COMPUTER ARCHITECTURE AND SOFTWARE EXECUTION PROCESS

MEMORY MANAGEMENT

Bachelor in Artificial Intelligence, Data and Management Sciences
CentraleSupelec and ESSEC Business School - 2024/2025

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OUTLINE

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MEMORY FOR WHOM AND WHY?

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For the operating system

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- When a machine is started, the **OS** is the **first program** loaded into memory.

- The **OS** needs a **memory space** for :
  - the **code** of its **Core**
  - the **interruptions** table
  - the **processes** table
  - data structures (**PCBs** and others)
  - ...

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- For **security** reasons, each **process** must use a separate memory area (**an address space**).

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For processes (running programs)

- When a process is created, the **OS creates a PCB** and allocates memory for the process.
- For **security** reasons, each **process** must use a separate memory area (**an address space**).
  - ➠ which mechanism for **allocating** this space ?
  - ➠ how to ensure the **protection** of this area ?
  - ➠ how to ensure the **transparency** of this space ?

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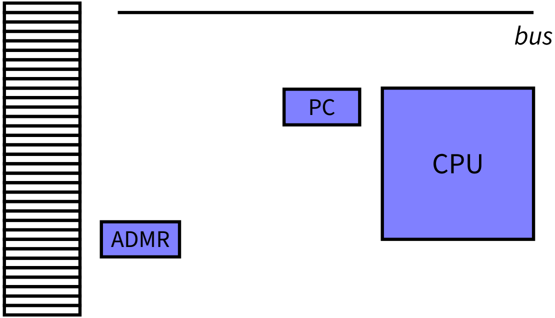

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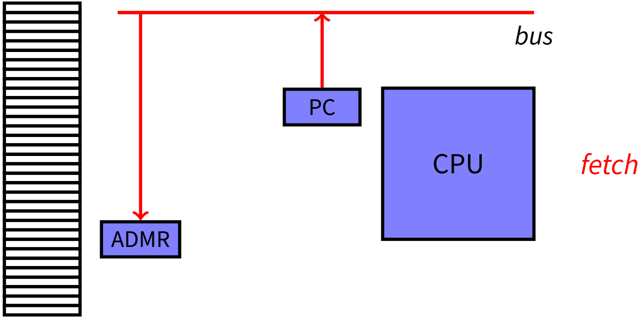

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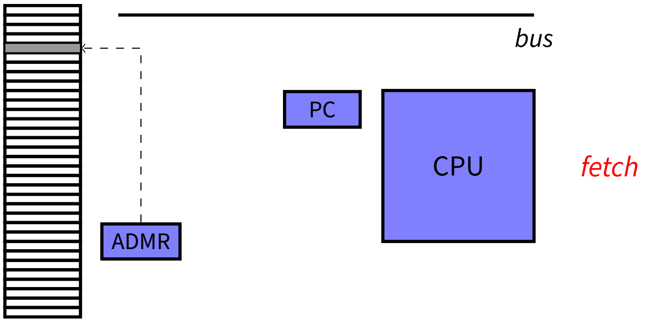

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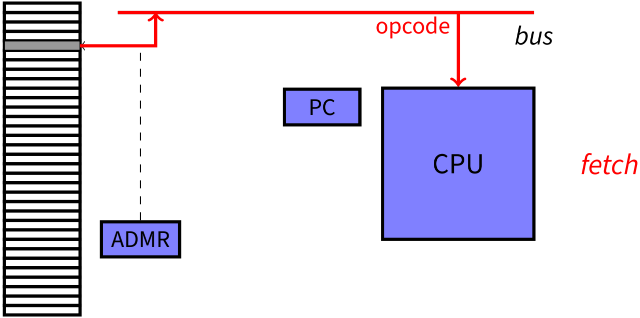

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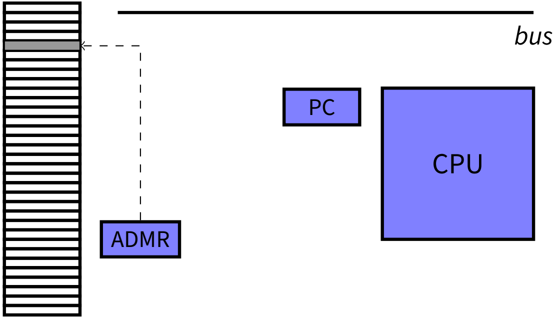

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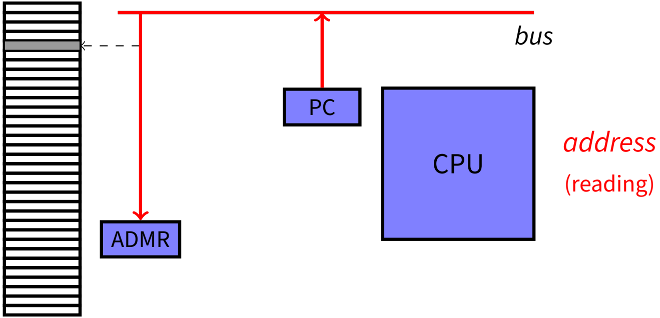

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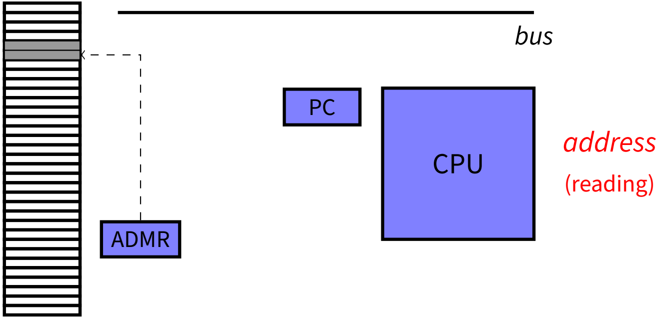

