

# Processor Design

Computer Architecture - INFR 2810 - Final  
Project

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# Understanding Processor Design Concepts and Components

The background is a solid orange color. In the top-left corner, there are three vertical bars of varying heights, each composed of three overlapping circles. In the bottom-right corner, there are four vertical bars of increasing height from left to right, each composed of four overlapping circles.

# **What is Processor Design?**



**Processor design is, in a sense, the blueprint and construction process for the "brain" of a computer, known as the processor (or CPU).**

It's a **specialized area within computer science and computer engineering** that focuses on designing this crucial piece of computer hardware.

**Think of it as developing the detailed plans and then overseeing the "fabrication" or manufacturing of that brain so it can efficiently handle all the calculations and instructions that make a computer work.**





## **What is a CPU(Central Processing Unit)?**

CPU's operate using a continuous cycle of commands. This process is managed by the control unit and synchronized by the computer clock, ensuring all operations happen in perfect time.



# What is a CPU(Central Processing Unit)?

A CPU performs its tasks by following a set routine called the **CPU instruction cycle**. This cycle determines how many times the basic computing instructions will repeat, based on the computer's **processing power**.

The steps in cycle:

- **Fetch:** This is when the CPU **retrieves data** from the computer's **memory**.
- **Decode:** The CPU's **decoder** translates the binary instructions it fetched into **electrical signals** that other parts of the CPU can understand and act upon.
- **Execute:** In this step, the CPU **interprets and carries out** the instructions from a computer program.



## What is it made of?

CPU**s** are built with microelectronic technology, which creates incredibly small electronic circuits.

They're the processing "brains" found in almost all modern electronics like computers and phones.

A CPU contains key parts like the control unit, arithmetic logic unit (ALU), and registers, all working together to execute instructions.



# How is it made?

Processors are secured into a compatible CPU socket on the motherboard.

Due to **significant heat generation**, a heat sink is placed over the CPU to **keep it cool** and functioning smoothly.

During installation, **the process is to align the CPU's notched corner with the socket**, matching its hundreds of bottom "socket holes" to the motherboard's pins.



PLATE FIN



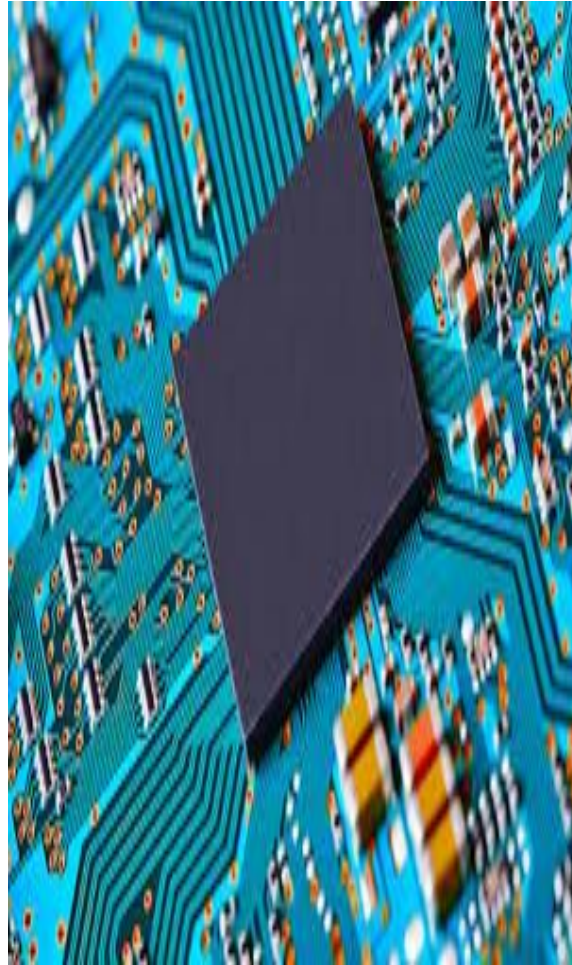
A CPU with socket holes and a notched corner.



