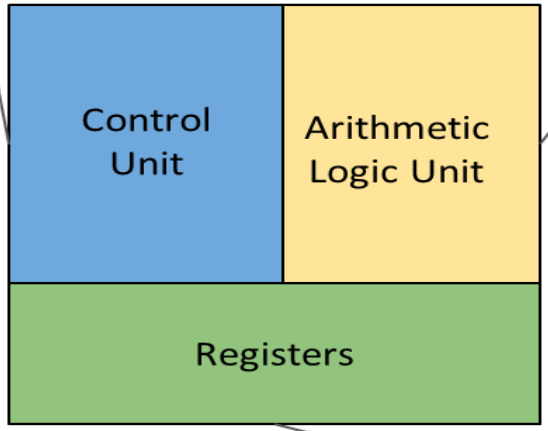
Keyword	Definition
Accumulator (ACC)	Holds the result of an instruction before it is transferred to memory.
Cache	A cache is a small, but extremely fast type of RAM, often located inside the CPU chip itself. It stores frequently used instructions.
Clock Speed	Clock speed is the number of instructions a CPU performs per second.
Core	A ‘core’ is a complete processing unit within the CPU - it has an ALU, Control Unit and Registers.
Embedded system	An embedded system is a dedicated computer system that performs one or more specific functions within a larger piece of equipment.
Memory Address Register (MAR)	Holds the memory address of the current instruction, and then the data that it uses, so that these can be fetched from memory.
Memory Data Register (MDR)	Holds the actual instruction, and then the data that has been fetched from memory.
Microcontroller	A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.
Non-Volatile	Data remains in the computer even if computer is switched off. ROM and HDD are non-volatile memory.
Processor	The central processing unit (CPU) is the most important hardware component in a computer. It has two main functions: to process data and instructions to control the rest of the computer system.
Program Counter (PC)	Holds the address of the next instruction to be executed.
Register	Very small but very fast pieces of memory that store instructions currently in use.
Virtual Memory	Virtual memory enables data that is in RAM and not currently being used to be transferred to the hard disk.
Volatile	Volatile memory is a type of memory that maintains its data only while the device is powered. If the power is interrupted for any reason, the data is lost.

Control Unit

The control unit coordinates and controls all of the activities taking place within the CPU.

- It decodes instructions and executes them
- It receives signals from the system clock
- It directs the timing and control of other parts of the CPU, much like the conductor of an orchestra



Arithmetic Logic Unit (ALU)

The ALU is responsible for performing calculations.

It performs tasks such as:

- Simple additional and subtraction
- Multiplication and Division by repeated addition and subtraction.
- Uses Boolean operators (AND, OR, NOT).

Registers

Registers are very small but very fast memory inside the CPU. They stored instructions that are currently in use. There are four registers.

Registers in the CPU

Program Counter (PC)

Holds the address of the next instruction to be executed.

Memory Address Register (MAR)

Holds the memory address of the current instruction, and then the data that it uses, so that these can be fetched from memory.

Memory Data Register (MDR)

Holds the actual instruction, and then the data that has been fetched from memory.

Accumulator (ACC)

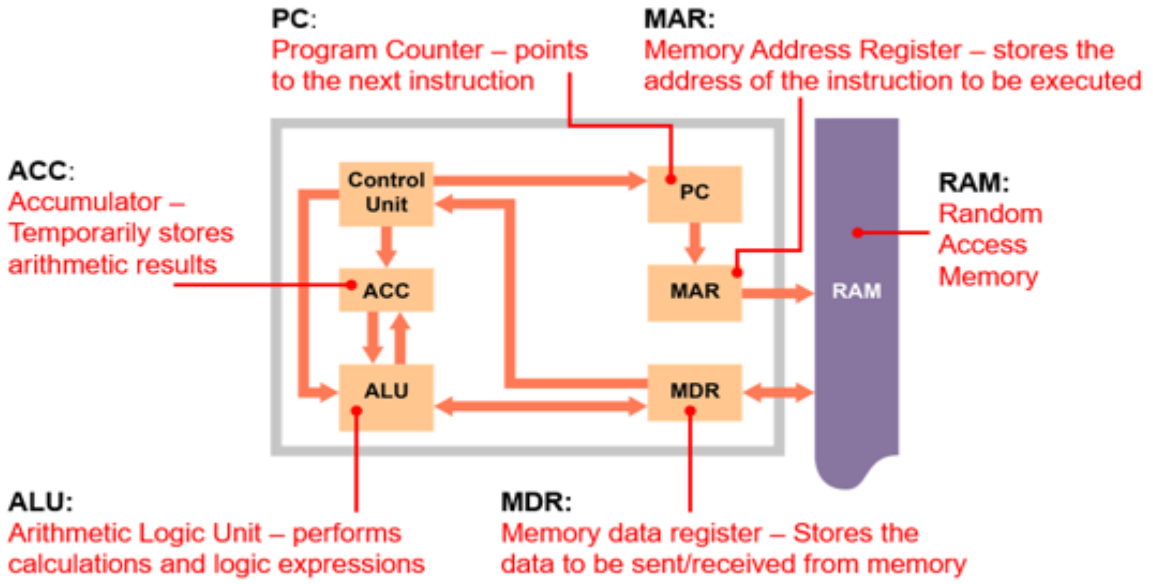
Holds the result of an instruction before it is transferred to memory.

