Computer Architecture

Computer System

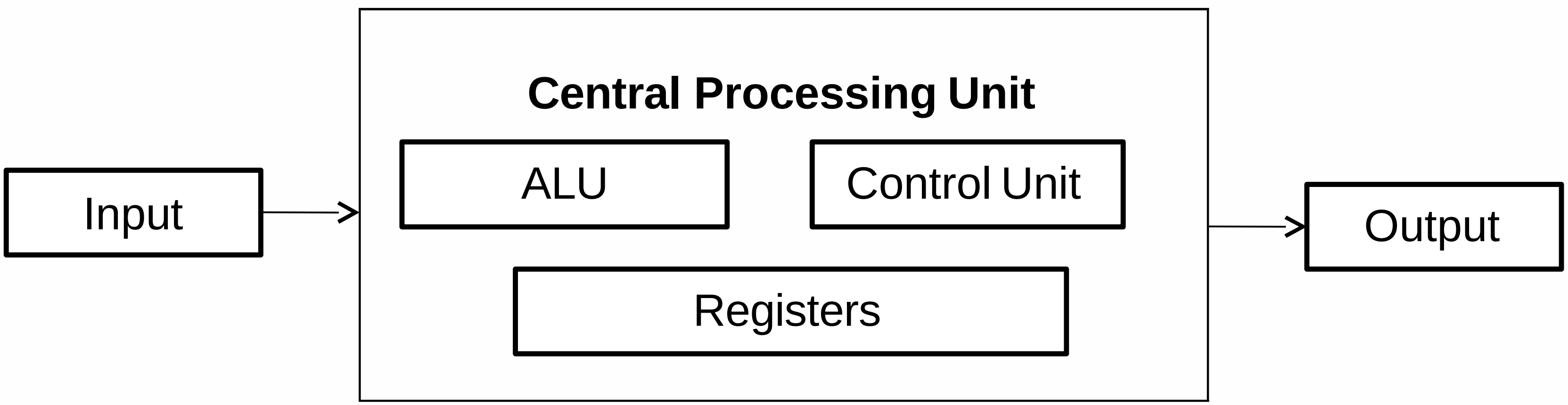
- Number of interrelated components like

  - Computer hardware - peripherals

  - Data communication equipments

  that work together with aim of converting data into information.
- A computer system essentially has three important components:
  - CPU
  - Input Unit
  - Output Unit

Computer System



- CPU: This unit performs processing of instructions and data inside the computer
- Input Unit: accepts instructions and data
- Output Unit: communicates the results to the user

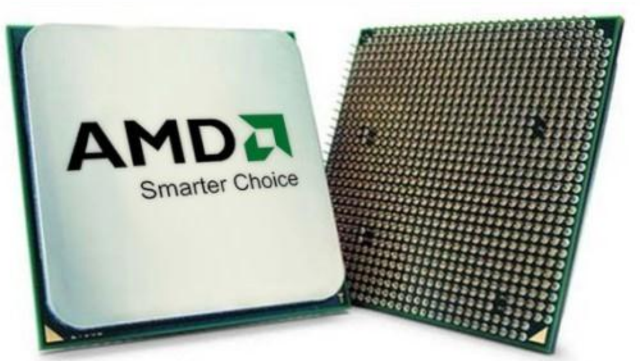
Central Processing Unit

- The CPU or microprocessor is referred as the ‘brain’ of a computer system.
- It is a silicon chip that contains millions of tiny electrical components.
- CPU controls all external and internal devices and performs arithmetic and logic operations.
- It interprets, coordinates the operations and supervises the instructions.

CPUs


intel
pentium 4

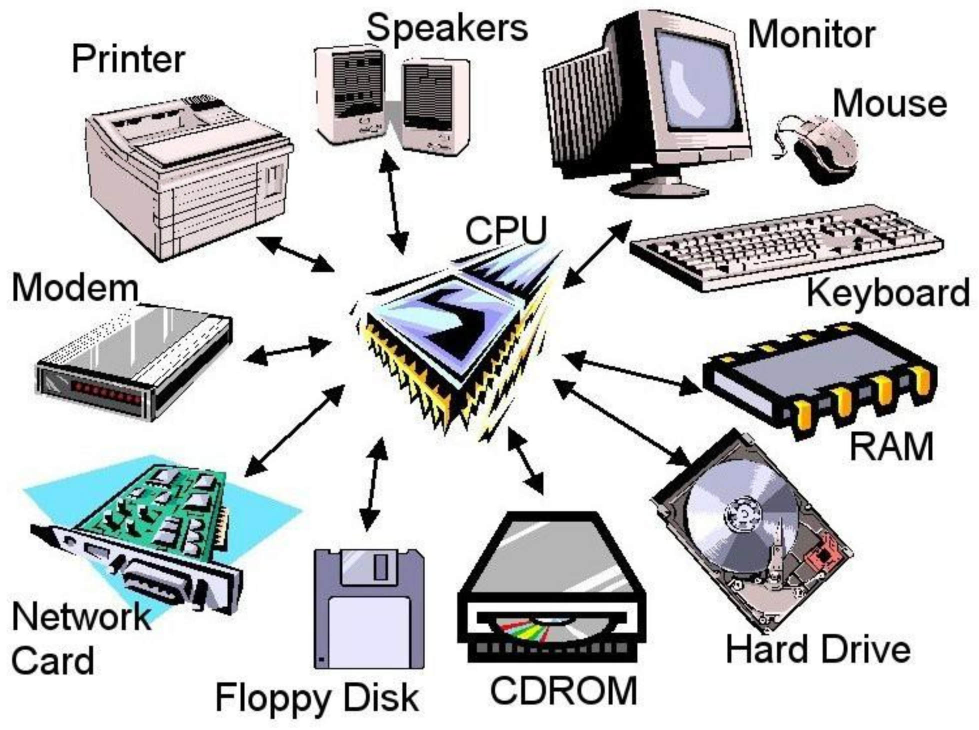

intel
Core™ i7


AMD
Smarter Choice


AMD Phenom™ II
HDT90ZFBK6DGR
CCBBE CB 1021FPMW
9E94093F00049
DIFFUSED IN GERMANY
MADE IN MALAYSIA

Component Interaction

The CPU controls all of the other resources within the system, in order to accomplish a task.



