

Embedded System Architecture - CSEN 701

Module 2: *Microcontroller Fundamentals*

Lecture 02: *Overview of Microcontrollers and Microprocessors*

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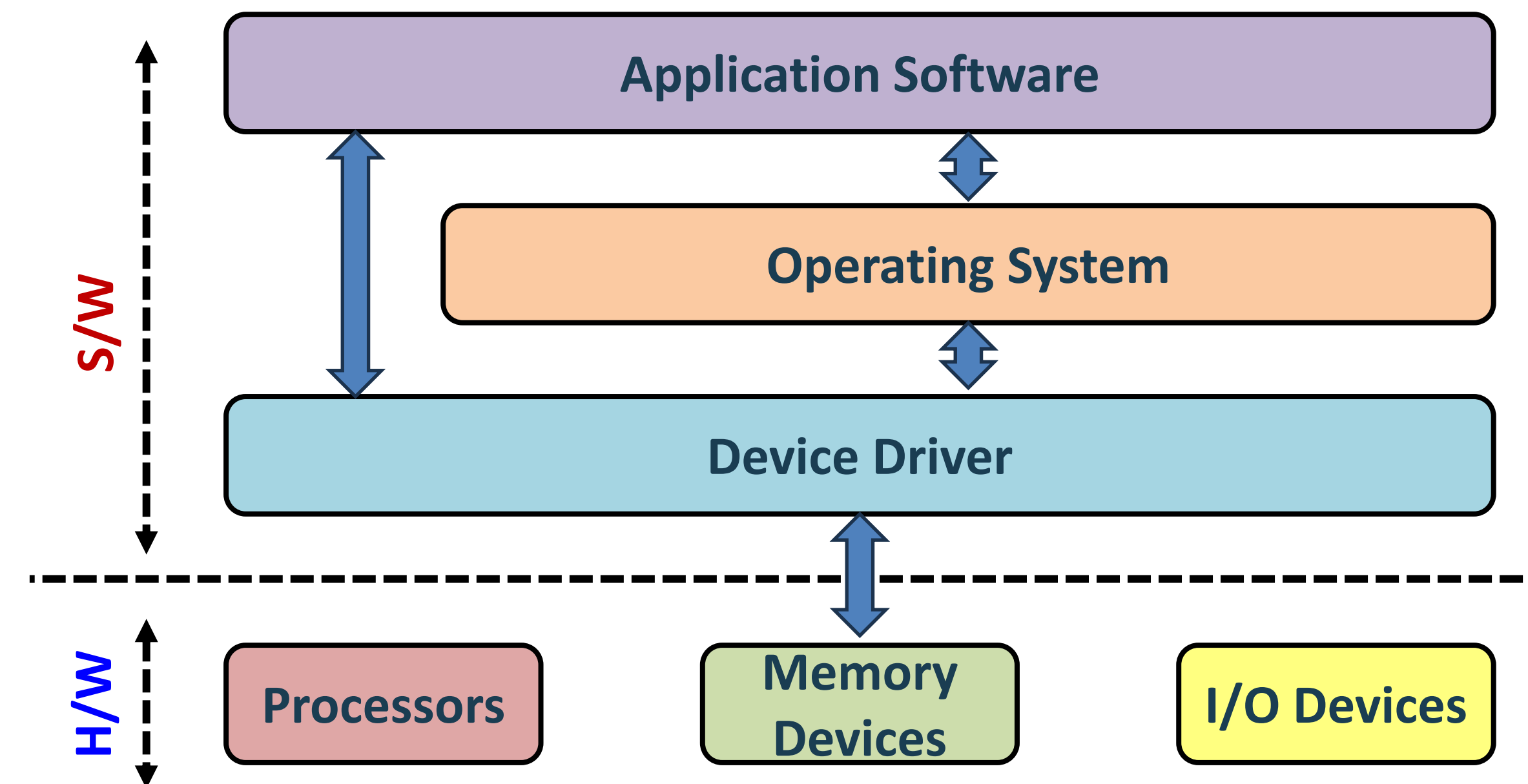
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- Embedded System Structure
- ES Processors
- Exploring Ardunio rp2040

Components

- An embedded system is composed of two main components; the **hardware** and the **software**.
- Each of these components is further divided into **number of elements**.
- These elements can **exchange the data** among themselves through busses.
- By both the S/W and the H/W parts, we can form our embedded system that is capable of **interacting with the environment**.



