

Computer Architecture
Lecture Week 1 (Part II)

Computer Layout: A Brief Overview

Artem Burmyakov

September 05, 2025



INNOPOLIS
UNIVERSITY

Computer Hardware



Computer Hardware

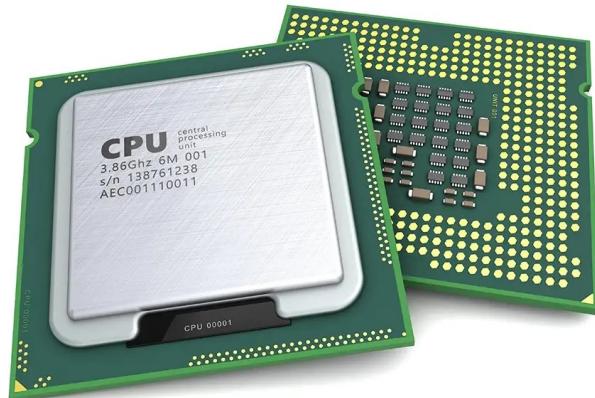
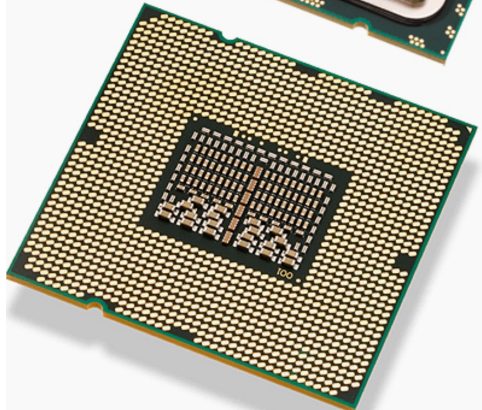
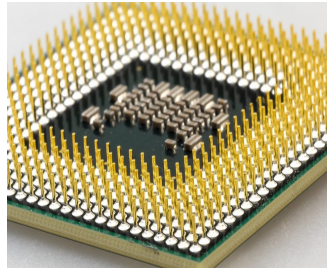
CPU

Central
Processing
Unit

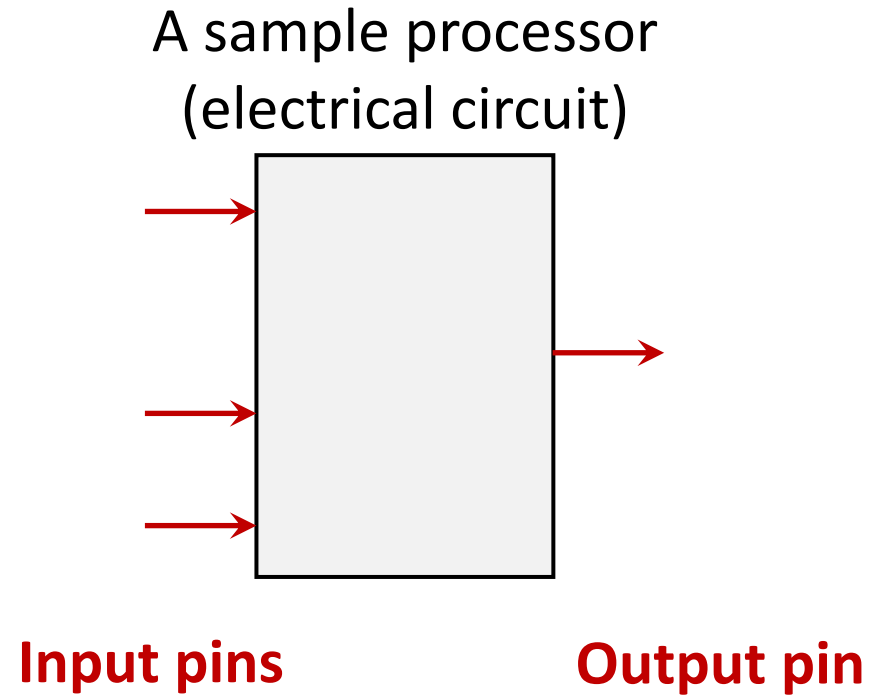
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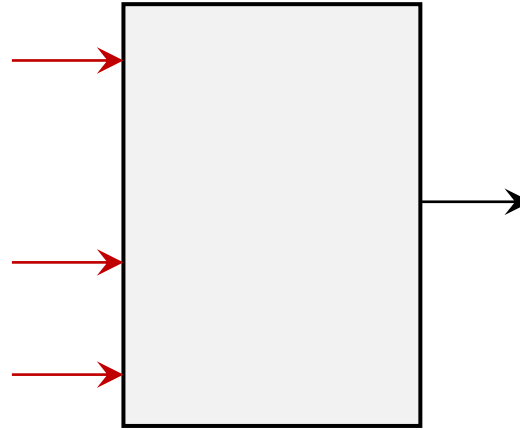


Computer Hardware: Processor Principle



Computer Hardware: Processor Principle

A sample processor
(electrical circuit)

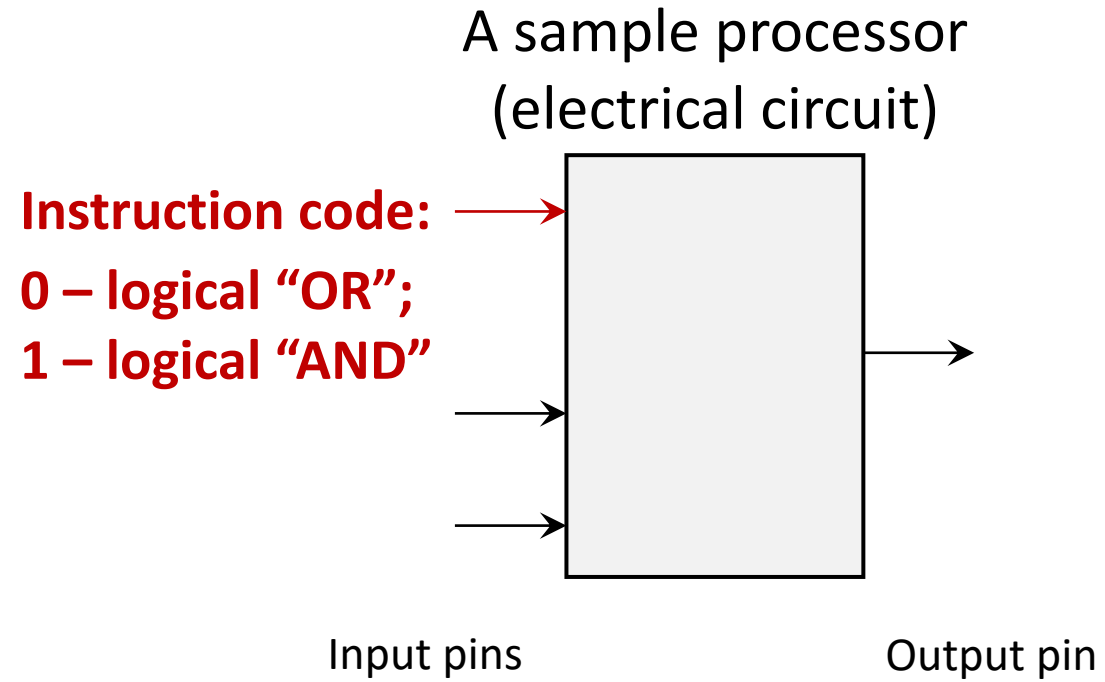


Input pins:

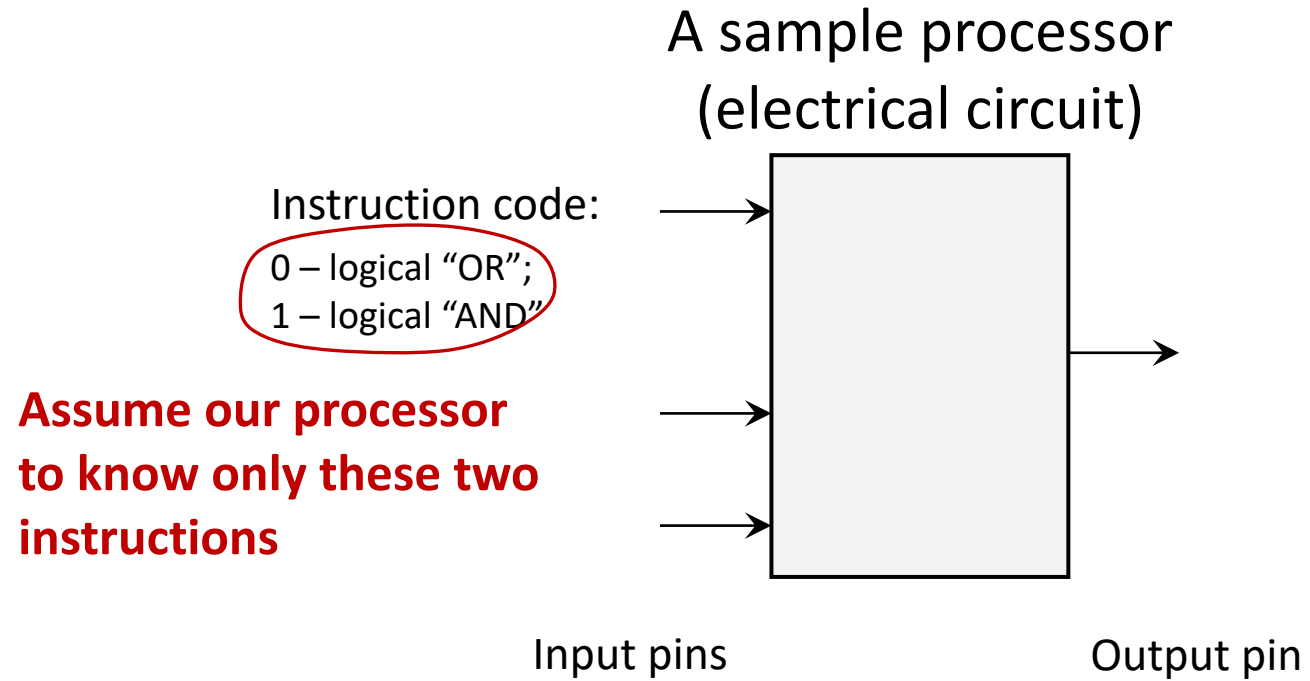
- **Instruction code**
- **Input arguments**

Output pin

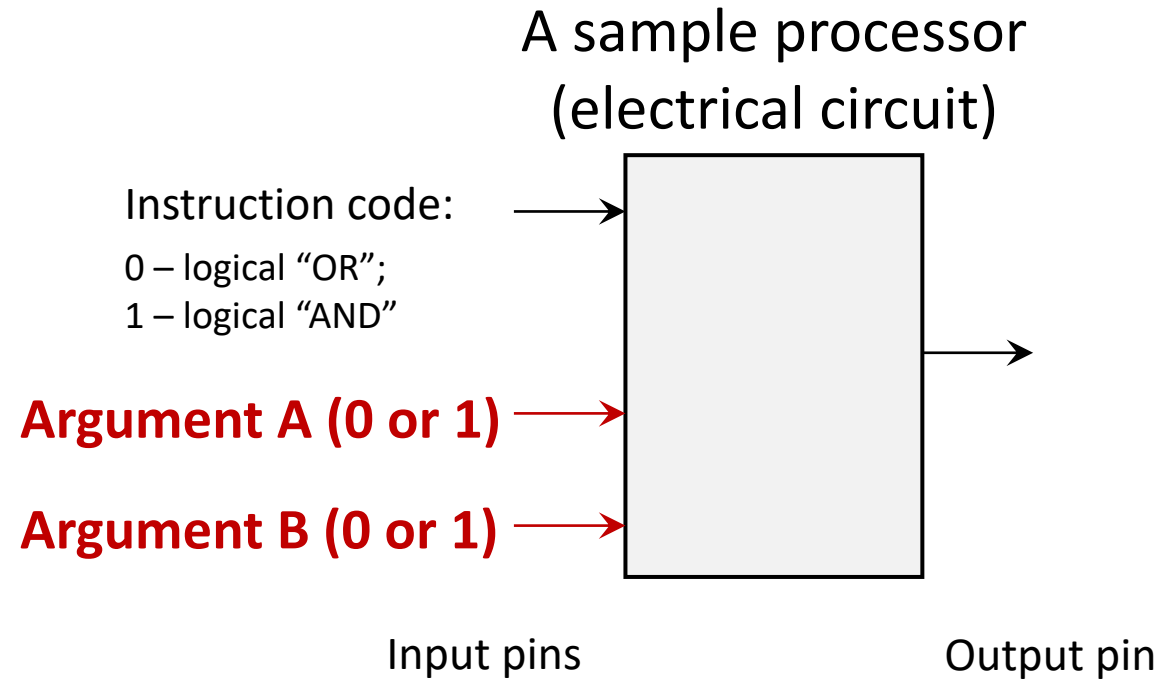
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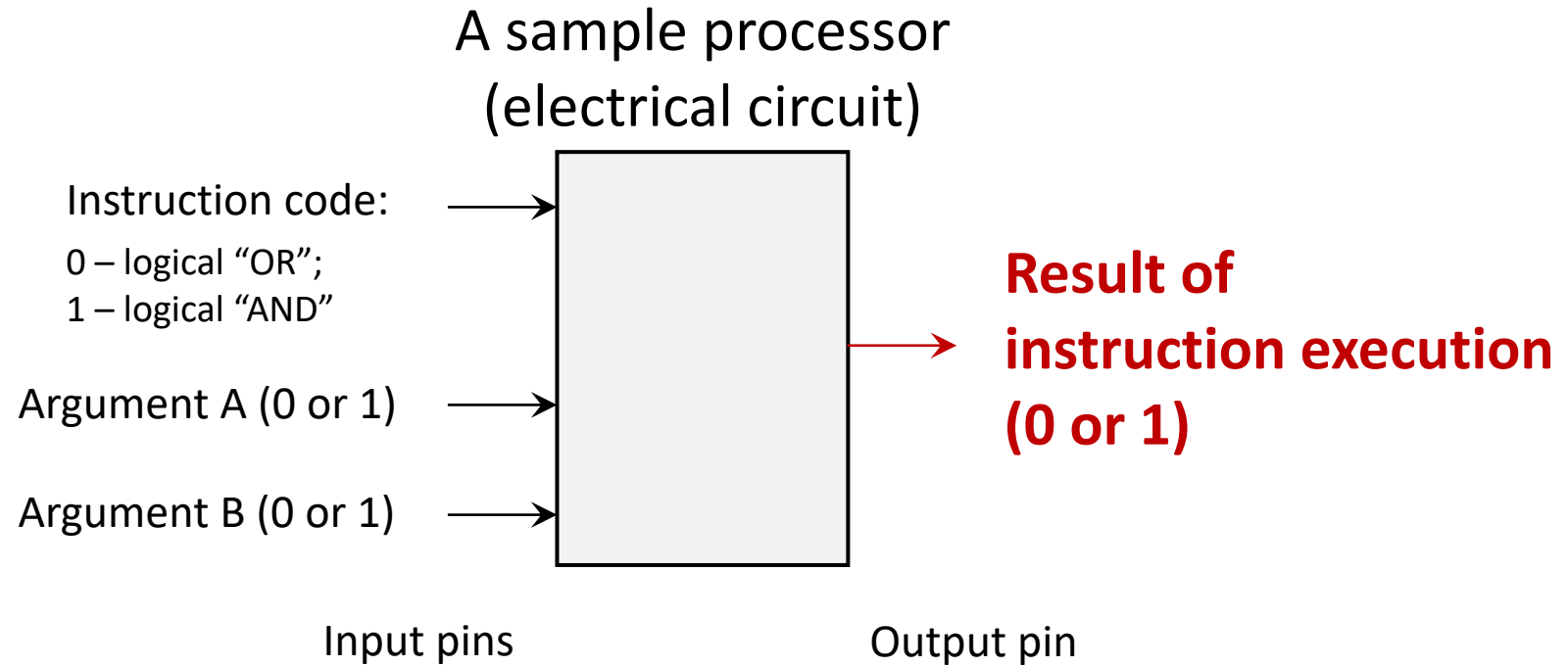
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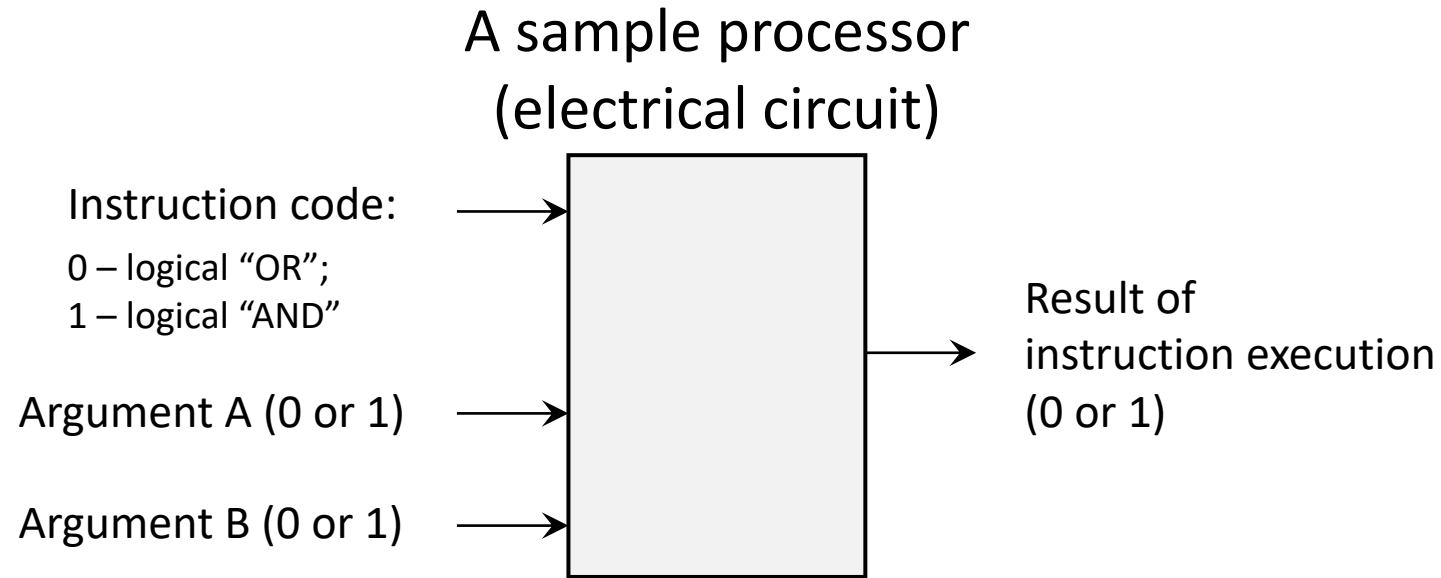
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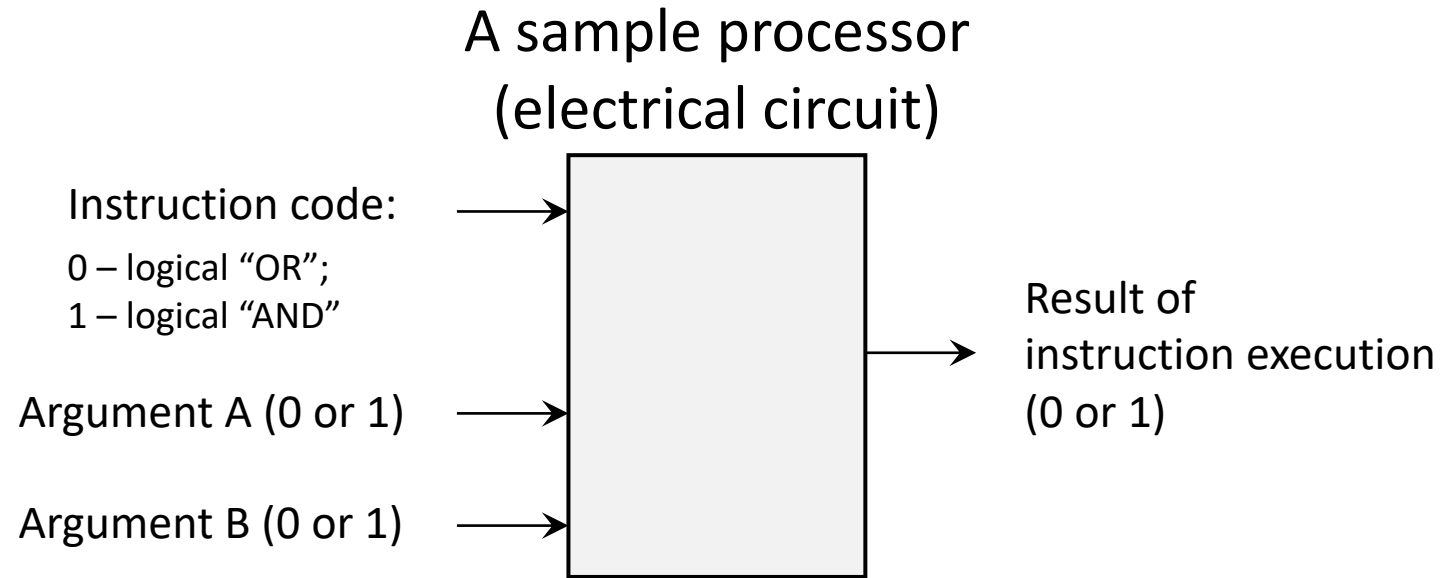
Computer Hardware: Processor Principle



