Operating Systems

Lecture 9: Limited Direct Execution + Memory Virtualisation

Nipun Batra

Aug 23, 2018

Administrative

1. Next Wednesday answer sheets in lab session
2. Projects - list would be available on Monday
    1. Project 5 -> 8% (3% reduced from homework)
    2. More details on Tuesday…

Space v/s Time Multiplexing

Time multiplexing : Share resource by dividing over time

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1. CPU scheduling on single core

Space v/s Time Multiplexing

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3. Class room scheduling - single class runs in at any given point of time

Space v/s Time Multiplexing

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4. TDMA??

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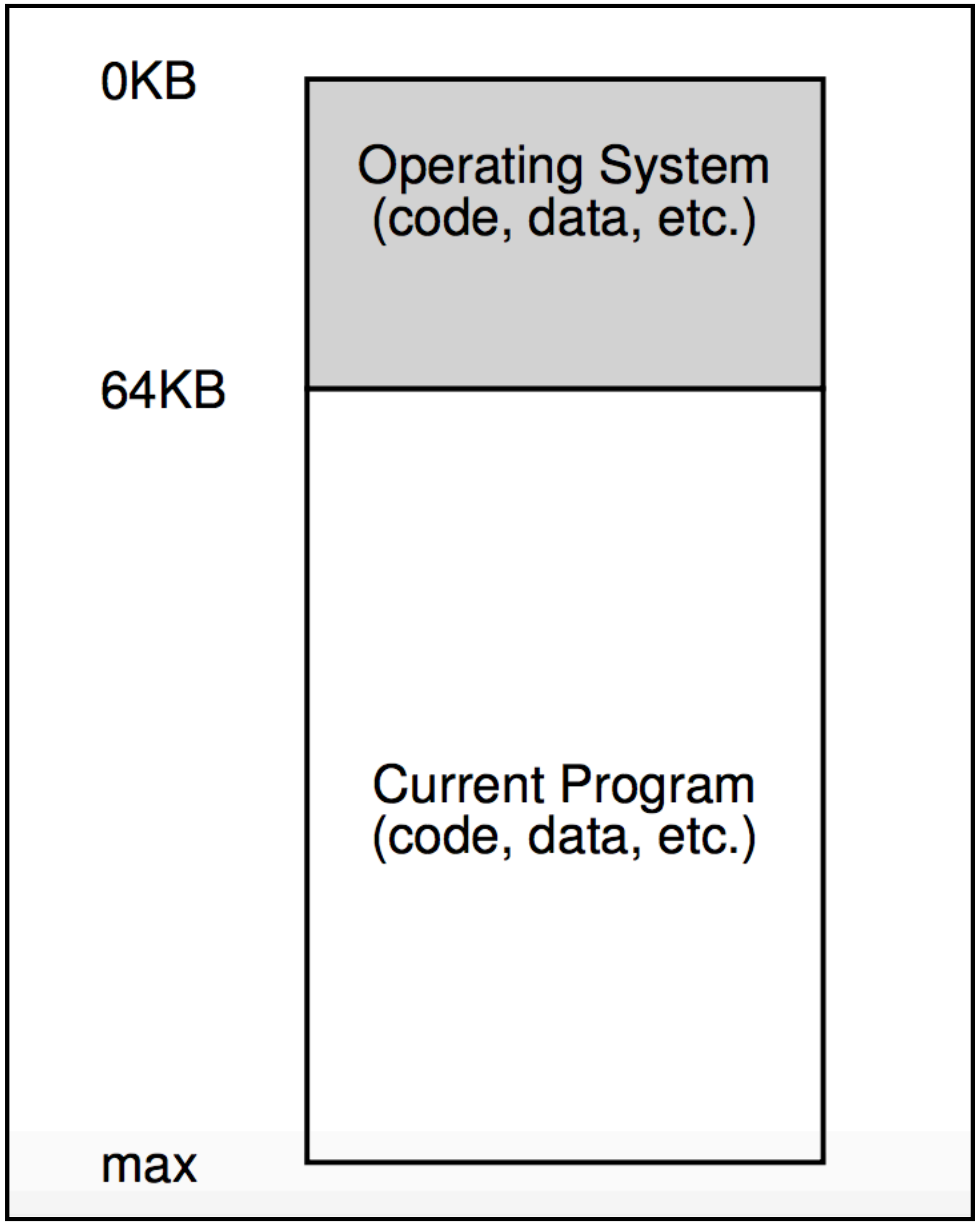
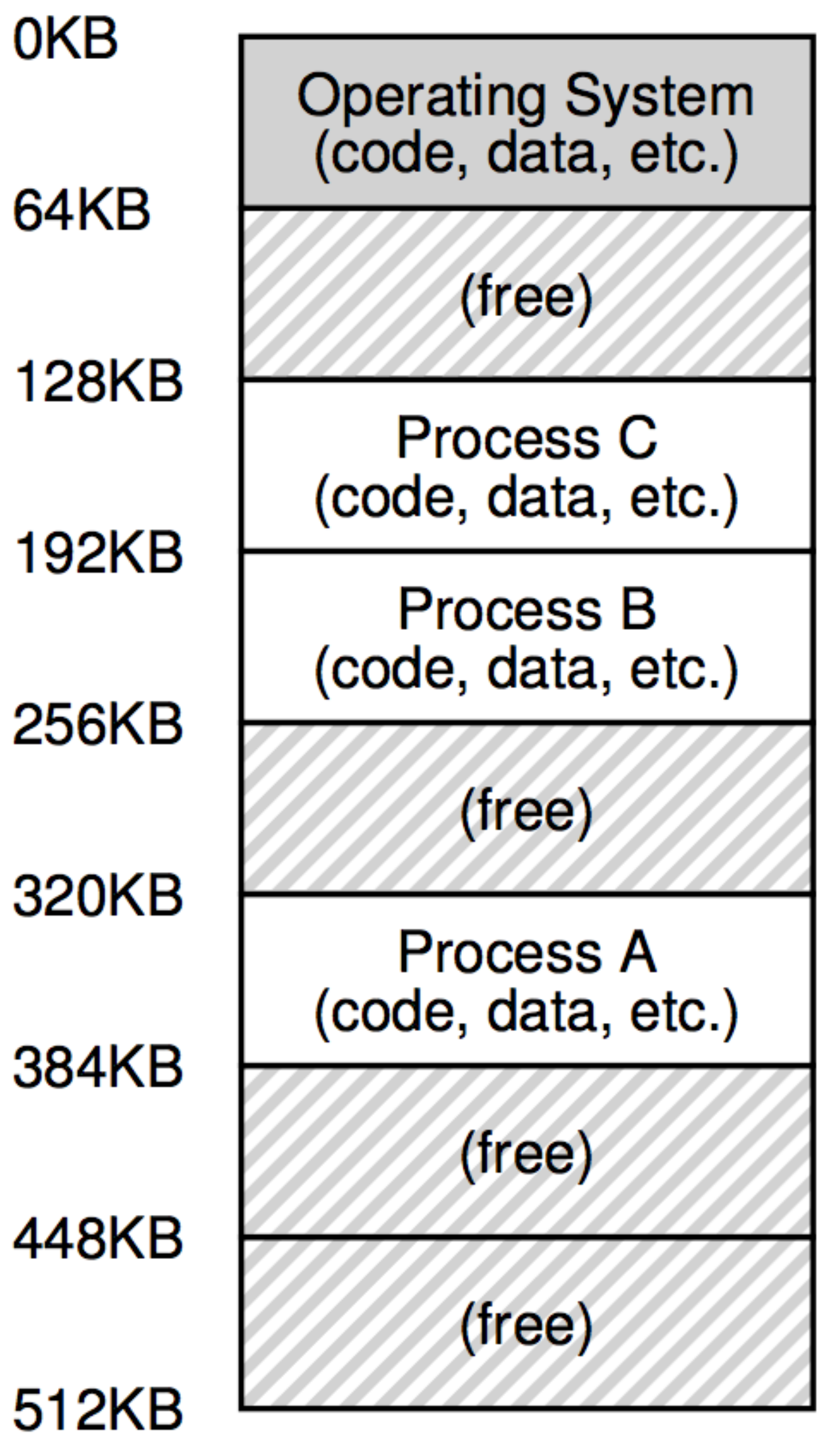
1. CPU scheduling on multiple cores?
2. Cake sharing
3. Think more?
4. Memory management