Hardware Components

M/H

Processors

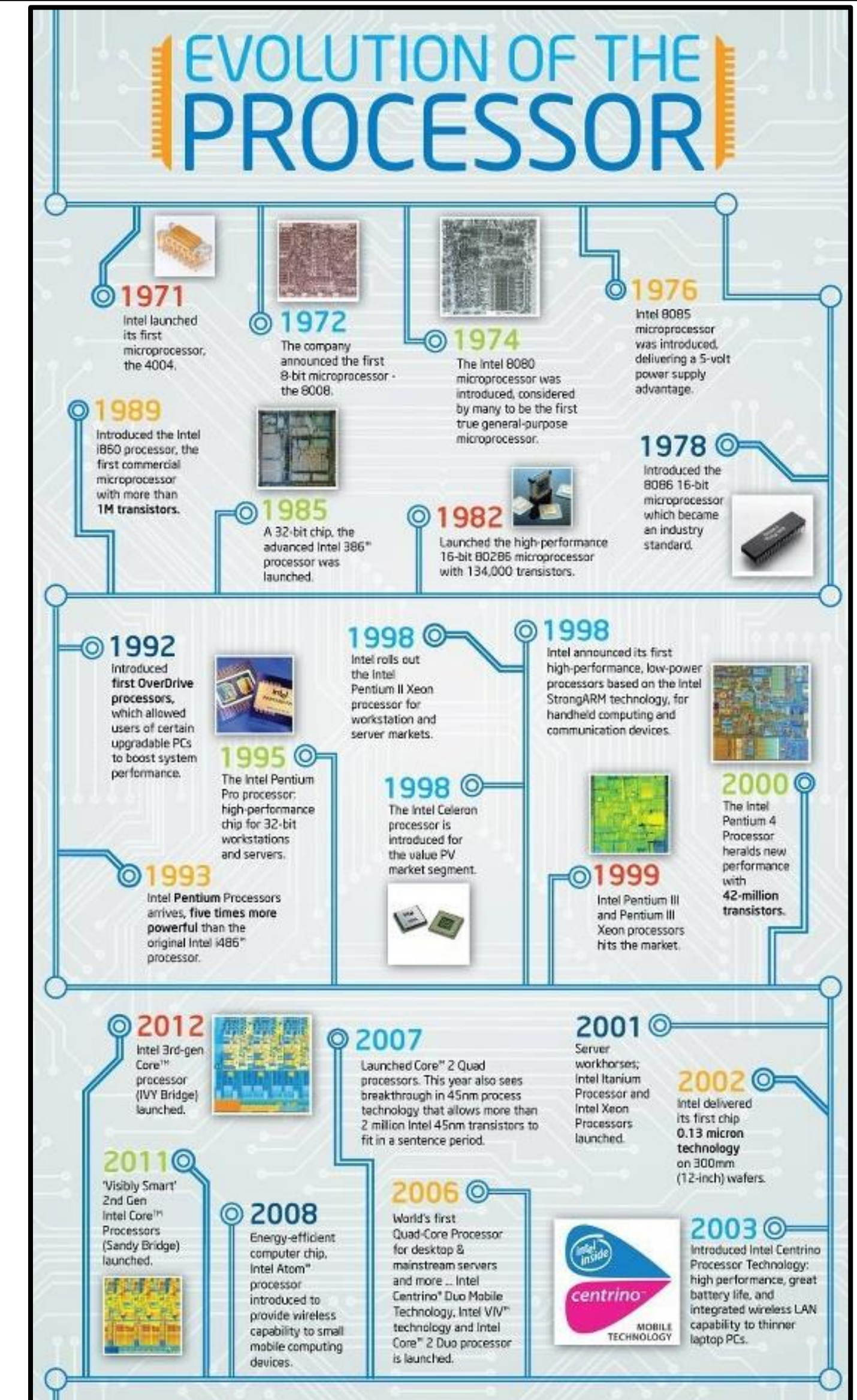
Memory
Devices

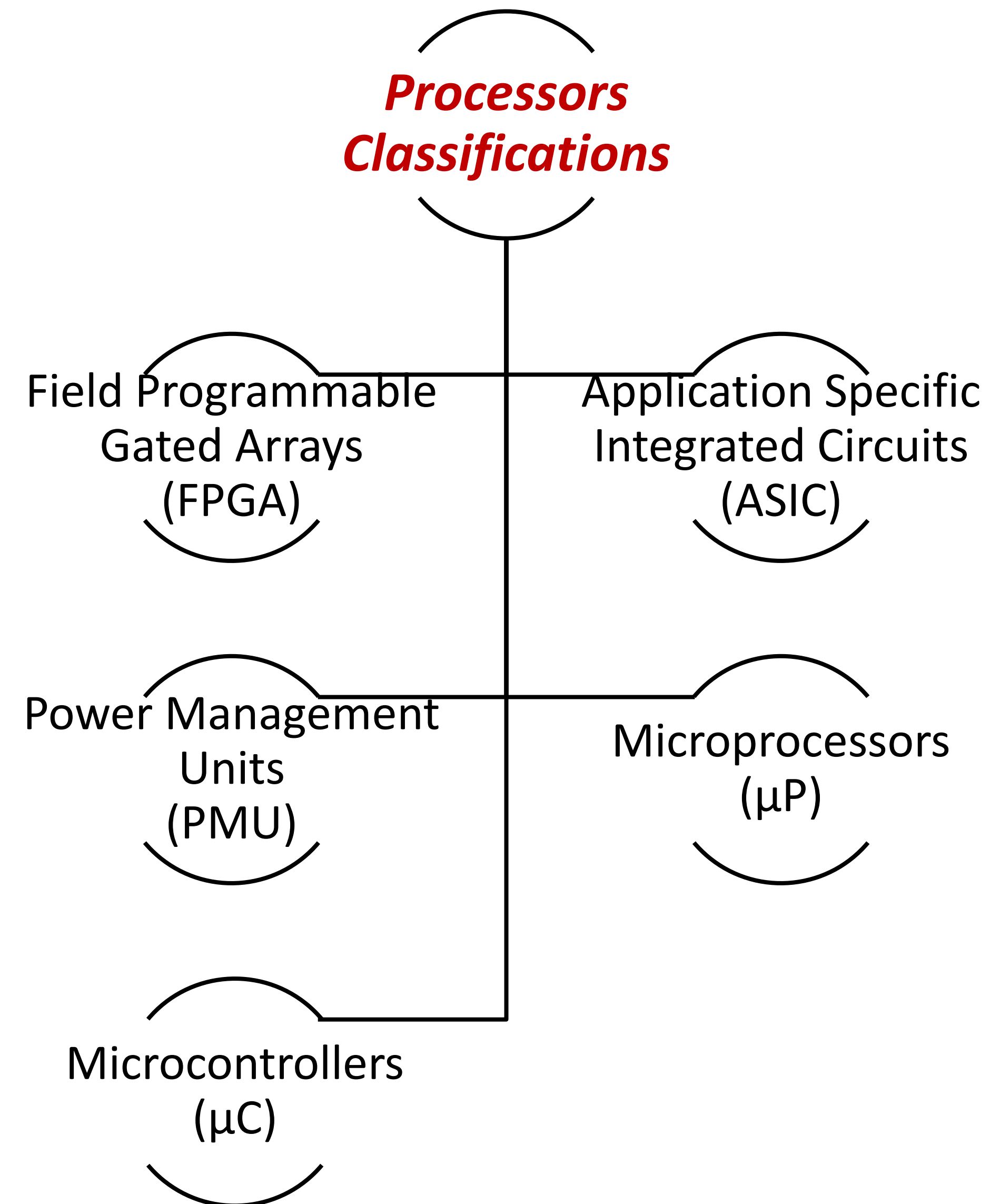
I/O Devices

- The processor in the ES should be capable of performing the **arithmetic** and **non-arithmetic** operations.
- This means, it should consists of a **CPU** with all of its elements:
 - Control Unit, Registers, and ALU.
- As for the memory devices, the ES should have both **program** and **data memory**.
- Through the I/O devices, the ES should be able to **interact with the external environment**. This will require having:
 - Communication Ports, User Interface, Sensors & actuators, ADC Converters, System Controllers, Power Management, Diagnostics Support, and others.

Evolution of Processors

- The evolution of the processors has started in 1971 when intel launched the first 4004 processor (Firstly used in a calculator).
- Since then, the development in the processors with the different classifications have been significantly increasing.