Machine instruction – string of *0*s and *1*s:

<Instruction code> <Value A> <Value B>

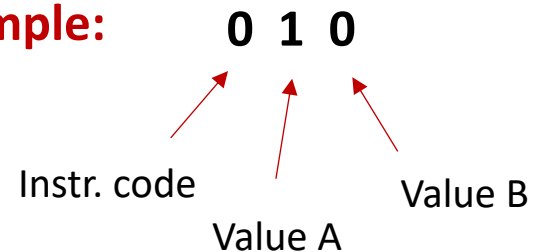
Computer Hardware: Processor Principle



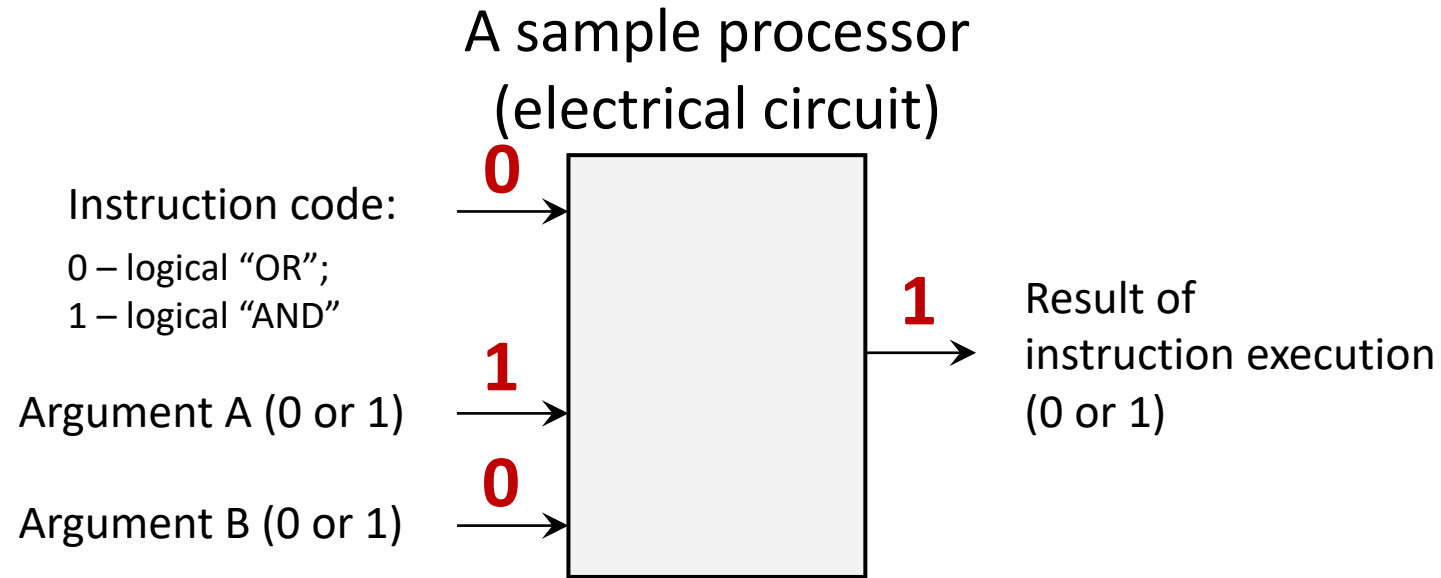
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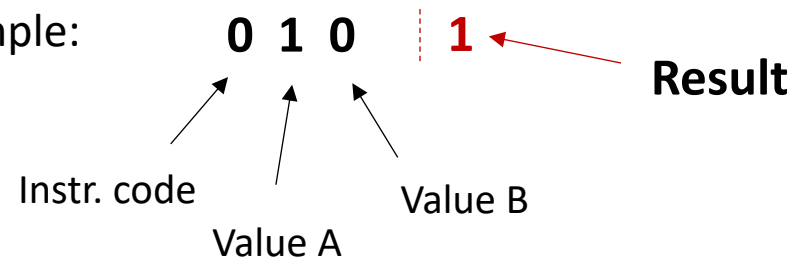
Computer Hardware: Processor Principle



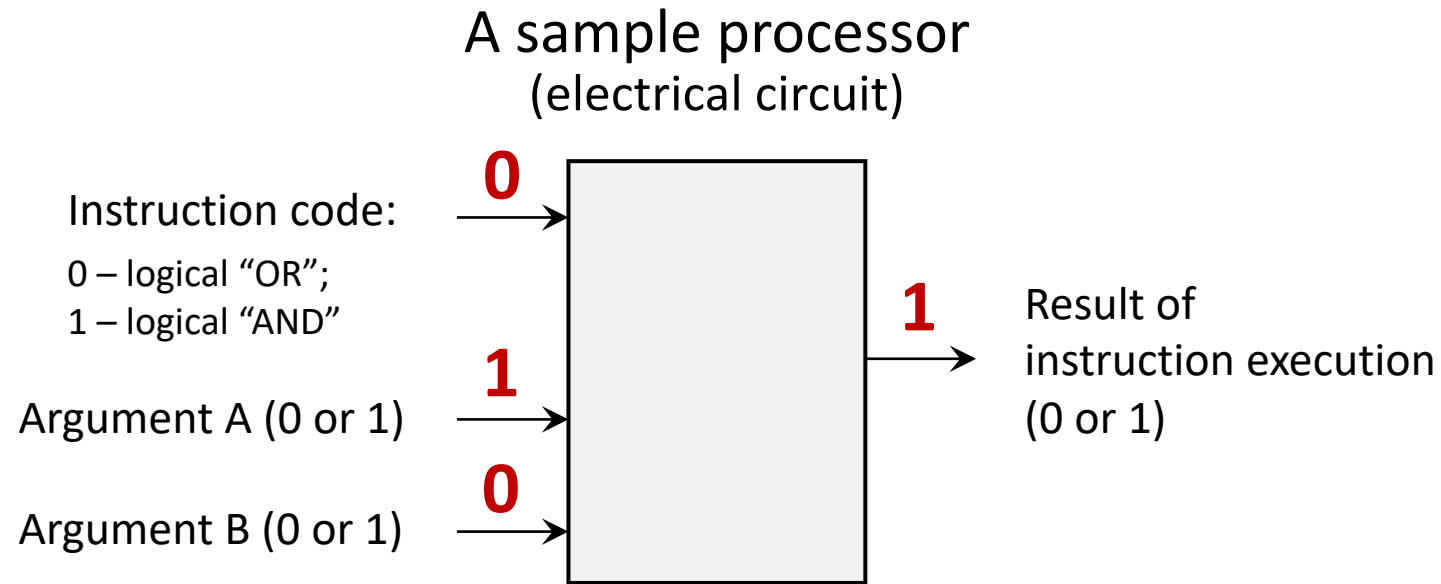
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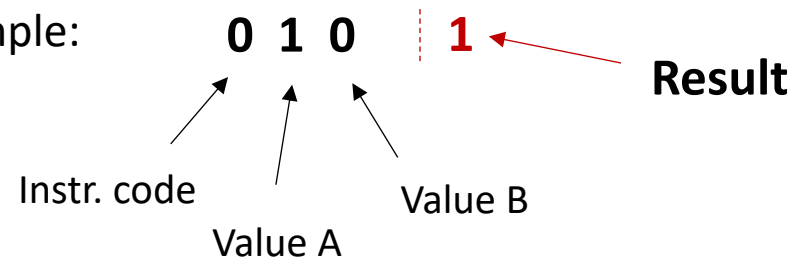
Computer Hardware: Processor Principle



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Example:



Computer Hardware



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Central
Processing
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Widely-known CPU architectures?



Computer Hardware



CPU:

Central
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Widely-known CPU architectures:

- **Intel x86**



Computer Hardware



CPU:

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Processing
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Widely-known CPU architectures:

- Intel x86
- **RISC-V (Reduced Instruction Set Computer)**



Computer Hardware



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Widely-known CPU architectures:

- Intel x86
- RISC-V (Reduced Instruction Set Computer)
- **AMD64 (Advanced Micro Devices)**



Computer Hardware

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Widely-known CPU architectures:

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- **ARM (Advanced RISC Machines)**



Computer Hardware

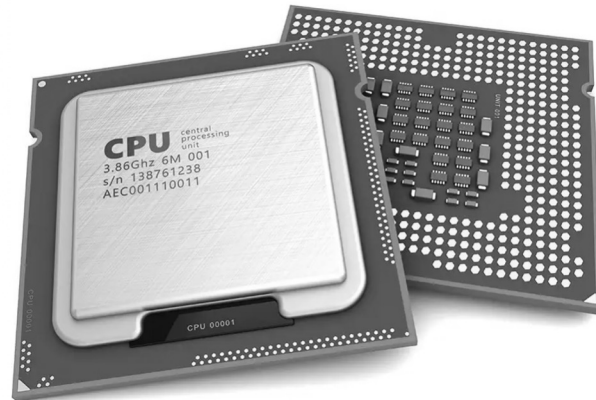
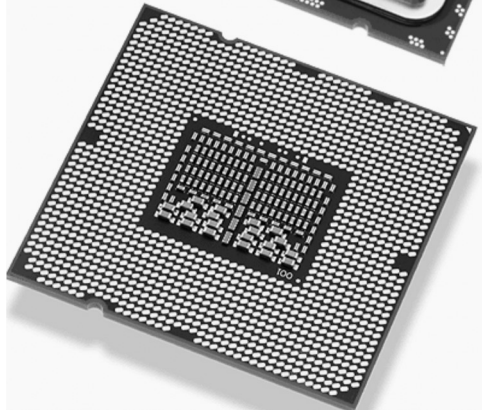
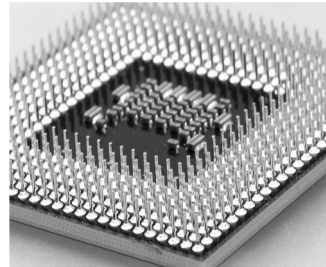
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Widely-known CPU architectures:

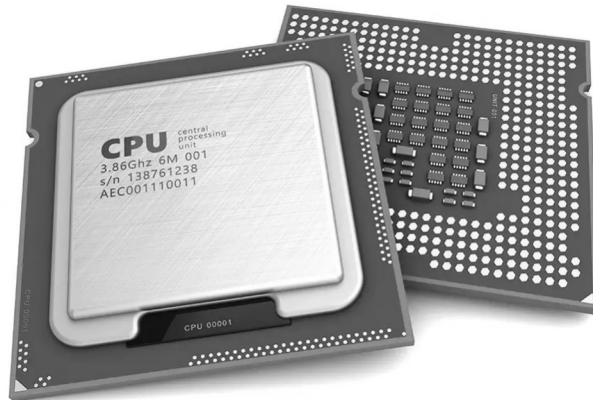
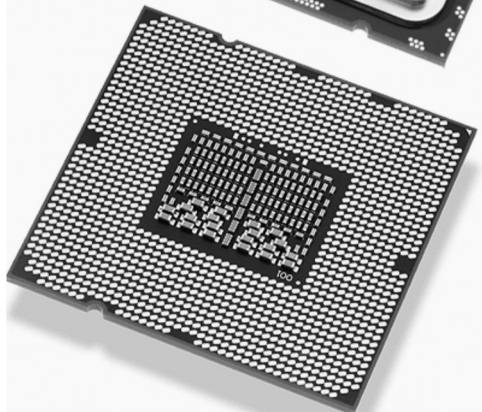
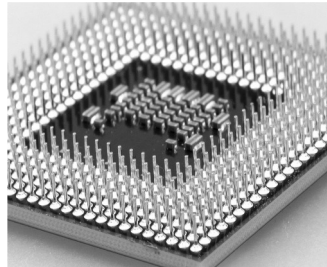
- Intel x86
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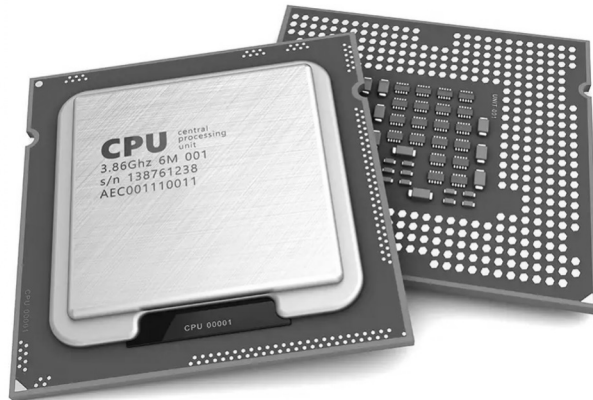
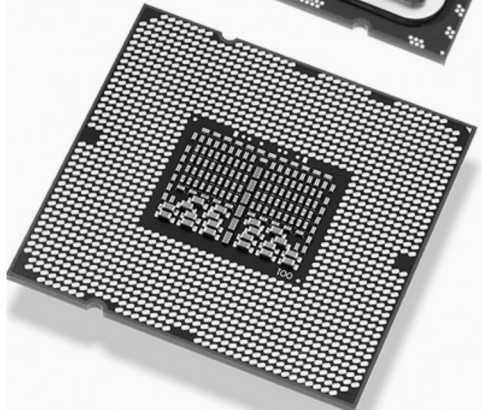
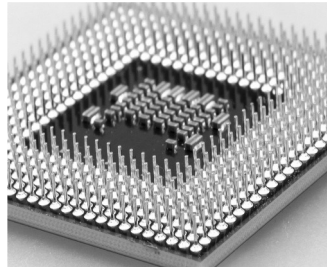
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Examples of Russian processor architectures?