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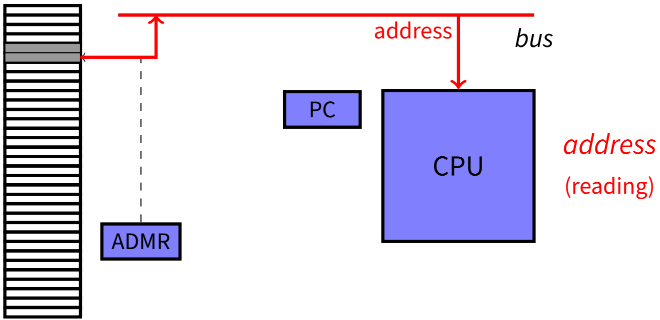

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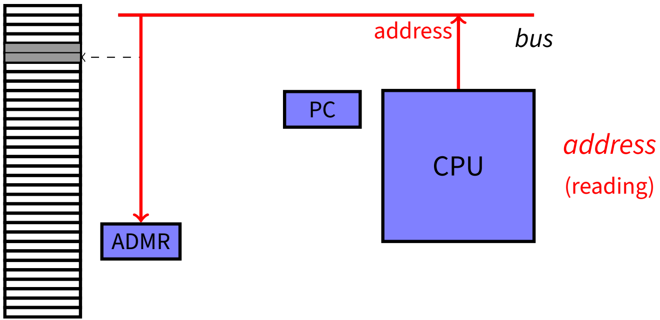

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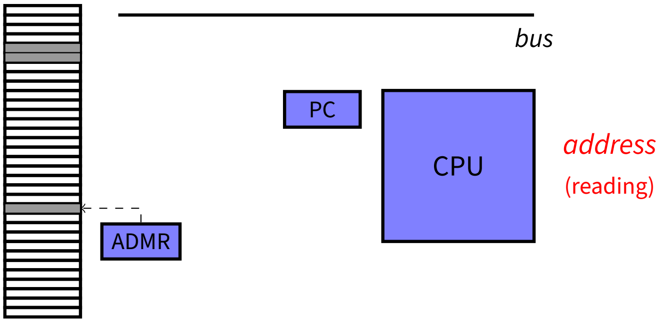

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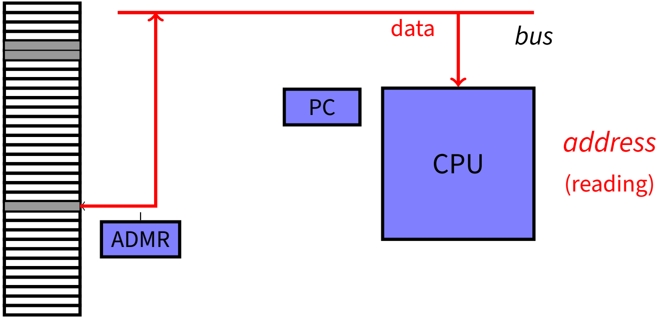

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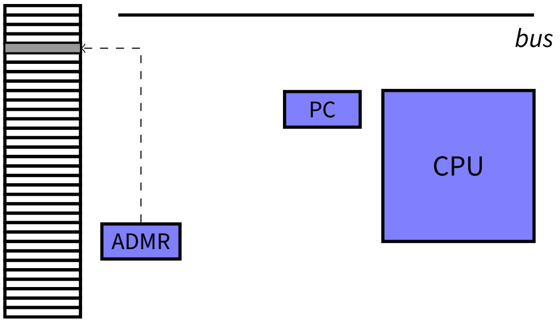

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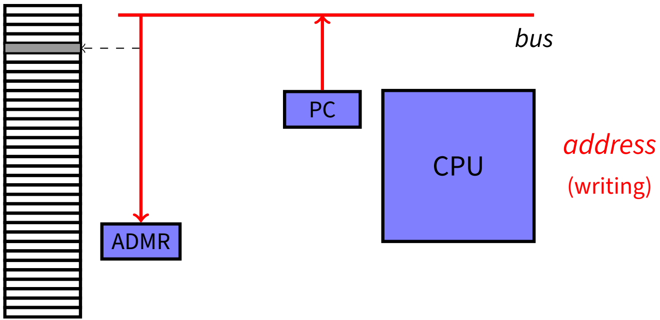

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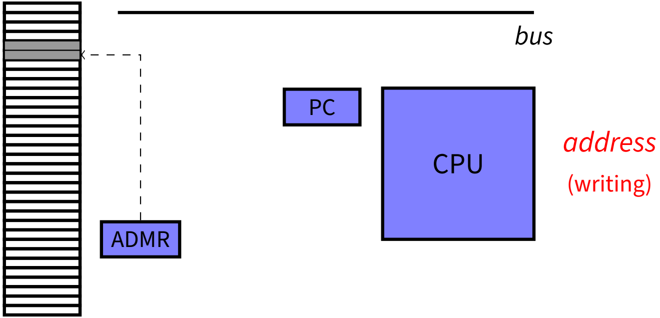

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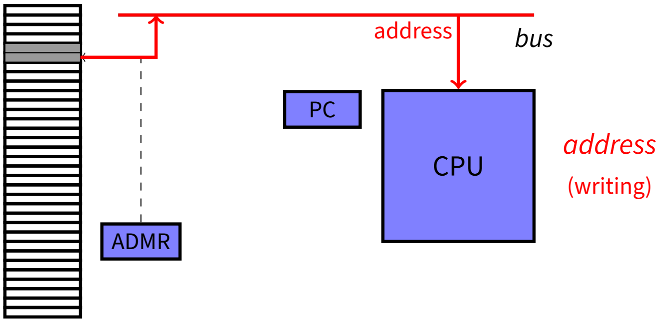

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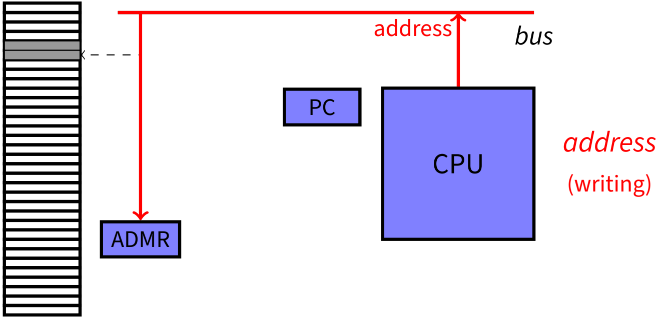