The CPU

- Basic functions of CPU are:

1. Carrying out arithmetic and logic functions and sends the result to the output unit.
2. Controlling the use of memory to store data and instructions.
3. Controlling the sequence of operations.
4. Controlling all parts of the computer system.

- How do computers represent data?

CPU works with only binary data.

BINARY DIGIT (BIT)	ELECTRONIC CHARGE	ELECTRONIC STATE
1		ON
0		OFF

- Recognize only two discrete states: on or off
- Use a **binary system** to recognize two states
- Use Number system with two unique digits: 0 and 1, called **bits** (short for binary digits)

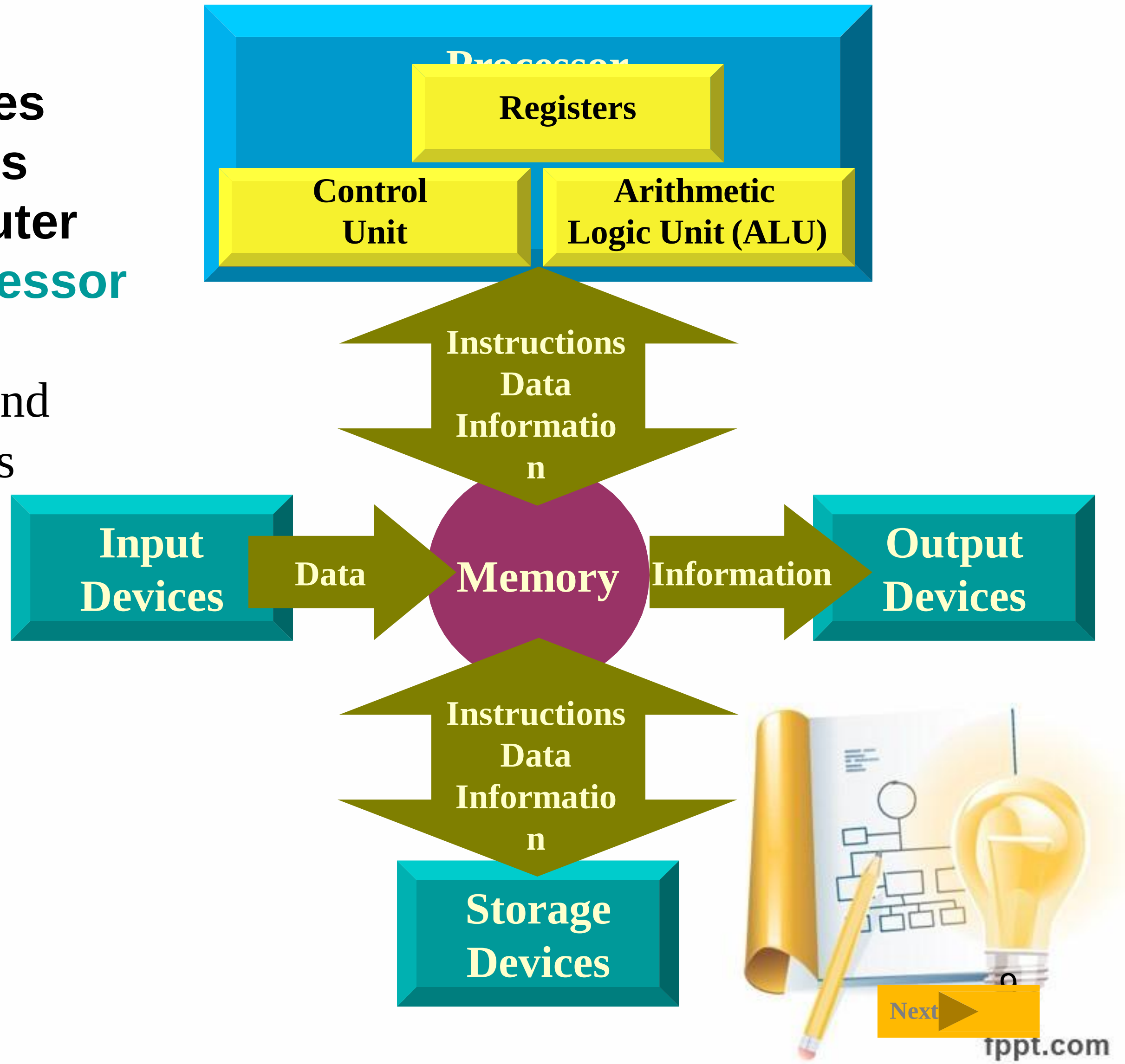
Interaction between functional blocks

- CPU:

 Interprets and carries out basic instructions that operate a computer
 Also called the **processor**

Control unit directs and coordinates operations in computer

Arithmetic logic unit (ALU) performs arithmetic, comparison, and logical operations