Computer Hardware

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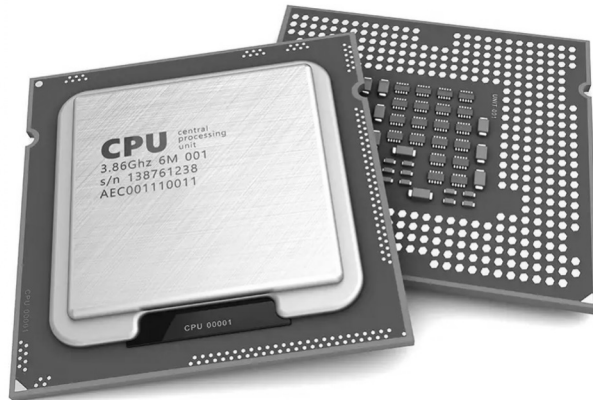
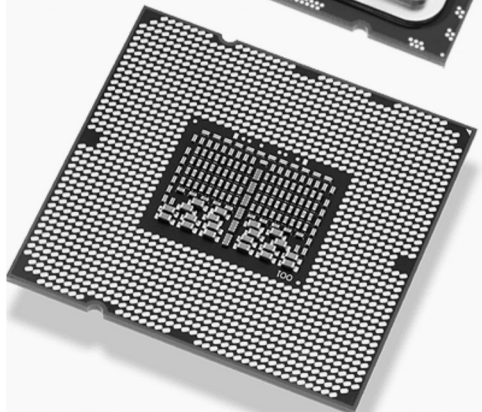
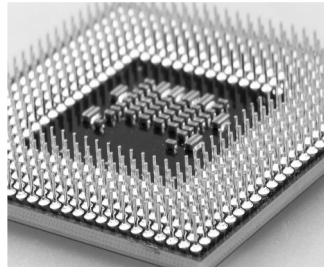
Widely-known CPU architectures:

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- **Baikal**
- **Elbrus**

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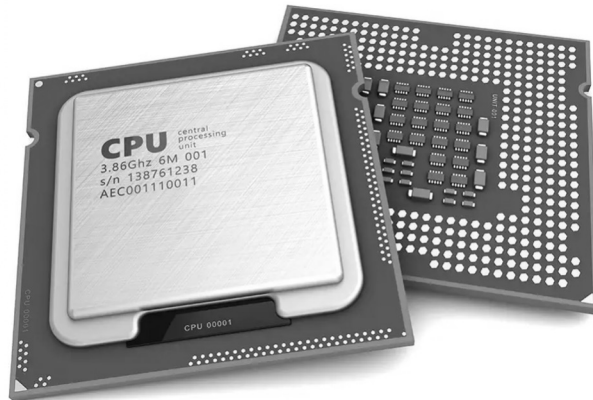
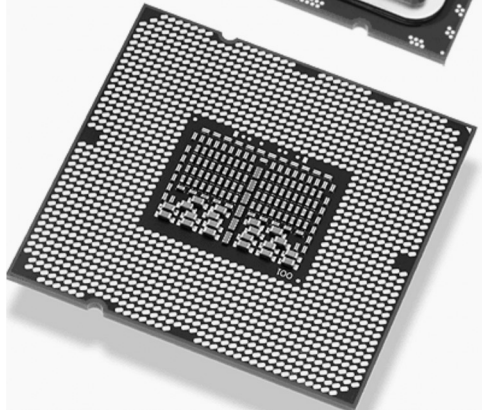
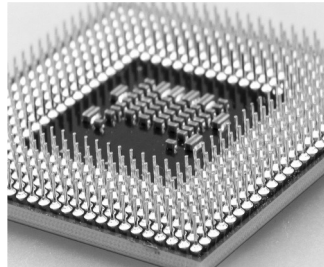
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- ARM (Advanced RISC Machines)
- Baikal
- Elbrus
- **Others: for embedded systems, tailored to specific needs (e.g. for car engine)**

Computer Hardware

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Widely-known CPU architectures:

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- Baikal, Elbrus, others

CPUs differ in various aspects

Computer Hardware

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CPUs differ in various aspects, including:

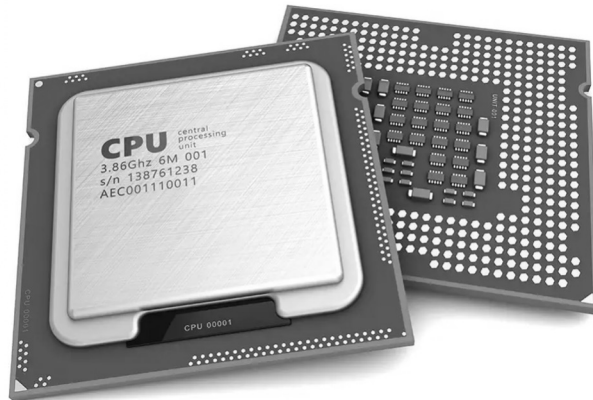
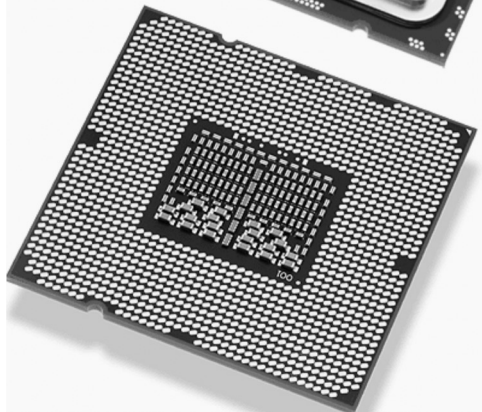
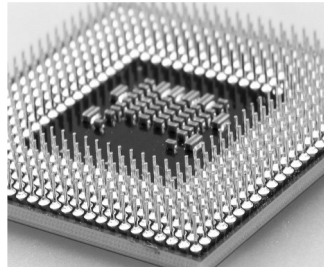
- **Speed of instructions execution**



Computer Hardware

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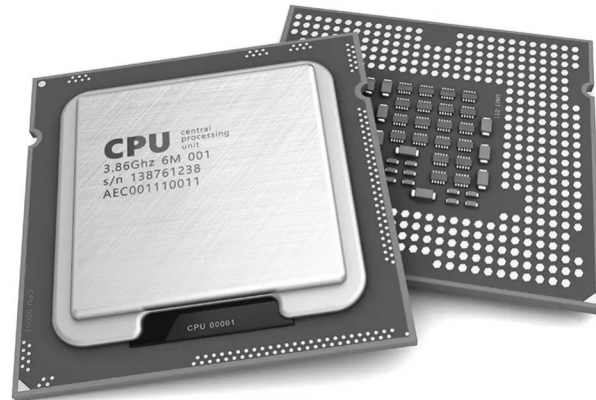
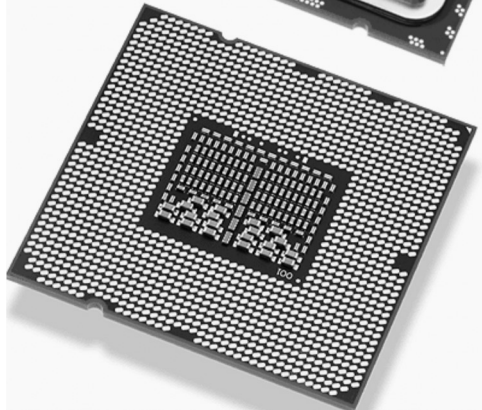
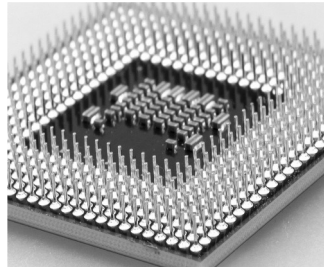
CPUs differ in various aspects, including:

- Speed of instructions execution
- **Supported instructions (CPU instruction set)**

Computer Hardware

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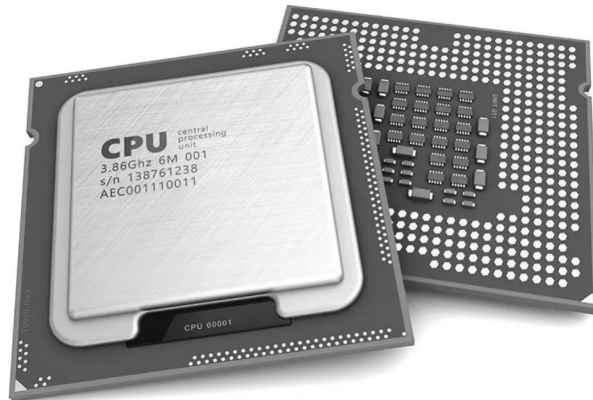
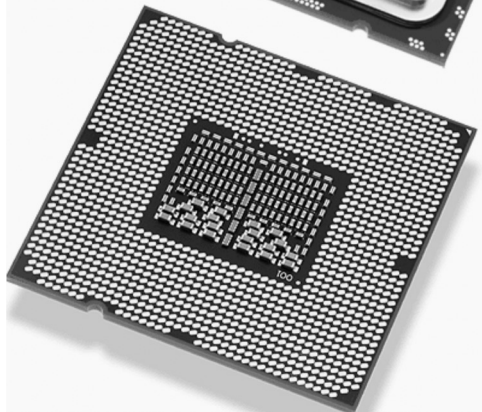
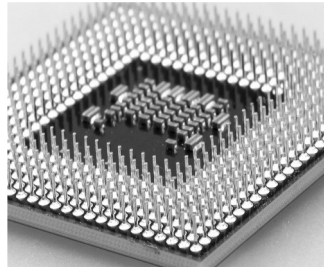
CPUs differ in various aspects, including:

- Speed of instructions execution
- Supported instructions (CPU instruction set)
- **Energy consumption**

Computer Hardware

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Widely-known CPU architectures:

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CPUs differ in various aspects, including:

- Speed of instructions execution
- Supported instructions (CPU instruction set)
- Energy consumption
- **Level 1 (L1) cache storage capacity**

Computer Hardware

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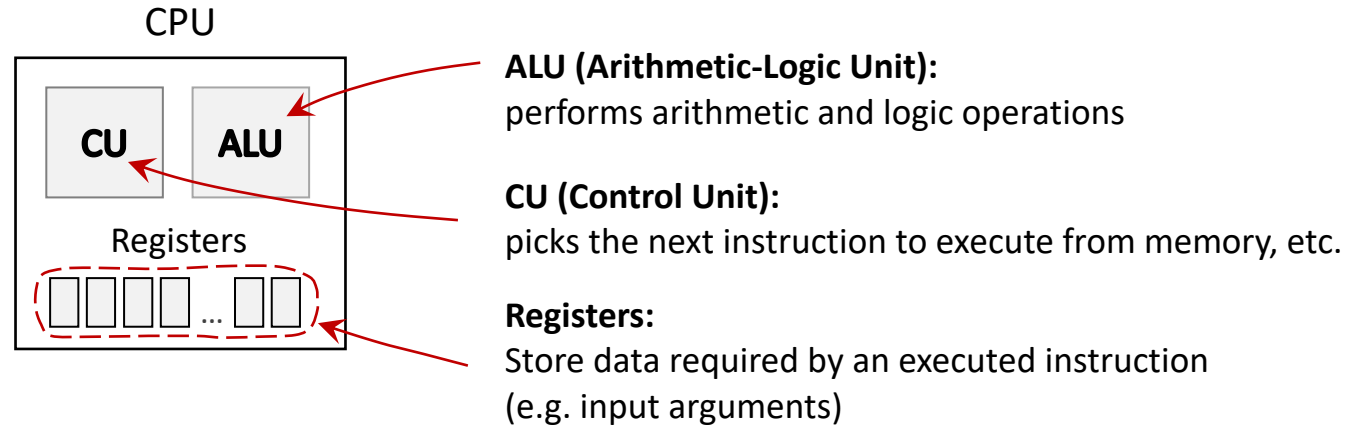
CPUs differ in various aspects, including:

- Speed of instructions execution
- Supported instructions (CPU instruction set)
- Energy consumption
- L1 cache storage capacity

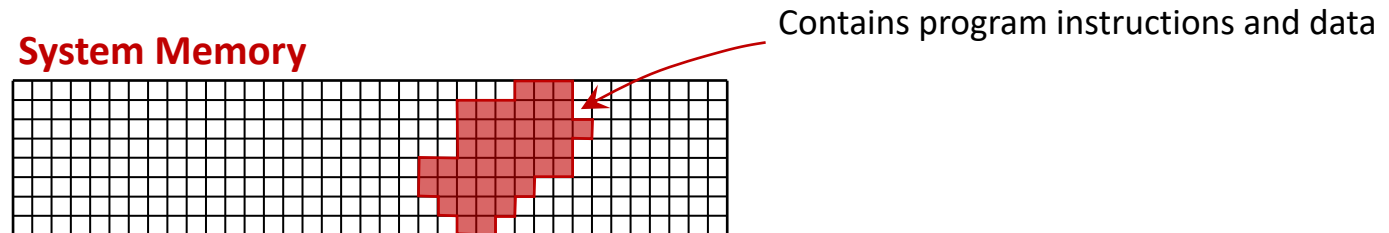
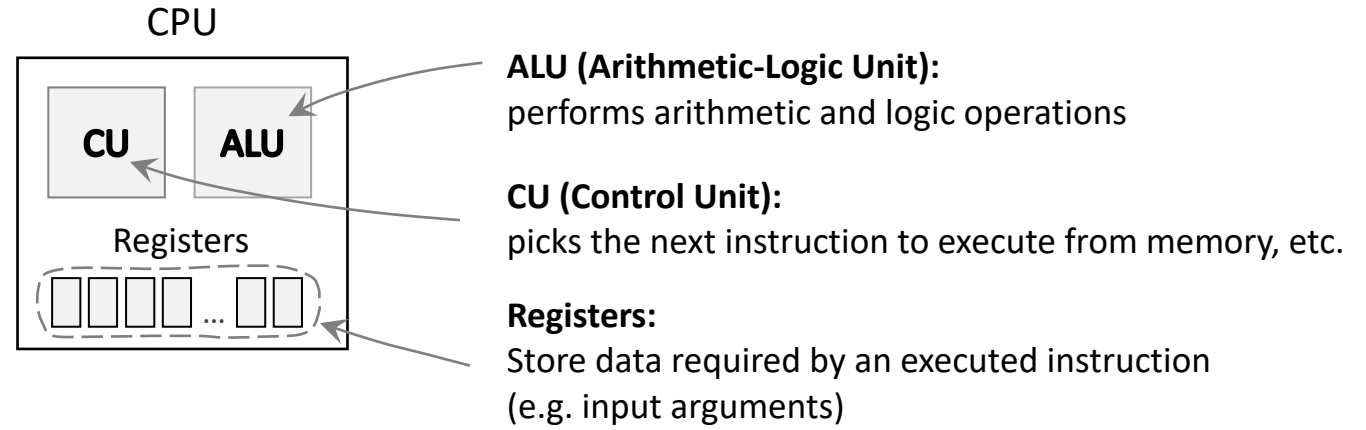


We will thoroughly study CPU performance aspects later

CPU Components



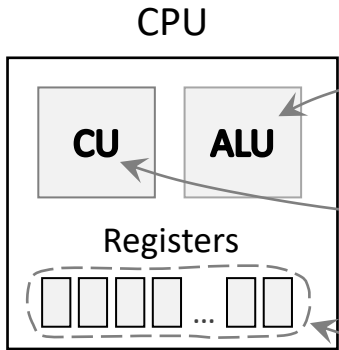
Computer Hardware: System Memory



Computer Hardware: System Memory



Image taken from: <https://en.wikipedia.org>

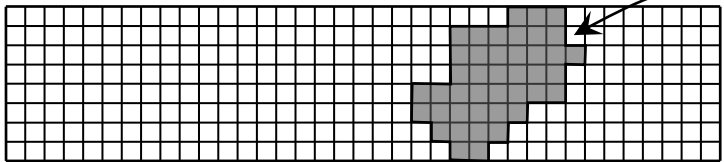


ALU (Arithmetic-Logic Unit):
performs arithmetic and logic operations

CU (Control Unit):
picks the next instruction to execute from memory, etc.

