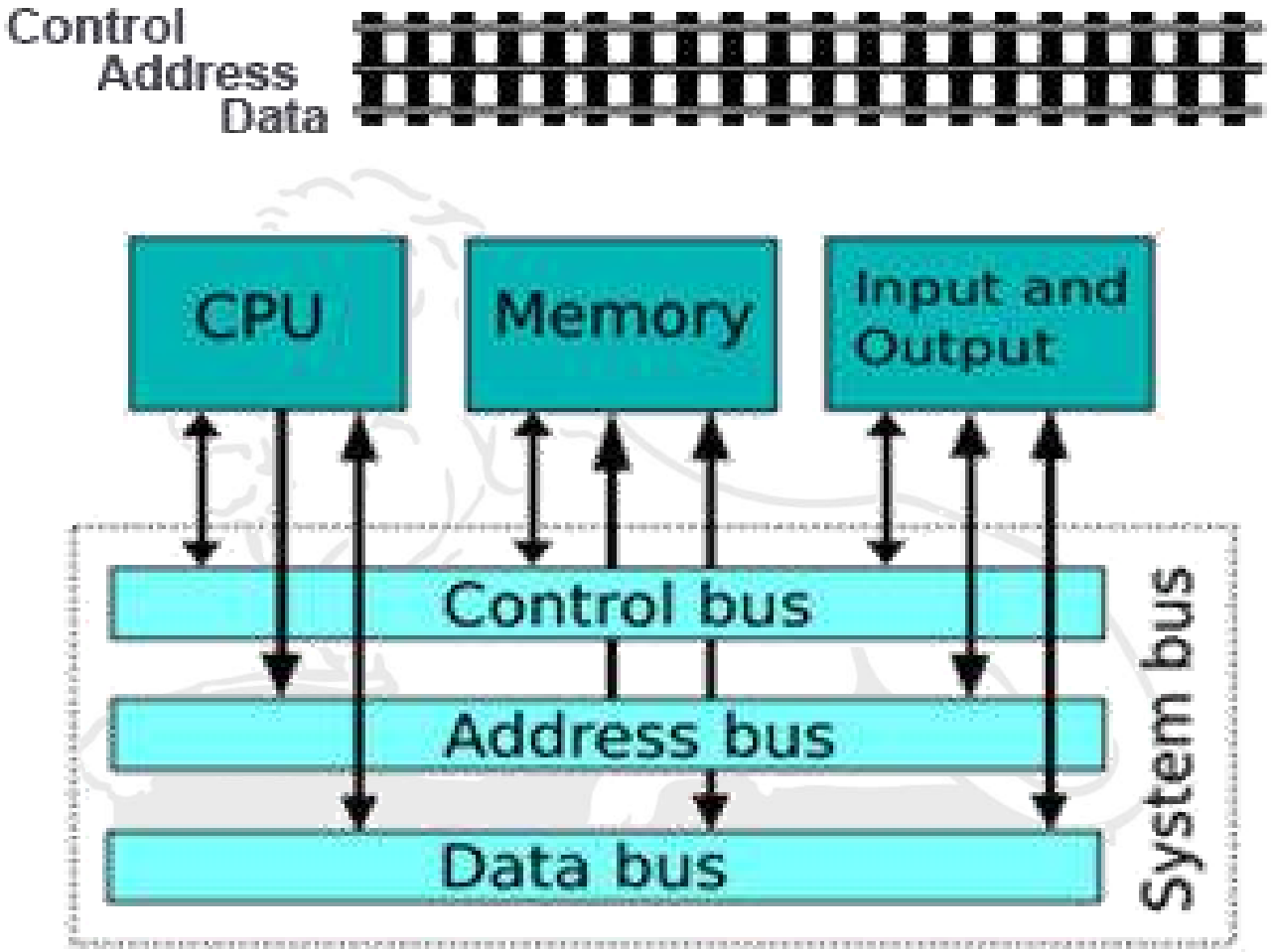
Bus structure

- The simplest and most common way of interconnecting various parts of the computer. To achieve a reasonable speed of operation, a computer must be organized so that all its units can handle one full word of data at a given time.
- A group of lines that serve as a connecting port for several devices is called a bus.
- Since the bus can be used for only one transfer at a time, only two units can actively use the bus at any given time. Bus control lines are used to arbitrate multiple requests for use of one bus.