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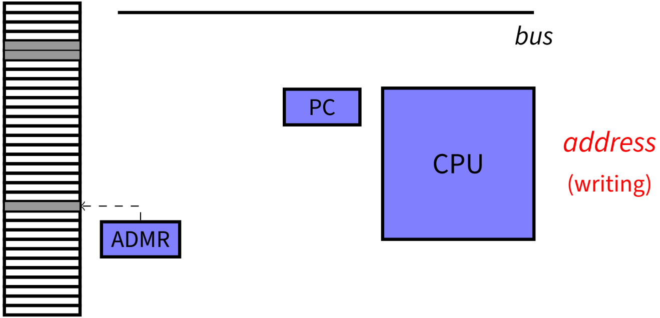

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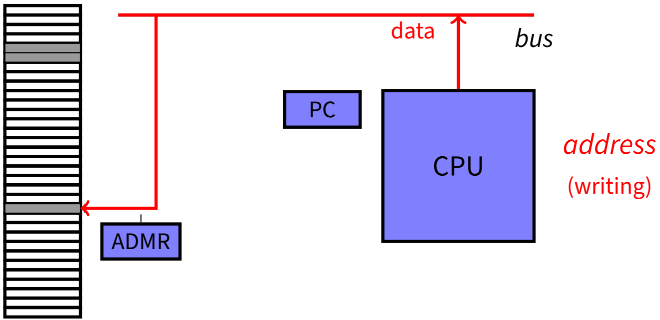

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- **Example** : 32 bits $\rightarrow 2^{32} \approx 4$ GB

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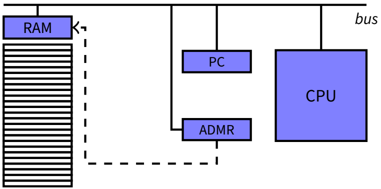
HOW MEMORY WORKS



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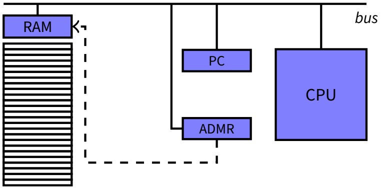
- The **CPU** will fetch instructions from memory **by using their address** (*fetch*) ;



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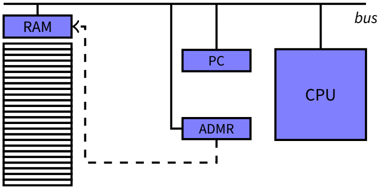

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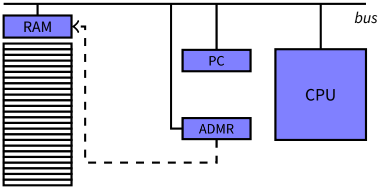
- The **CPU** writes on variables **at a given address** in memory.



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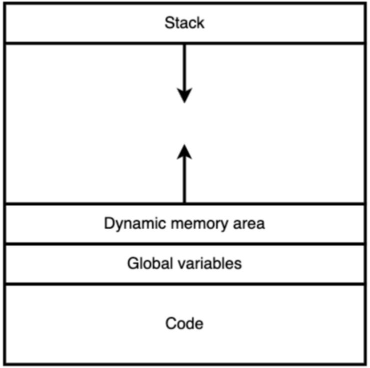
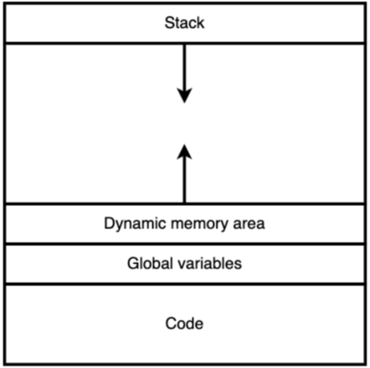
ADDRESS SPACE USAGE

- What does a process's memory space contain ?



ADDRESS SPACE USAGE

- What does a process's memory space contain ?
  - Code (known size)
  - Global variables (known size)
  - Stack (unknown size)
  - Dynamic memory area (unknown size)
  - ...



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Question
what are the addresses of the variables in memory?

PROGRAM VS PROCESS

symbolic addresses vs **memory** addresses

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int a = 3;
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    mov ebx, 2
    add ecx, eax, ebx
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Link editing

When creating processes, the **OS instantiates** the program.

➠ transform **names** of variables into **addresses**.

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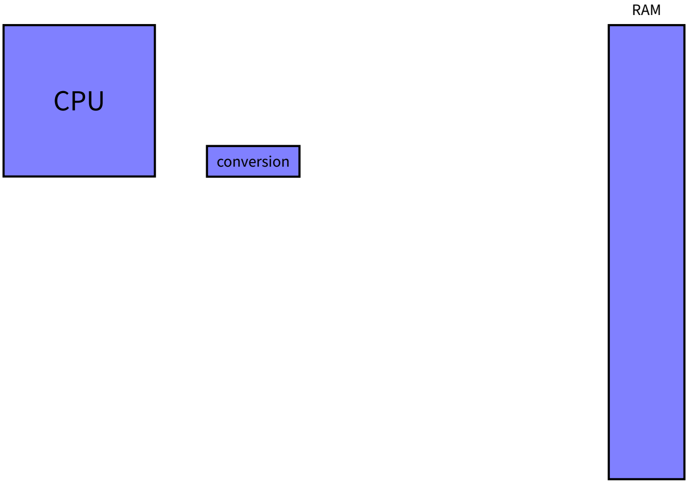
ADDRESS RESOLUTION