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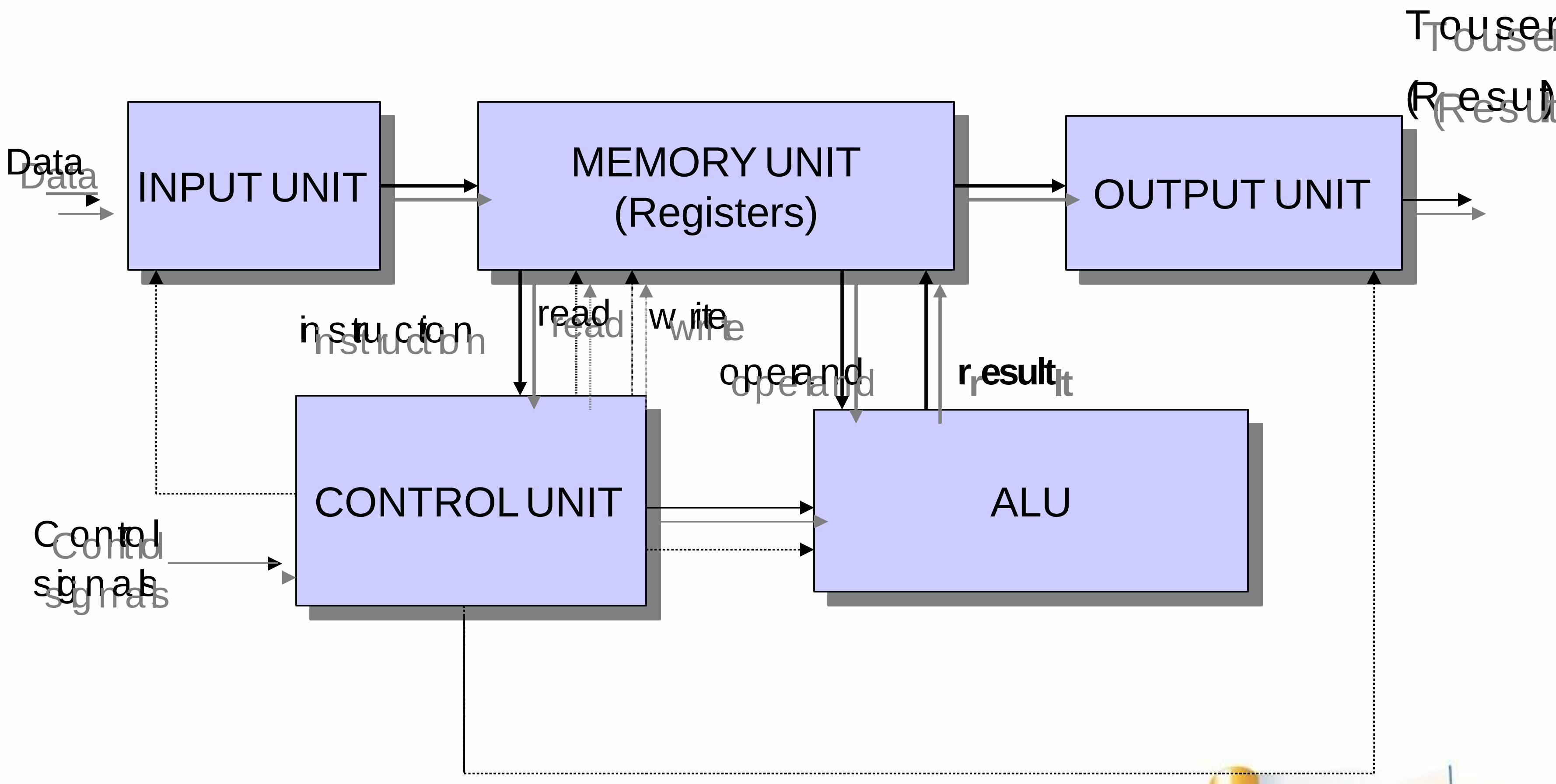
Interaction between functional blocks



____ data flow

------Control flow

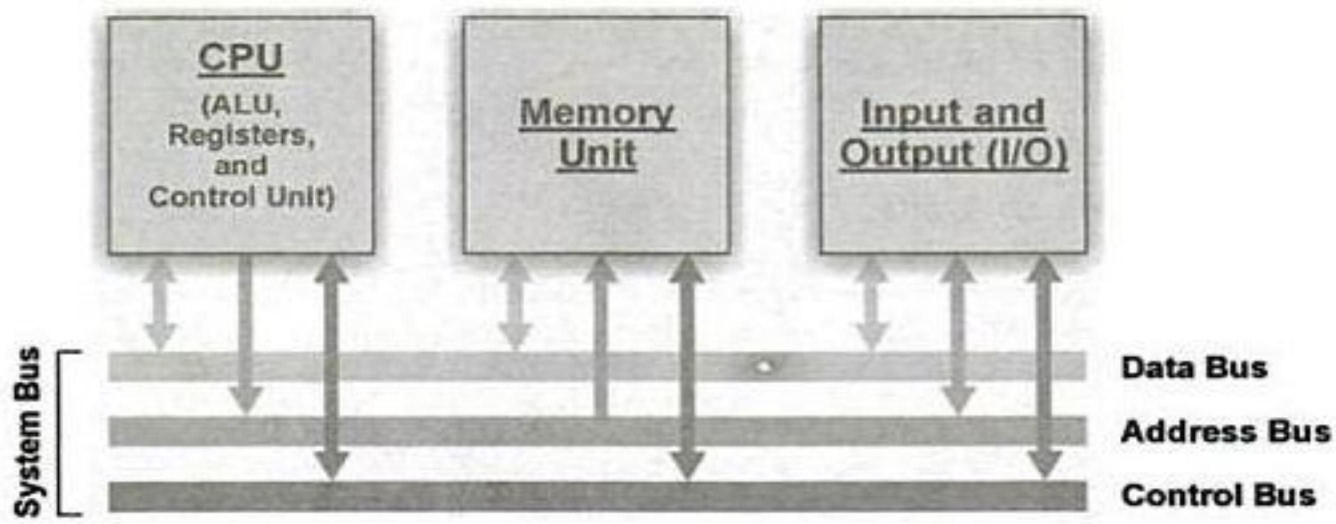
Interaction between functional blocks

- The set of wires used for interconnection is known as system bus.
- System bus is used to transmit data from one unit to another.
- System bus is collection of wires through which data is transmitted from one unit to another (CPU, Memory and I/O devices)
- System bus has certain size or width called data path which is measured in bits.