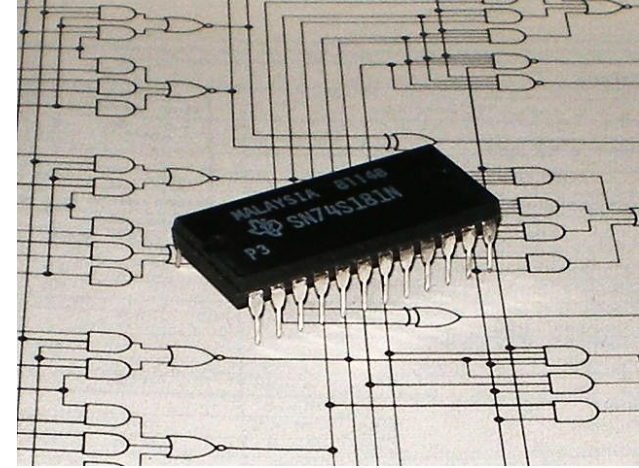


**Processor design, is a complex field that involves creating the architecture of the central processing unit (CPU) of a computer.**

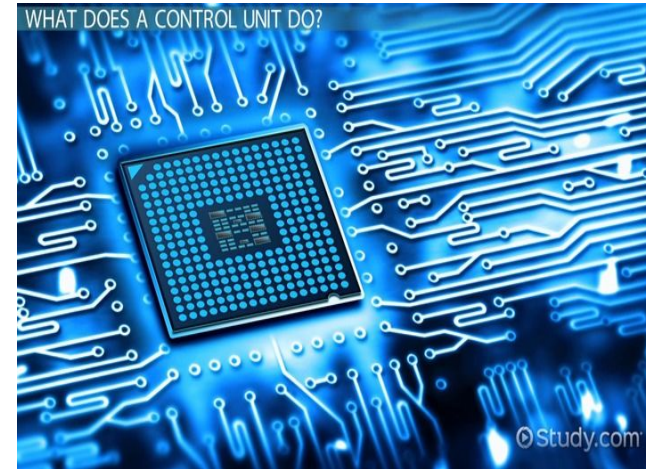
**Which is responsible for executing instructions in a computer system. There are many components of Processor design.**



↑ **Cache Memory** ↑



↑ **Arithmetic Logic Unit (ALU)** ↑  
↓ **Control Unit (CU)** ↓





# Cache Memory





Cache memory, is about providing fast access to frequently used data and instructions, which significantly reduces **latency (the delay before a transfer of data begins following an instruction for its transfer)**.

This speed comes from its ability to store often-reused information and even pre-load predicted instructions. Cache is organized into progressively larger yet slower levels: **L1 cache is the fastest and closest to the CPU, while L2 and L3 caches offer additional quick-access storage.**

By minimizing the time spent waiting for data, **cache directly translates to a smoother, faster computing experience.** Without this, the ability of the general user to retrieve data would be very hard and long.



# Arithmetic Logic Unit (ALU)





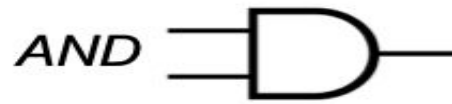
**An ALU is a critical component of a computer's central processing unit (CPU) responsible for performing arithmetic and logical operations.**

It performs tasks like addition, subtraction, bitwise operations, and comparisons.

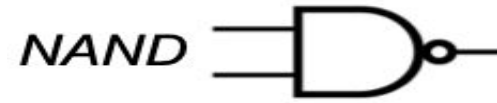
The ALU receives inputs from its registers and produces outputs based on the instruction it receives.