Registers:
Store data required by an executed instruction
(e.g. input arguments)

System Memory

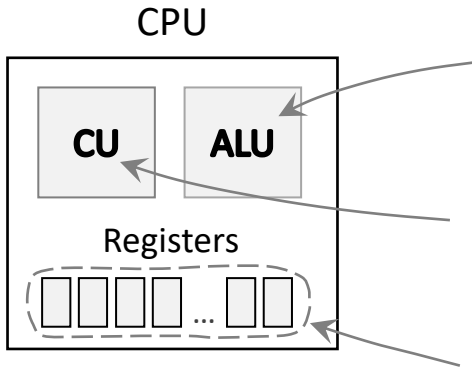


Contains program instructions and data

Key Computer Components: System Memory

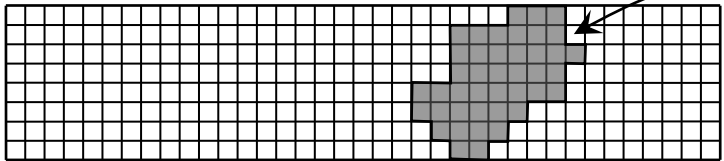


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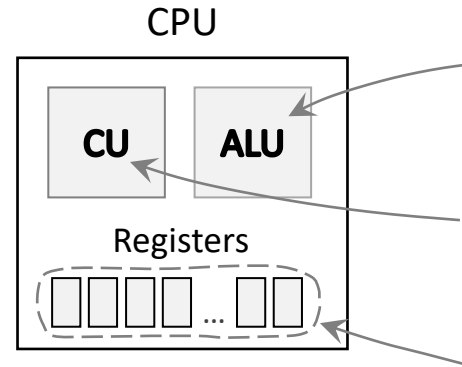
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Differ in storage capacity, access speed, and other aspects

Key Computer Components: System Memory



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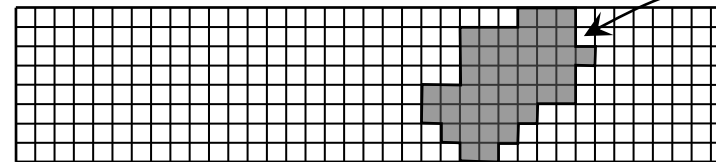
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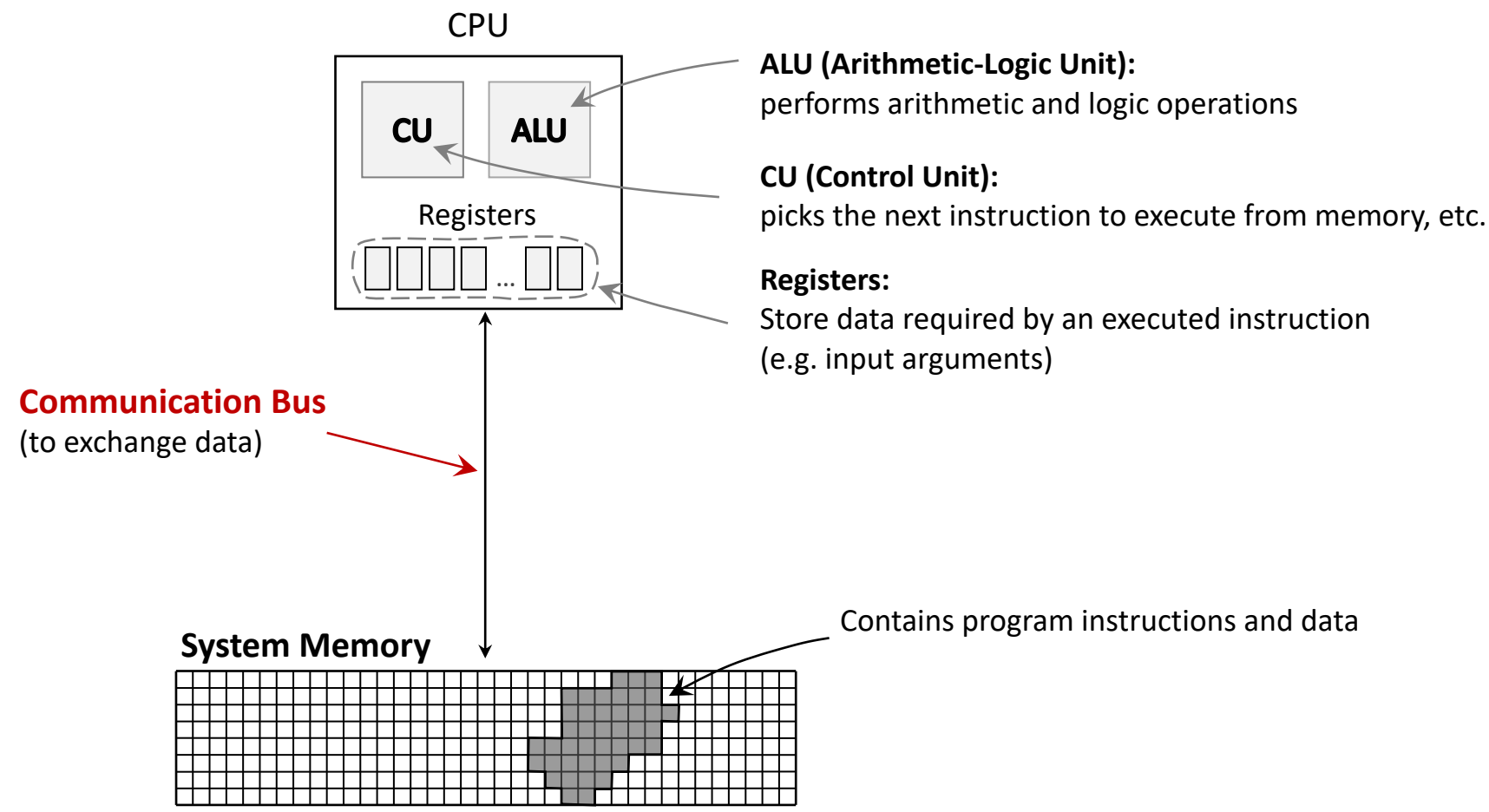


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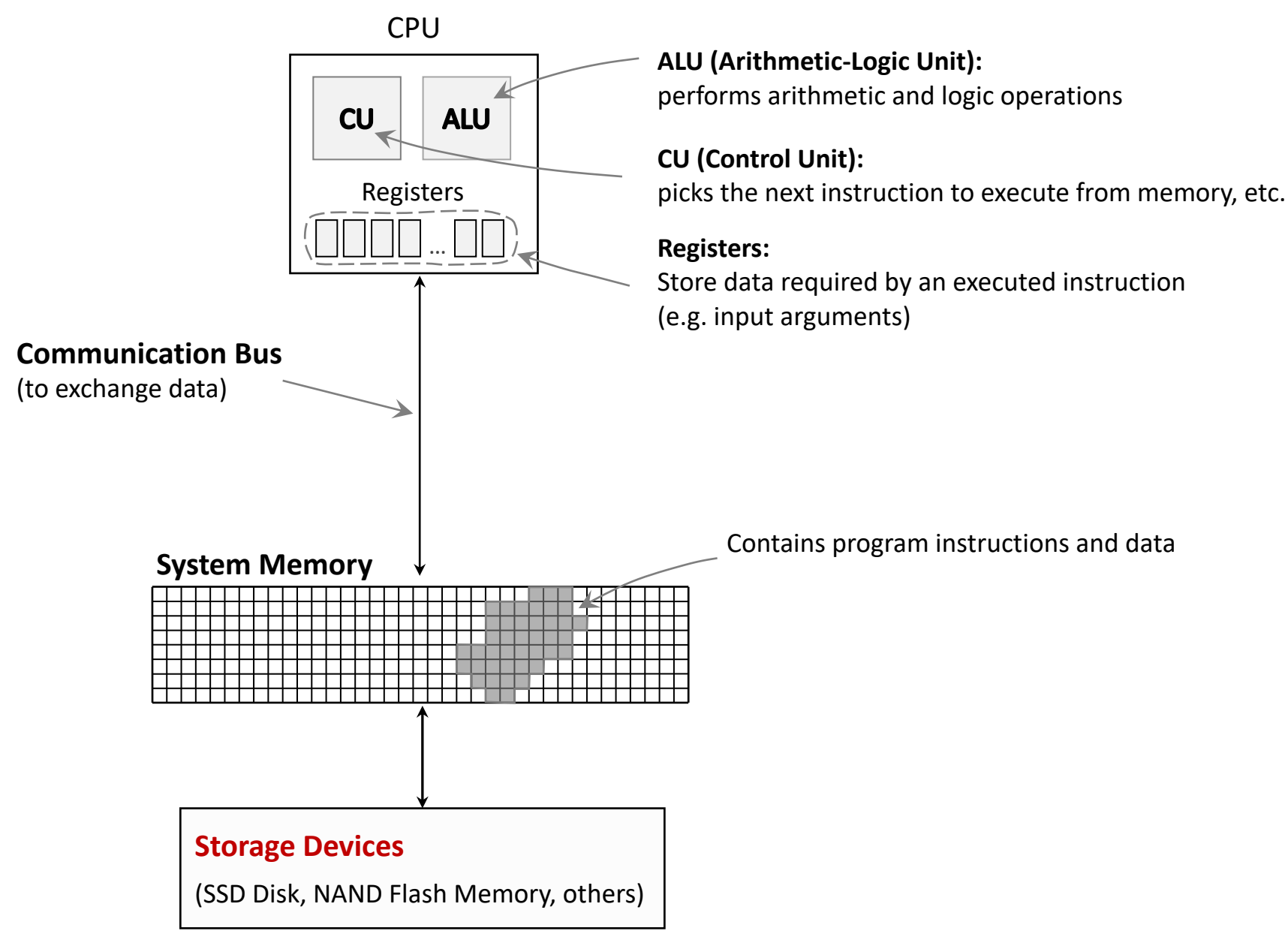
Differ in storage capacity, access speed, and other aspects;

System memory of a larger storage capacity might have a slower access speed

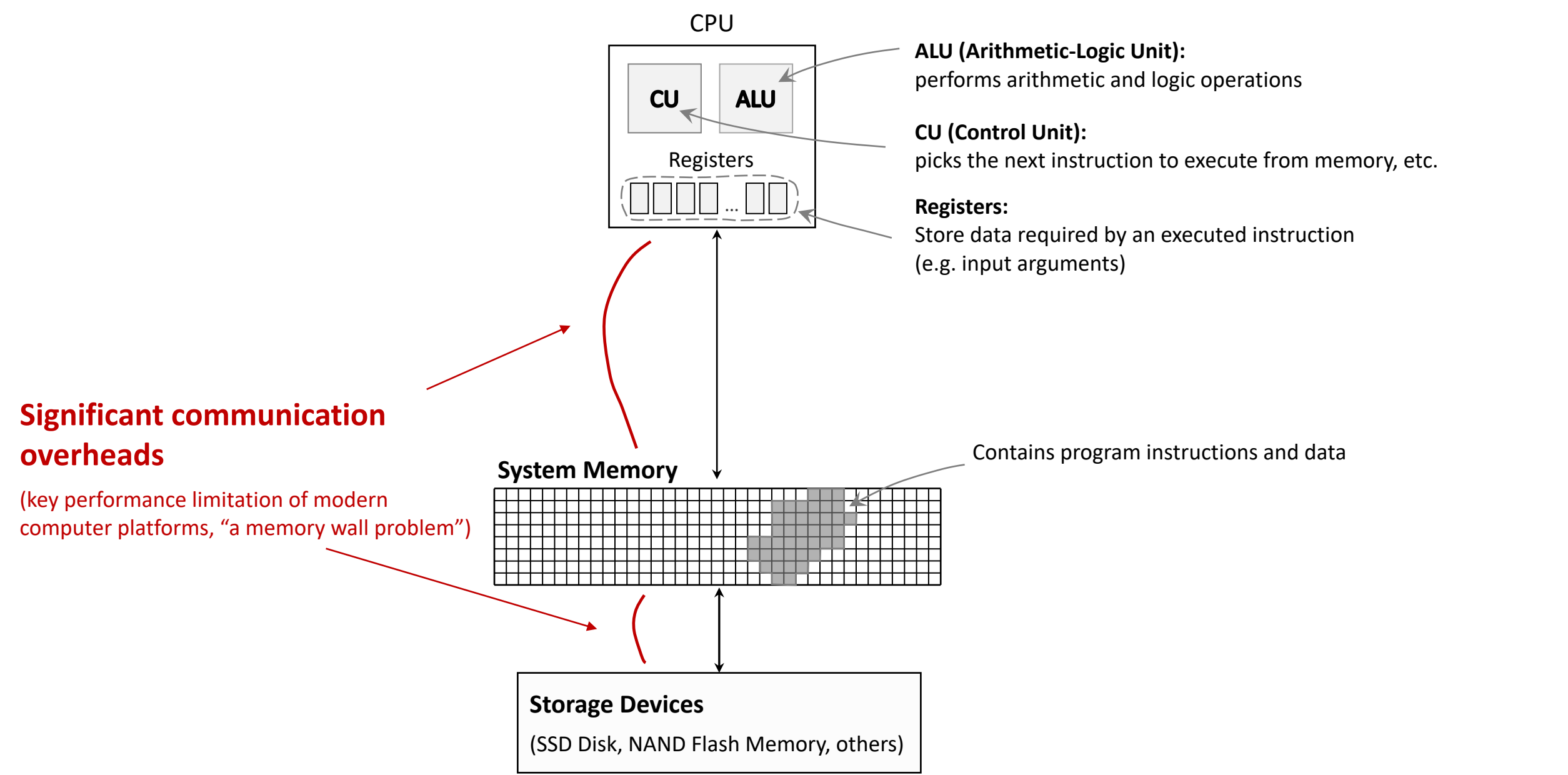
Key Computer Components: Communication Bus