MEMORY MANAGEMENT UNIT - MMU



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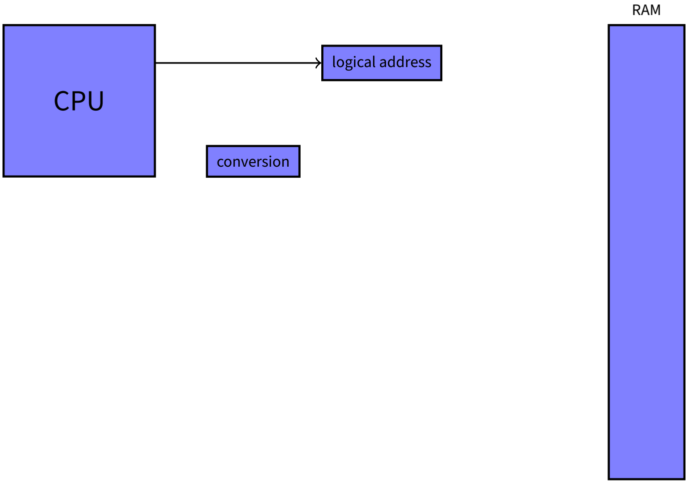

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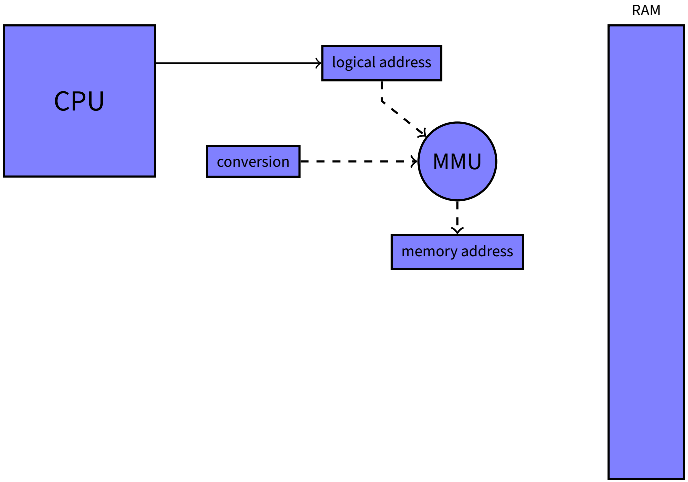

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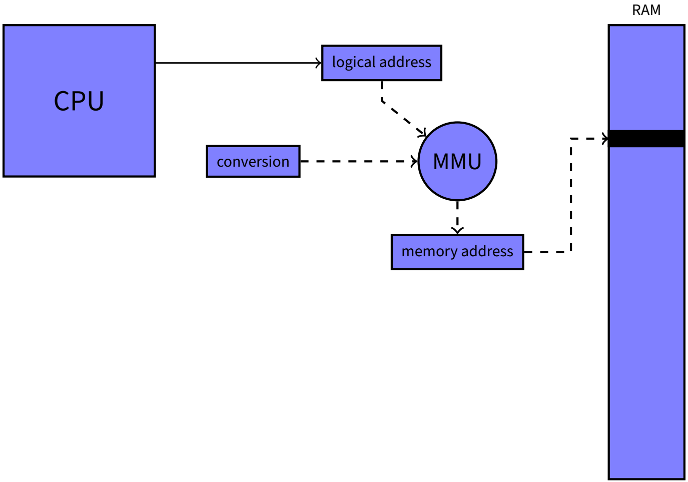

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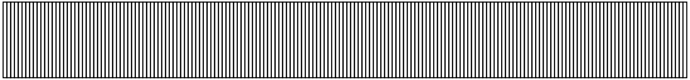
  2. **Non-contiguous allocation** (**by pagination**)

MULTIPROGRAMMING WITH PARTITIONS

Process constitutes **a single, non-decomposable block.**

RAM



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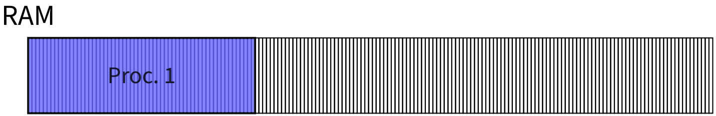

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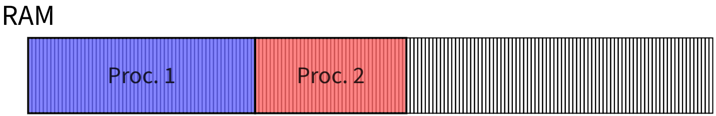

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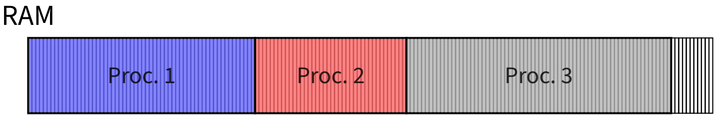

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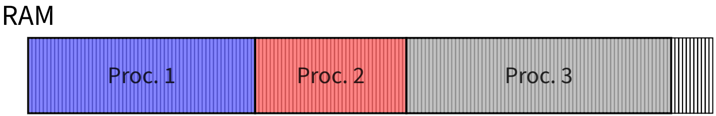

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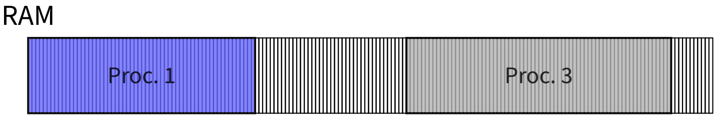

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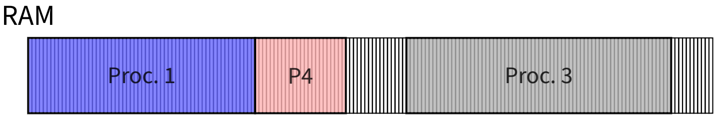

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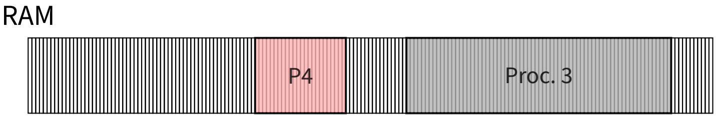

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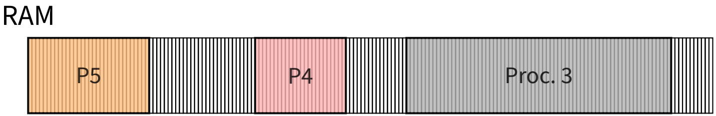

