Computer Architecture

Overview of computer architecture

BURKINA INSTITUTE OF TECHNOLOGY

Computer Science and Entrepreneurship
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Generalities

Computers have become an integral part of our daily lives. They power everything from smartphones to hospital systems and have shaped society to such an extent that many people simply couldn't live without the hardware and software that defines the world.

Despite this, the majority of people still have no idea how computers work and the role of hardware and software in powering the modern technologies we use today.

1. What is computer architecture?

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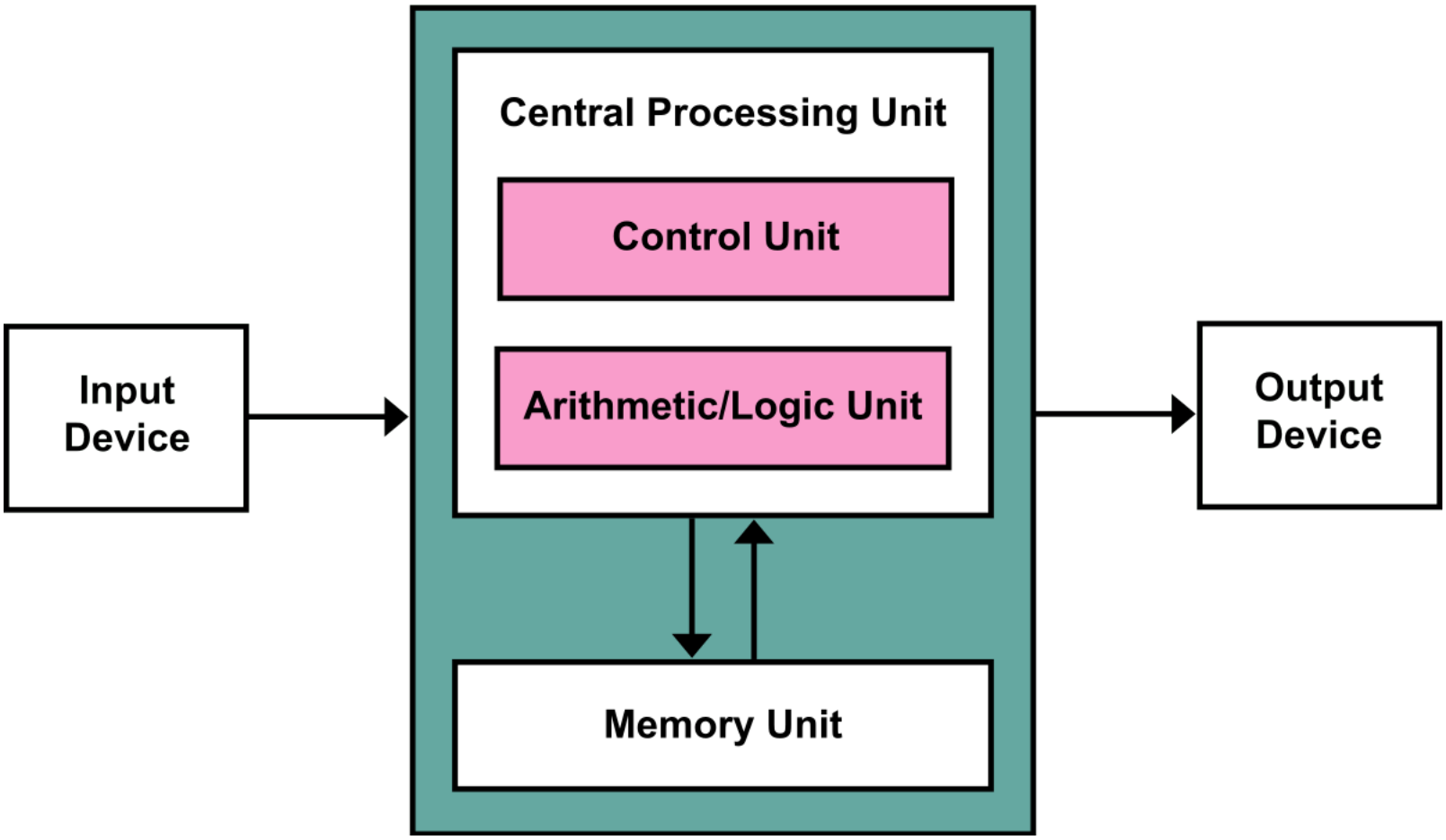
Computer architecture is the functional design and structure of a computer system. It focuses on how a computer's hardware components, like the CPU and memory, work together to execute instructions efficiently.

Architecture describes what a computer does and serves as the blueprint for designing computer systems. It is developed before computer organization during the system design process.

Understanding the meaning of computer architecture is crucial for both computer scientists. It helps programmers write software that can take full advantage of a computer's capabilities.

1. Example computer architecture



2. Components of computer architecture

2.1 Central Processing Unit (CPU)

Often referred to as the **brain** of the computer, the CPU executes instructions, performs calculations, and manages data. Its architecture dictates factors such as instruction set, clock speed, and cache hierarchy, all of which significantly impact overall system performance.