Bus structure

- All the interconnected devices are not of same speed & time leads to a bit of a problem. This is solved by using cache registers (i.e. buffer registers).
- These buffers are electronic registers of small capacity when compared to the main memory but of comparable speed.
- The instructions from the processor at once are loaded into these buffers and then the complete transfer of data at a fast rate will take place.

Bus structure



Performance

- The most important measure of the performance of a computer is how quickly it can execute programs.
- The speed with which a computer executes a program is affected by the design of its hardware.
- For best performance, it is necessary to design the compiler, the machine instruction set, and the hardware in a coordinated way.
- The total time required to execute the program is elapsed time is a measure of the performance of the entire computer system.

Performance

- It is affected by the speed of the processor, the disk, and the printer. The time needed to execute an instruction is called the **processor time**.
- The elapsed time for the execution of a program depends on all units in a computer system; the processor time depends on the hardware involved in the execution of individual machine instructions.

Performance

- At the start of execution, all program instructions and the required data are stored in the main memory.
- As the execution proceeds, instructions are fetched one by one over the bus into the processor, and a copy is placed in the cache later if the same instruction or data item is needed a second time, it is read directly from the cache.
- The processor and relatively small cache memory can be fabricated on a single IC chip.
- The internal speed of performing the basic steps of instruction processing on chip is very high and is considerably faster than the speed at which the instruction and data can be fetched from the main memory.

Processor clock

- Processor circuits are controlled by a timing signal called a clock. The clock designer the regular time intervals called clock cycles.
- To execute a machine instruction the processor divides the action to be performed into a sequence of basic steps that each step can be completed in one clock cycle.
- The length P of one clock cycle is an important parameter that affects the processor performance.
- Processors used in today's personal computers and work station have clock rates that range from a few hundred million to over a billion cycles per second.

8085 Assembly Language : Introduction

- A microprocessor executes instructions given by the user
- Instructions should be in a language known to the microprocessor
- Microprocessor understands the language of 0's and 1's only
- This language is called Machine Language
- For e.g.
  - 01001111
  - Is a valid machine language instruction of 8085
  - It copies the contents of one of the internal registers of 8085 to another