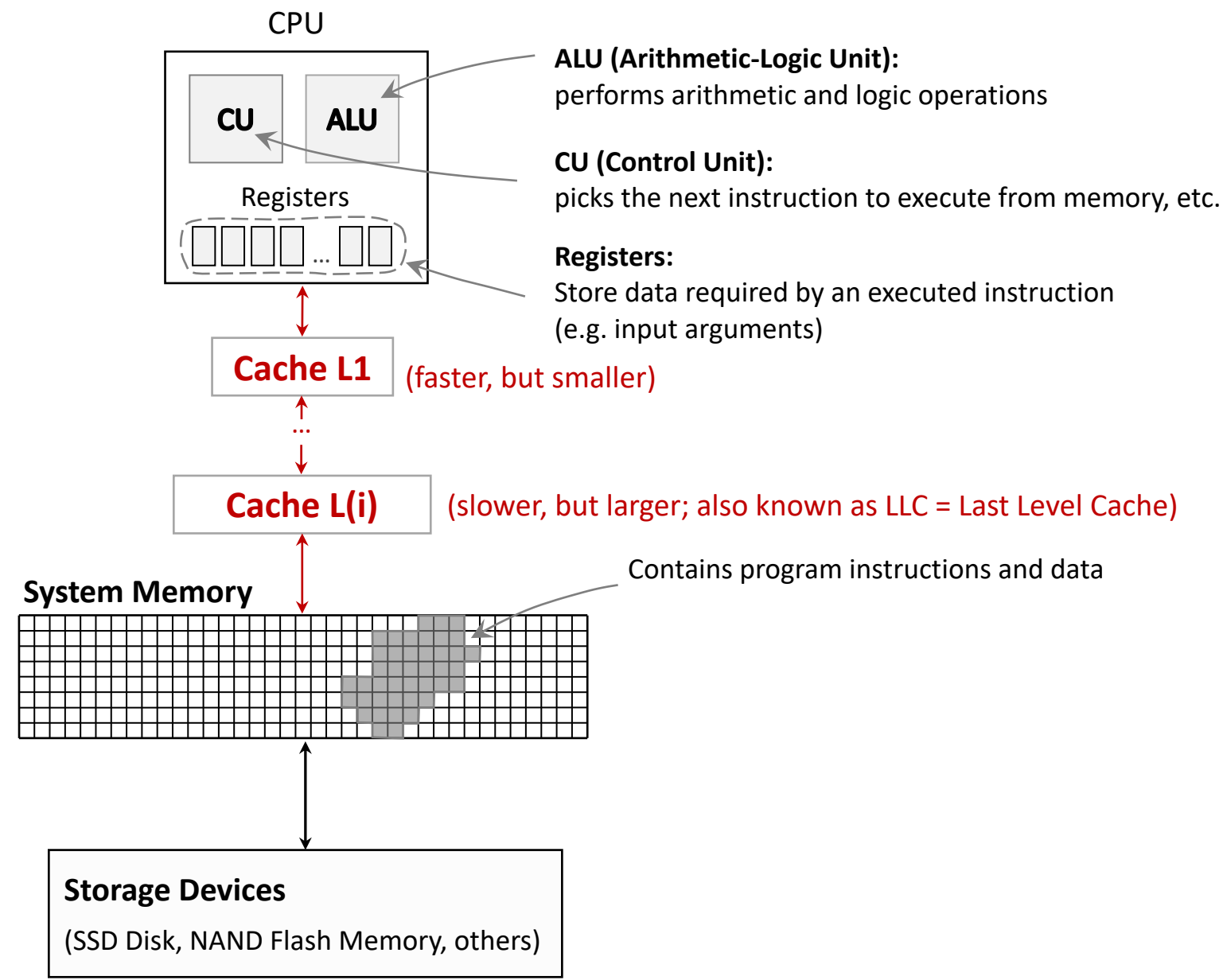
Key Computer Components: Remote Storage Devices



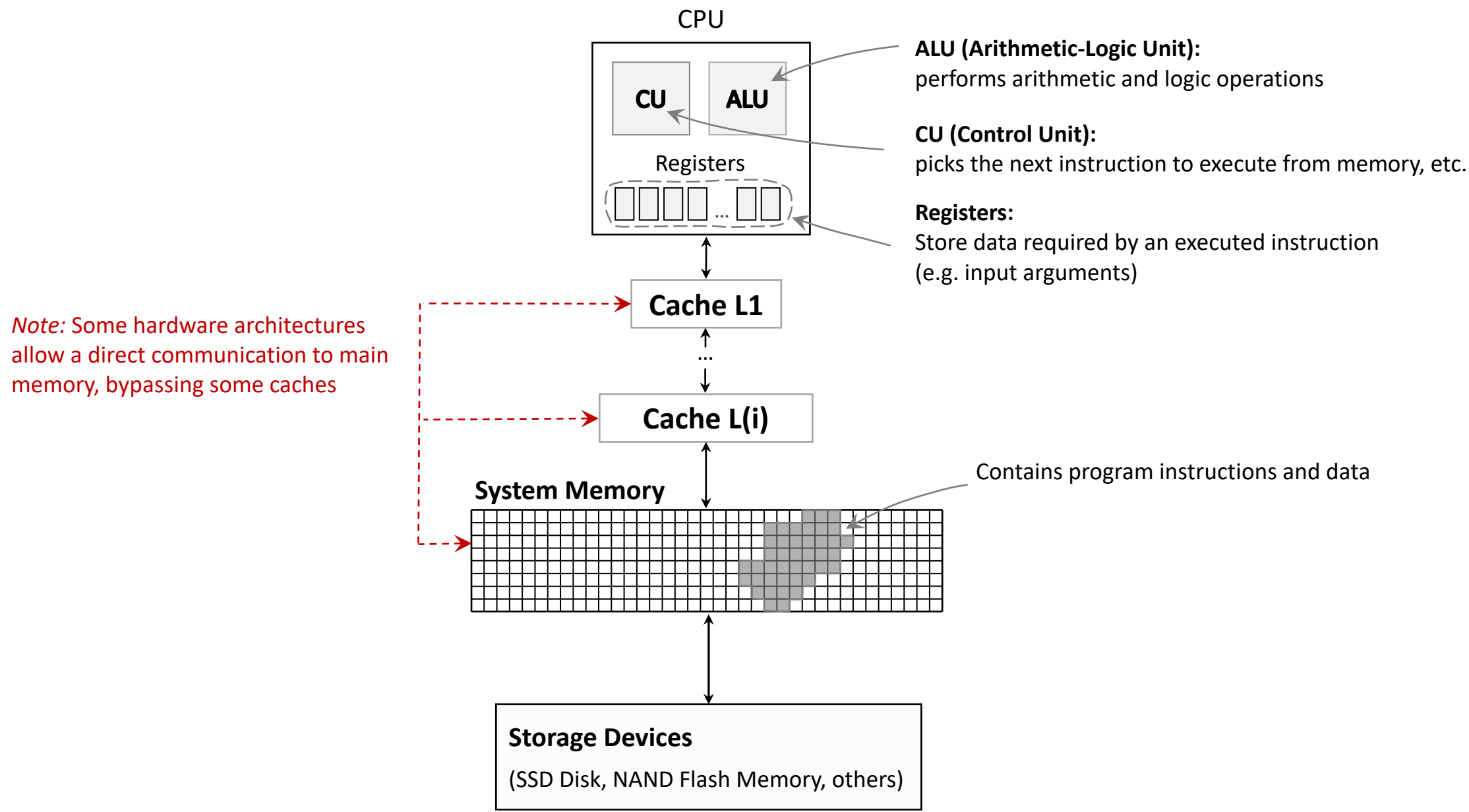
Key Computer Components: Communication Bus Overheads



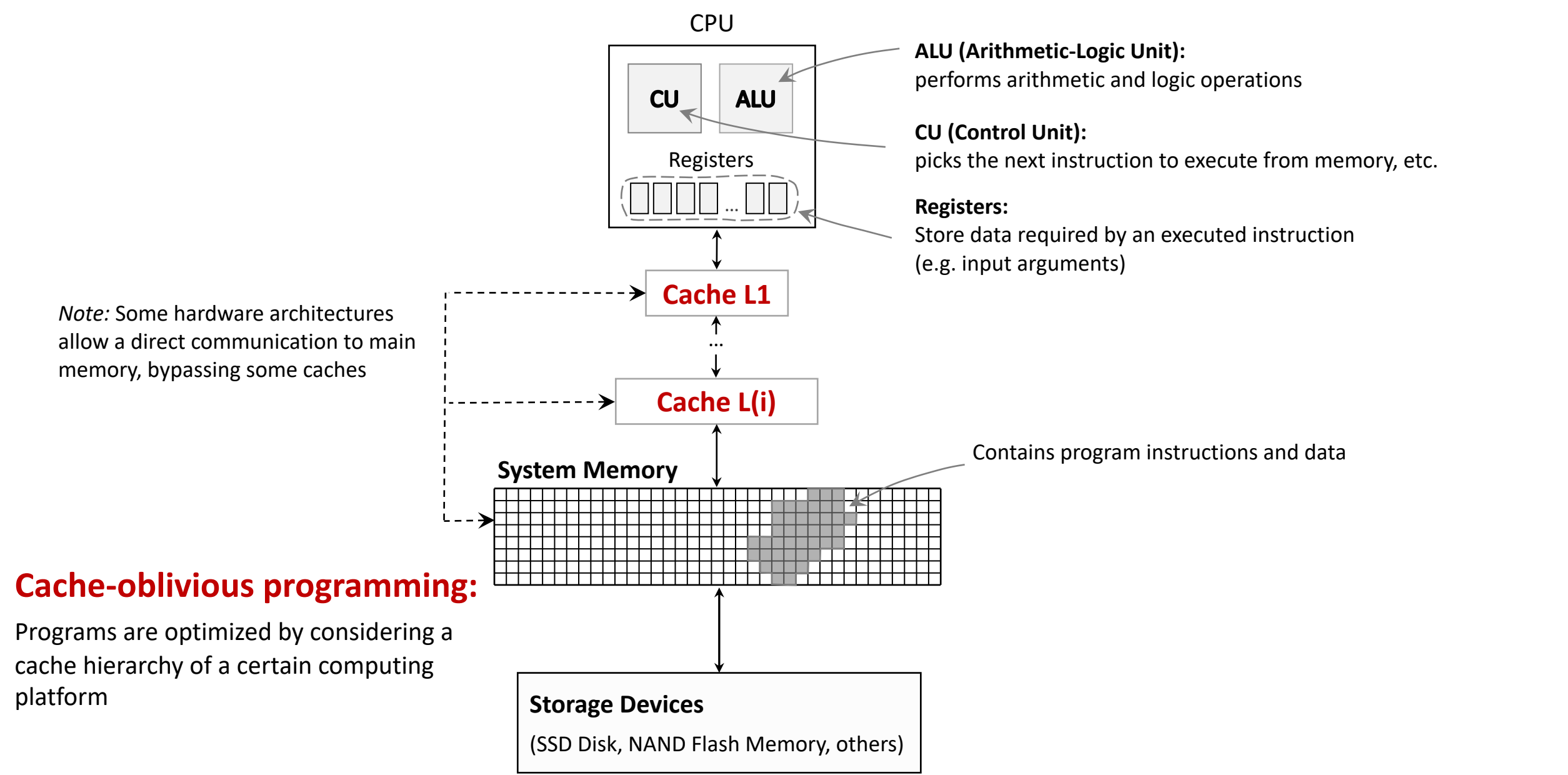
Key Computer Components: CPU Cache



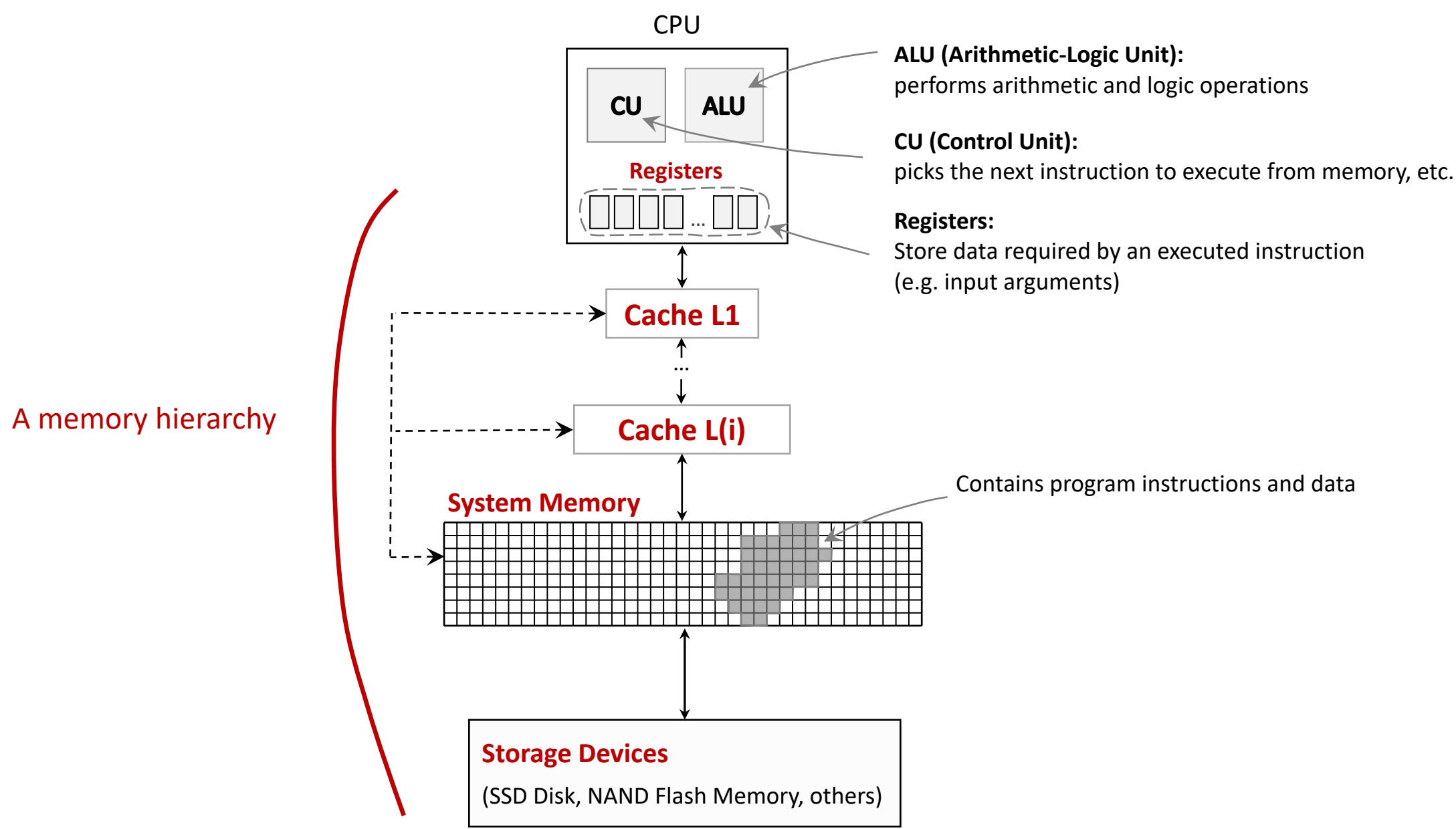
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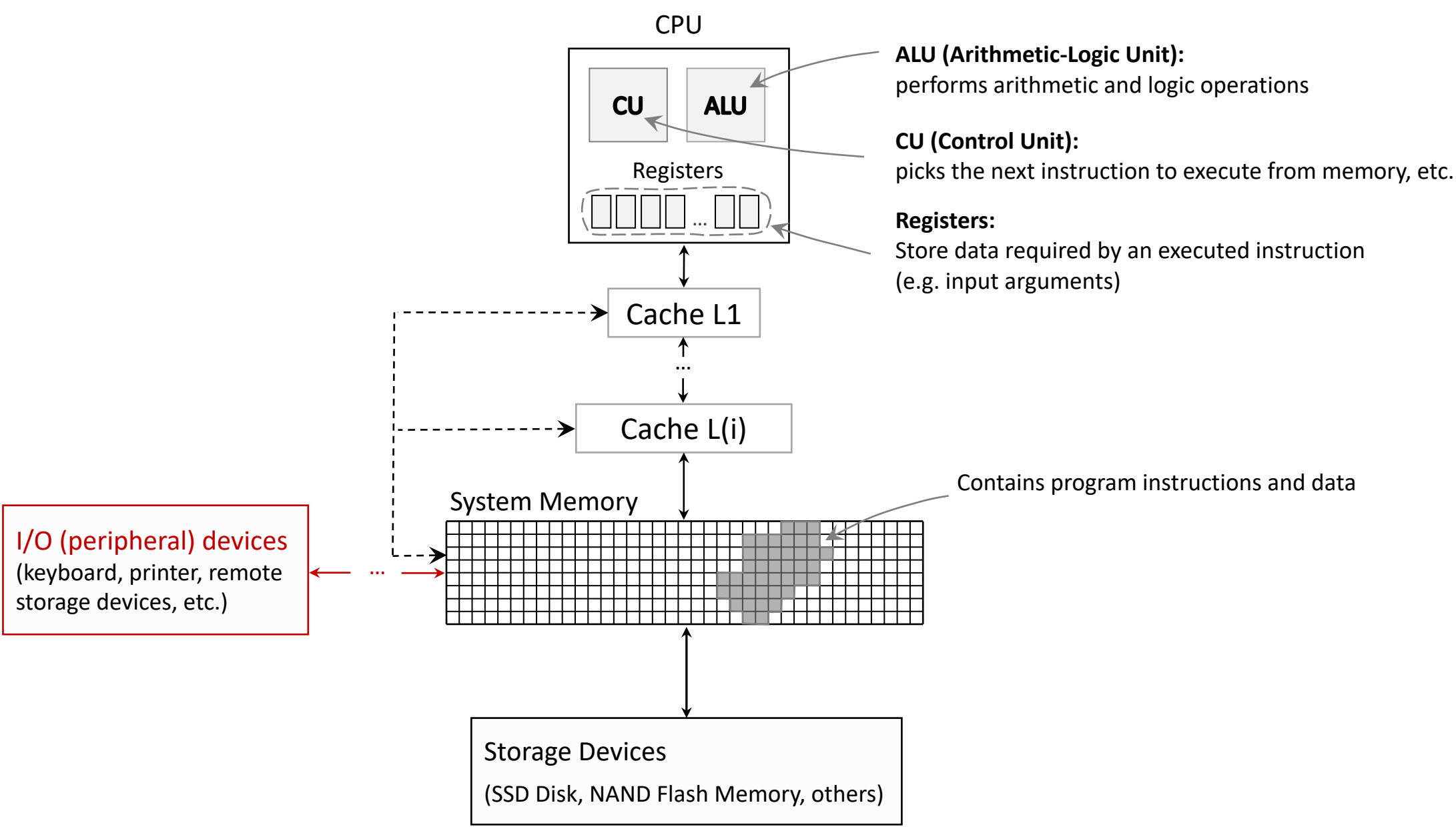
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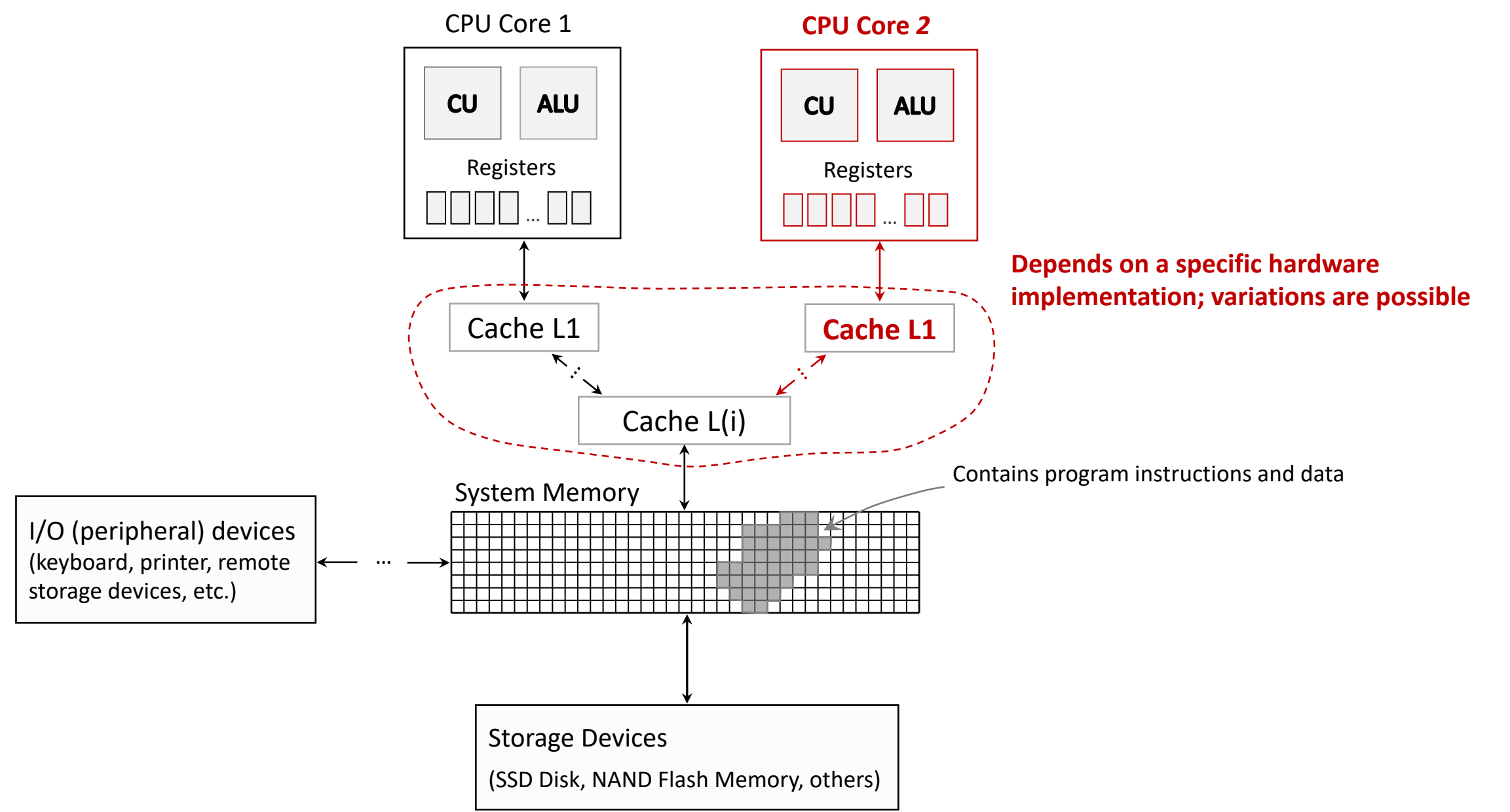
Key Computer Components: A memory Hierarchy