2.2 Memory Hierarchy

This includes various types of memory, such as cache memory, random access memory (RAM), and storage devices. The memory hierarchy plays a crucial role in optimizing data access times, as data moves between different levels of memory based on their proximity to the CPU and the frequency of access.

2. Components of computer architecture

2.3 Input/Output (I/O) System

The I/O system enables communication between the computer and external devices, such as keyboards, monitors, and storage devices. It involves designing efficient data transfer mechanisms to ensure smooth interaction and data exchange.

2.4 Storage Architecture

This deals with how data is stored and retrieved from storage devices like hard drives, solid-state drives (SSDs), and optical drives. Efficient storage architectures ensure data integrity, availability, and fast access times.

2. Components of computer architecture

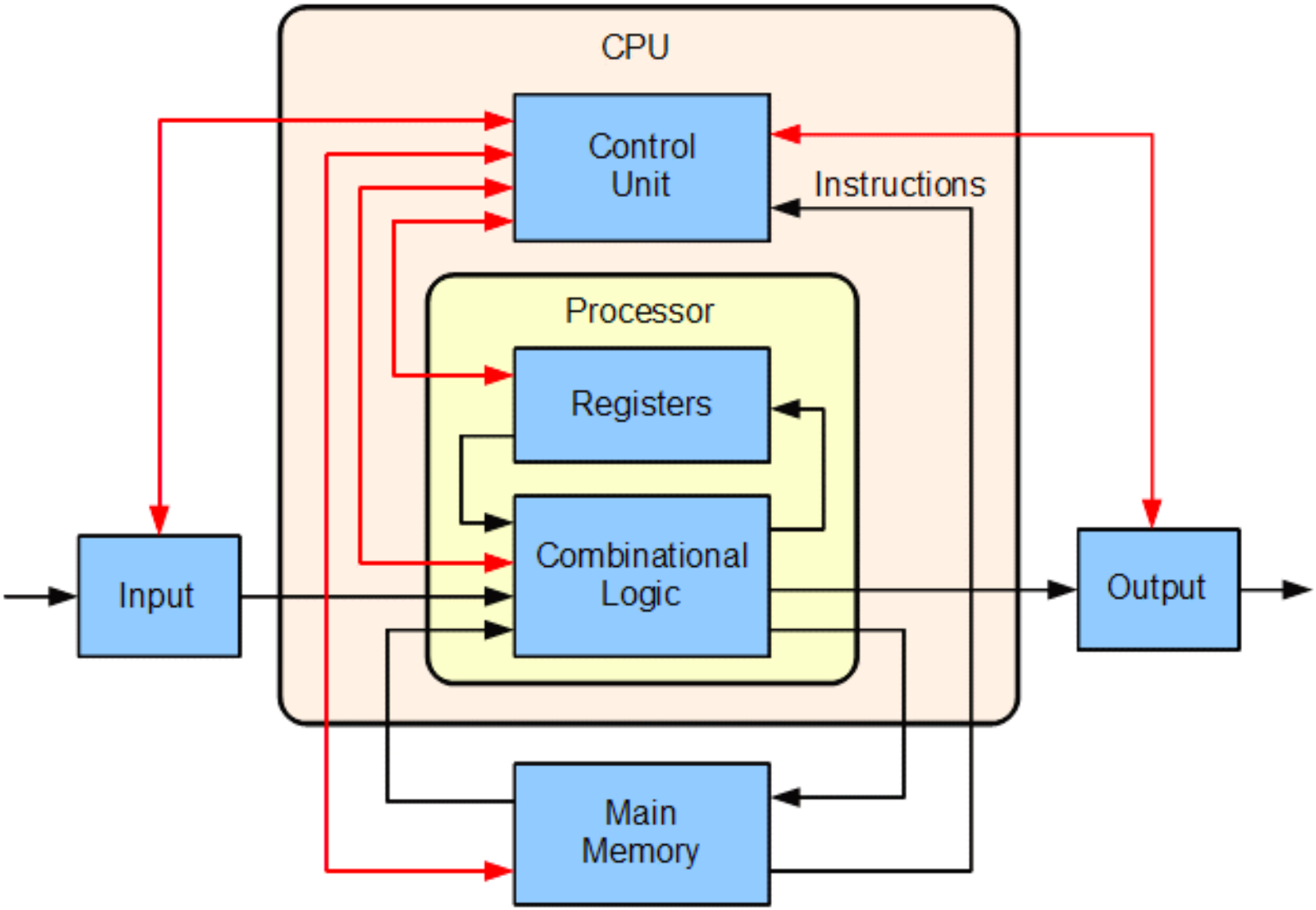
2.5 Instruction Pipelining

Modern CPUs employ pipelining, a technique that breaks down instruction execution into multiple stages. This allows the CPU to process multiple instructions simultaneously, resulting in improved throughput.

2.6 Parallel Processing

This involves dividing a task into smaller subtasks and executing them concurrently, often on multiple cores or processors. Parallel processing significantly accelerates computations, making it key to tasks like simulations, video rendering, and machine learning.