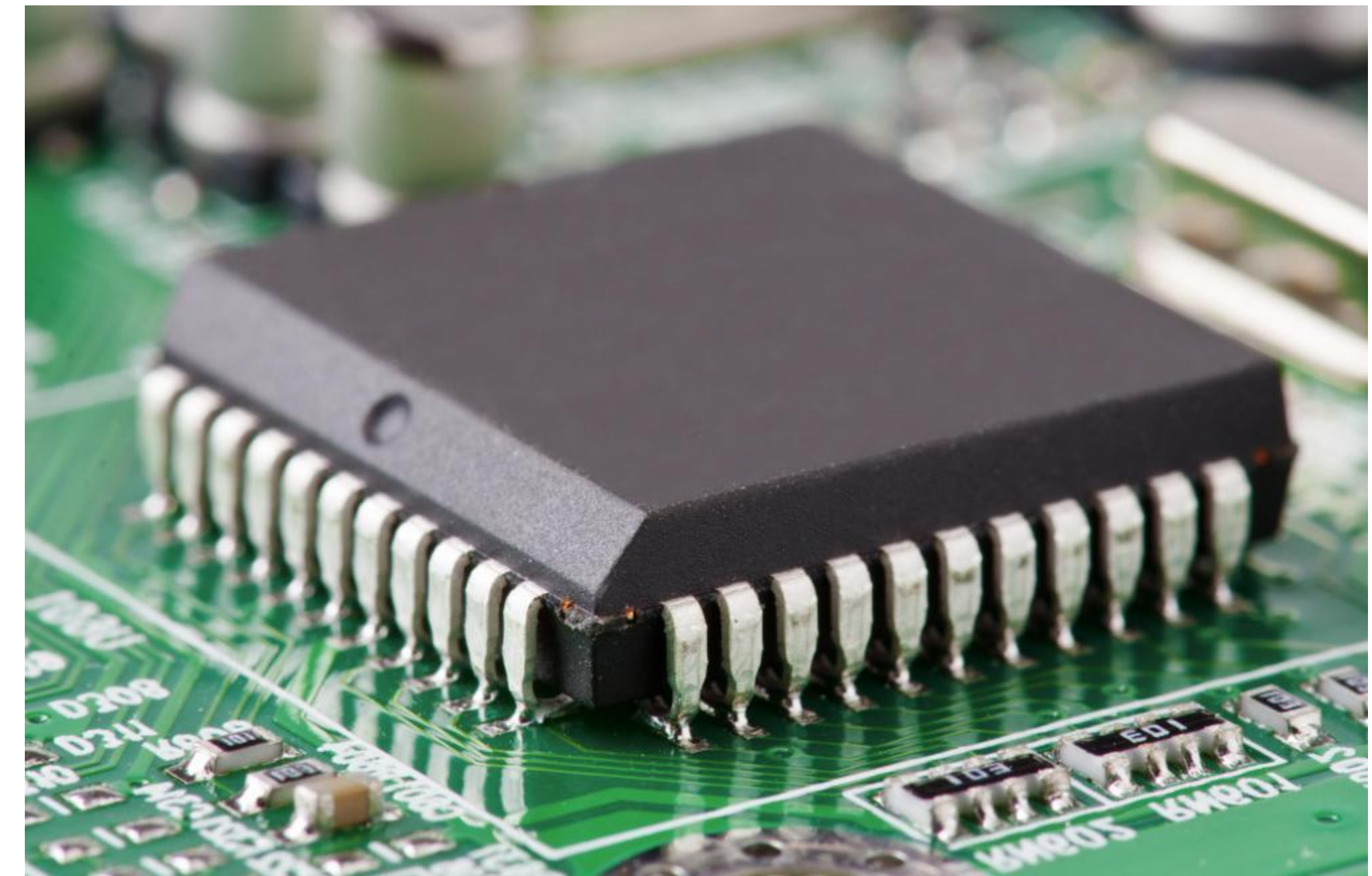
Field Programmable Gated Arrays (FPGA)

- Array of Programmable blocks with a programmable interconnect which can be used to **create programmable hardware designs**.
- Designs are typically captured in an **HDL** and can be **synthesized** for the FPGA technology and **downloaded** into an FPGA and then used along with other devices in a system.
- **Reconfiguration** is possible by changing the design and downloading to same FPGA which makes this very useful for **prototyping** as well as **making changes**.



Application Specific Integrated Circuits (ASIC)

- **Custom designed** for a specific application.
- It is normally designed by a company for a **specific use** or for a **specific customer** alone.
- **Optimized** power and performance of that specific application.
- ASICs have great utility in **aerospace** applications. Because they are **not** field programmable, they are more radiation tolerant.



Power Management Units (PMU)

- Power Management Integrated Circuit **handles the power sequence of the board**
- It **supplies** power to the different **components inside** the board,
- PMU protects the board from unsupported **over-voltage** and **under-voltage**,
- It might **handle** different **external** power supplies,
- It can provide other **misc. features** (GPIO, ADC, ...),
- It is usually **software-controllable** (often as an i2c device)