Interaction between functional blocks

- System bus is further divided into three logical units: address bus, data bus and control bus
- **Data Bus:** It transfers actual data or instructions between the processor, memory and I/O devices.
- **Address Bus:** It informs the CPU about the location of the data residing in the memory.
- Before data or instructions can be written into or read from memory by cpu or I/O sections, address must be transmitted to memory over the address bus.
- **Control Bus:** It is responsible for making CPU, memory and I/O devices work together as a functional system, carrying signals to instruct other units.
- status ready/ not ready for read/write of other device

Interaction between functional blocks

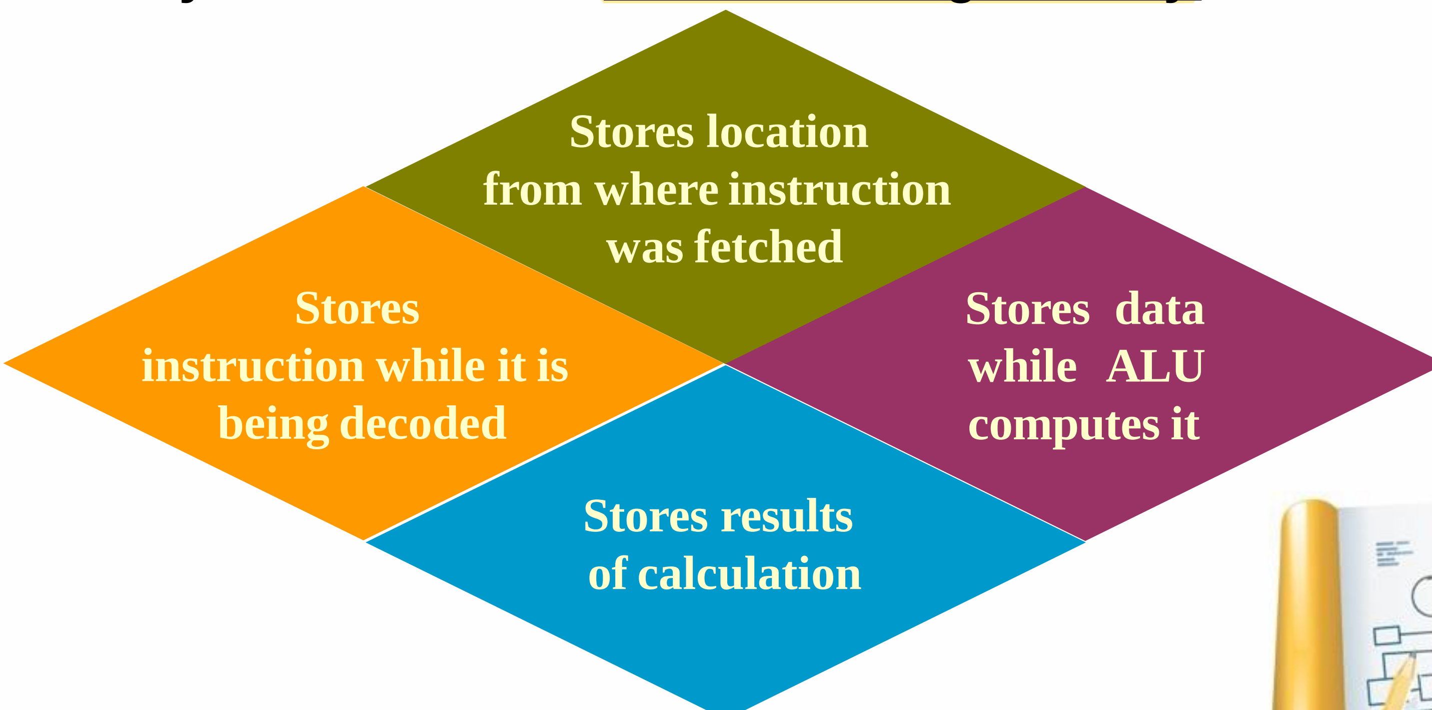


- Processor and memory units holds a bidirectional relationship with the control and data bus.
- In case of address bus, the communications with processors and memory is unidirectional.
- The processor provides location of data (stored in memory), to be fetched from memory, to the address bus and data bus carries the required data to processor.

What is a register?

- **Temporary high-speed storage area that holds data and instructions**

- **They hold the information that the CPU is currently working on so they also known as <u>CPU's working memory.</u>**



p. 185

Next

Registers

Register Name	Function
Program Counter (PC)	A Program counter keeps track of next instructions to be executed.
Instruction Register (IR)	An IR holds the instructions to be decoded by the control unit.
Memory Address Register (MAR)	MAR holds address of the next location in memory to be accessed.
Memory Buffer Register (MBR)	MBR is used for storing data either coming to the CPU or data being transferred by the CPU.
Accumulator (ACC)	An accumulator is general purpose register used for storing temporary results and results produced by arithmetic logic unit.
Data Register (DR)	A Data register is used for storing the operands and other data.