Assembly Language of 8085

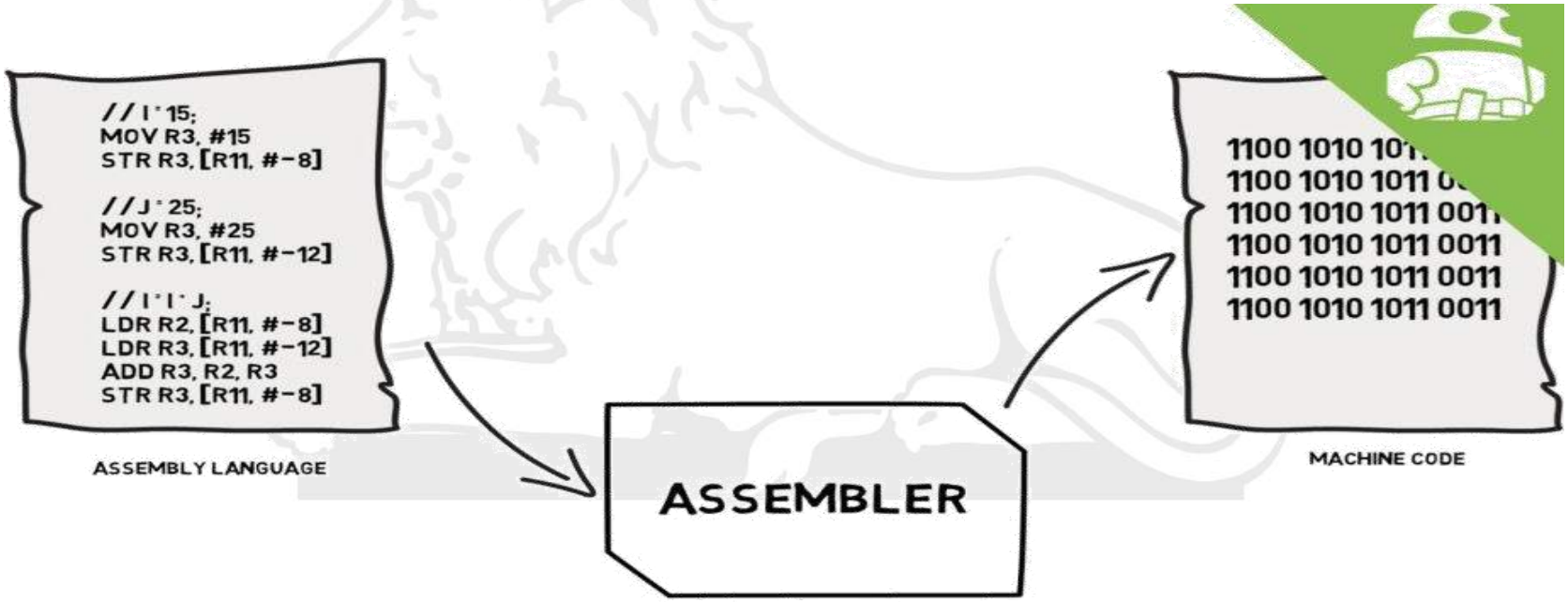
- It uses English like words to convey the action/meaning
- For e.g.
  - MOV to indicate data transfer
  - ADD to add two values
  - SUB to subtract two values

Assembly language program to add two numbers

- Load the first number from memory location 2050 to the accumulator.
- Move the content of the accumulator to register H.
- Load the second number from memory location 2051 to the accumulator.
