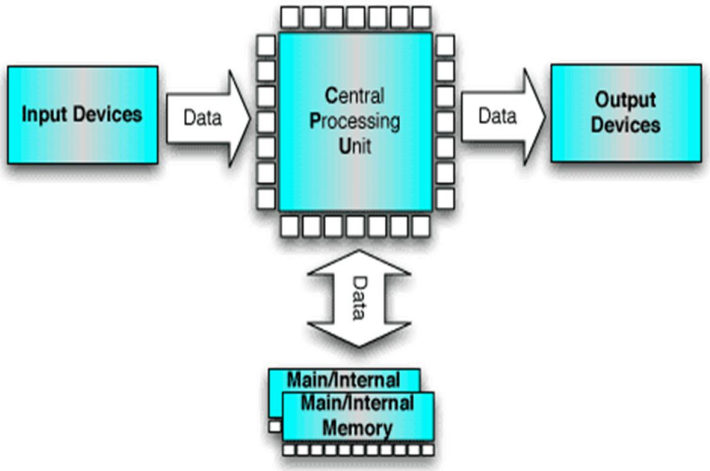
# BLOCK DIAGRAM OF A COMPUTER SYSTEM

**Analysis of CPU**




- In order to work, a computer needs some sort of "brain" or "calculator".
- At the core of every computer is a device roughly the size of a large postage stamp.
- This device is known as the central processing unit or CPU for short.
- It is a small chip inside the computer.
- It reads and executes program instructions, performs calculations, and makes decisions.
- The CPU is responsible for storing and retrieving information on disks and other media.
- A fast CPU leads to good performance.
- A poor CPU may hang the computer.

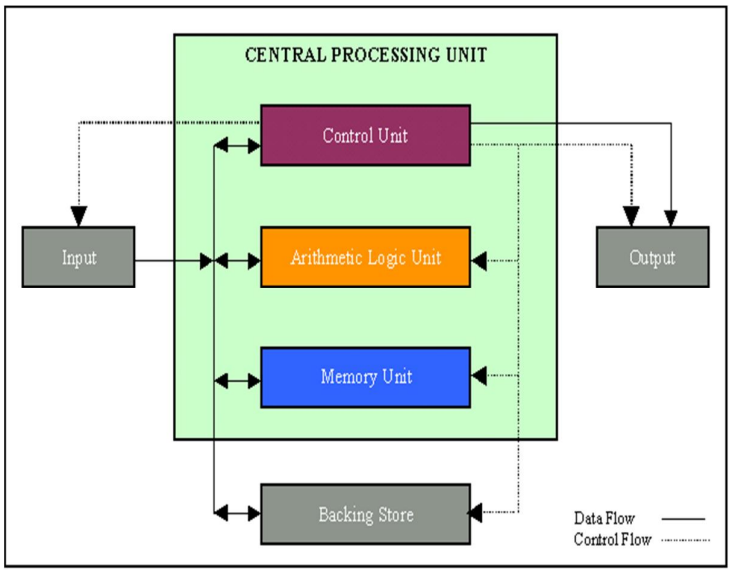
**What does the CPU do?**

- CPU carries out instructions and tells the rest of the computer system what to do.
- This is done by the Control Unit of the CPU which sends command signals to the other components of the system.
- Performs arithmetic calculations and data manipulation, eg. Comparisons, sorting, combining, etc.
- The computer's calculator is a part of the CPU known as the Arithmetic Logic Unit.
- Holds data and instructions which are in current use. These are kept in the Main Store or Memory.

**Structure of CPU:**

CPU consists of several sections:

- Control Unit (CU):
- Arithmetic and Logic Unit (ALU):
- Memory Unit:
- A number of Registers:
  - Program Counter (PC)
  - Instruction Decoder
  - Instruction Register (IR)
  - Process Status Register
  - Accumulator (ACC)
  - some General Purpose Registers



**Control Unit:**

- Å The control unit directs the entire computer system to carry out stored program instructions.
- Å The control unit must communicate with both the arithmetic logic unit and main memory.
- Å The control unit uses the instruction contained in the Instruction Register to decide which circuits need to be activated.
- Å The control unit co-ordinates the activities of the other two units as well as all peripheral and auxiliary storage devices linked to the computer.
- Å The control unit instructs the arithmetic logic unit which arithmetic operations or logical operation is to be performed.

**Instruction Register (IR):**

- Å A special register in the CPU that holds the next instruction to be performed within the CPU.
- Å The Control Unit accesses this register to decide which circuits need to be activated.