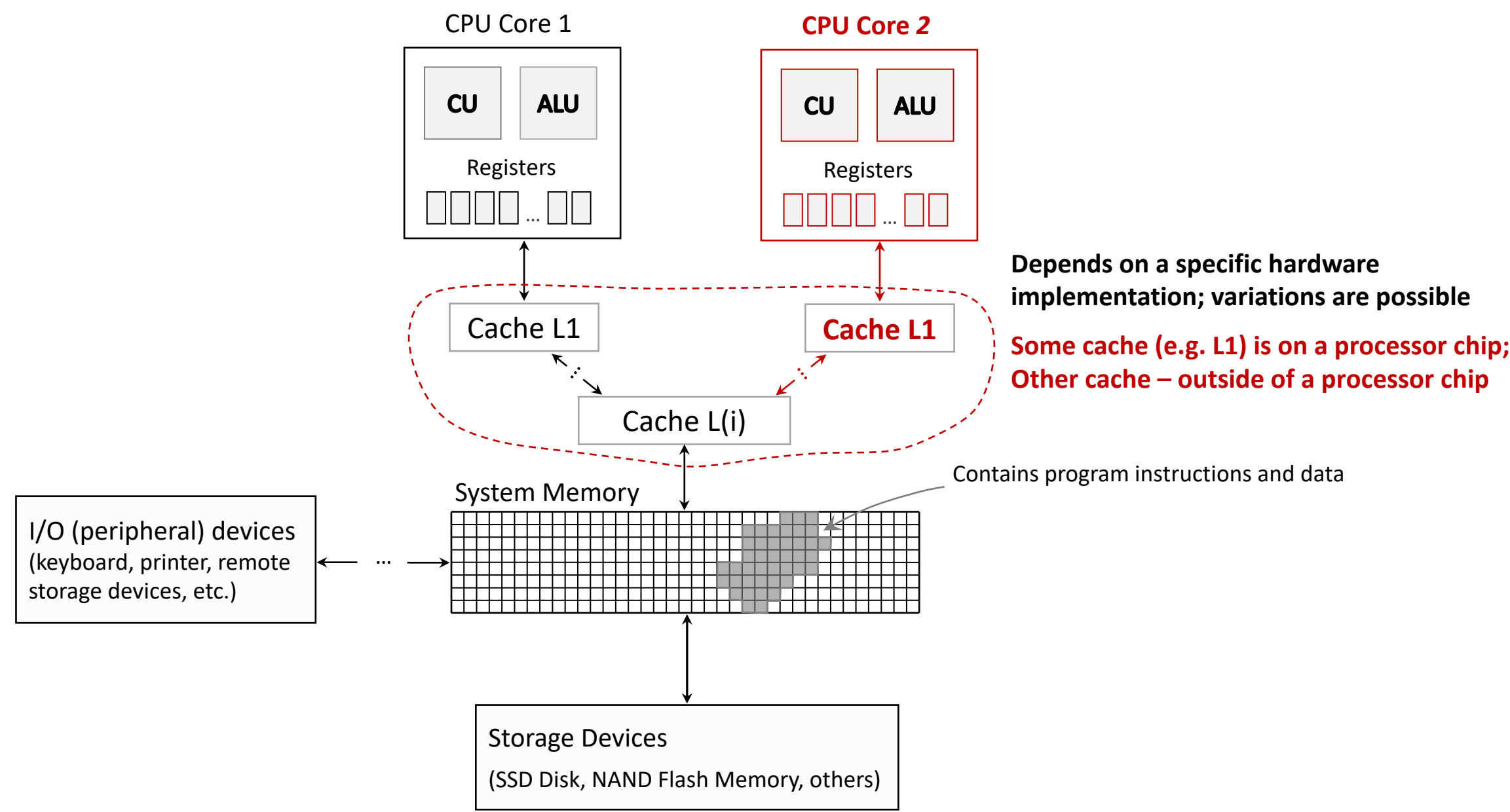
Key Computer Components: Input/Output (Peripheral) Devices



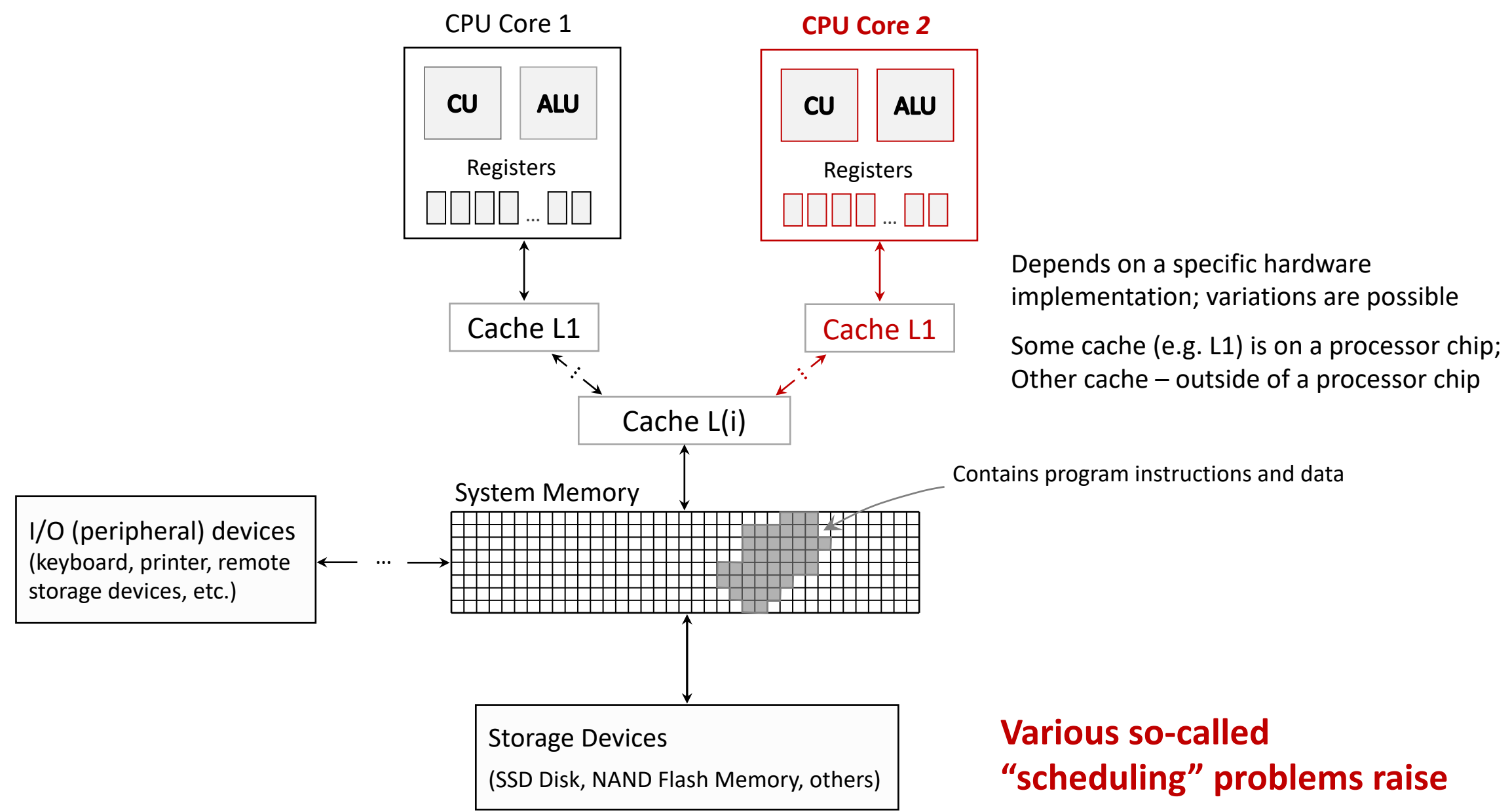
Key Computer Components: Multicore (Multiprocessor) Systems



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Key Computer Components: Multicore (Multiprocessor) Systems



Depends on a specific hardware implementation; variations are possible

Some cache (e.g. L1) is on a processor chip;
Other cache – outside of a processor chip

**Various so-called
“scheduling” problems raise**

Key Computer Components: CPU and Cache

Different levels of CPU caches (L1, L2, L3, etc.)



Image taken from: <https://jbwyatt.com>

Key Computer Components: CPU and Cache



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Different levels of CPU caches (L1, L2, L3, etc.):

- L1 cache:
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Key Computer Components: CPU and Cache



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Different levels of CPU caches (L1, L2, L3, etc.):

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 - **the fastest**

Key Computer Components: CPU and Cache



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Different levels of CPU caches (L1, L2, L3, etc.):

- L1 cache:
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 - the smallest storage capacity

Key Computer Components: CPU and Cache



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Different levels of CPU caches (L1, L2, L3, etc.):

- L1 cache:
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- L(i) cache

Key Computer Components: CPU and Cache



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Key Computer Components: CPU and Cache



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- L1 cache:
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- L(i) cache:
 - either on or outside of a CPU chip,
 - slower, but has a larger storage capacity, than L(i-1) cache