Memory Virtualisation

Early days
Single program



Shared Memory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Operating System (code, data, etc.)
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(free)
128KB
Process C (code, data, etc.)
192KB
Process B (code, data, etc.)
256KB
(free)
320KB
Process A (code, data, etc.)
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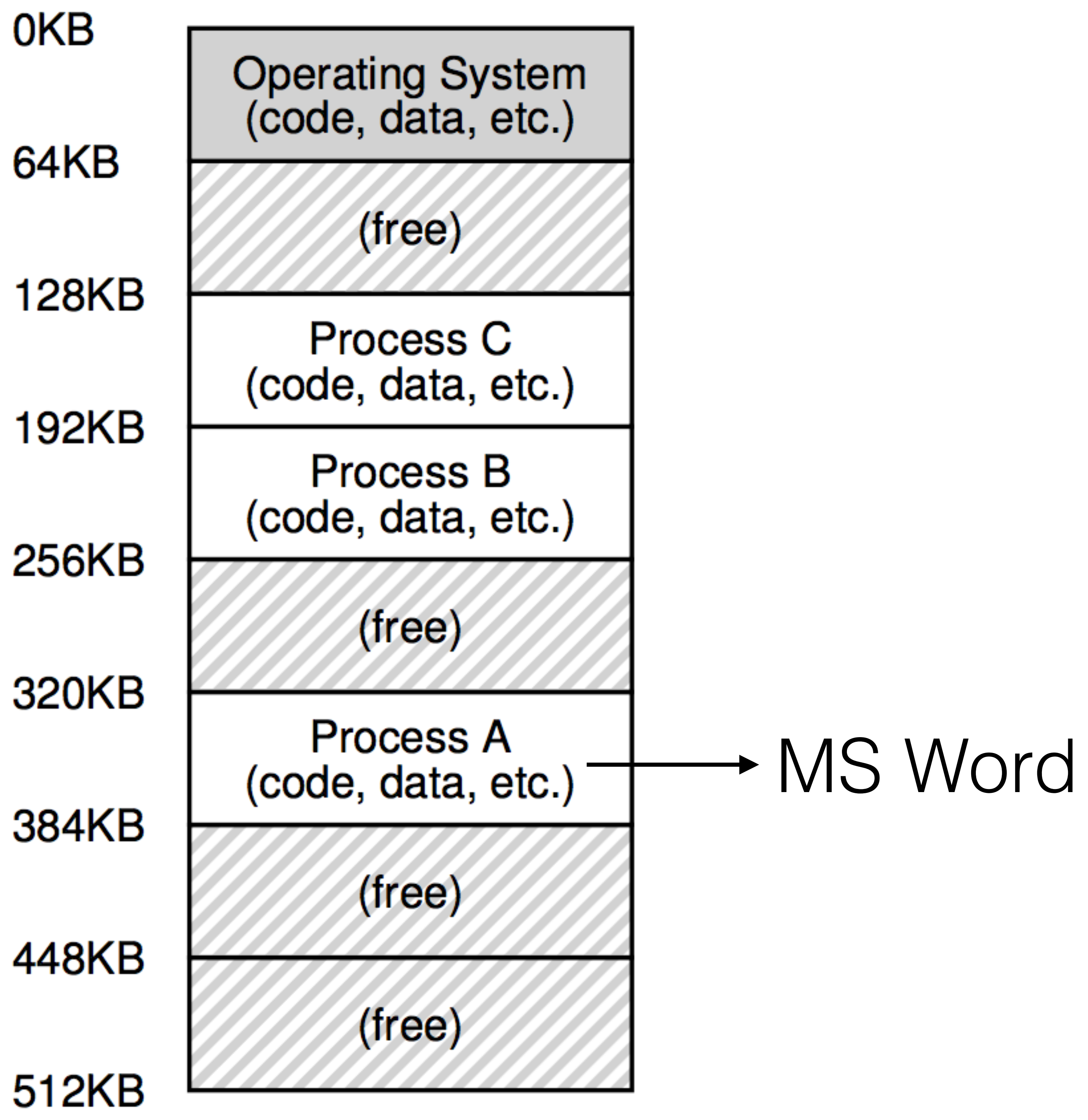
(free)
448KB
(free)
512KB