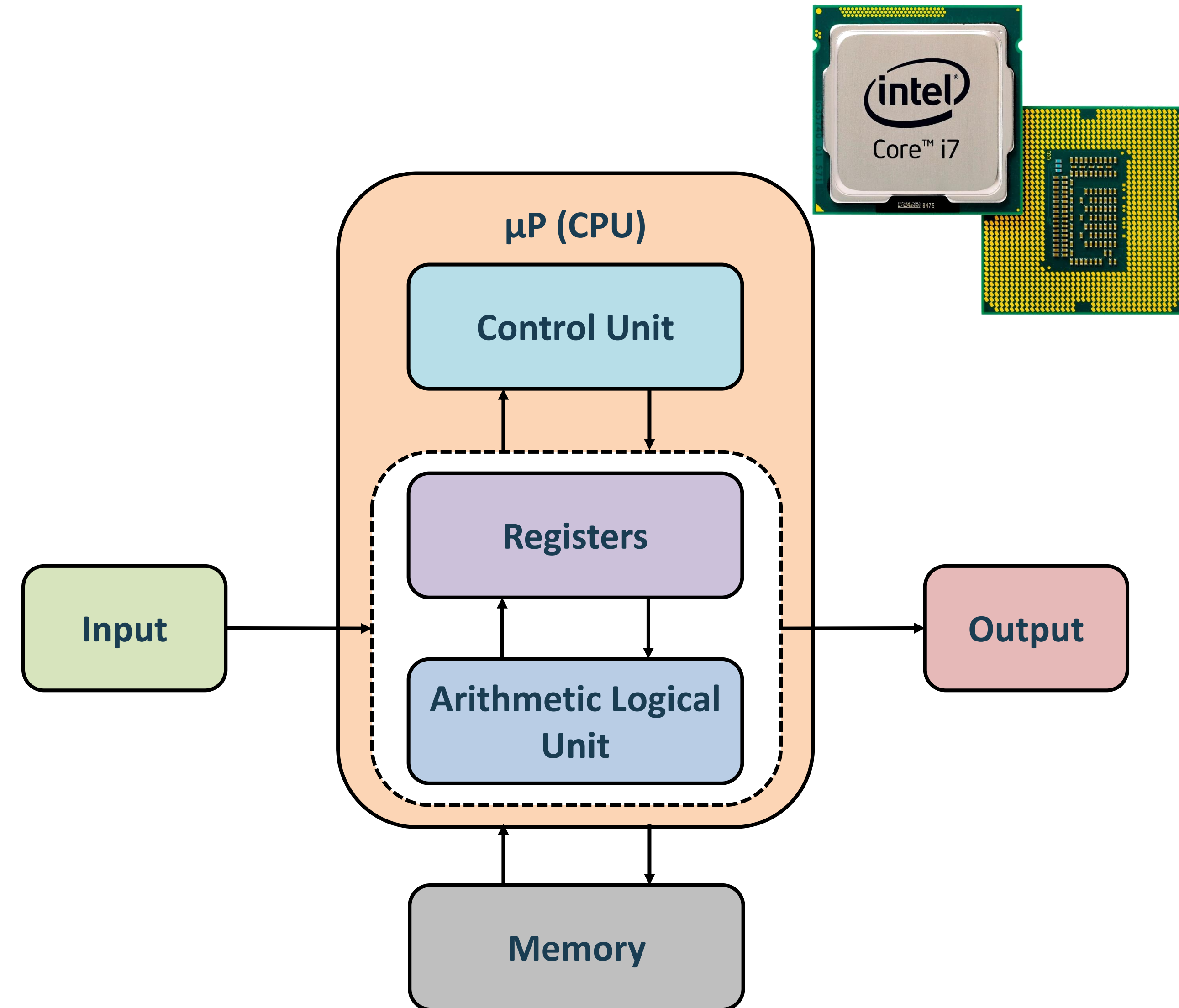


Microcontroller Vs. Microprocessor



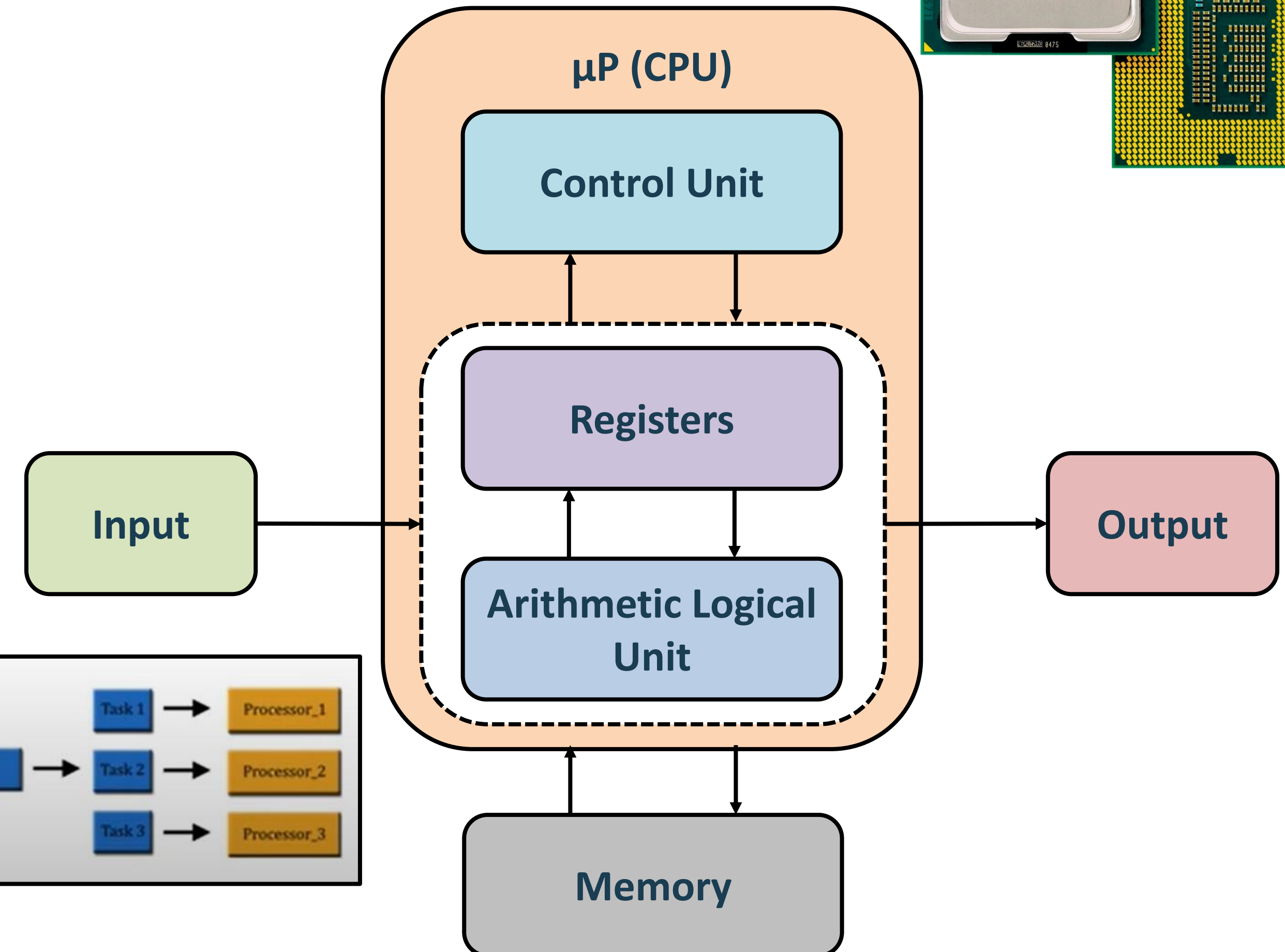
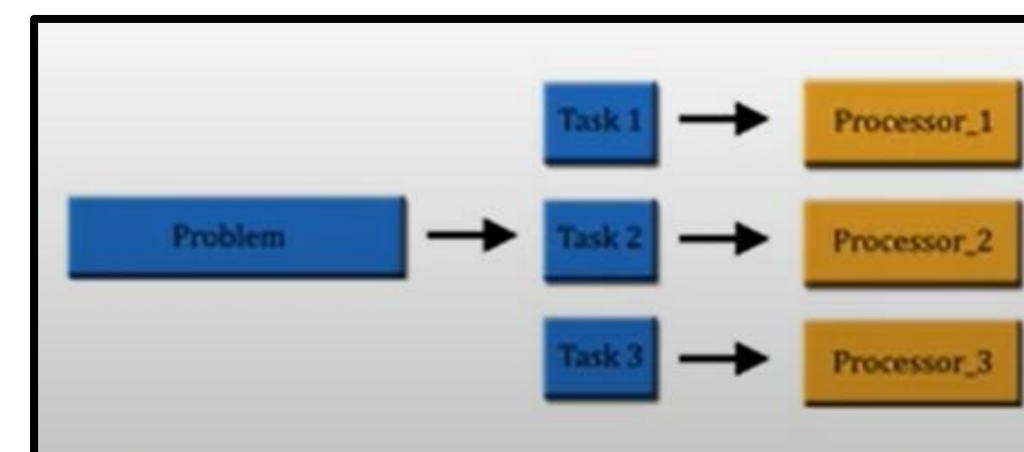
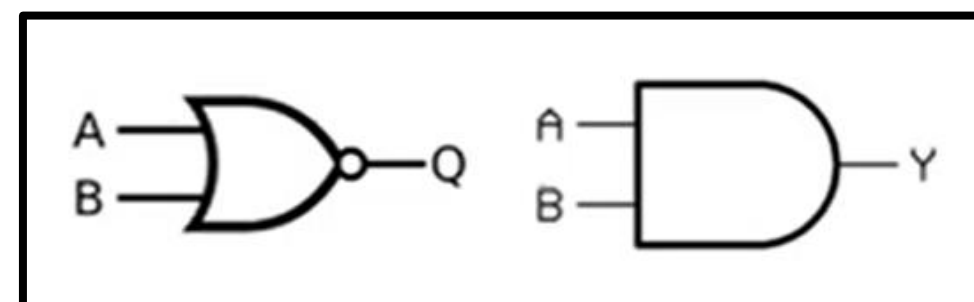
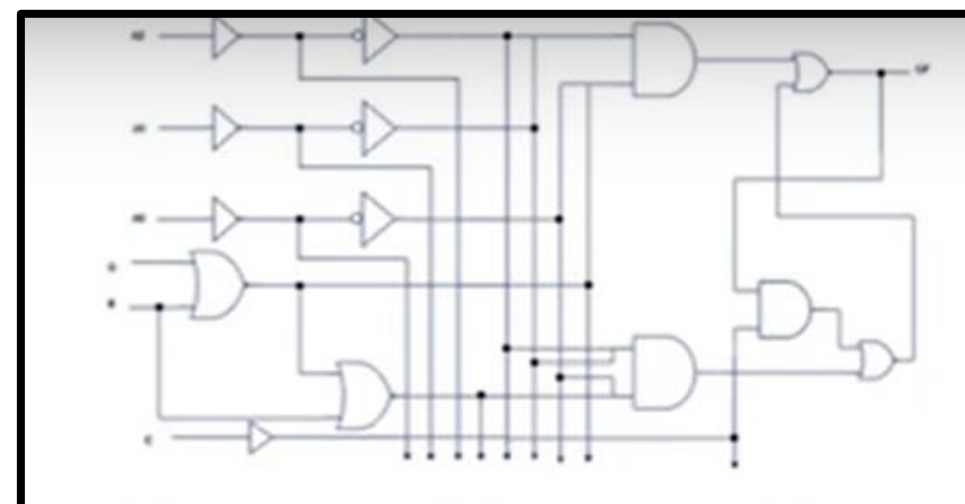
Microprocessors