Key Computer Components: CPU and Cache

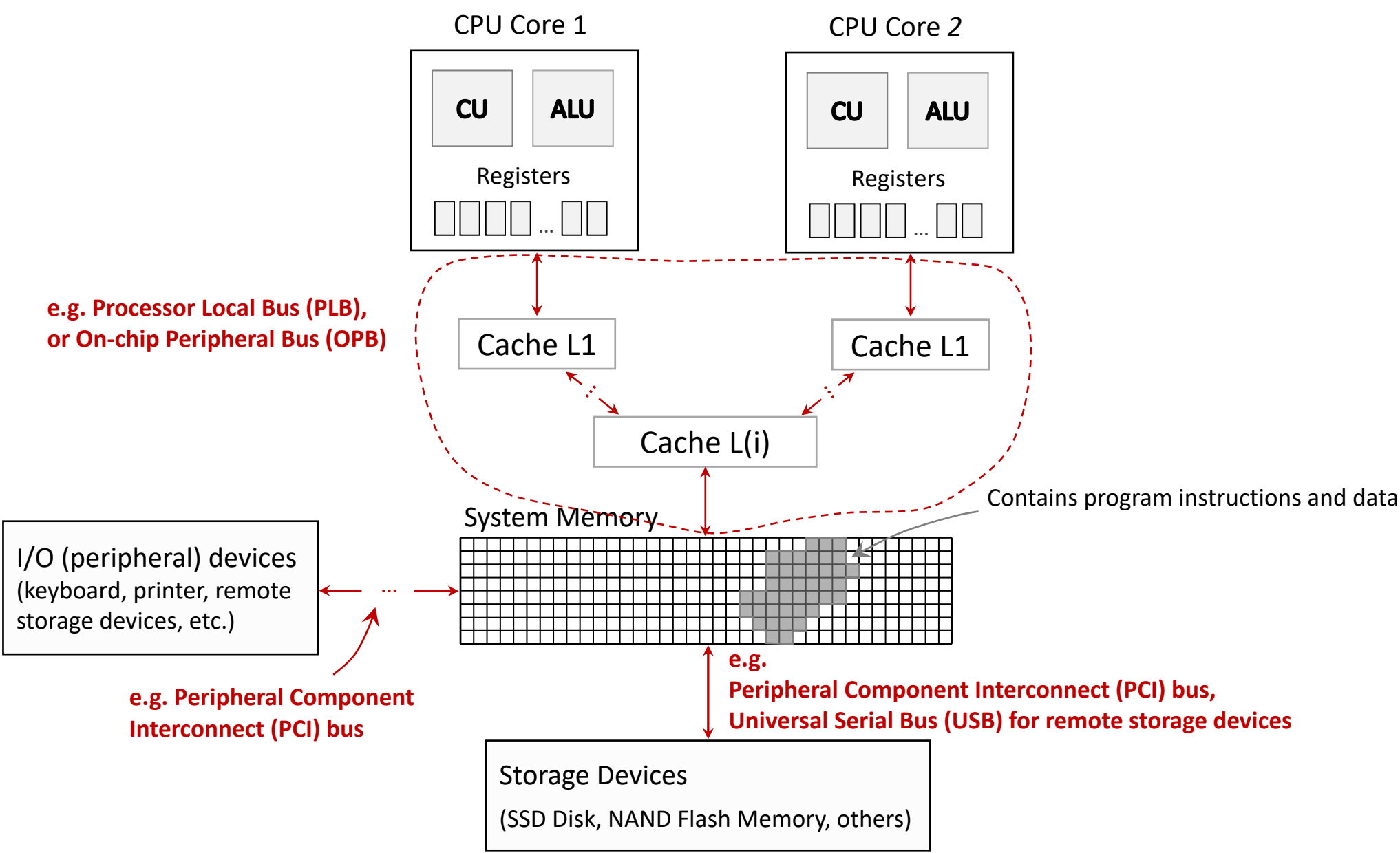


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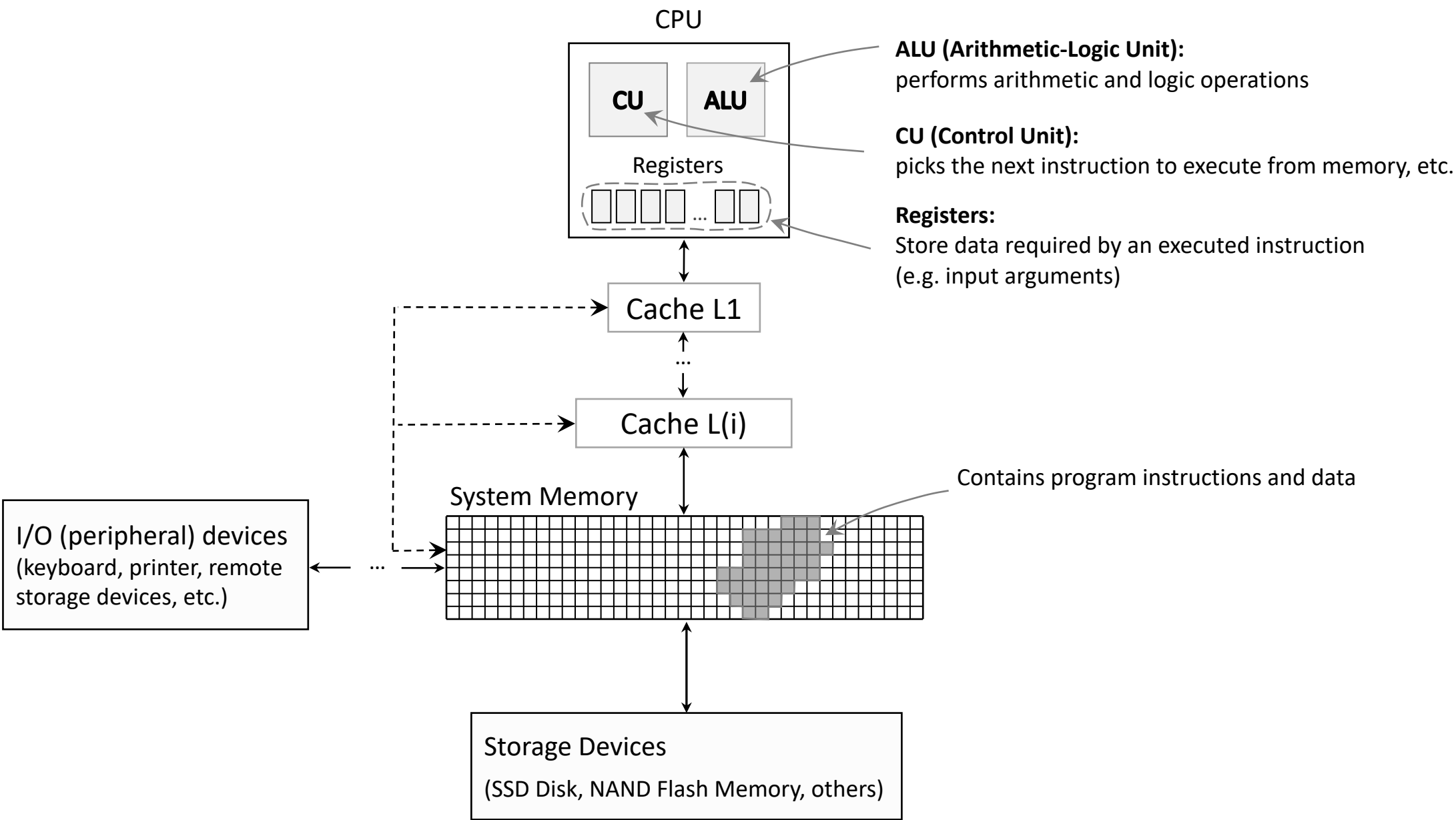
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Key Computer Components: Sample Communication Buses

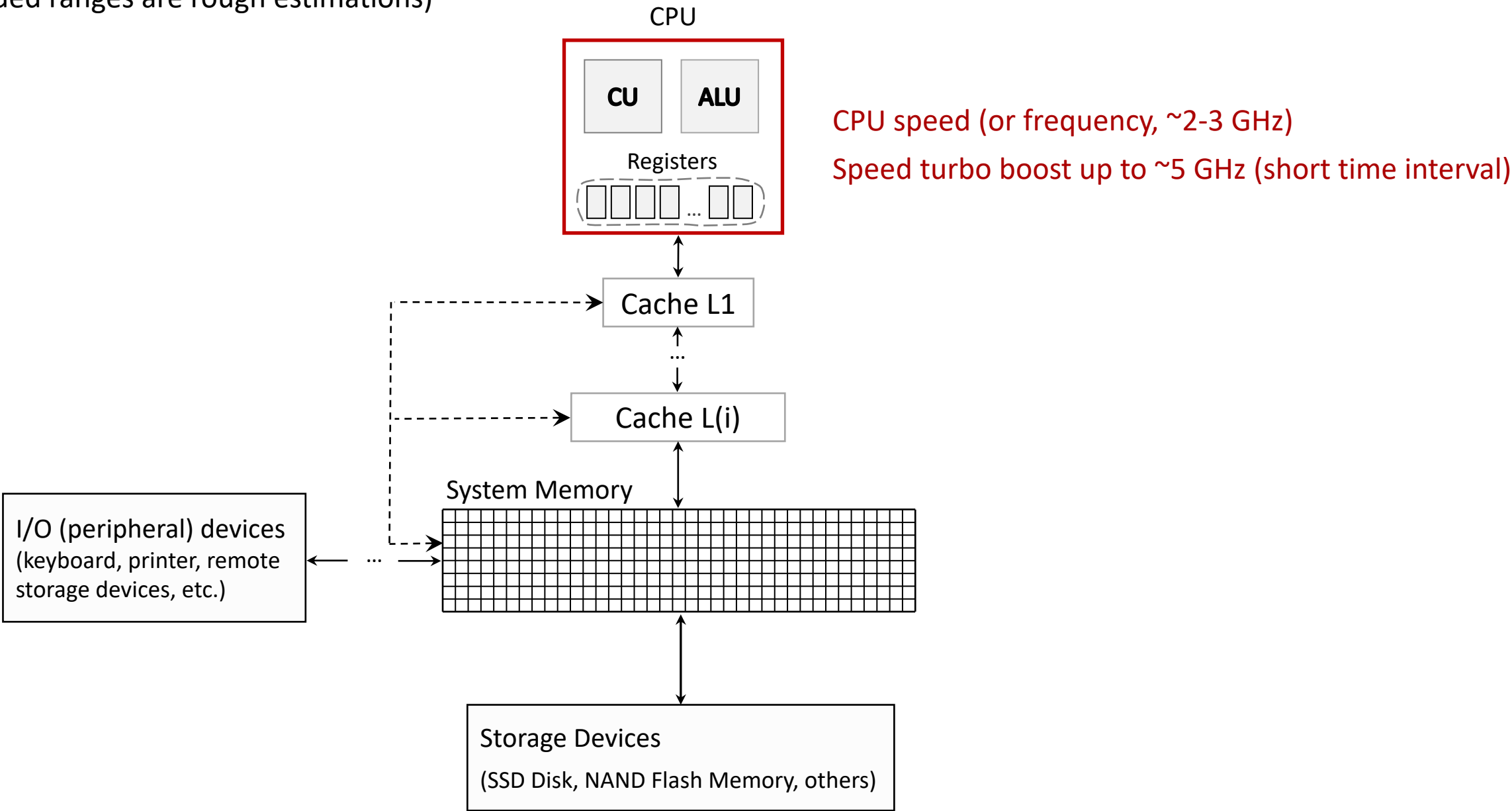


Some Performance Metrics



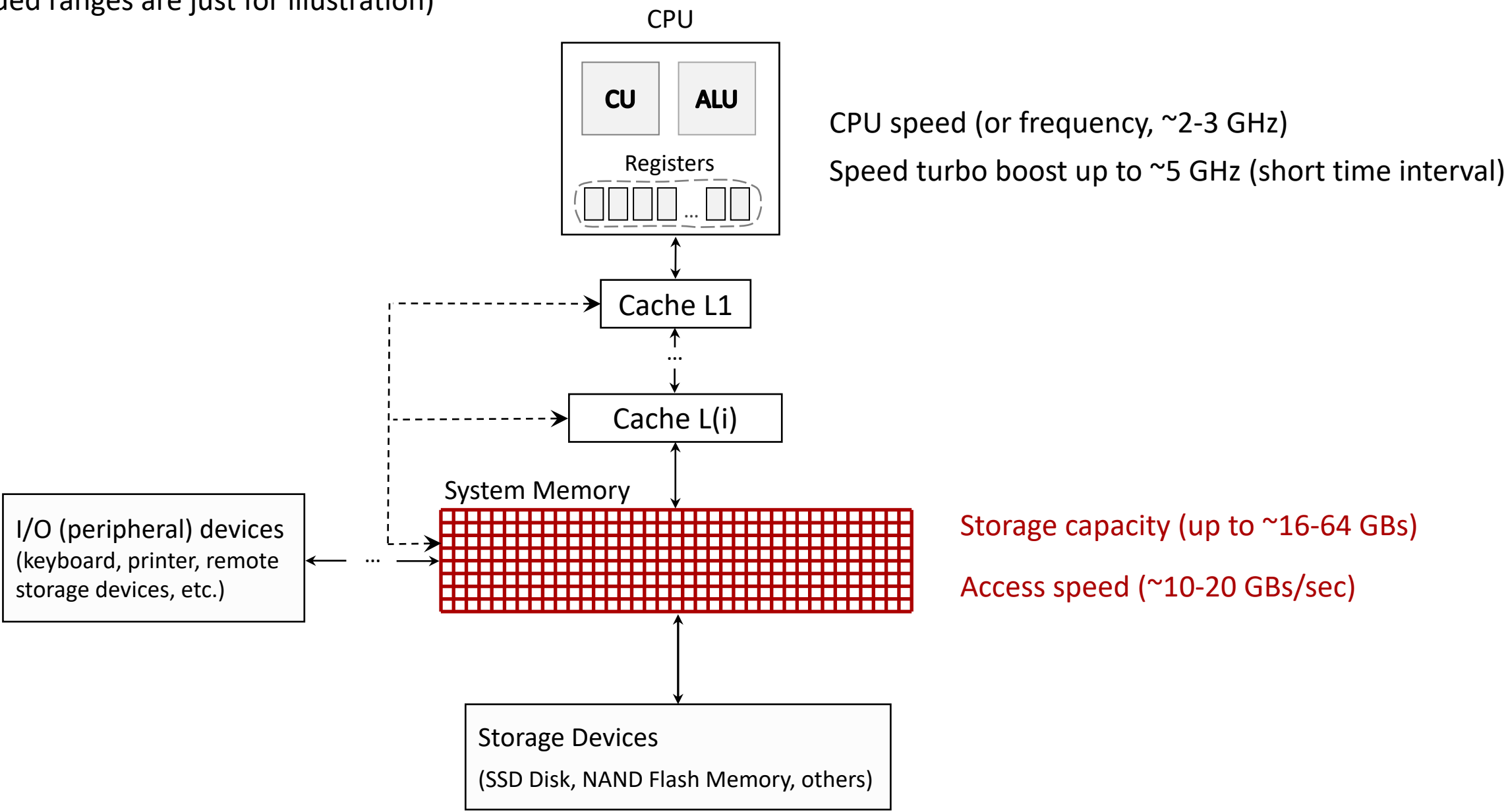
Some Performance Metrics

(provided ranges are rough estimations)



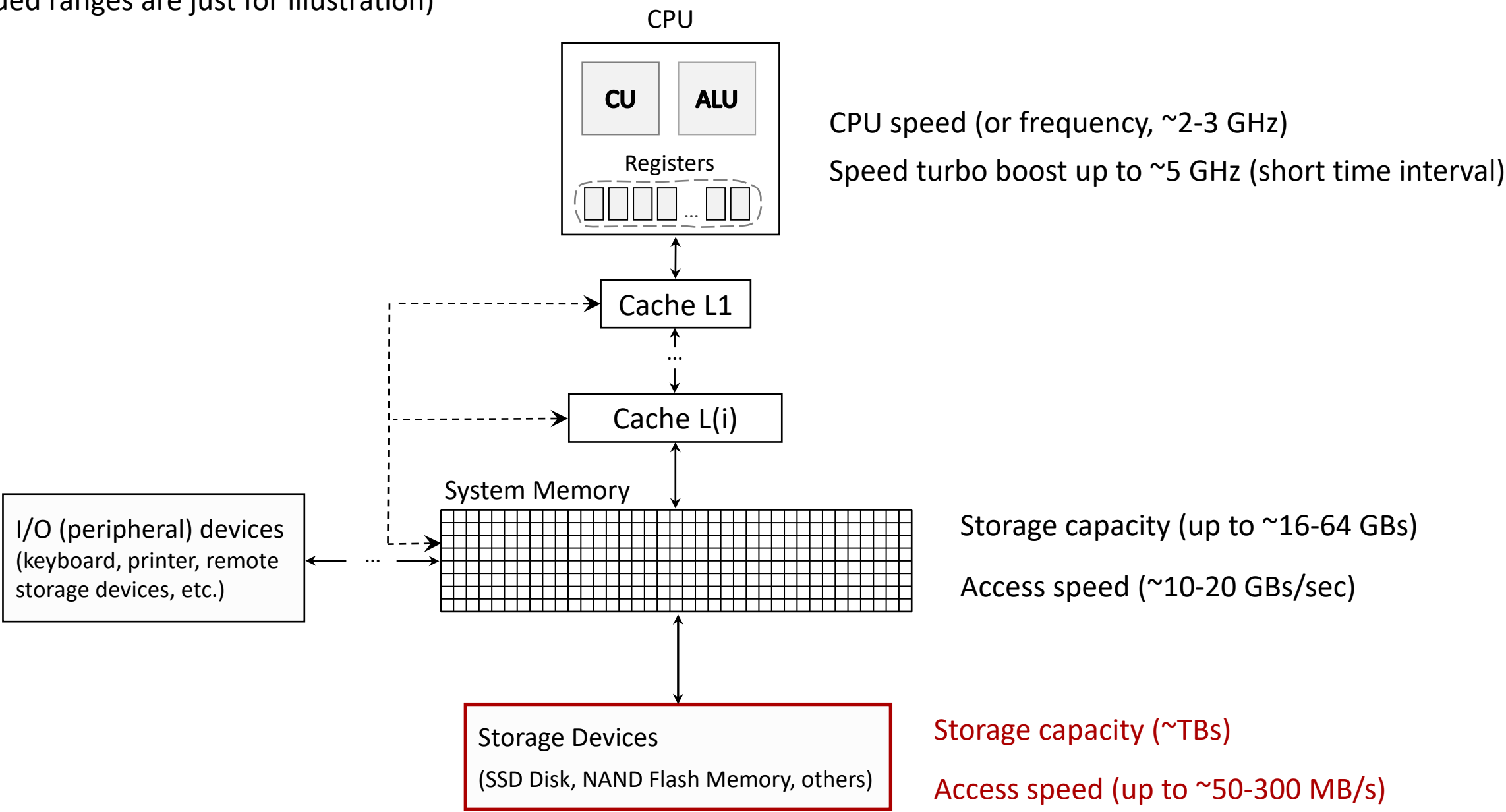
Some Performance Metrics

(provided ranges are just for illustration)