2. Components of computer architecture



2. What is computer organization?

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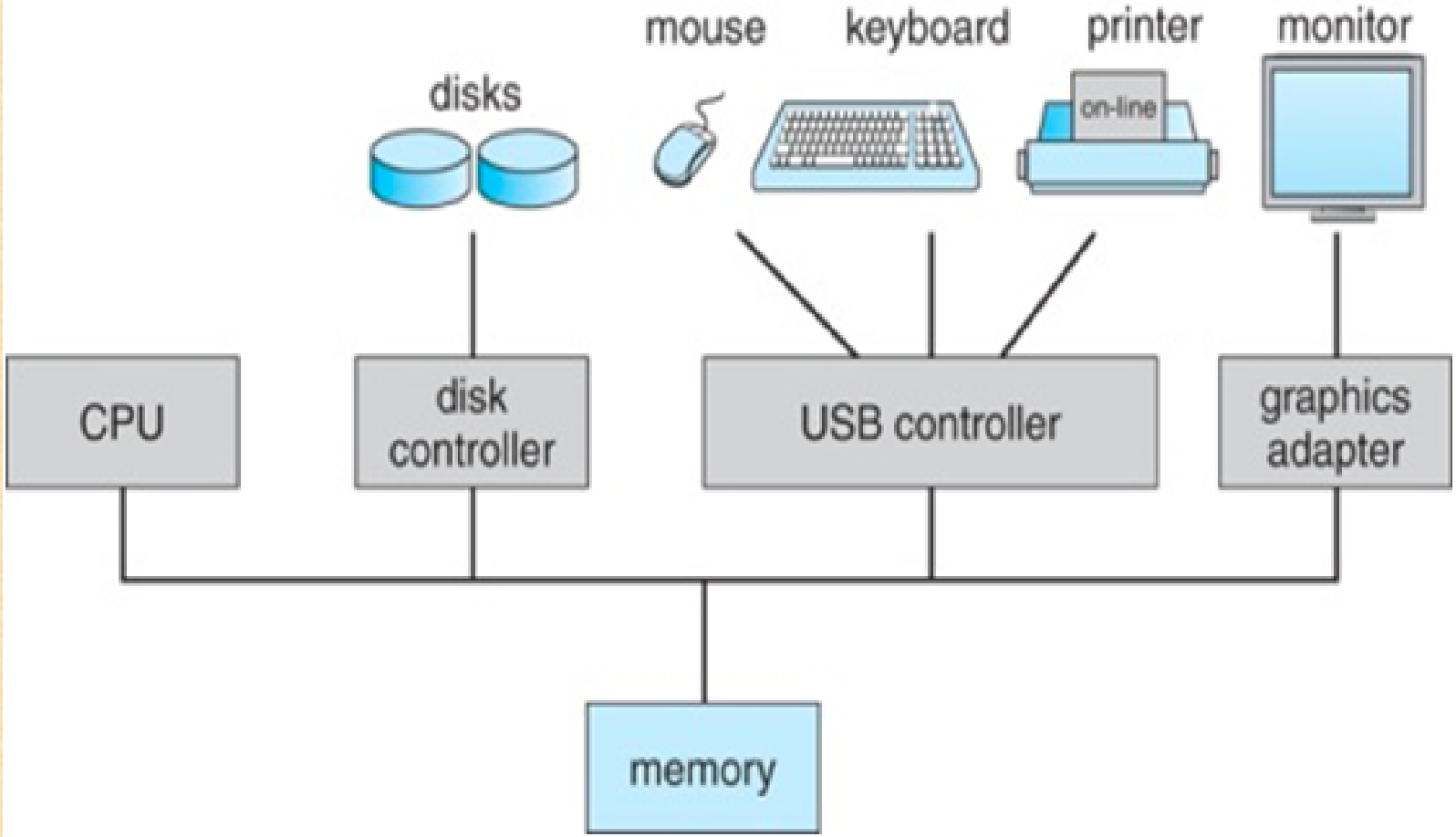
Computer organization focuses on the physical implementation of a computer system based on its architecture. It deals with how different hardware components, like the CPU, memory, and input/output devices, are connected and work together to execute tasks.

While computer architecture explains what a computer does, computer organization describes how it does it.