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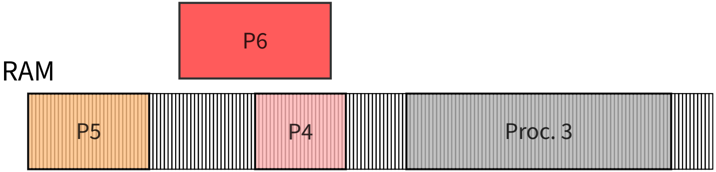

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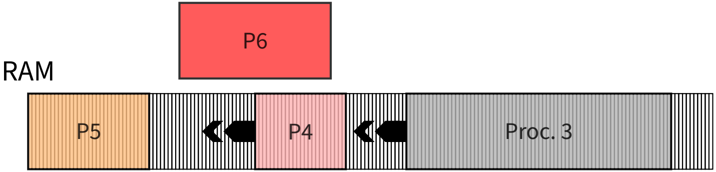

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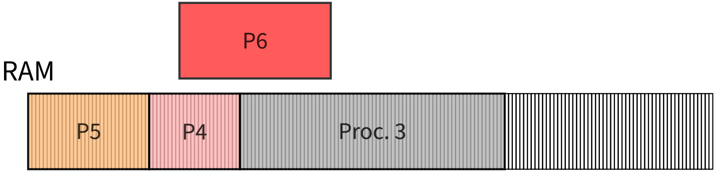

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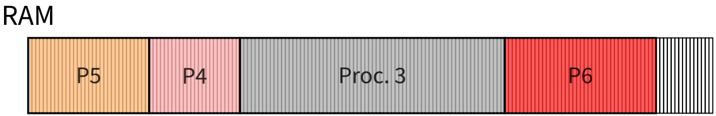

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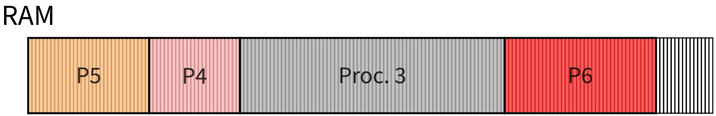

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MULTIPROGRAMMING WITH PARTITIONS

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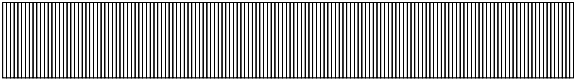
MULTIPROGRAMMING WITH PAGING

RAM



Process :

code, libraries
environment, heap, stack…

MULTIPROGRAMMING WITH PAGING

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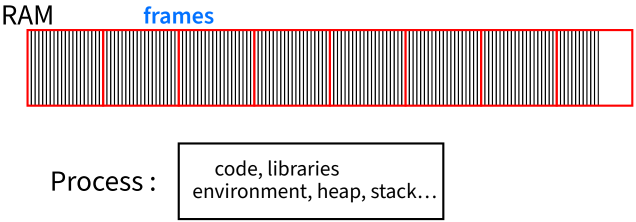

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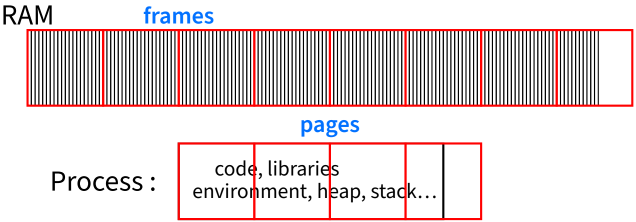

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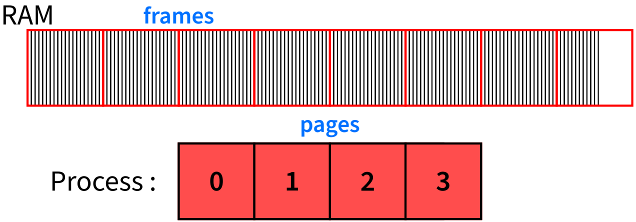

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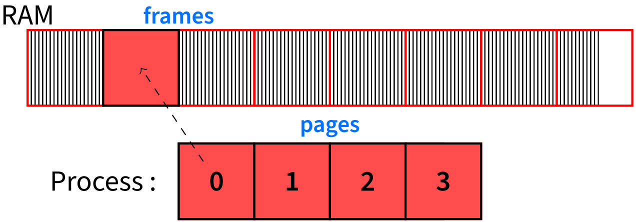

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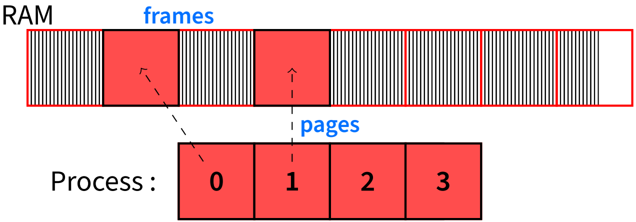

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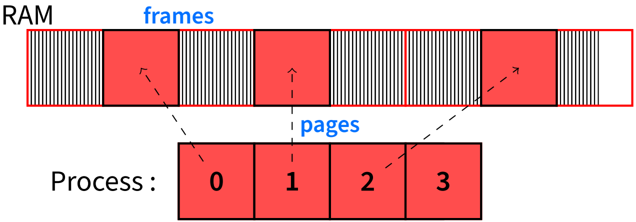

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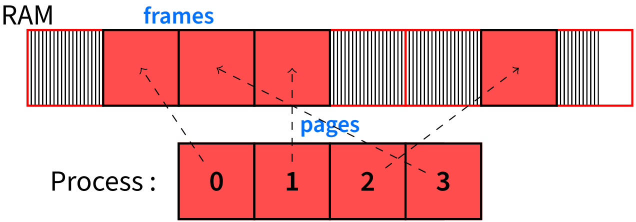

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MULTIPROGRAMMING WITH PAGING

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- **Virtual memory** : load only the pages that the process needs.