Von Neumann Architecture

In the early days of computing (1940s), computers were built to carry out a very specific task, for example breaking secret wartime codes. But if the computer then had to do another job, it literally had to be completely re-wired by hand. This could take weeks. There was no such thing as a 'software update' in those days! Mr Von Neumann was a scientist who had an idea of how to create a computer that was far easier to change, this is known as the **Von Neumann architecture**. Von Neumann architecture is where both the data and the software that are currently being used are stored in computer memory (RAM). It is also known as a '**stored program**' computer. With this architecture, the task a computer is working on can be changed by simply loading a different program into memory.

The von Neumann computer allows the computer to store programs and data in memory. The memory and CPU work together using the Fetch, Execute cycle for the computer to function.

This allows the user to change programs without having to change the computer itself and storing multiple programs at once.



Fetch an instruction from Main Memory

- The Program Counter is loaded with the location of the next instruction to be executed.
- This address is then loaded into the Memory address register (MAR) which is connected directly to the address bus. What this means is that the address bus is now pointing to the instruction in RAM
- This instruction is copied from RAM on to the data bus which then allows the Memory Data Register (MDR) to store a copy of it.

Decode the instruction

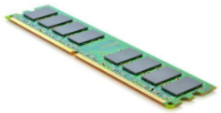
- Check to see if the MDR contains a valid CPU instruction - if it is, load the instruction register with the instruction. If it is not valid, then ideally an error is flagged so that the program can deal with it.
- Set up the program counter with the address of the next instruction to be carried out.

Execute the instruction

The instruction often involves handling data in the accumulator. For example 'Increment accumulator' would increase the value in the accumulator by 1 'Add 5 to the accumulator' does exactly what it says.

Once the execute phase is complete, the 'fetch' phase is visited once again. This is possible because the program counter was pre-loaded in the decode phase to point to the next instruction.

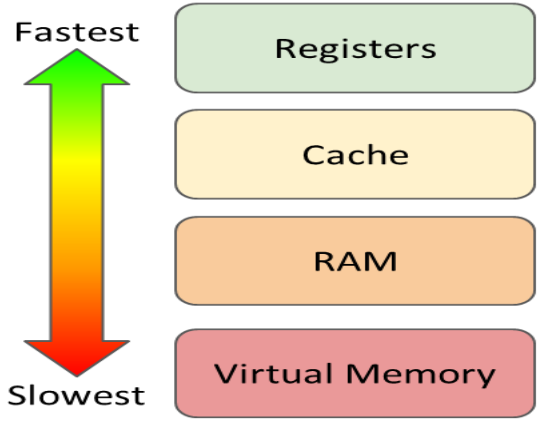
Primary Storage



RAM (Random Access Memory)
Stores running programs and data temporarily while the computer is running. The is lost when the computer is turned off. RAM is volatile.

ROM (Read Only Memory)
Non-volatile memory that stores data permanently such as boot up instructions. ROM is read only and cannot be written to.