2. Example computer organization



3. Computer Organization and Architecture

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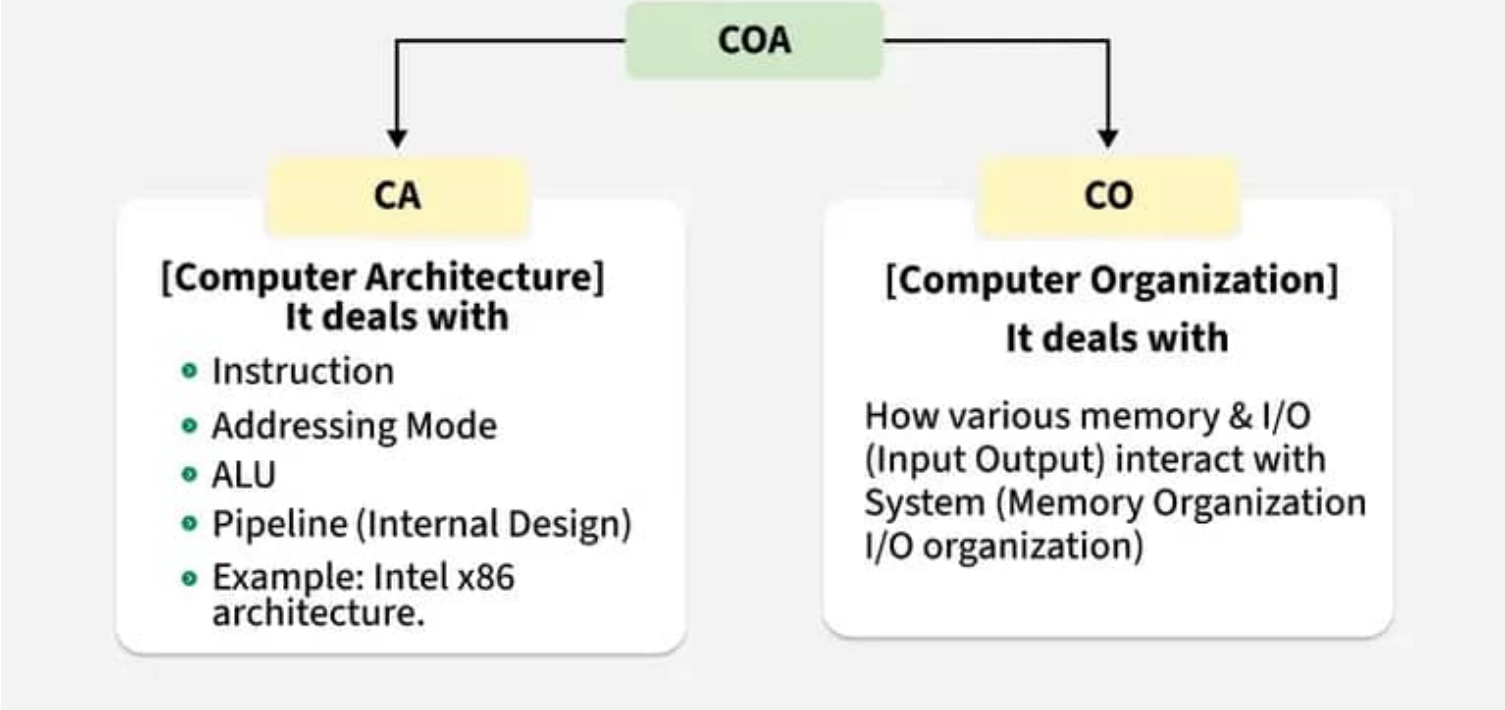
Computer architecture explains what a computer does, computer organization describes how it does it.

Computer Organization and Architecture is used to design computer systems.

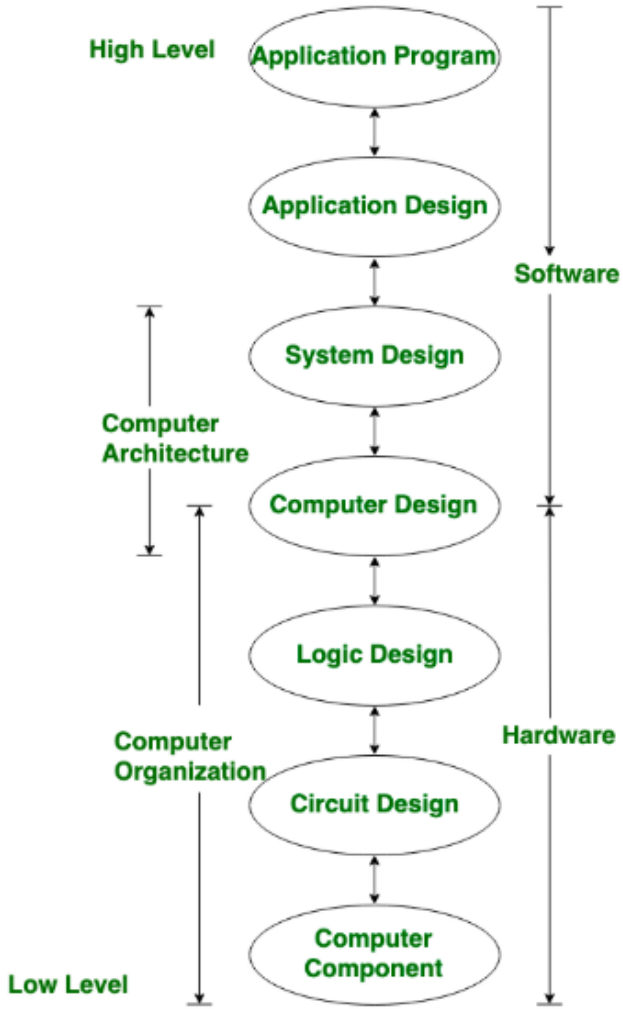
3. Example computer organization and architecture



3. Difference between computer architecture and organization

Computer Architecture	Computer Organization
Architecture describes what the computer does.	The Organization describes how it does it.
Computer Architecture deals with the functional behavior of computer systems.	Computer Organization deals with a structural relationship.
In the above figure, it's clear that it deals with high-level design issues.	In the above figure, it's also clear that it deals with low-level design issues.
Architecture indicates its hardware.	Whereas Organization indicates its performance.
As a programmer, you can view architecture as a series of instructions, addressing modes, and registers.	The implementation of the architecture is called organization.
For designing a computer, its architecture is fixed first.	For designing a computer, an organization is decided after its architecture.
Computer Architecture is also called Instruction Set Architecture (ISA).	Computer Organization is frequently called microarchitecture.