Arithmetic / Logic Unit
ALU

Performs arithmetic operations

Performs logical operations

Arithmetic Operations

+

Addition

-

Subtraction

Multiplication

Division

/

*

Logical Operations

- Evaluates conditions
- Makes comparisons
- Can compare
  - Numbers
  - Letters
  - Special characters

NOT

AND

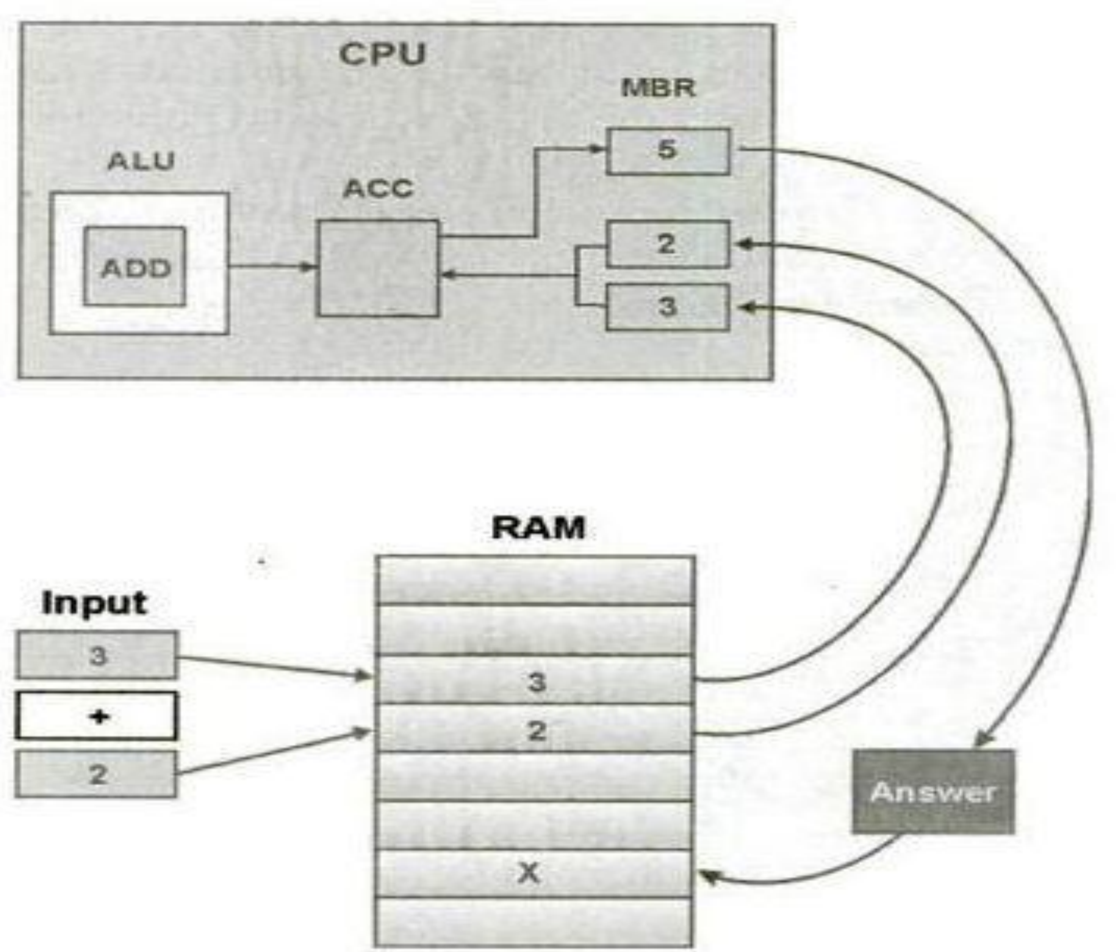
OR

= > < <> >= <=

ALU

- In arithmetic calculations, it is only limited to addition.
  - Multiplication is repeated addition.
    - E.g. 2 * 3 is 2+2+2
  - Adding the negative of that number performs subtraction.
    - E.g. x-y is same as x+ (-y).
  - Division can be achieved by multiplying the inverse of the number.
    - E.g. x/y is same as x * 1/y.
- Therefore, most processors include only the add function.

ALU



ALU

- Following steps for adding two numbers:

1. The numbers (2 and 3) to be added up are put into two separate memory locations.
2. The control unit fetches the two numbers from their memory locations into the data registers.
3. The AU looking at the operator (+) uses the accumulator and adds the two numbers.
4. The ALU stores the result 5 in memory buffer register.
5. Then the control unit stores the result into a user desired memory location.