- A Microprocessor is basically a **standalone CPU** with all of its elements; CU, ALU, and registers.
- The μP is connected to the other **peripherals externally**.
- μP can be used in **complex embedded systems**, yet they are commonly used in laptops, computer gaming, laser printers, modem, digital telephone, and others.



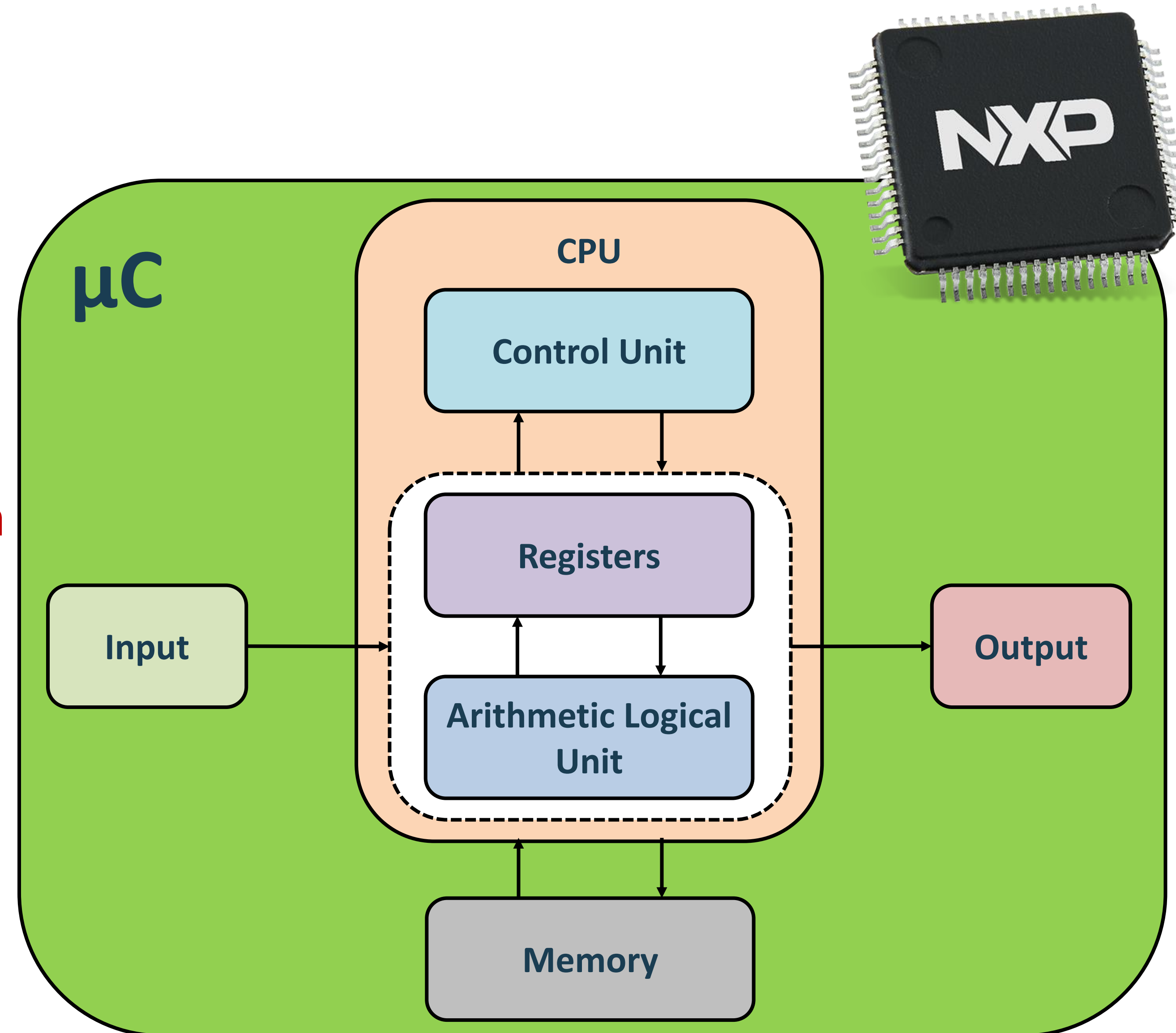
Microprocessors

- The μ P is **characterized** by: Flexible, needs more energy, expensive, OS-based, faster.
- It has three types:
 - **Complex** Instruction Set Computer (**CISC**)
 - **Reduced** Instruction Set Computer (**RISC**)