3. Difference between computer architecture and organization



4. The types of computer architecture

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Despite the rapid advancement of computing, the fundamentals of computer architecture remain the same.

There are four main types of computer architecture: **Von Neumann architecture, Harvard architecture, Modified Harvard Architecture, and the RISC & CISC Architectures.**

Computer Organization and Architecture is used to design computer systems.

4. The types of computer architecture

4.1 Von Neumann architecture

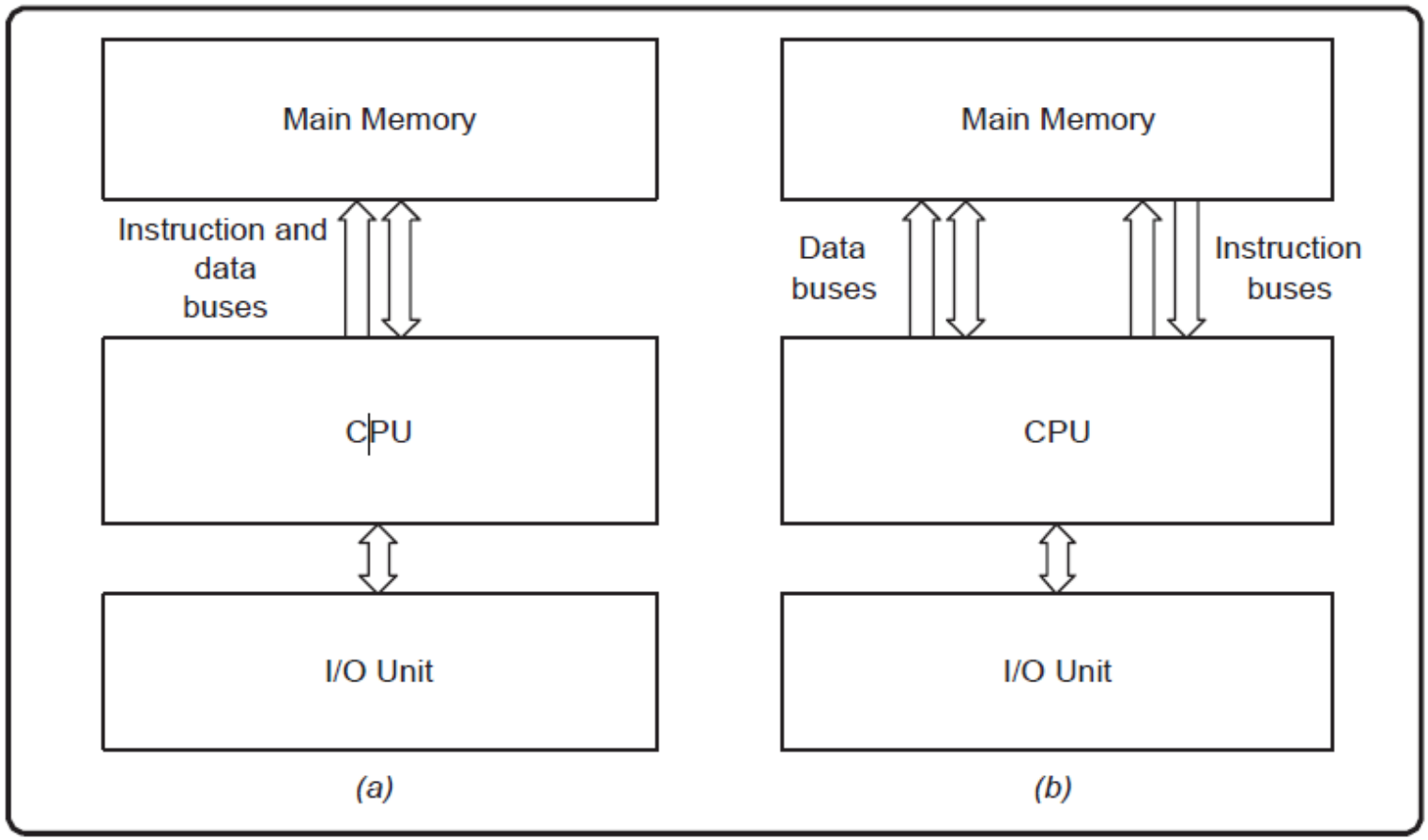
The Von Neumann architecture features a single memory space for both data and instructions, which are fetched and executed sequentially.

This means that programs and data are stored in the same memory, allowing for flexible and easy modification of programs. same.