ALU

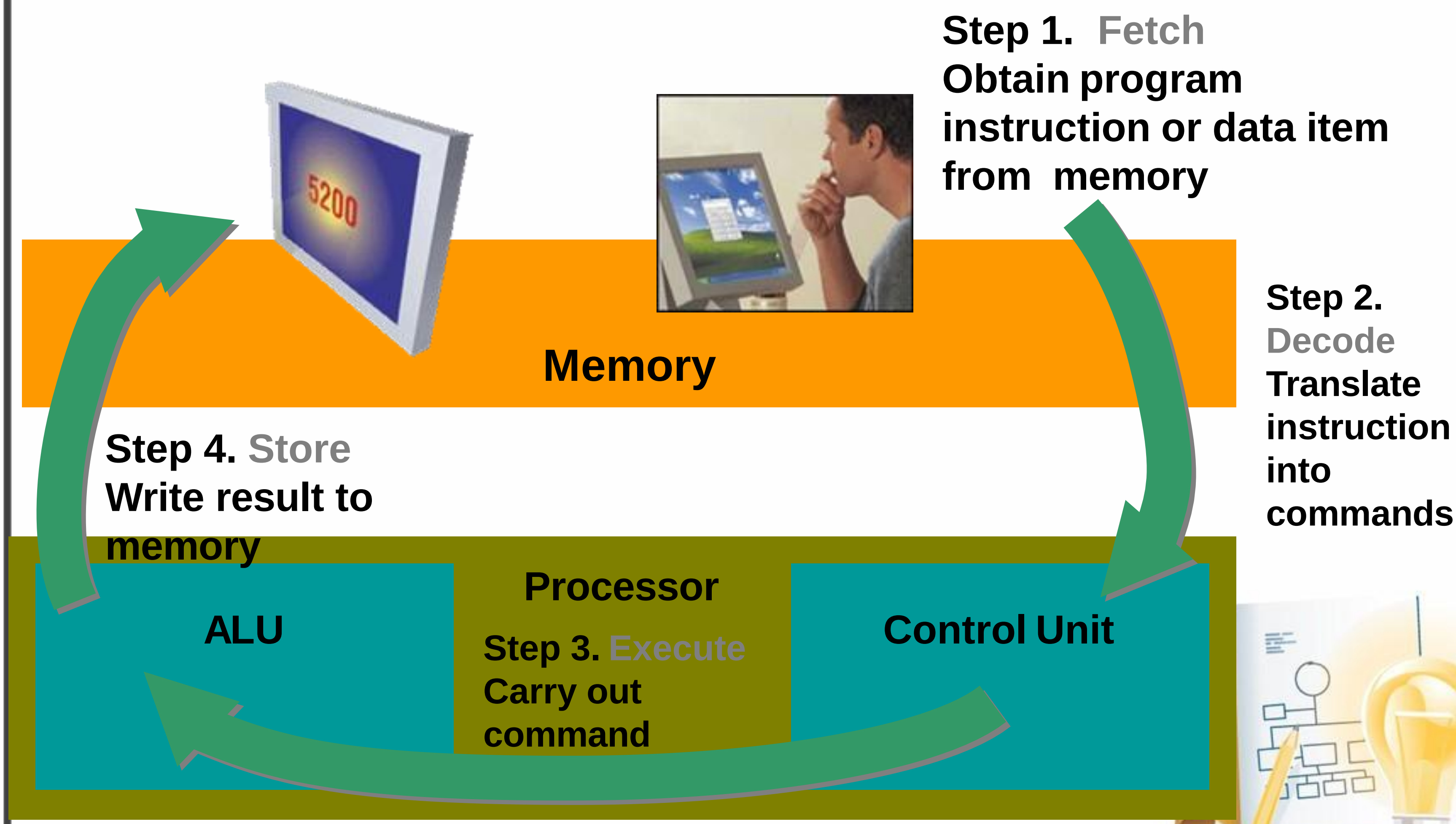
Logic Unit (LU):

- It provides ability to the CPU to make logical operations based on the instruction provided to it.
- These operations include logically comparing two data items and take different actions based on the results of the comparison.

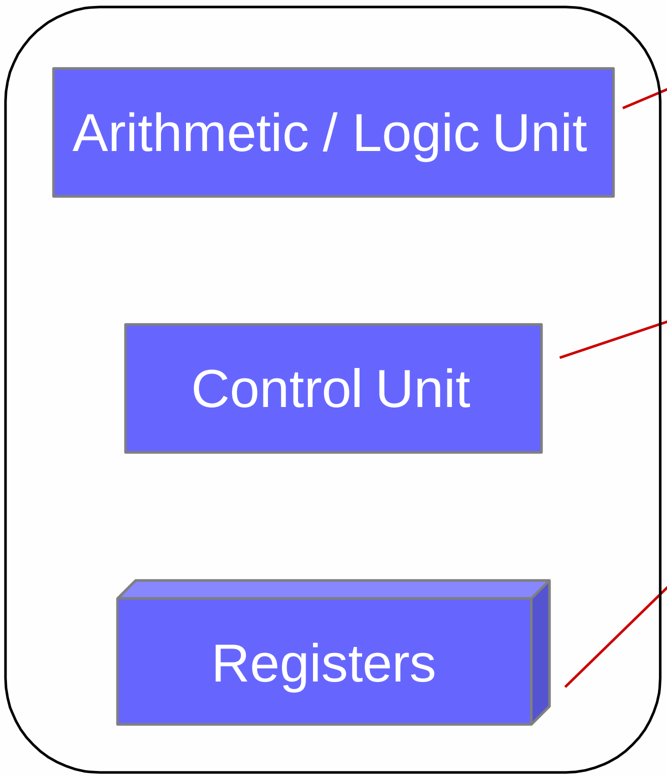
Control Unit
CU

- Heart of the CPU
- It controls the I/O devices and transfer of data to and from primary storage.
- Directs the computer system to execute stored program instructions
- Communicates with other parts of the hardware
- It determines what data is needed, where it is stored, where to store the results of the operation.

Control Unit



Central Processing Unit (CPU)



Performs calculations and decisions

Coordinates processing steps

Small, fast storage areas for instructions and data

Communication between various Units of a Computer System

- **Processor to memory communication**

- The following sequence of events take place when information is transferred from memory to the processor:

1. The processor places the address in MAR via the address bus.
2. The processor issues a READ command via the control bus.
3. The memory places the retrieved data on the data bus, which is then transferred on the processor.