 - Explicitly Parallel Instruction Computing



Microcontrollers

- A Microcontroller is a **compact low-cost microcomputer**.
- μ C are mainly designed to perform **embedded systems activities**.
- All peripherals, ports, and memories are embedded together along with the CPU **in a single board** to form the μ C.



Microcontrollers

- A Microcontroller can be categorized in terms of the **bits**:

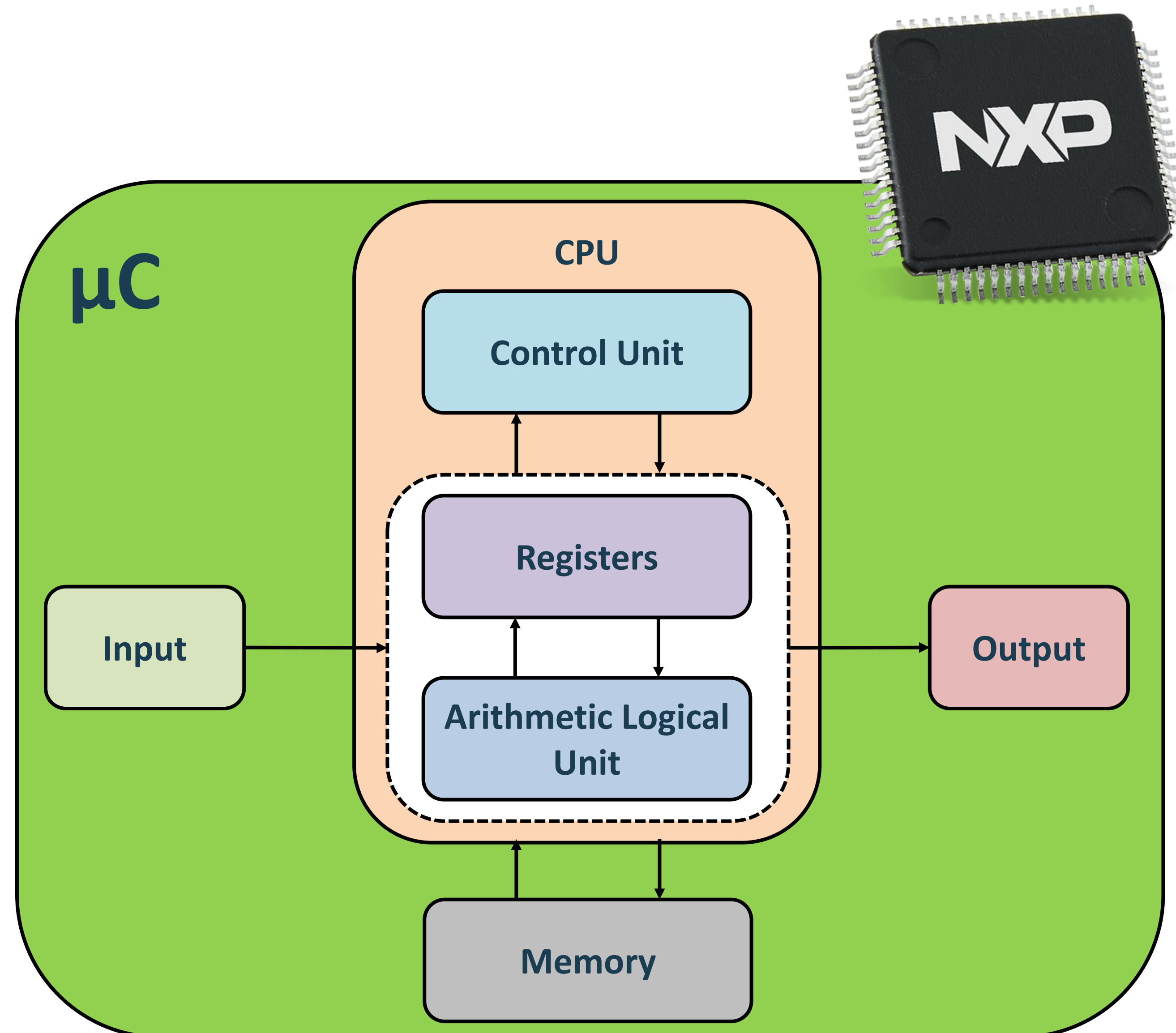
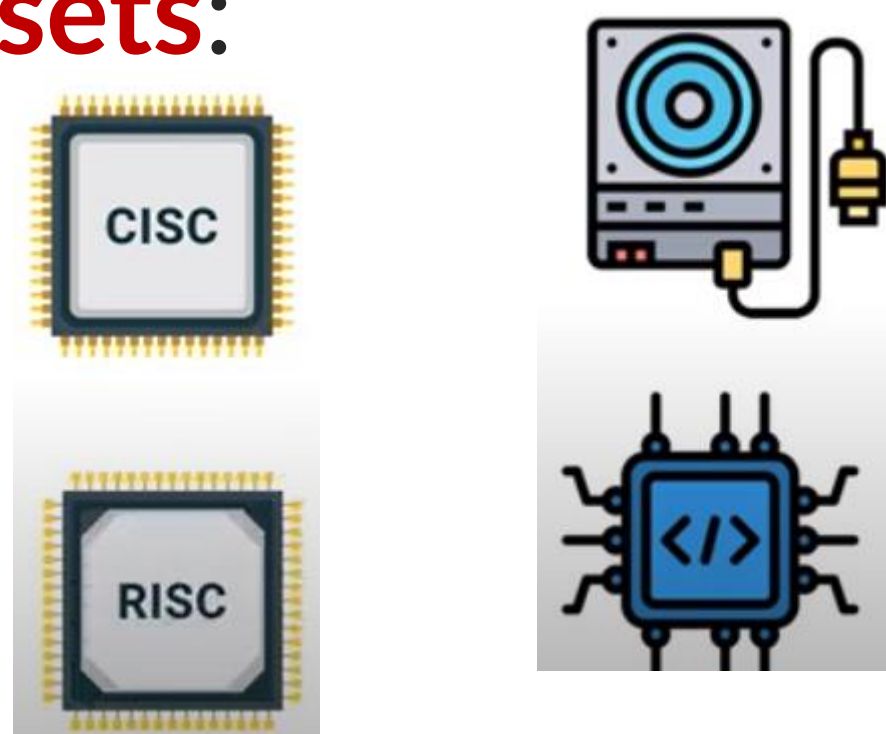
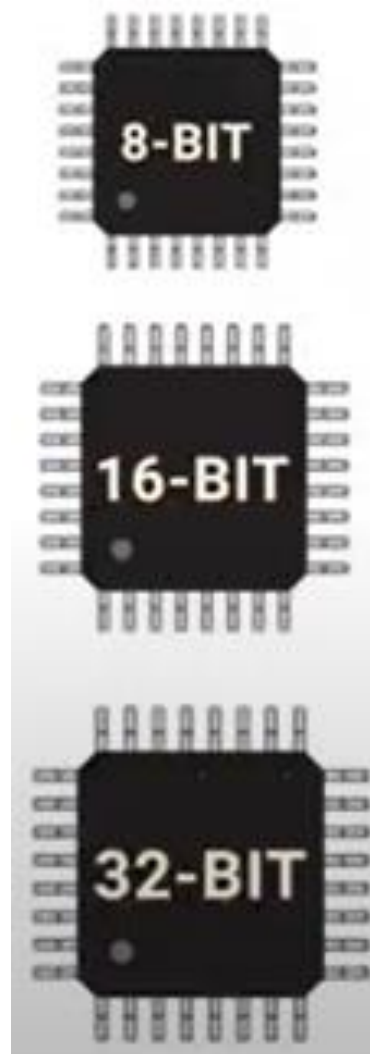
- 8-bit, 16-bit- or 32-bit