But instructions are also fetched and executed one at a time, which creates a bottleneck where the CPU can't fetch instructions and data simultaneously. This is known as the Von Neumann bottleneck. To address this, modern CPUs employ techniques like caching and pipelining to improve efficiency.

4. The types of computer architecture

4.1 Von Neumann architecture



4. The types of computer architecture

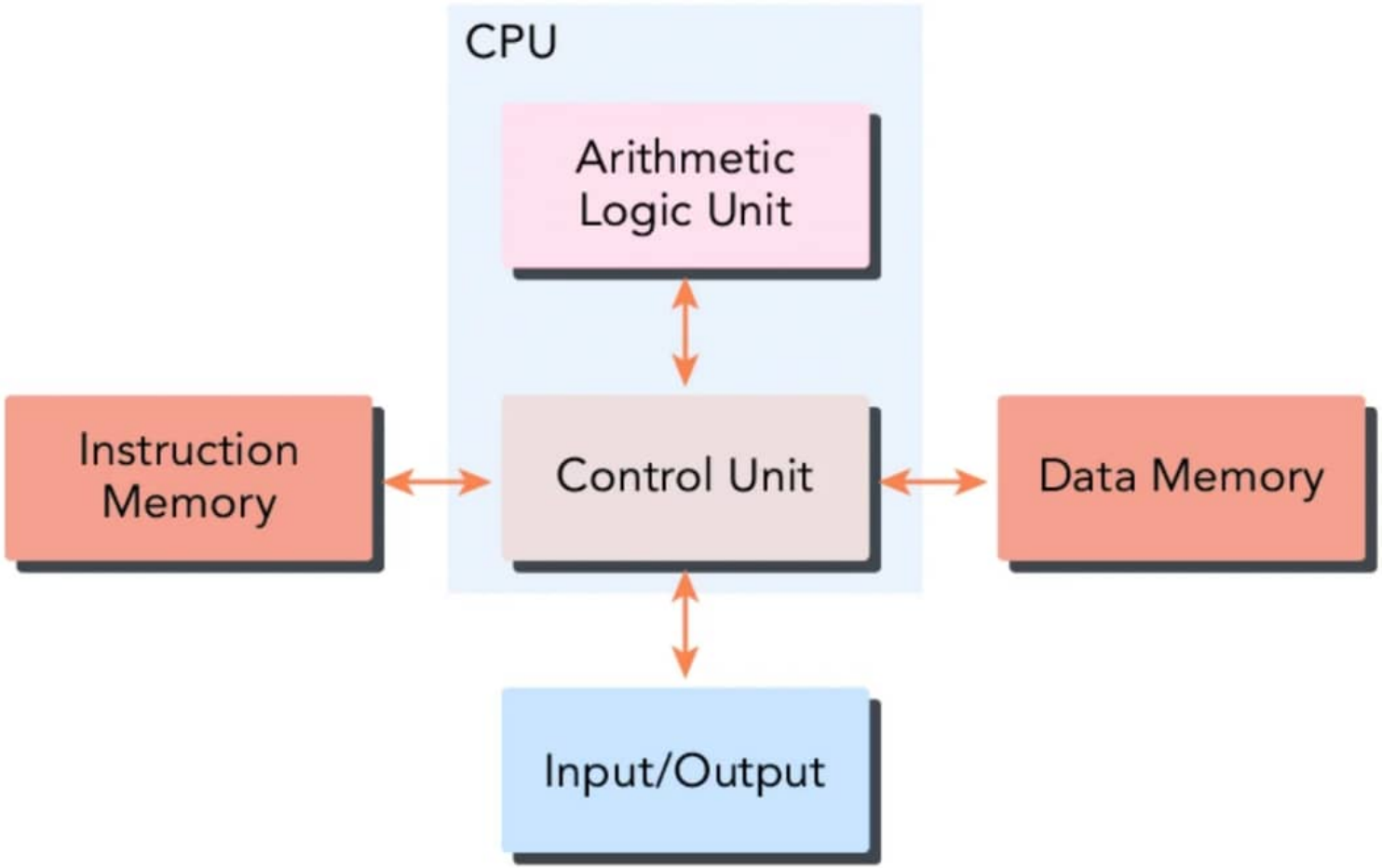
4.2 Harvard architecture

Harvard architecture is a type of computer architecture that has separate storage units and dedicated pathways for instructions and data. This allows for simultaneous access to instructions and data, potentially improving performance.

By having separate pathways, the CPU can fetch instructions and access data at the same time, without waiting for each other, leading to faster program execution, especially for tasks that involve a lot of data movement.