- Then add the content of register H and accumulator using “ADD” instruction and storing result at 3050
- The carry generated is recovered using the “ADC” command and is stored at memory location 3051

Microprocessor understands Machine Language only

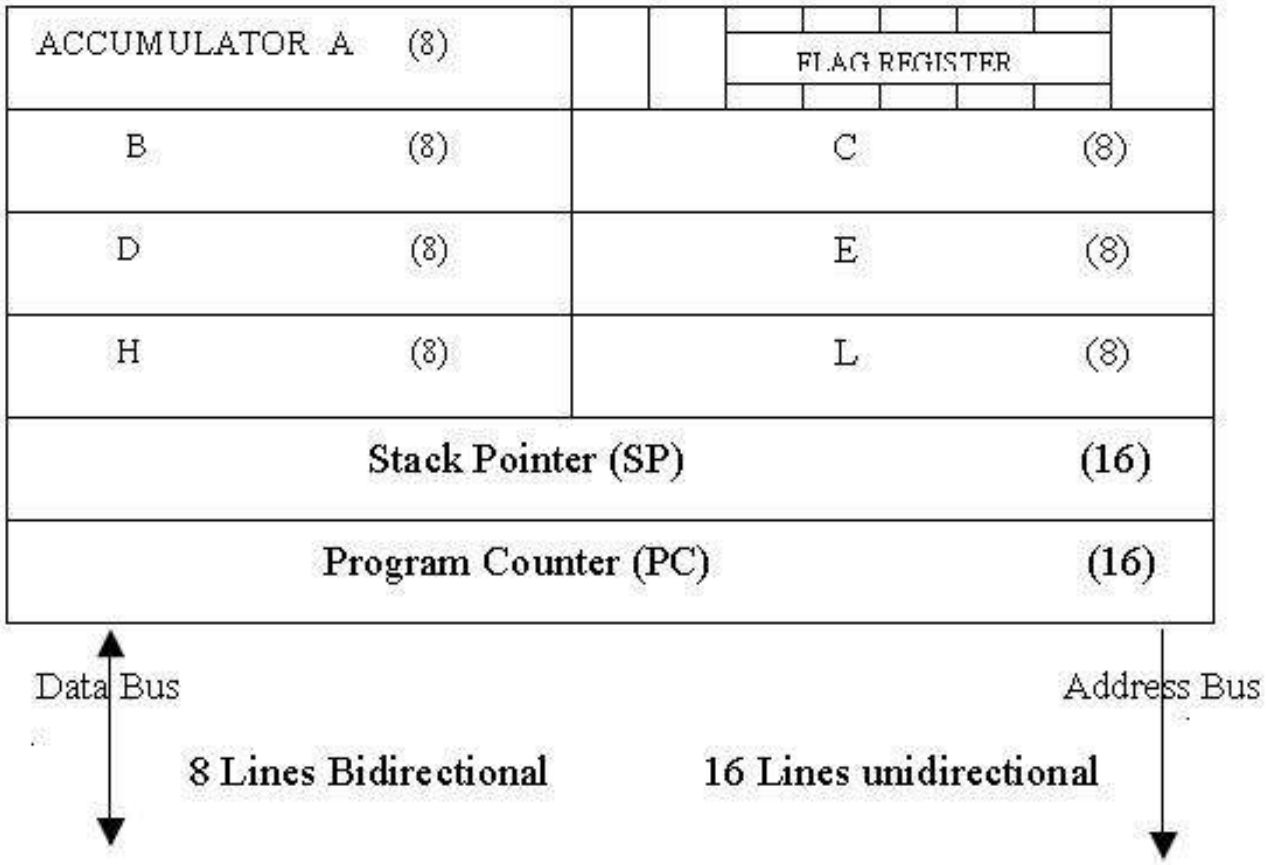
- Microprocessor cannot understand a program written in Assembly language
- A program known as Assembler is used to convert a Assembly language program to machine language