The one of the **main components of an ALU include logic gates (AND, OR, XOR etc. ) and arithmetic circuits (half/full adders etc.).**

# Logic Gates And Truth Tables



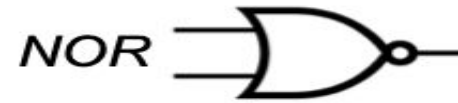
<b>X</b>	<b>Y</b>	<b>OUT</b>
0	0	0
0	1	0
1	0	0
1	1	1



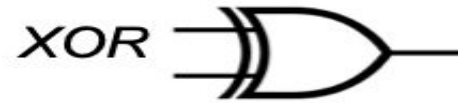
<b>X</b>	<b>Y</b>	<b>OUT</b>
0	0	0
0	1	0
1	0	0
1	1	1



<b>X</b>	<b>Y</b>	<b>OUT</b>
0	0	0
0	1	0
1	0	0
1	1	1



<b>X</b>	<b>Y</b>	<b>OUT</b>
0	0	0
0	1	0
1	0	0
1	1	1



<b>X</b>	<b>Y</b>	<b>OUT</b>
0	0	0
0	1	0
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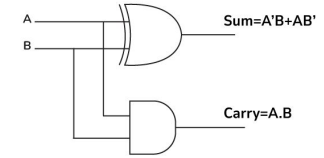
<b>X</b>	<b>Y</b>	<b>OUT</b>
0	0	0
0	1	0
1	0	0
1	1	1



<b>X</b>	<b>OUT</b>
0	1
1	0

# Half/Full Adder And Truth Tables

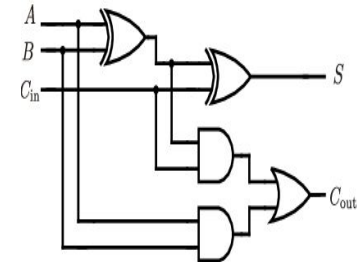
## Half Adder



Truth Table

A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

↑ Half Adder ↑  
↓ Full Adder ↓



Inputs			Outputs	
A	B	C <sub>in</sub>	S	C <sub>out</sub>
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