Shared Memory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MS Word
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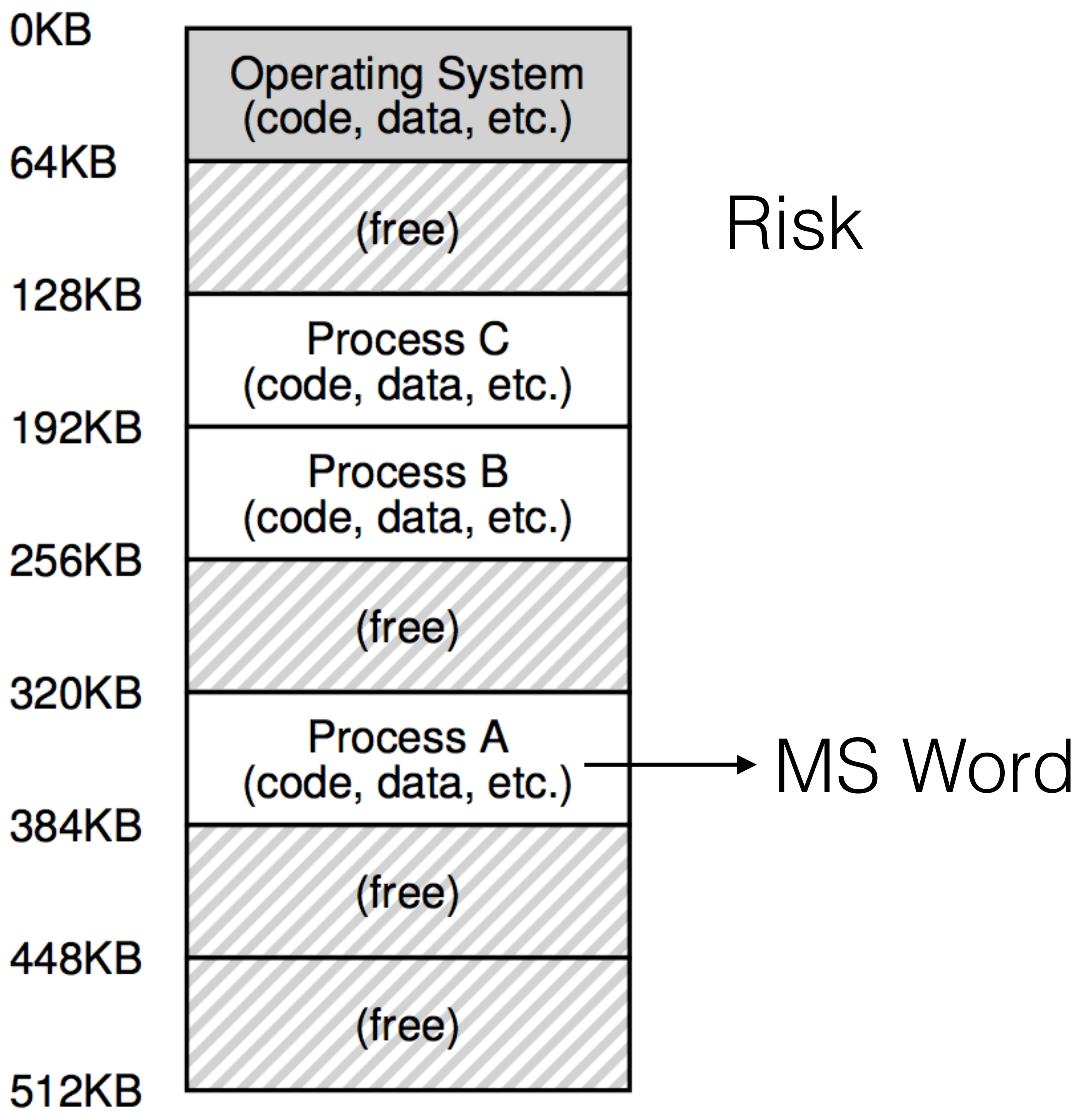
(free)