Low-level/High-level languages

- Machine language and Assembly language are both Microprocessor specific (Machine dependent) so they are called Low-level languages
- **Machine independent** languages are called High-Level Languages
  - For e.g. BASIC, PASCAL,C++,C,JAVA, etc.
  - A software called Compiler is required to convert a high-level language program to machine code

Programming Model of 8085



Overview: 8085 Programming model

- **Six general-purpose Registers**
  - B,C,D,E,H,L
  - Can be combined as register pairs to perform 16-bit operations (BC,DE,HL)

- **Accumulator** – identified by name A
  - This register is a part of ALU
  - 8–bit data storage
  - Performs arithmetic and logical operations
  - Result of an operation is stored in accumulator

Flag Register

- This is also a part of ALU
- 8085 has five flags named
  - Zero flag (Z)
  - Carry flag (CY)
  - Sign flag (S)
  - Parity flag (P)
  - Auxiliary Carry flag (AC)

Flag Register

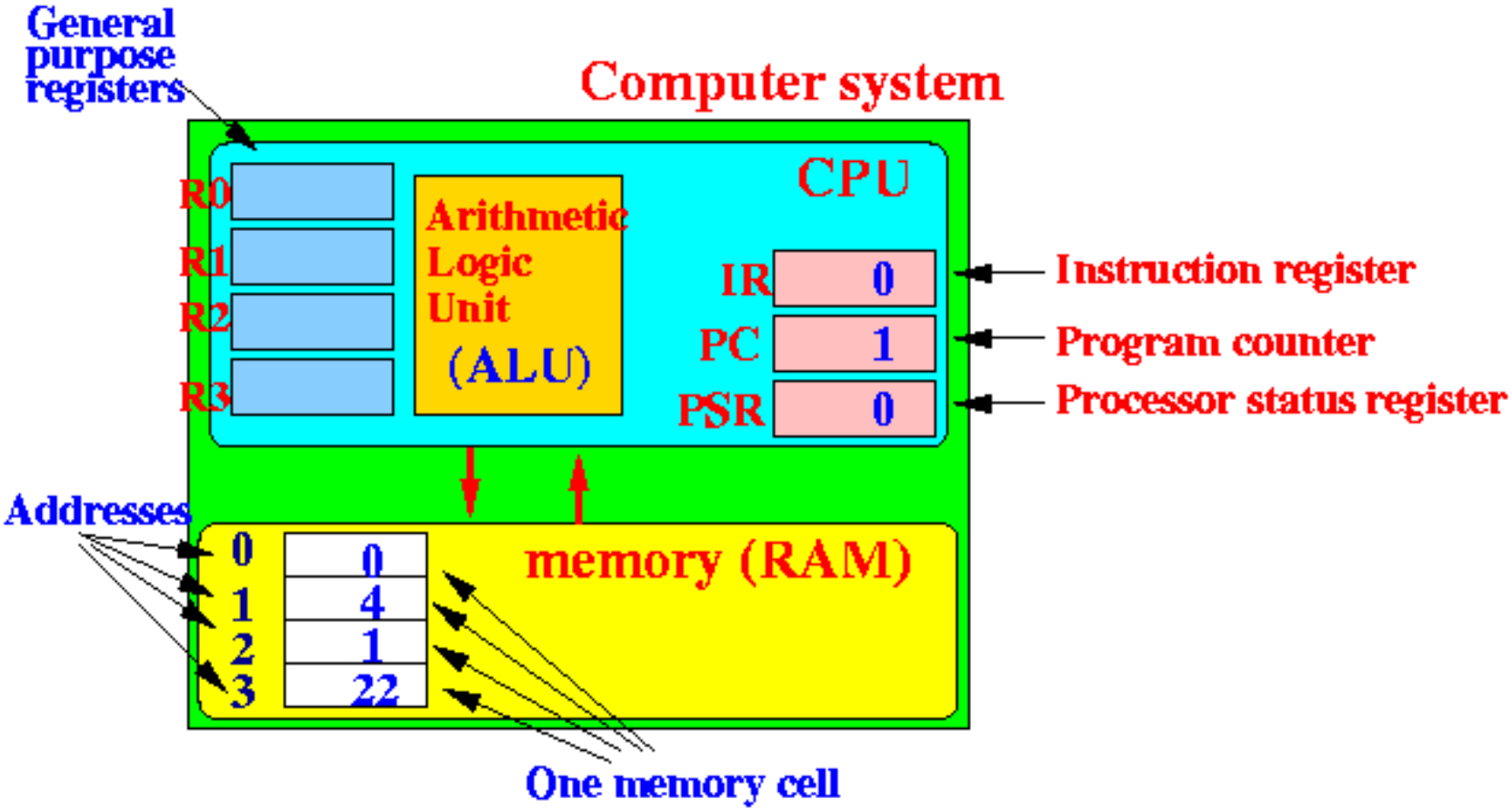
- These flags are five flip-flops in flag register
- Execution of an arithmetic/logic operation can set or reset these flags
- Condition of flags (set or reset) can be tested through software instructions
- 8085 uses these flags in decision-making process

Program Counter (PC)

Program Counter (PC)

- A 16-bit memory pointer register
- Used to sequence execution of program instructions
- Store's address of a memory location
  - Where next instruction byte is to be fetched by the 8085
- When 8085 gets busy fetching current instruction from memory
  - PC is incremented by one
  - PC is now pointing to the address of the next instruction