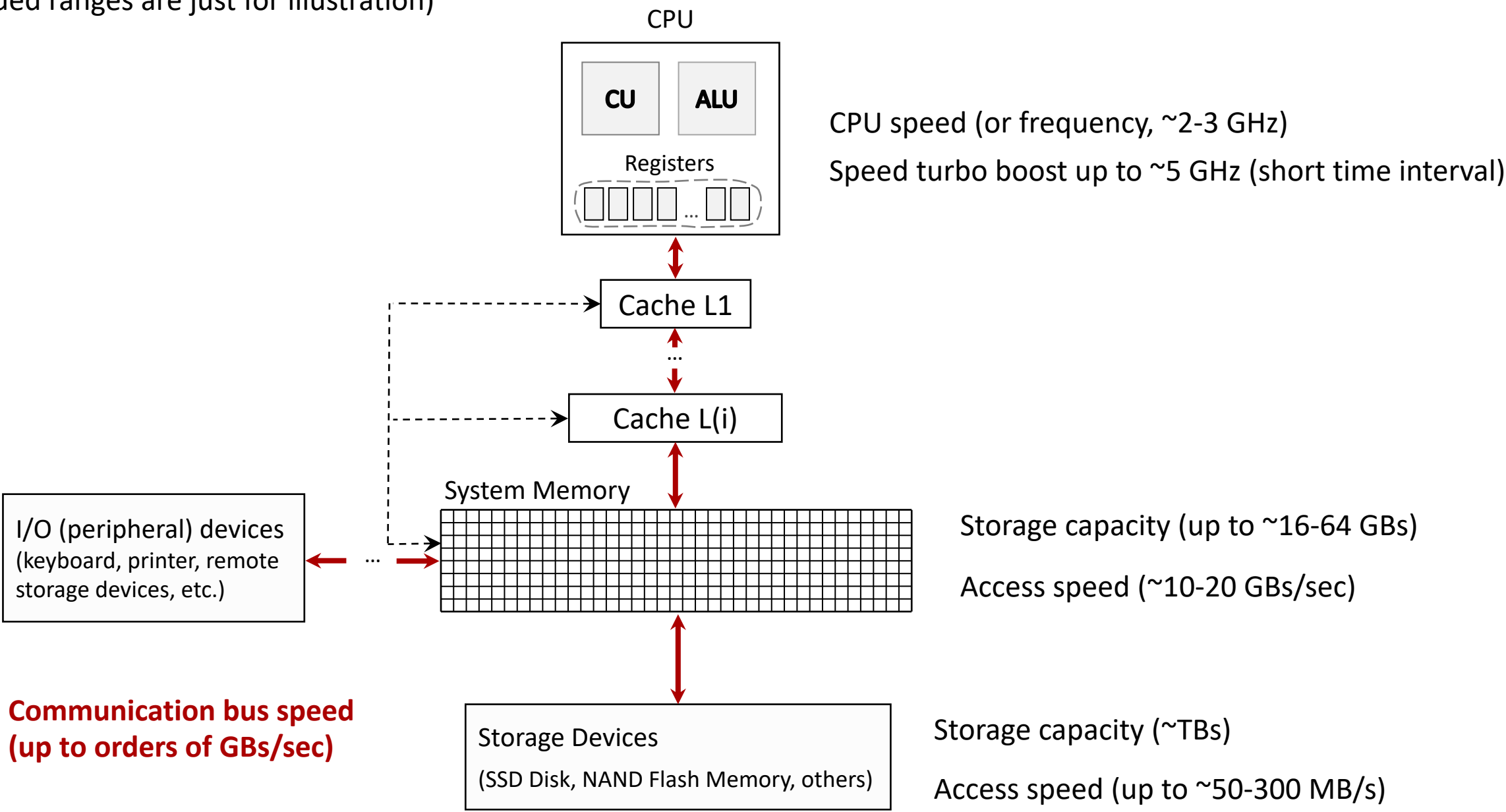
Some Performance Metrics

(provided ranges are just for illustration)



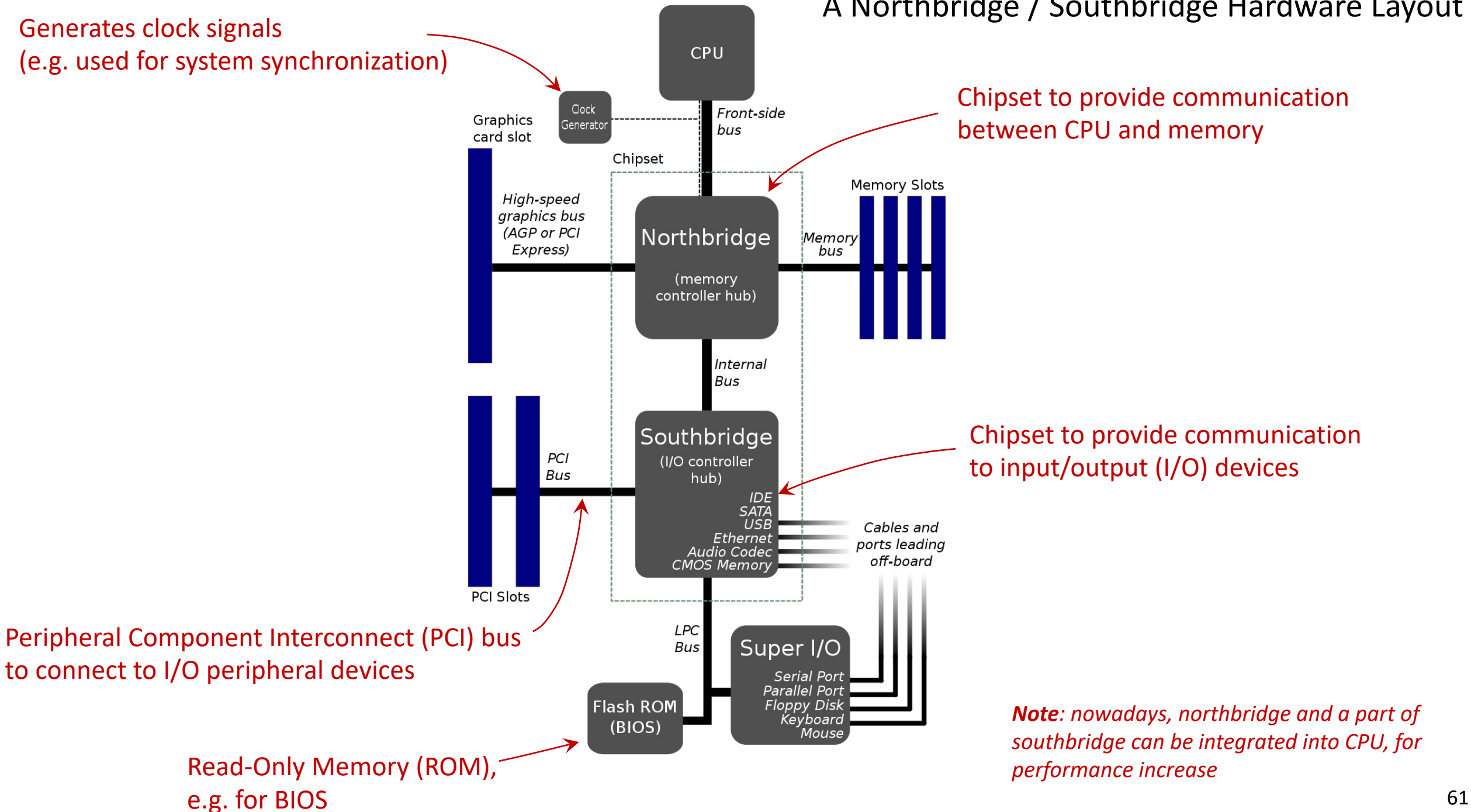
Some Performance Metrics

(provided ranges are just for illustration)

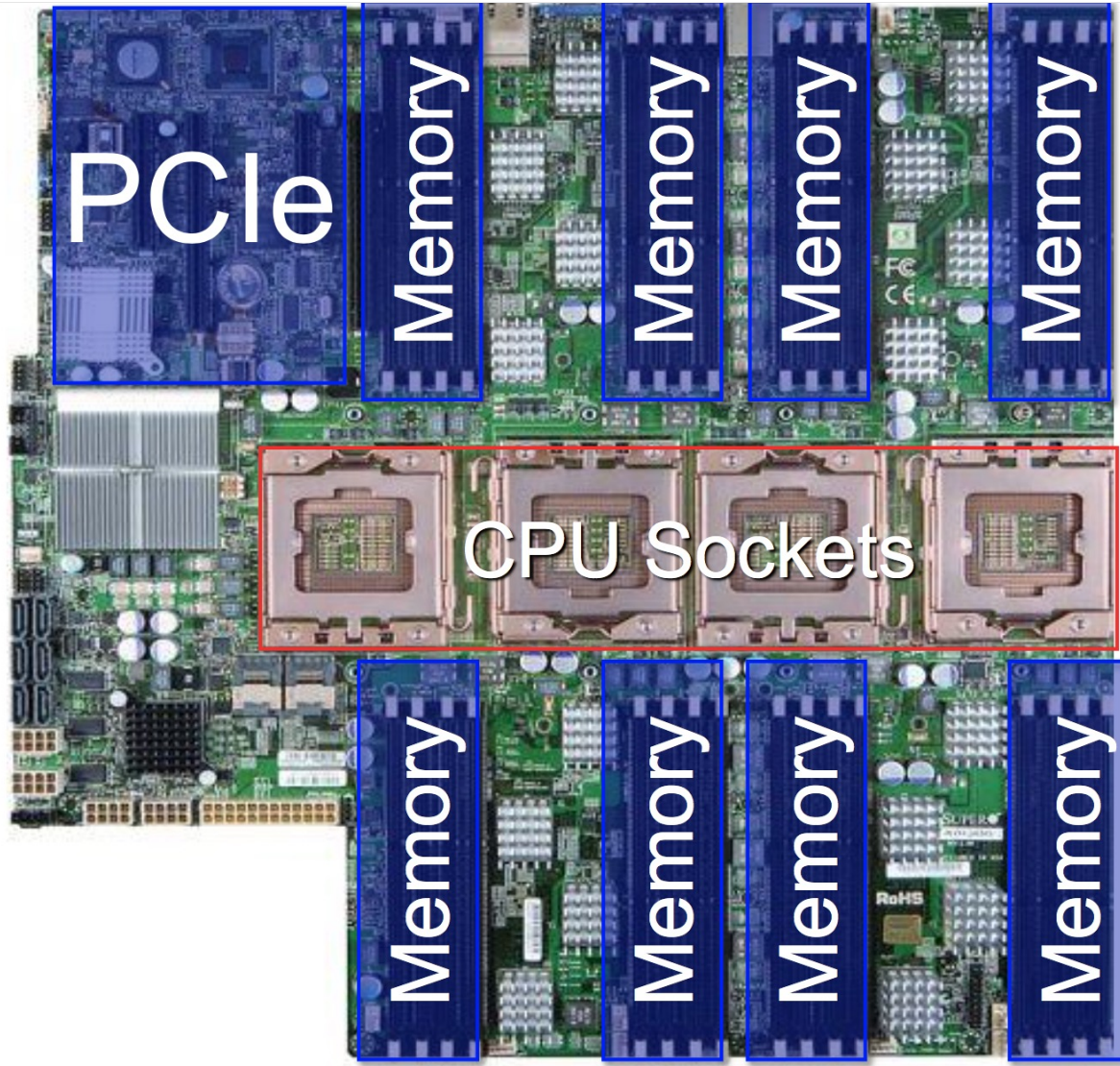


A Northbridge / Southbridge Hardware Layout

Generates clock signals
(e.g. used for system synchronization)



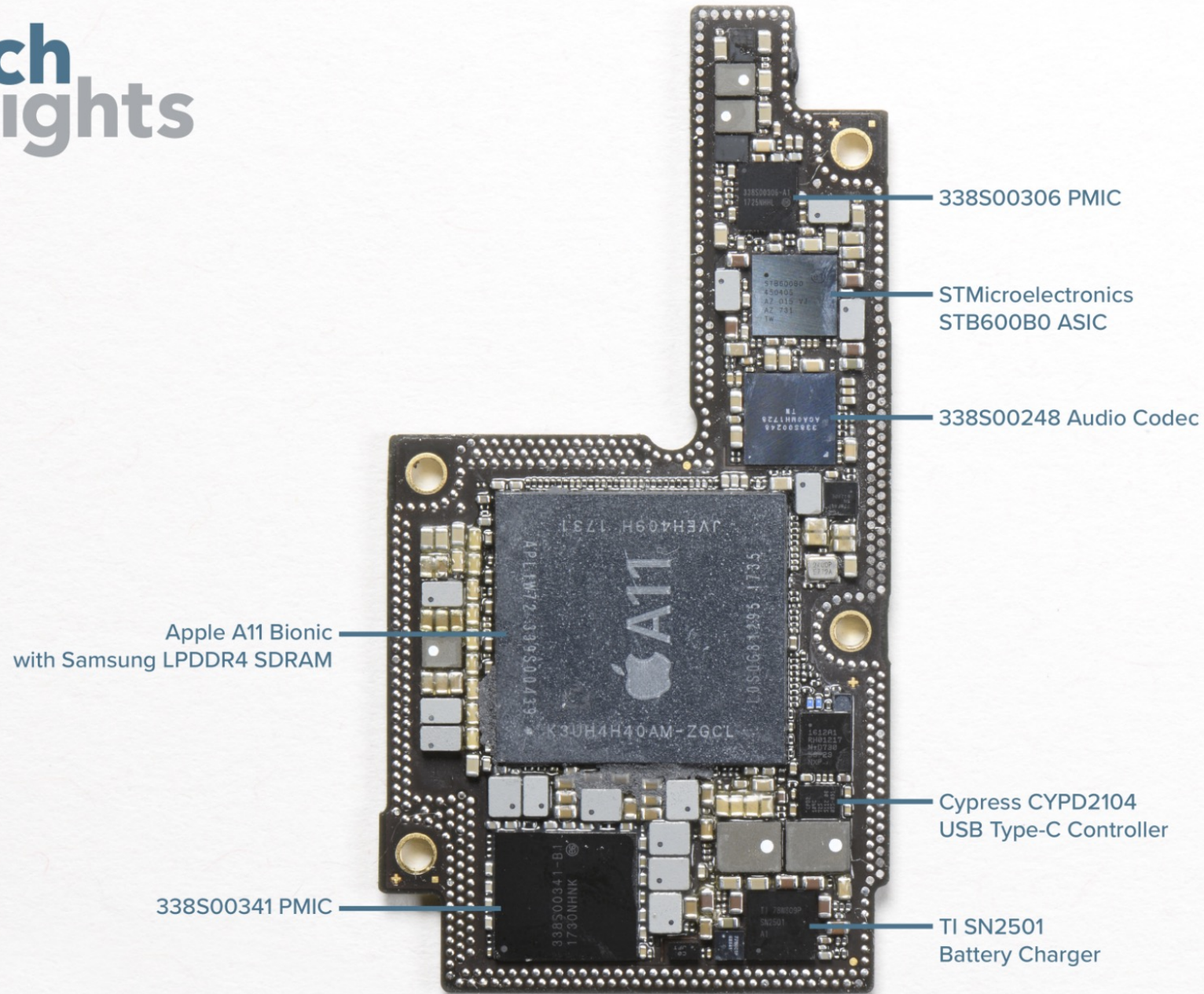
Example: Computer Server Architecture



Server has multiple CPUs and system memory slots

Another Example: iPhone X Architecture

Tech
Insights



Computer Systems are Omnipresent

(including general-purpose computers and embedded computers)



Many more...

Acknowledgment

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