4. The types of computer architecture

4.2 Harvard architecture



4. The types of computer architecture

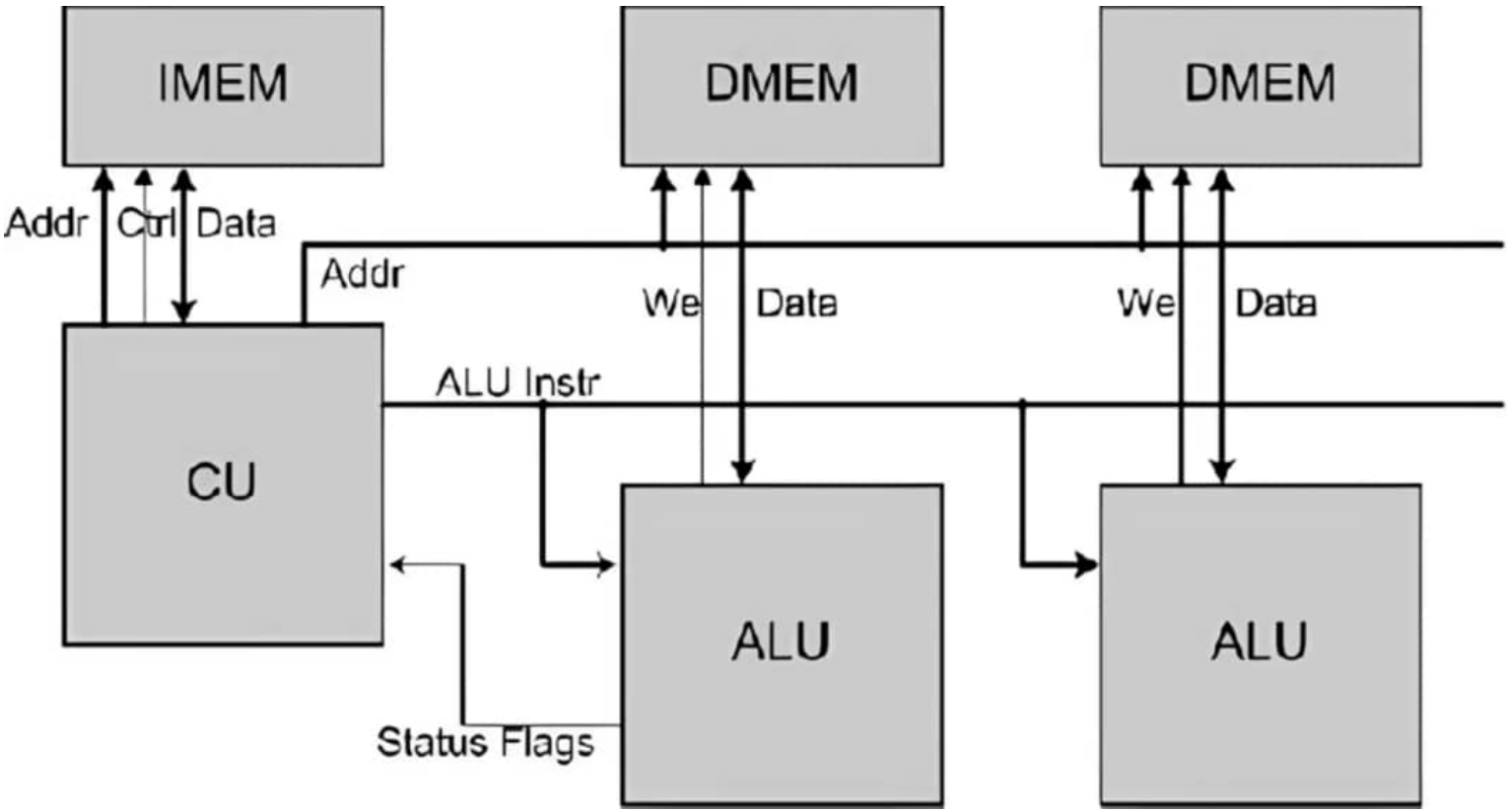
4.3 Modified Harvard architecture

A Modified Harvard Architecture is a hybrid type of computer architecture that combines features of both the classic Harvard architecture and the more widely used von Neumann architecture.

Like a true Harvard architecture, a modified Harvard architecture utilizes separate caches for instructions and data. These caches are much faster than main memory, so frequently accessed instructions and data can be retrieved quickly.

4. The types of computer architecture

4.3 Modified Harvard architecture



4. The types of computer architecture

4.4 RISC & CISC Architectures

RISC (Reduced Instruction Set Computing) and CISC (Complex Instruction Set Computing) are two different architectures for computer processors that determine how they handle instructions.

RISC processors are designed with a set of basic, well-defined instructions that are typically fixed-length and easy for the processor to decode and execute quickly. The emphasis in RISC is on designing the hardware to execute simple instructions efficiently, leading to faster clock speeds and potentially lower power consumption. Examples of RISC processors include ARM processors commonly found in smartphones and tablets, and MIPS processors used in some embedded systems.