# Control Unit (CU)



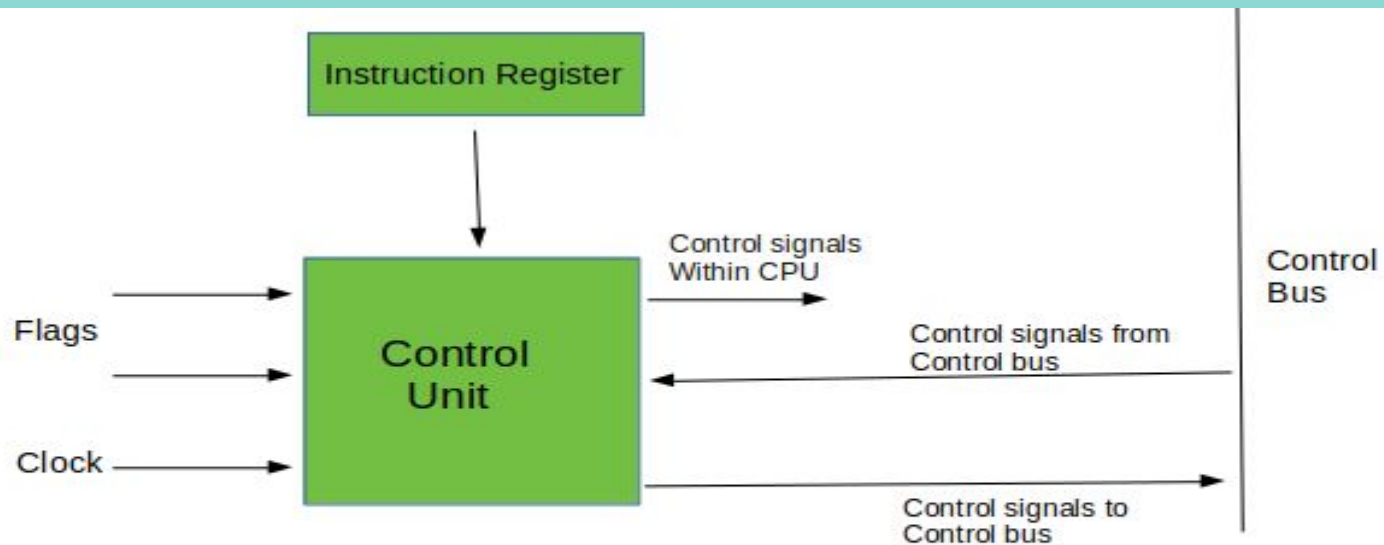


**The control unit (CU) is a vital part of a computer's CPU, acting like its "brain." It directs and coordinates how instructions are carried out.**

The CU interprets instructions pulled from memory, manages data flow between different CPU components, and oversees the processor's entire operation.

**Its main job is to translate instructions into control signals—pulses of electricity or light—that tell other CPU parts what to do.**

This includes fetching data, performing calculations in the arithmetic logic unit (ALU), and sending out results, all to ensure the computer precisely follows program instructions.



Block Diagram of the Control Unit

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# History and Evolution Processor Design



# The ORIGIN



The **Central Processing Unit (CPU)** concept solidified in the 1950s with the rise of stored-program computers like the UNIVAC I and IBM 701.

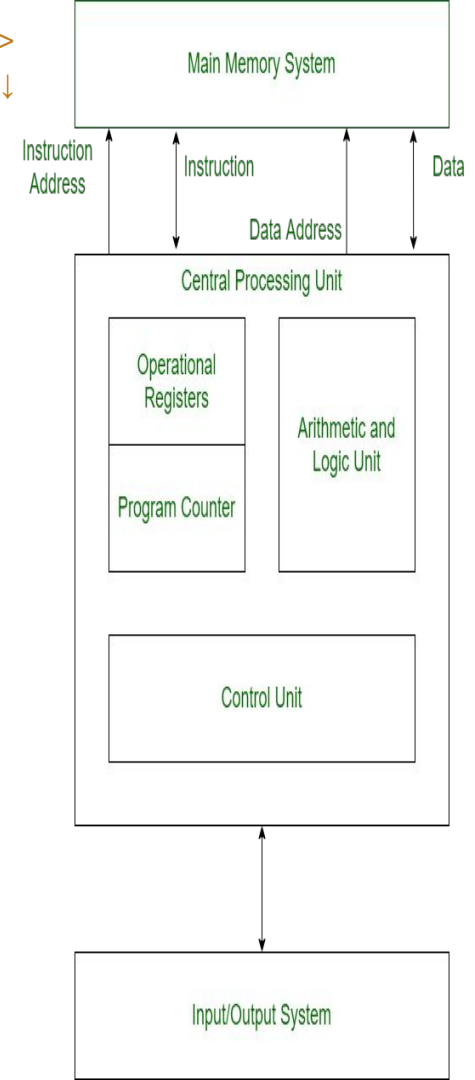
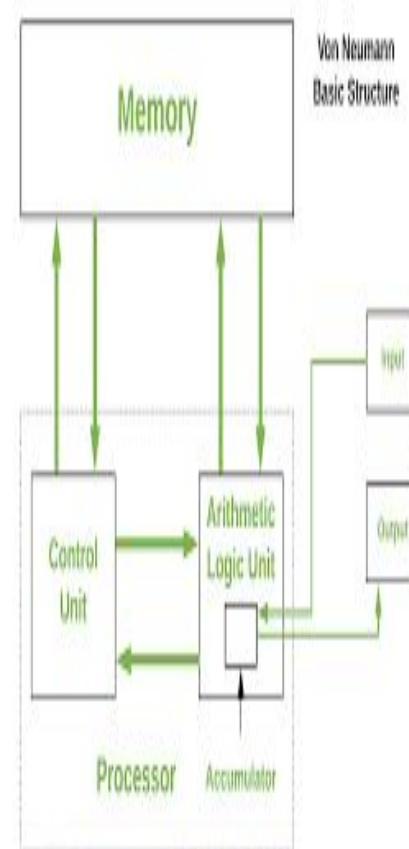
The established foundational model of fetching, decoding, and executing instructions,

Their design **was influenced by the Harvard architecture** (separate instruction and data memory) and, the **von Neumann architecture** (single memory space for both).