**Program Counter (PC):**

- Å It keeps track of the next memory address of the instruction that is to be executed.
- Å In other words, it holds the address of the memory location of the next instruction when the current instruction is executed by the microprocessor.
- Å Each instruction is read from the memory into the instruction register.
- Å The process of reading an instruction is often referred to as the fetch-execute process.

**Arithmetic Logic Unit:**

- Å The arithmetic logic unit executes arithmetic and logical operations.
- Å Arithmetic operations include addition, subtraction, multiplication and division.
- Å Logical operations compare numbers, letters and special characters.
- Å Comparison operations test for three conditions: equal-to condition in which two values are the same less-than condition in which one value is smaller than the other greater-than condition in which one value is larger than the other.
- Å Relational operations (=, <, >) are used to describe the comparison operations used by the arithmetic logic unit.
- Å The arithmetic logic unit performs logic functions such as AND, OR and NOT.

**Accumulator:**

- Å The accumulator is used to accumulate results.
- Å It is the place where the answers from many operations are stored temporarily before being put out to the computer's memory.

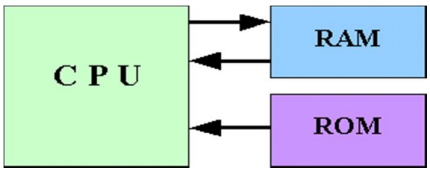
**General Purpose Registers:**

- Å The other general-purpose registers hold data on which operations are to be performed by the arithmetic logic unit.

**RAM:**

- Å RAM stands for Random Access Memory.
- Å This is the main store and is the place where the programs and software we load gets stored.
- Å When the Central Processing Unit runs a program, it fetches the program instructions from the RAM and carries them out.
- Å If the Central Processing Unit needs to store the results of calculations it can store them in RAM.
- Å Random Access Memory can have instructions READ from it by the CPU and also it can have numbers or other computer data WRITTEN to it by the CPU.
- Å The more RAM in your computer, the larger the programs you can run.
- Å When we switch a computer off, whatever is stored in the RAM gets erased.

**ROM:**




- ROM stands for Read Only Memory.
- The CPU can only fetch or read instructions from Read Only Memory (or ROM).
- ROM comes with instructions permanently stored inside and these instructions cannot be over-written by the computer's CPU.
- ROM memory is used for storing special sets of instructions which the computer needs when it starts up.
- When we switch the computer off, the contents of the ROM does not become erased but remains stored permanently.
- Therefore it is non-volatile.
- The following is a diagram showing the relationship between the Central Processing Unit and the Main Memory (RAM and ROM).

**Memory Unit consists of:**

- **Memory Address Register:** The memory address register (MAR) holds the address of the memory location where the next instruction is to be executed. While the first instruction is being executed, the address of the next memory location is held by it.
- **Memory Data Register:** The **memory data register** (MDR) is the register that contains the data to be stored in the computer storage (e.g. RAM), or the data after a fetch from the computer storage. It acts like a buffer and holds anything that is copied from the memory ready for the processor to use it.
- **Address Decoder:** It interprets the address in the MAR and selects the appropriate cell in the main memory to be accessed. Then, we'll have a look in the read/write of memory:

**How to read data from memory:**

- The Control Unit sends a "read" signal to the memory.
- MAR gets the address of required data word .
- Address Decoder select appropriate memory cell.
- The required data word is sent to MDR, then send to outside via data bus .

**How to write data to memory:**

- The Control Unit sends a "write" signal to the memory.
- MAR gets the address of target memory cell.
- MDR gets the data word being written.
- Address Decoder select appropriate memory cell.
- The data word in MDR is transferred to target memory location.

**How the CPU works**:

- The CPU is centrally located on the motherboard.
- Since the CPU carries out a large share of the work in the computer, data pass continually through it.
- The data come from the RAM and the units (keyboard, drives, etc.).
- After processing, the data is sent back to the RAM and the units.
- The CPU continually receives instructions to be executed.
- Each instruction is a data processing order.
- The work itself consists mostly of calculations and data transport.