MULTIPROGRAMMING WITH PAGING

ADDRESSING

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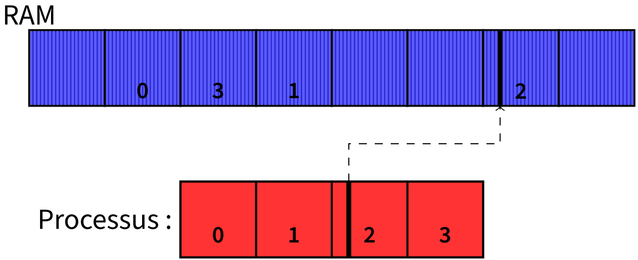

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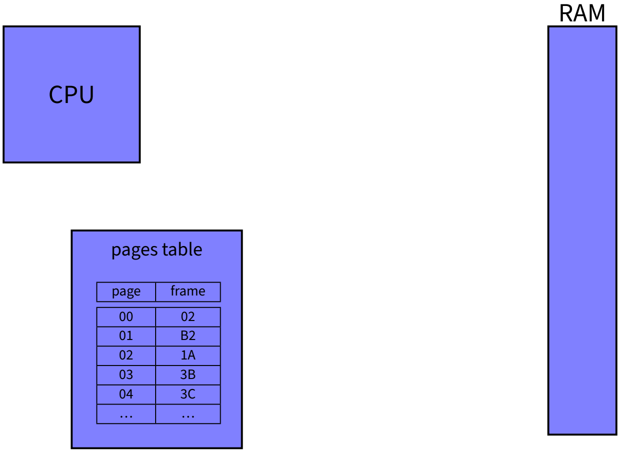

page	frame
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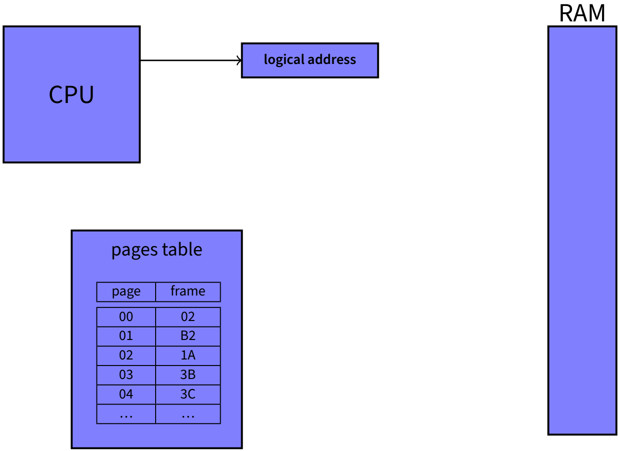

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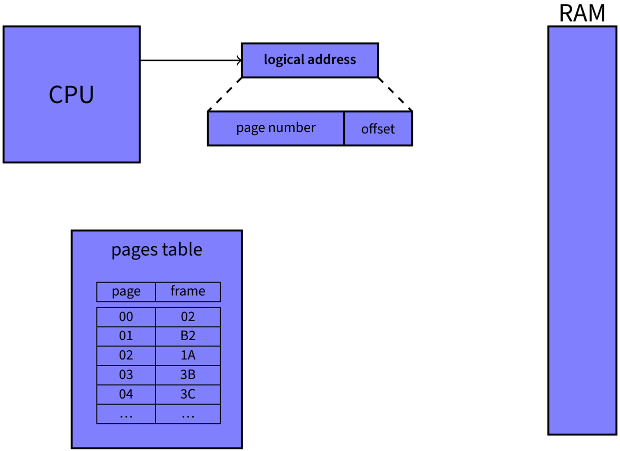

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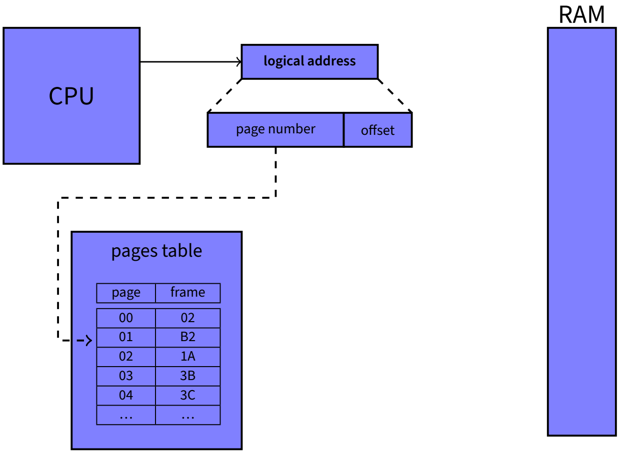

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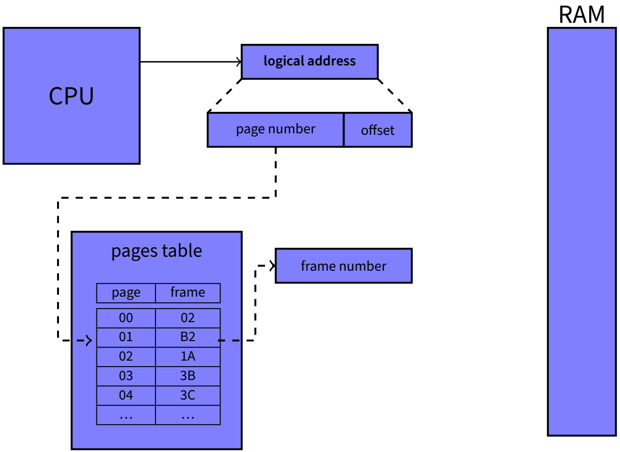

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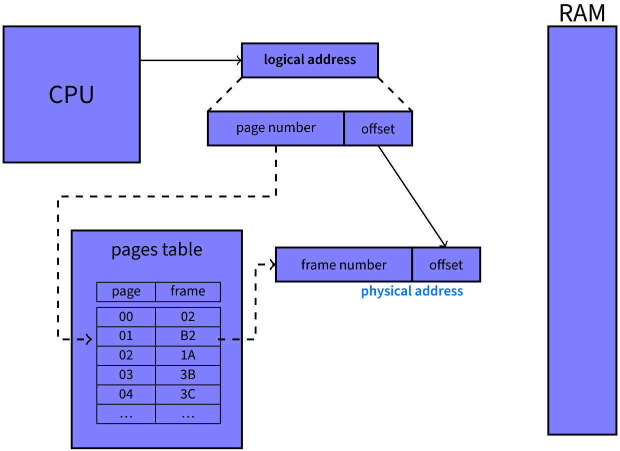