- Can be categorized in terms of the **memory arrangement**:

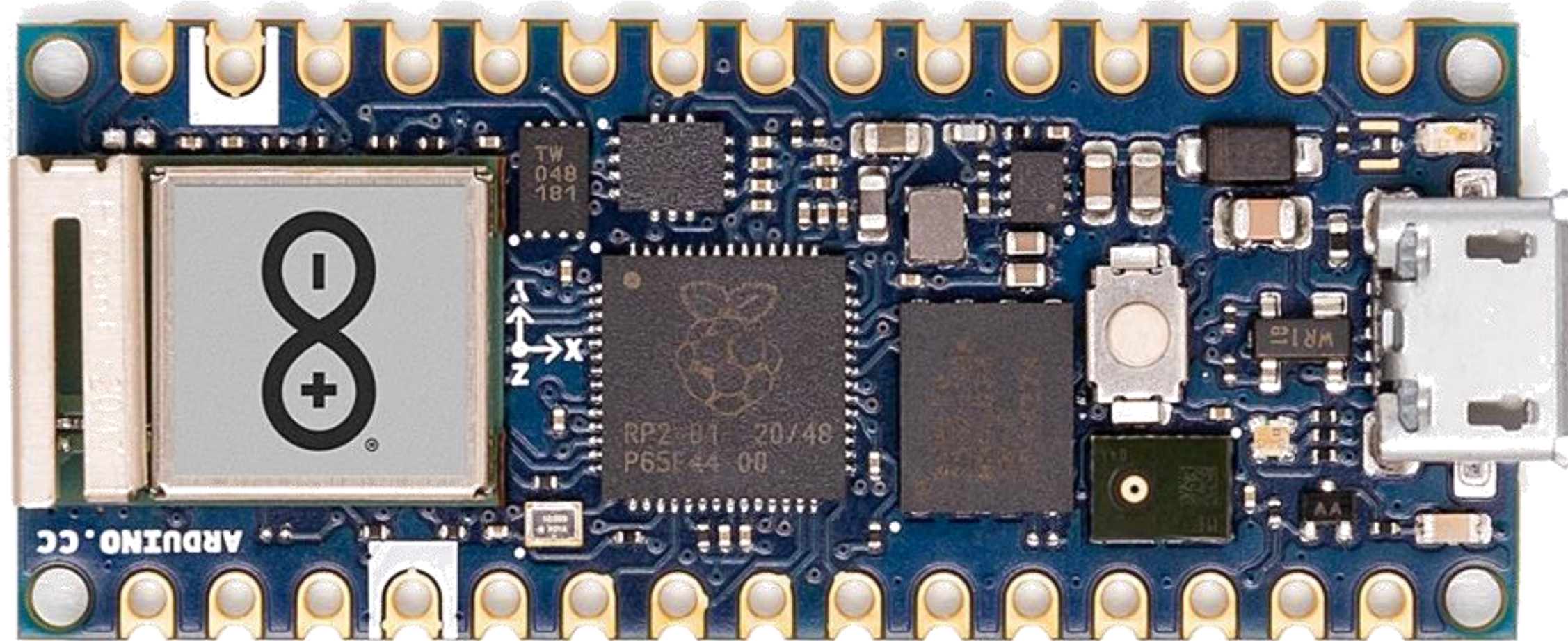
- External or embedded

- Can be categorized in terms of the **instruction sets**:

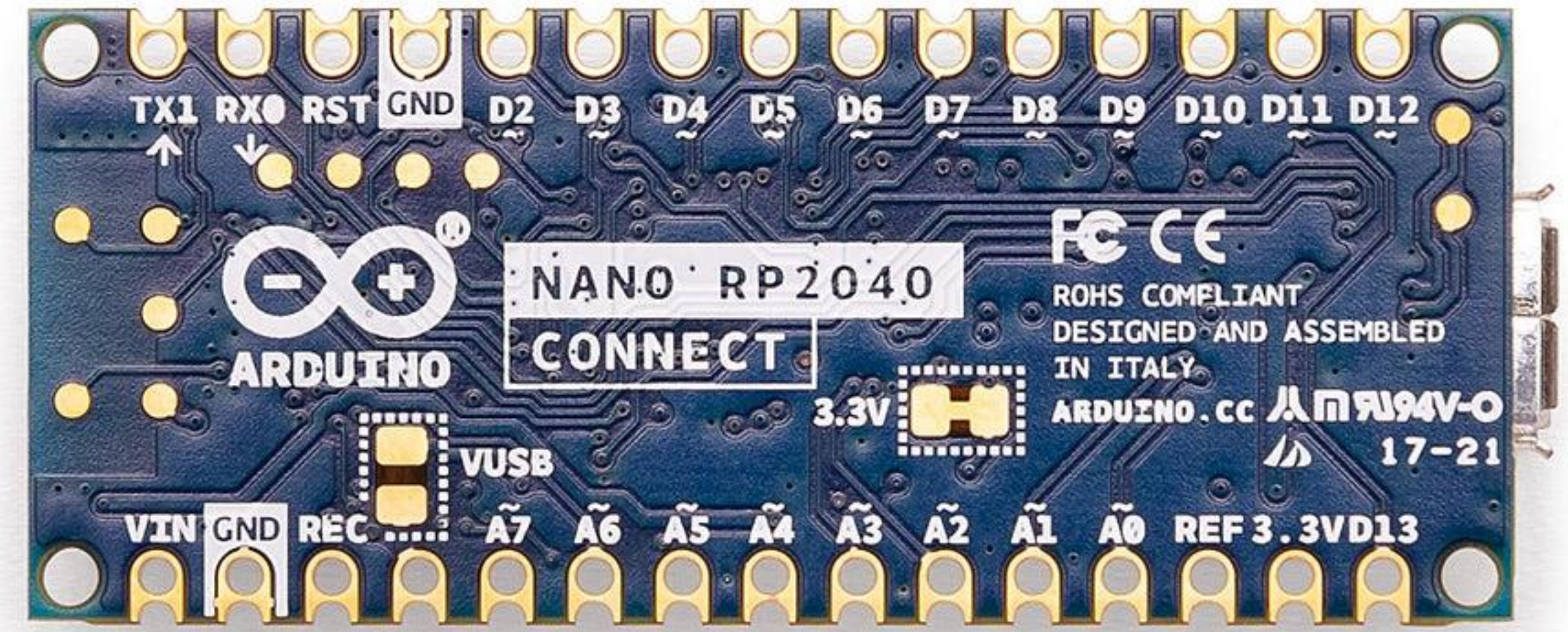
- CISC or RISC



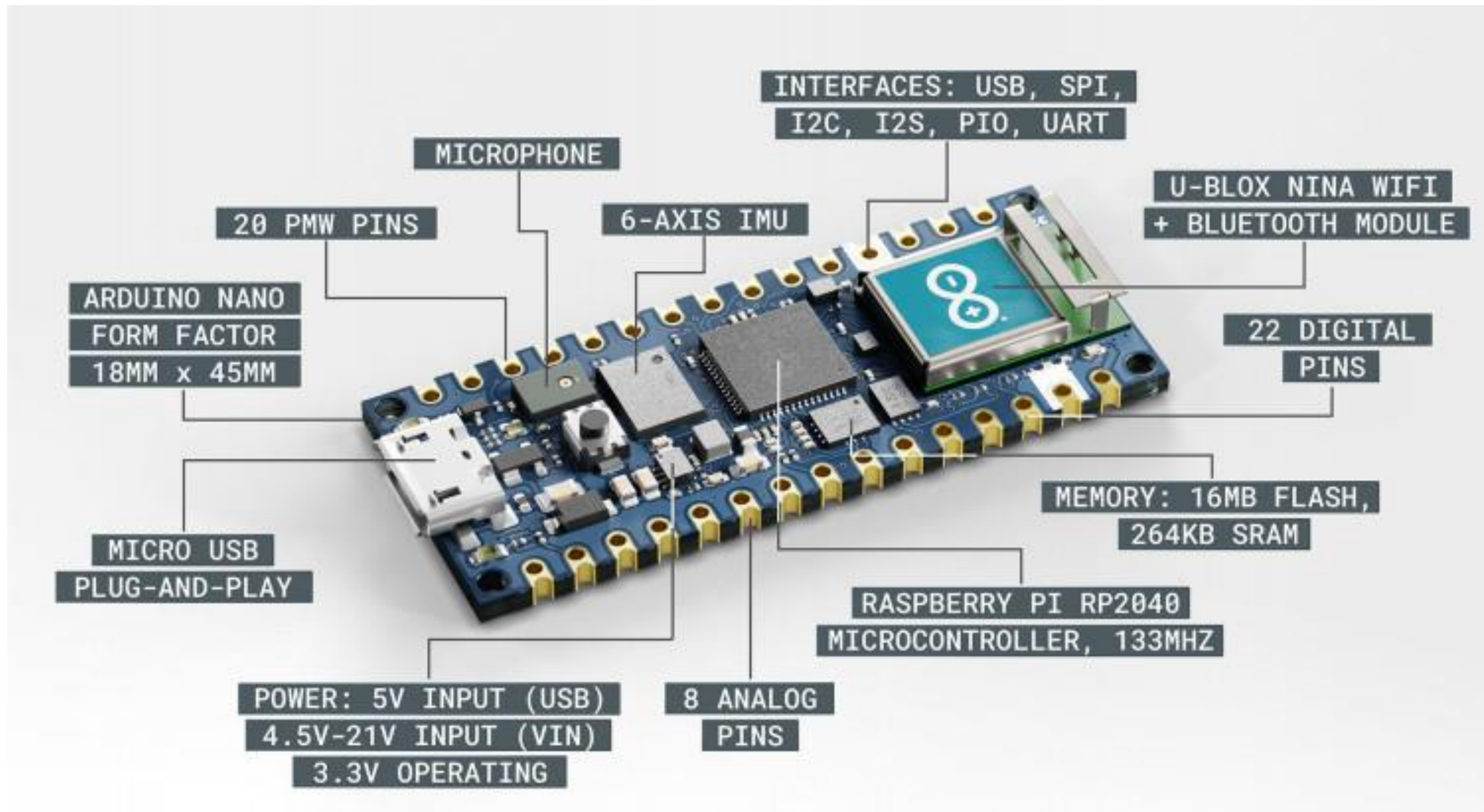
Frontal View




Back View



Frontal View



For Further Inquiries, Please
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Thank you for your attention!

See you next time 😊