**The Instruction-Execution Cycle:**

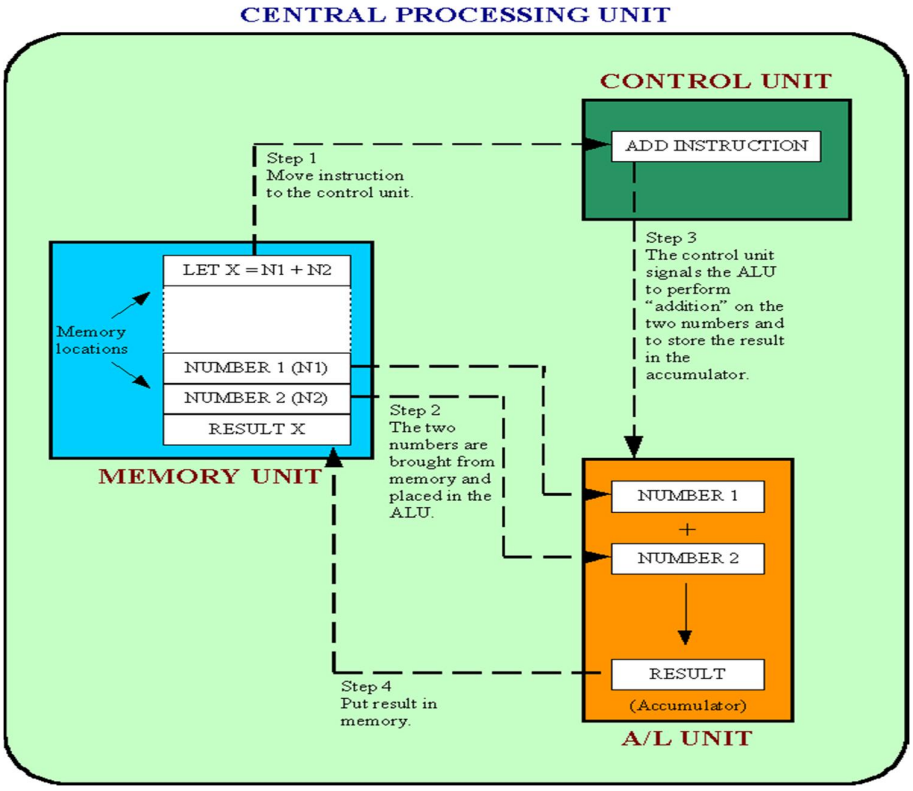
- The CPU performs four steps in executing an instruction:

- ï The control unit gets the instruction from memory.
- ï The control unit decides what the instruction means and directs the necessary data to be moved from the memory to the arithmetic logic unit.
- ï The arithmetic logic unit performs the actual operation on the data.
- ï The result of the operation is stored in memory or a register.

- Å The first two instructions make up what is called the instruction time.
- Å The last two instructions make up what is called the execution time.
- Å The combination of these two is called a machine cycle.
- Å Each central processing unit has an internal clock (or system clock), which produces pulses at a fixed rate to synchronize all computer operations.
- Å A single machine cycle instruction is made up of a number of sub instructions, each of which must take at least one clock cycle.

**How the CPU finds Instructions and Data:**

- Å The location in memory for each instruction and each piece of data is identified by an address, or a number that stands for a location in the computer memory.
- Å The following is an example of a simple case of adding two numbers together and placing the result in a location X.
  The command executed is - Let X = N1 + N2.
- Å See the diagram below.




**Execution of Instruction:**

Take "X= n1+ n2;", such a simple addition, as an example:

**The CPU need to:**

- Å Load the content of memory cell associate with n1 to the Accumulator.
- Å Add the content of memory cell associate with n2 to the Accumulator.
- Å Store the content of accumulator to memory cell associate with x.
- Å You may once again think that the 3 operations above is simple.
- Å Actually, to load the content of n1 to Accumulator, the CPU already needs to:
- Å Transfer the content of PC to MAR

- Decode the address held by MAR
- Transfer the instruction to MDR
- Instruction are carried to IR by MDR
- Increment of PC
- Decode the Instruction in IR by Instruction Decoder
- Operand part of Instruction is transferred to MAR
- Decode the Address held by MAR
- Transfer the content to MDR
- MDR carries the content to Accumulator

**Communication Pathways (BUS):**

- The Control Unit, ALU and the primary Storage unit must have a way to communicate.
- These links among and within the various units are called busses.
- A bus, in computing, is a set of physical connections (cables, circuits, etc.) which can be shared by multiple hardware components in order to communicate with one another.
- A bus is classified by name according to its function.
  1. **Control Bus:** It is the pathway for all timing and controlling functions sent by the control unit to the other units of the system.
  2. **Address Bus:** It is the pathway that is used to locate the storage position in memory where the next instruction to be executed or the next piece of data will be found.
  3. **Data Bus:** It is the pathway where the actual data transfer takes place.

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