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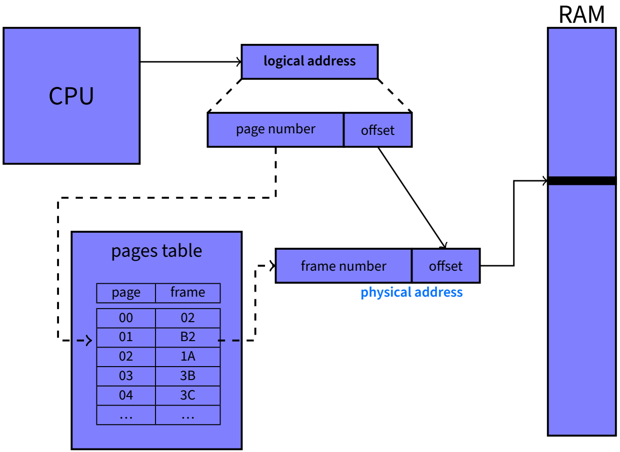

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OUTLINE

Back to the begin - Back to the outline

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MEMORY STATE

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MULTIPROGRAMMING WITH VIRTUAL MEMORY

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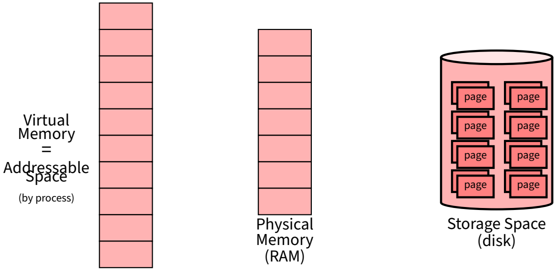

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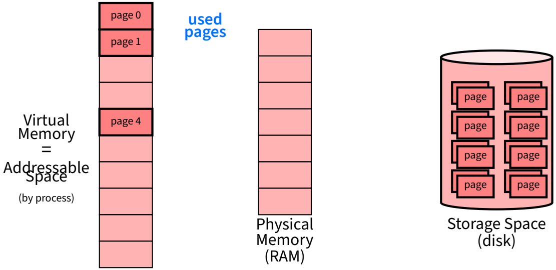

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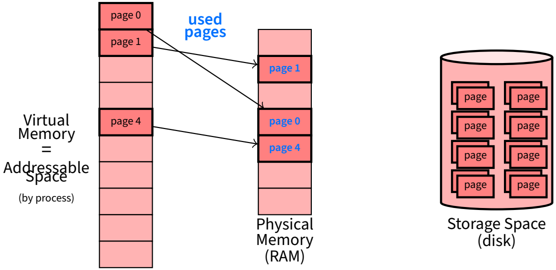

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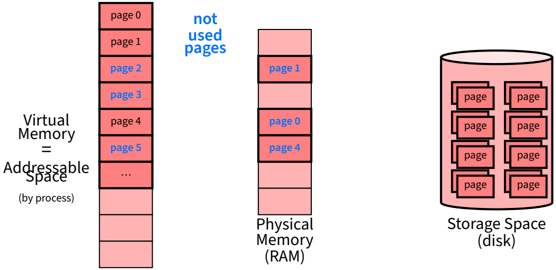

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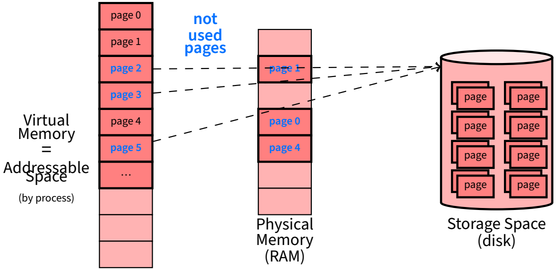

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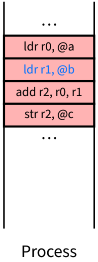

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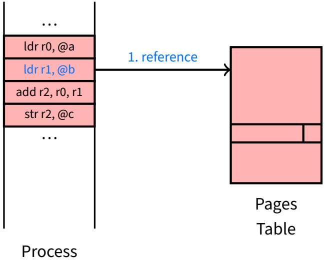

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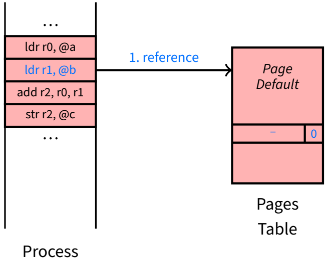

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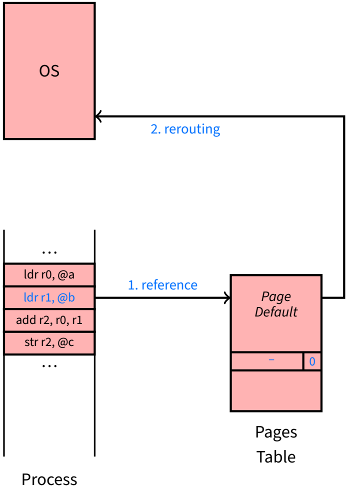

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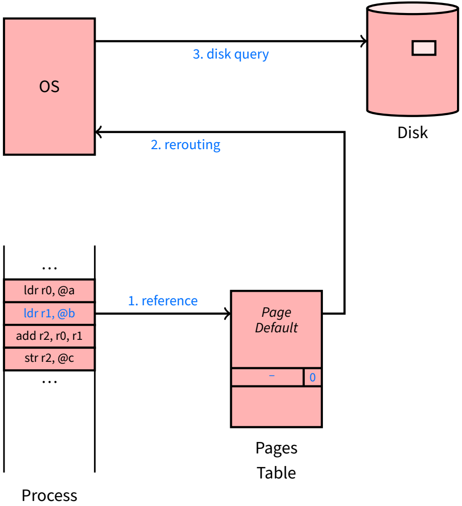