**This latter model is the basis for most modern CPUs.**

These innovations shifted computing from hardwired control to programmable logic. The current standard of modern CPU technology.

Harvard architecture ->  
↓ Von Neumann architecture ↓





# The RISE



The “modern” **Central Processing Unit (CPU)** emerged in the early 1970s, driven by semiconductor advancements.

Intel's 4004 microprocessor, released in 1971, was a pivotal breakthrough, integrating an entire processor onto a single chip and minimizing computers.

The 1980s then introduced **RISC (Reduced Instruction Set Computing)**, which simplified CPU design for mass production.



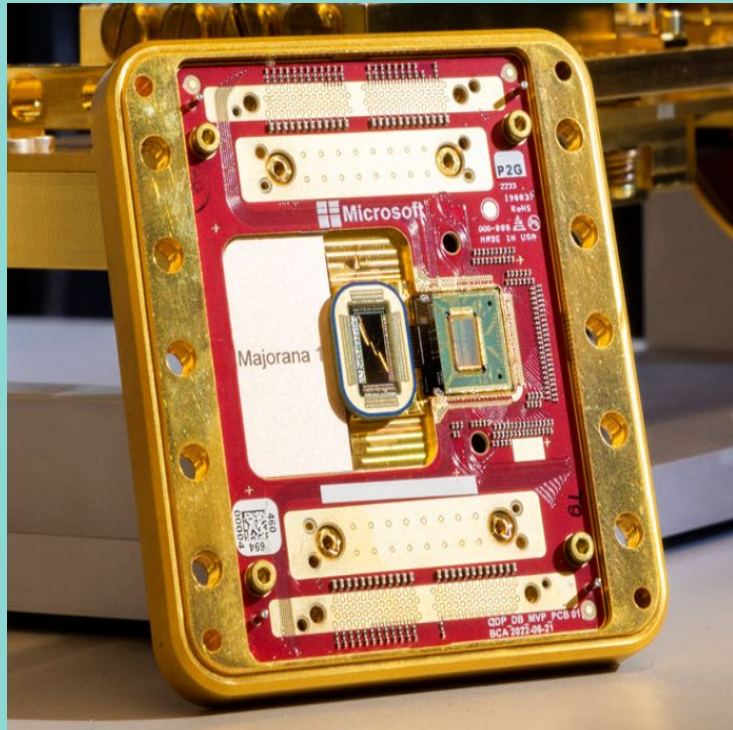


# **Real-World Applications of Processor Design**





## CPU's at work





# **Microsoft Majorana 1 Chip**

Microsoft's Majorana 1 chip is **designed to accelerate AI and machine learning workloads, offering performance specifically optimized for next-gen AI applications.**

Majorana 1 integrates a specialized architecture to boost the efficiency of large-scale model training and inferencing in real-time.

Its design focuses on reducing latency and power consumption while ensuring that AI models run faster and more efficiently.

Microsoft intends to **use Majorana 1 in both cloud services and edge computing, enabling smarter AI solutions across industries.**



## Apple M4 Chip

The Apple M4 chip is expected to be Apple's next-generation custom ARM-based processor, following the success of the M1 and M2 chips.

ARM stands for Acorn RISC Machine, and it refers to the processor architecture designed for high efficiency and performance.

The M4 will likely incorporate cutting-edge advancements in AI and machine learning, similar to previous M-series chips, but with even more power and efficiency.

With advancements in the neural engine, it will **likely provide users enhanced capabilities for tasks like real-time video processing and complex AI workloads.**



# The Future of Processor Design



Unknown.





**Thank you.**