Processor to memory communication

- The following sequence of events takes place when information is written into memory

1. The processor places the address in memory address register via the address bus.

2. The processor transmit the data to be written in memory via the data bus.

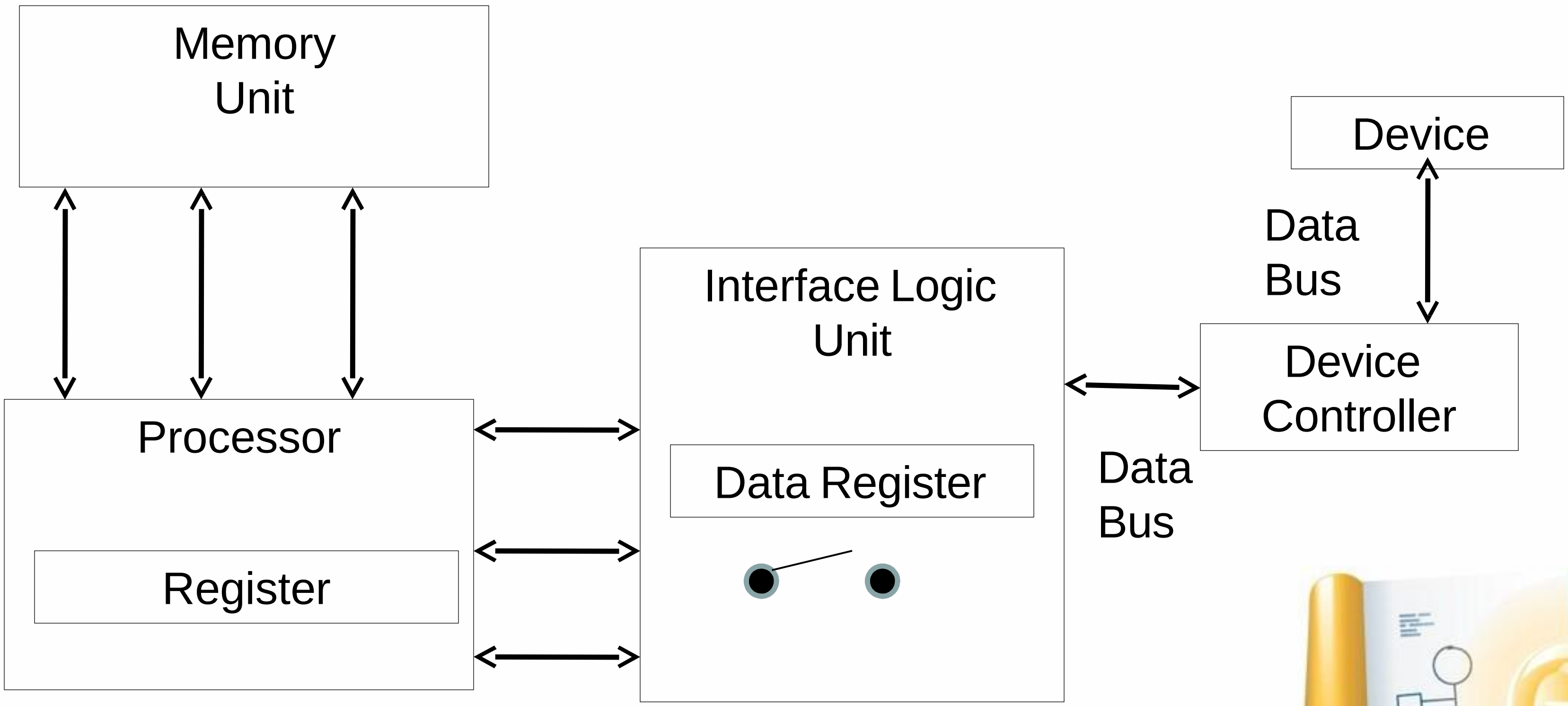
3. The processor issues a WRITE command to memory via the control bus.

4. The data is written in memory on the address specified in memory address register.

Processor to I/O Devices Communication

- I/O units are connected to the computer system via the system bus.
- Each I/O devices in a computer system has a controller, which controls the operation of that device.
- The controller is connected to the buses via interface logic unit.
- The interface logic unit decodes the controler commands received from processor and send them to controller.
- It also buffers the flow of data from the device to the processor and vice versa.
- The method of the transfer of information between processor and I/O device is called ***program controlled transfer***.

Processor to I/O Devices Communication



Processor to I/O Devices Communication

- Steps to transfer of data between processor and I/O devices:

1. Processor sends the address of device from which data is to be read via system bus.

2. Control unit issues a READ command.

3. The device interface logic acknowledge the signal and turns on a device busy flip-flop (state 0).

4. I/O device reads data and places it in data register of the interface. It also set data ready flip flop (state 1).

5. The processor continually interrogates the data ready flip flop and waits until this flip-flop is set (state 0).

6. When data ready flip-flop is set, the processor reads data from interface data register and places it in the appropriate processor register.

Processor Speed

- The processor is the main hardware that drives the computer, the faster the processor, the better the performance.
- The overall speed of computer system is determined by several factors, most notably:
  - Clock speed
    - The rate at which the processor process information and this is measured in millions of cycles per second (Megahertz)
    - E.g. 700 MHz
    - The more the number of hertz, the faster is the processing speed
  - Speed and size of the data bus
    - Larger the bus width and the faster the bus speed the grater amount of data which can travel on it