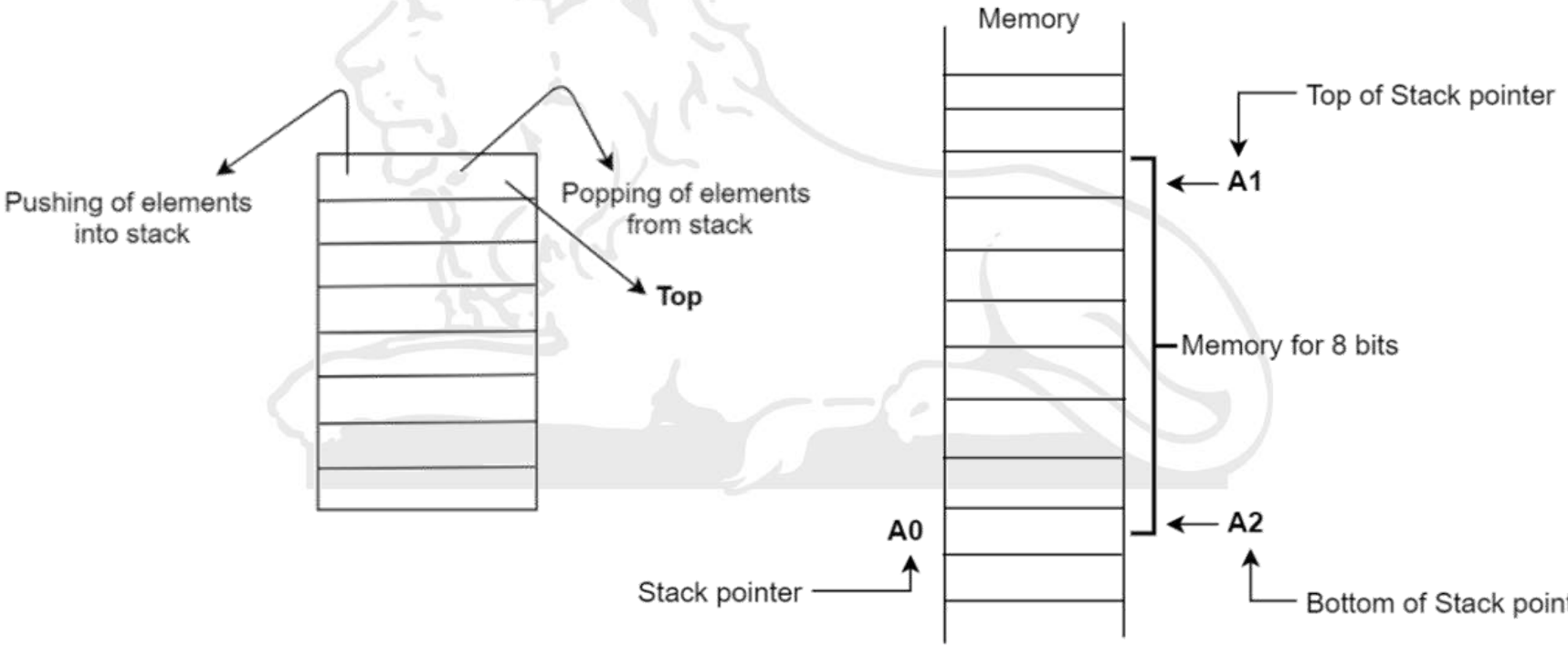
Program Counter (PC)