4. The types of computer architecture

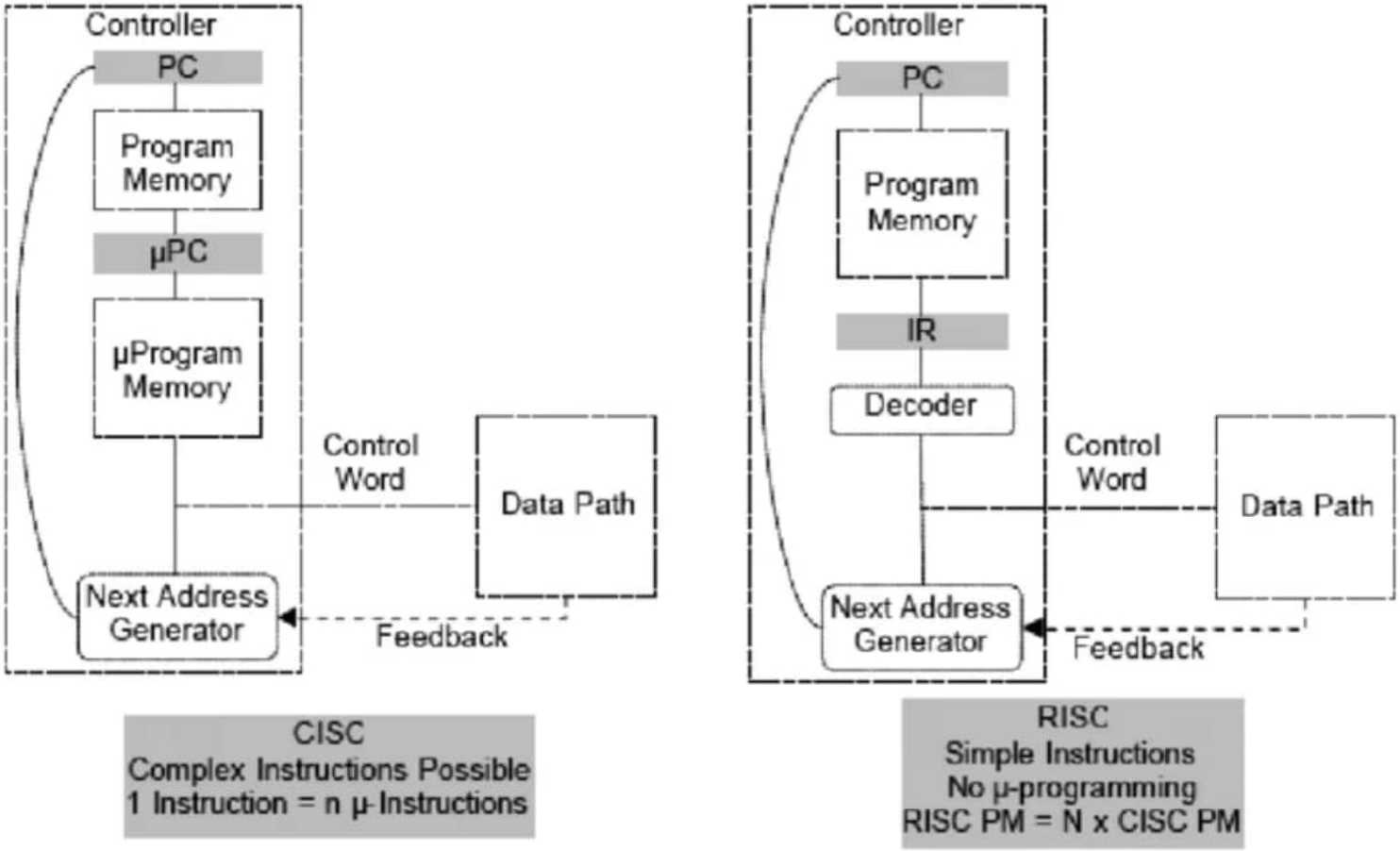
4.4 RISC & CISC Architectures

CISC processors, however, have a wider range of instructions, including some very complex ones that can perform multiple operations in a single instruction. This can be more concise for programmers but can take the processor more time to decode and execute.

The goal of CISC is to provide a comprehensive set of instructions to handle a wide range of tasks, potentially reducing the number of instructions a programmer needs to write. Examples of CISC processors include Intel's x86 processors, which are used in most personal computers, and Motorola 68000 family of processors which are used in older Apple computers.

4. The types of computer architecture

4.4 RISC & CISC Architectures



5. The future of computer architecture

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Graphics Processing Units (GPUs), for instance, are designed to handle complex calculations required for rendering graphics and simulations. They are often found in systems built for graphic-heavy applications like video editing or gaming.

With recent advancements in AI, there's also the possibility of computer architecture evolving into neuromorphic computing, a type of computer architecture Inspired by the human brain that uses artificial neurons and synapses to process information. Neuromorphic Computing holds promise for applications in artificial intelligence and machine learning that deal with complex patterns and relationships.

6. Questions

5. Questions

1. How does computer architecture affect system performance?

Computer architecture affects system performance by determining the set of instructions, data paths, and control logic that directly impact the efficiency, processing speed, and overall capabilities of the system.

2. Is computer organization more focused on hardware or software?

Computer organization is more focused on hardware. It addresses how components like processors, memory, and input/output devices are organized and how they interact to execute instructions.

3. Can a computer's organization be changed without affecting its architecture?

Yes, changes can be made to the organization (such as upgrading components or optimizing interconnections) without altering the underlying architecture, as long as the abstract design and instruction set architecture (ISA) remain the same.

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