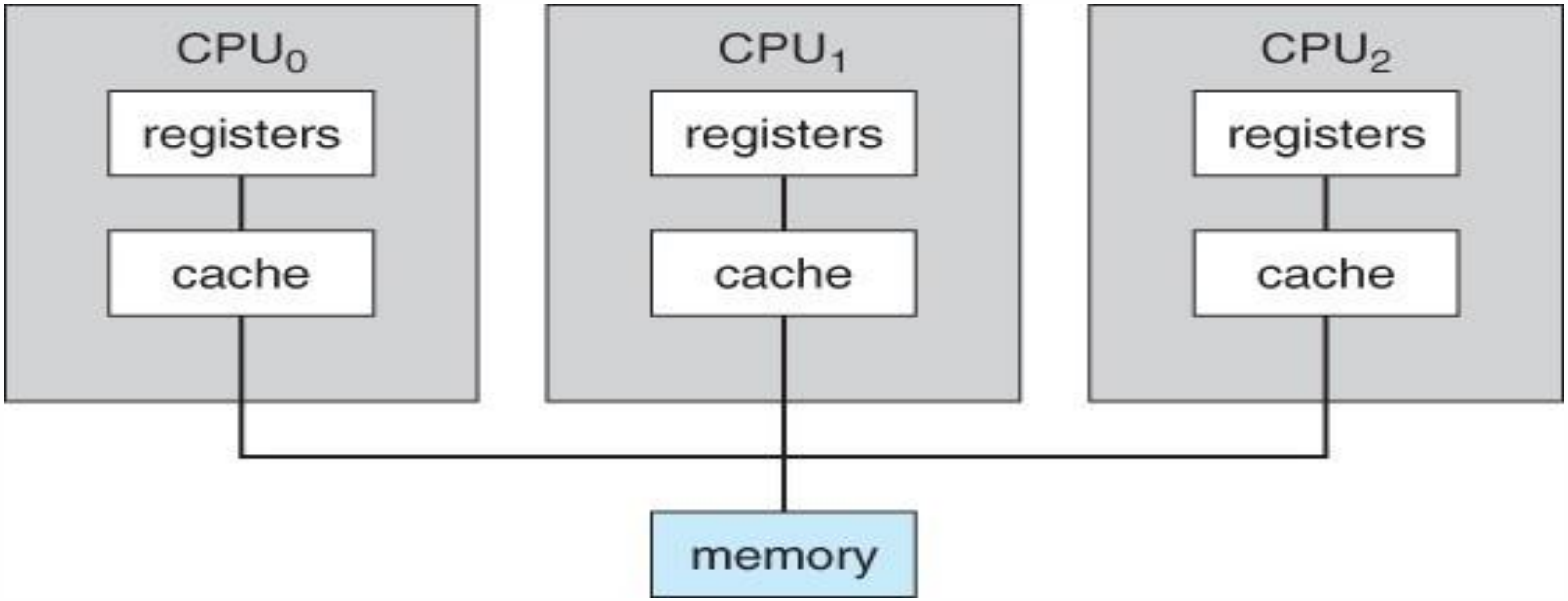
Processor Speed

- While purchasing computer system, a perfect match between the bus size, bus speed and the speed of clock should be considered.
- For e.x. ,if computer can deliver data of 256 bits at a time to the processor, the processor can only use 8 bits at a time, and has slower clock speed
  - Then it will not function optimally
  - Data can be corrupted
  - There will be a queue of data, waiting to get off the bus

Processor Speed

- In a similar scenario, computer can deliver data of 256 bits at a time to the processor, the processor can use 64 bits at a time, and has a faster clock speed
  - Will function properly
  - The processor will sit idle for data to be received
  - Hence, there is wastage of the precious

Multiprocessor systems



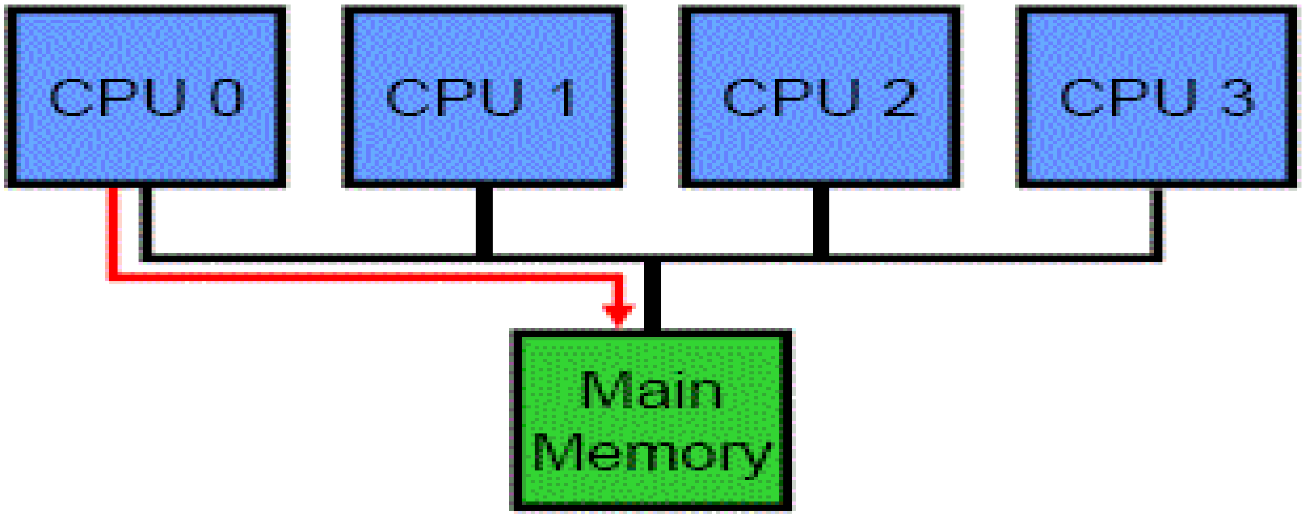
- A computer system which includes only one processor is called a single-processor system.

- Computer system that include more than one processor are called multiprocessor systems.

Multiprocessor systems

- Two popular architectural approaches for building multiprocessor computer systems are:
  - Symmetric Shared Memory Multiprocessor
  - Asymmetric Shared Memory Multiprocessor

Symmetric MultiProcessor



- Common pool of memory connected with high speed bus
- All processor can access all these memory

Asymmetric Multiprocessor

- One processor act as a controller termed as *master processor*, which controls memory unit and other processors.
- Rest of the processor are termed as *slave processor*
- The master has access to whole memory

but

Slave has access to limited memory