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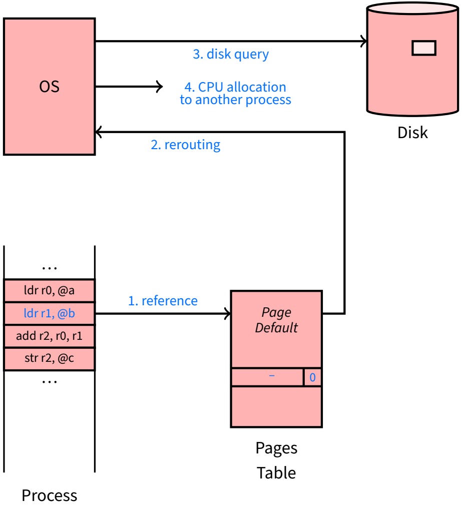

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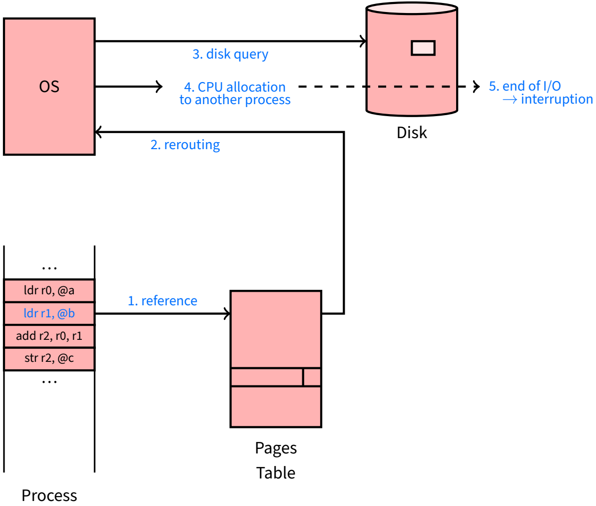

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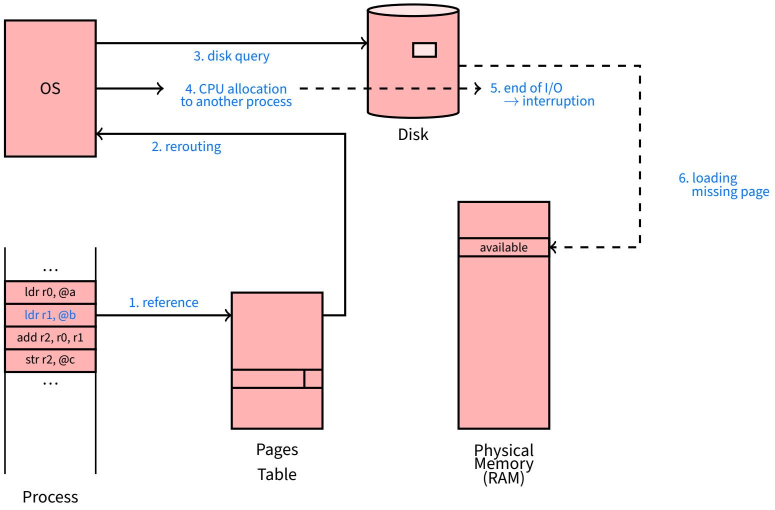

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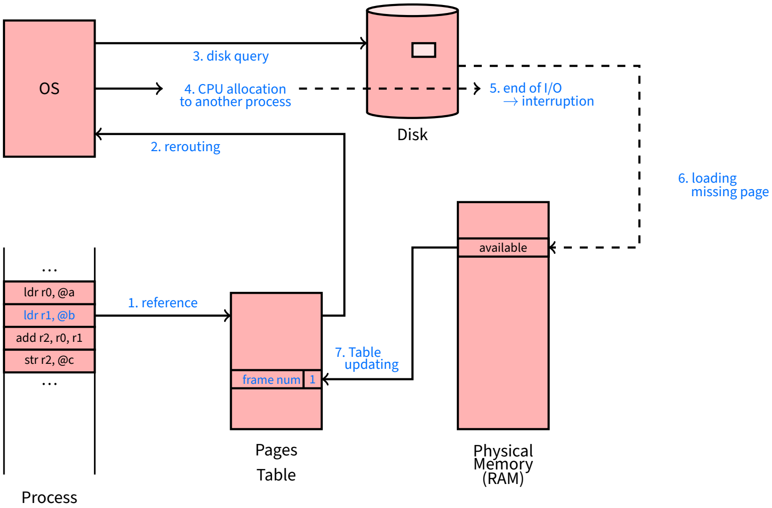

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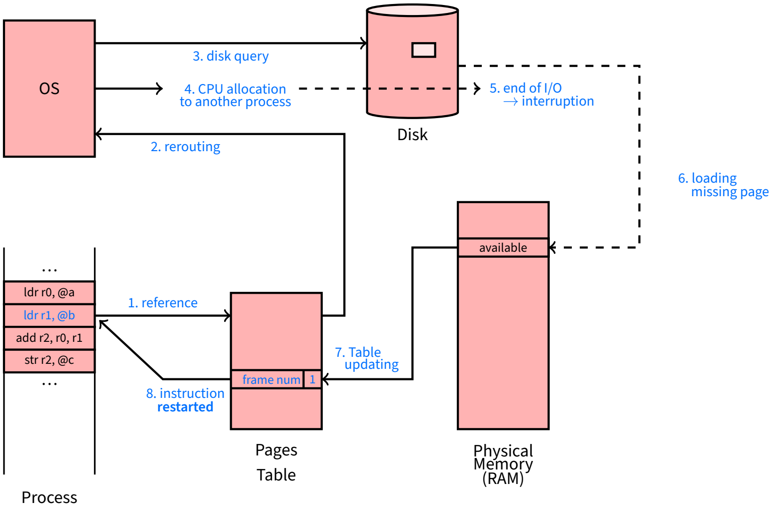

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