Memory Speeds

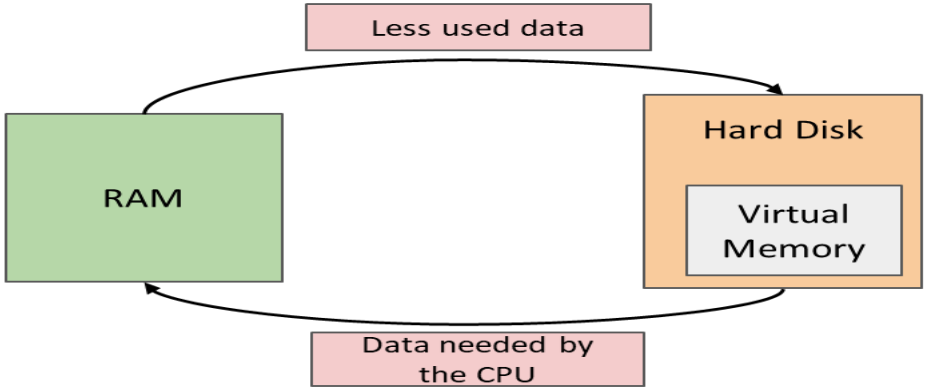


Virtual Memory

Programs must be stored in RAM to be processed by the CPU. Even if there is insufficient space in RAM for all programs the computer can use the hard disk drive (HDD) as an extension of RAM - this is called virtual memory.

If new data is needed to be stored in RAM then unused data in RAM is moved to the hard drive so the new data can be transferred into RAM.

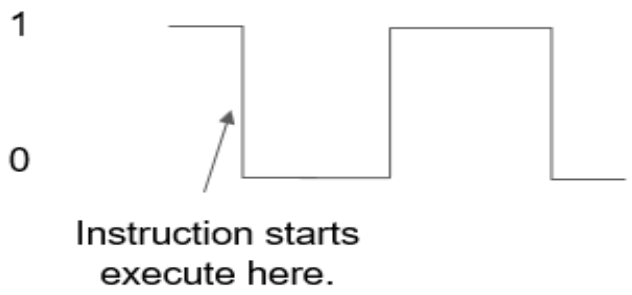
When required, the data can be moved back from virtual memory into RAM. Using virtual memory allows users to run more programs simultaneously with less system slow down.



Clock

Clock speed is the number of instructions a CPU performs per second. Measured in hz (hertz) for every hertz, an instruction is performed. CPU's are now often measured in GHz.

1 kilohertz (kHz) = 1,000 cycles per second.
1 Megahertz (MHz) = 1,000,000 cycles per second.
1 Gigahertz (GHz) = 1,000,000,000 cycles per second.



Cache

Cache is small, but extremely fast type of memory, often located inside the CPU chip itself. However, cache memory is more expensive than RAM. So to help speed up the processing time, cache memory is used to store instructions or data that are either frequently used, have recently been used or are about to be used. This means that they don't have to be fetched directly from RAM.

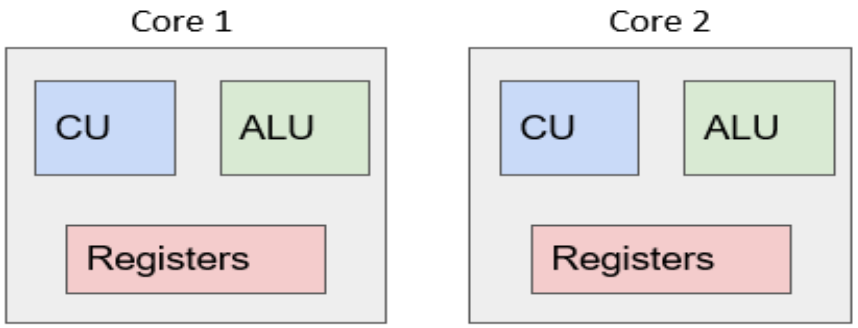
Cores

A 'core' is a complete processing unit within the CPU - it has an ALU, Control Unit and Registers.

Now it is common for a CPU chip to have two, four, eight cores or more. A cpu with two cores is called a 'dual core' and one with four cores is called a 'quad-core'.

A quad-core processor working on many different tasks simultaneously, under ideal conditions can be up to four times faster than a single-core processor. If the computer is running a single program, it is not necessarily any faster, since the program may have been designed to only run on one core.

Dual CPU Core Example



Embedded Systems

An embedded system is a dedicated computer system that performs one or more specific functions within a larger piece of equipment.

Embedded computers are often built as a single unit, with everything mounted on a printed circuit board. RAM, ROM, CPU, Clock and connectors are all pre-installed.

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

Characteristics of Embedded Systems

- Handle a set of inputs
- Provide a set of outputs
- Be programmable
- Low power consumption
- Be cheap
- Be reliable
- Be compact

Examples of Embedded Systems

Systems that have one specific purpose.

Microwave

Card Reader

Washing Machine

Examples of General Purpose Machines

Systems that have multiple purposes.

Tablet

Smartphone

Laptop