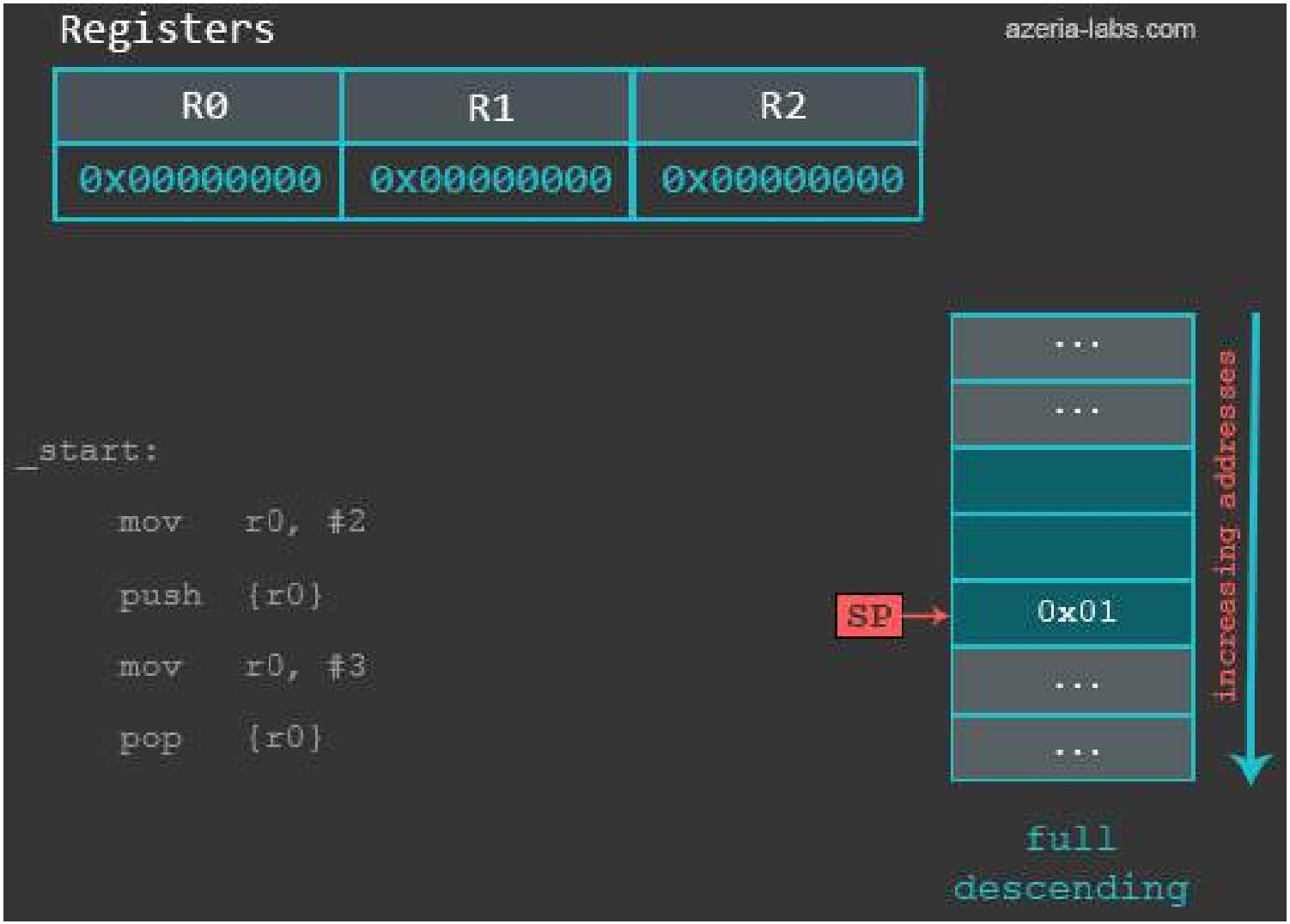
Stack Pointer Register

Stack Pointer Register

- A stack register is a computer central processor register whose purpose is to keep track of a call stack.
- a 16-bit memory pointer register



Stack Pointer



Instruction Set of 8085

- 8085 instructions can be classified as

1. Data Transfer
2. Arithmetic
3. Logical and Bit manipulation
4. Branch
5. Machine Control

Data Transfer (Copy) Operations

1. **Load** an 8-bit number in a Register
2. **Copy** from Register to Register
3. **Copy** between Register and Memory
4. **Copy** between Input/Output Port and Accumulator
5. **Load** a 16-bit number in a Register pair
6. **Copy** between Register pair and Stack memory

Example :

1. Load an 8-bit number 4F in register B

Ans: MVI B, 4FH

Arithmetic Operations

1. Addition of two 8-bit numbers
2. Subtraction of two 8-bit numbers
3. Increment/ Decrement a 8-bit number

Example:

1. Add a 8-bit number 32H to Accumulator

Ans: ADI 32H

2. Add contents of Register B to Accumulator

Ans: ADD B

Logical & Bit Manipulation Operations

1. AND two 8-bit numbers
2. OR two 8-bit numbers
3. Exclusive-OR two 8-bit numbers
4. Compare two 8-bit numbers
5. Complement
6. Rotate Left/Right Accumulator bits

Example:

1. Logically AND Register H with Accumulator

Ans: ANA H

2. Logically OR Register L with Accumulator

Ans: ORA L

Branching Operations

- These operations are used to control the flow of program execution

1.Jumps

- Conditional jumps
- Unconditional jumps

2.Call & Return

- Conditional Call & Return
- Unconditional Call & Return

Machine Control Instructions

These instructions affect the operation of the processor.

For e.g. HLT Stop program execution NOP Do not perform any operation

Thanks…