Shared Memory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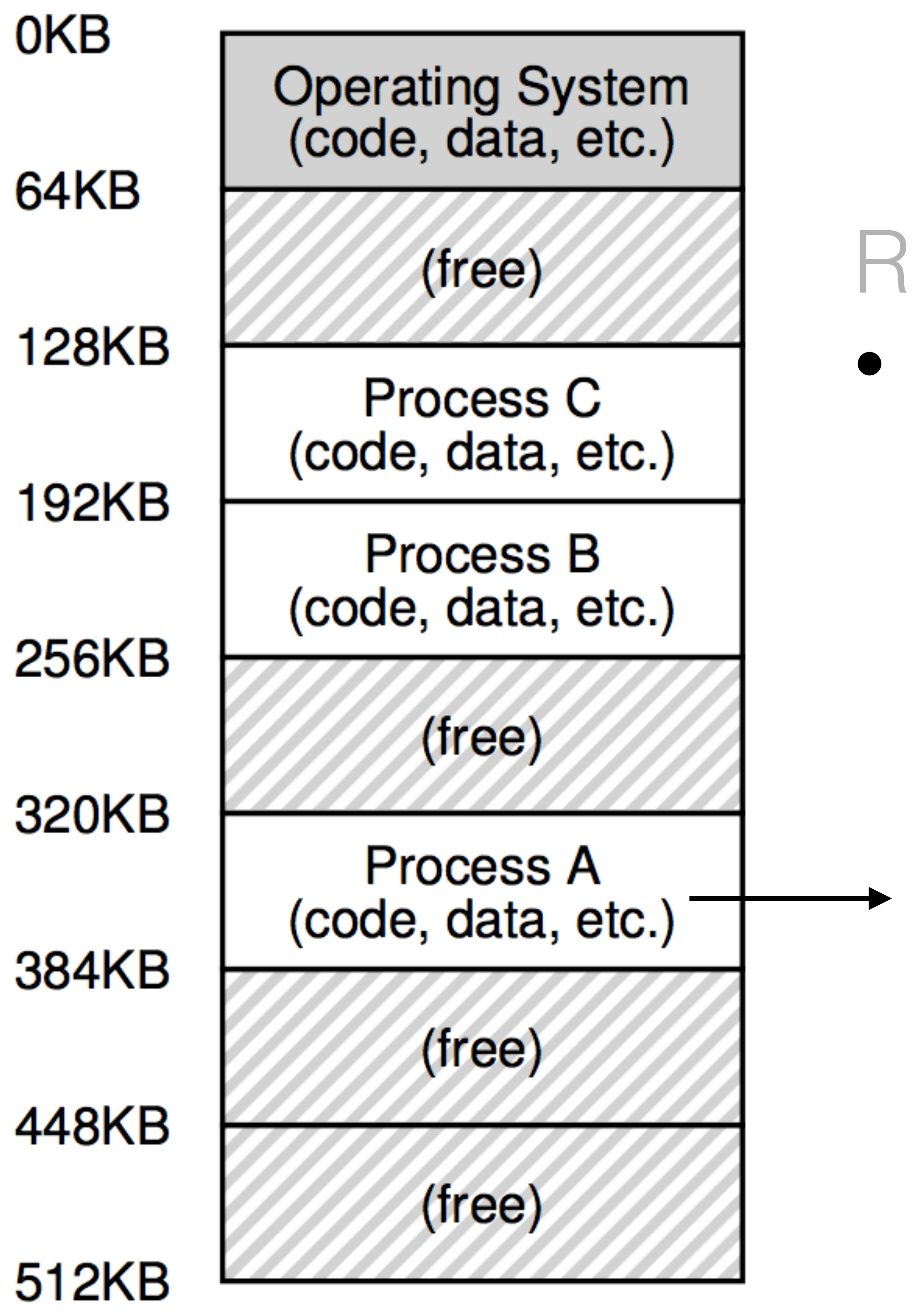
Risk

Shared Memory



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(free)

Risk

- Programs accessing others' memory

MS Word

Direct Physical Memory Multiplexing

CE
MTA16ATF1G64HZ-2G1B1 1619
8GB 2RX8 PC4-2133P-SBB-11
Product of CHINA DPAGB2M014

Direct Physical Memory Multiplexing

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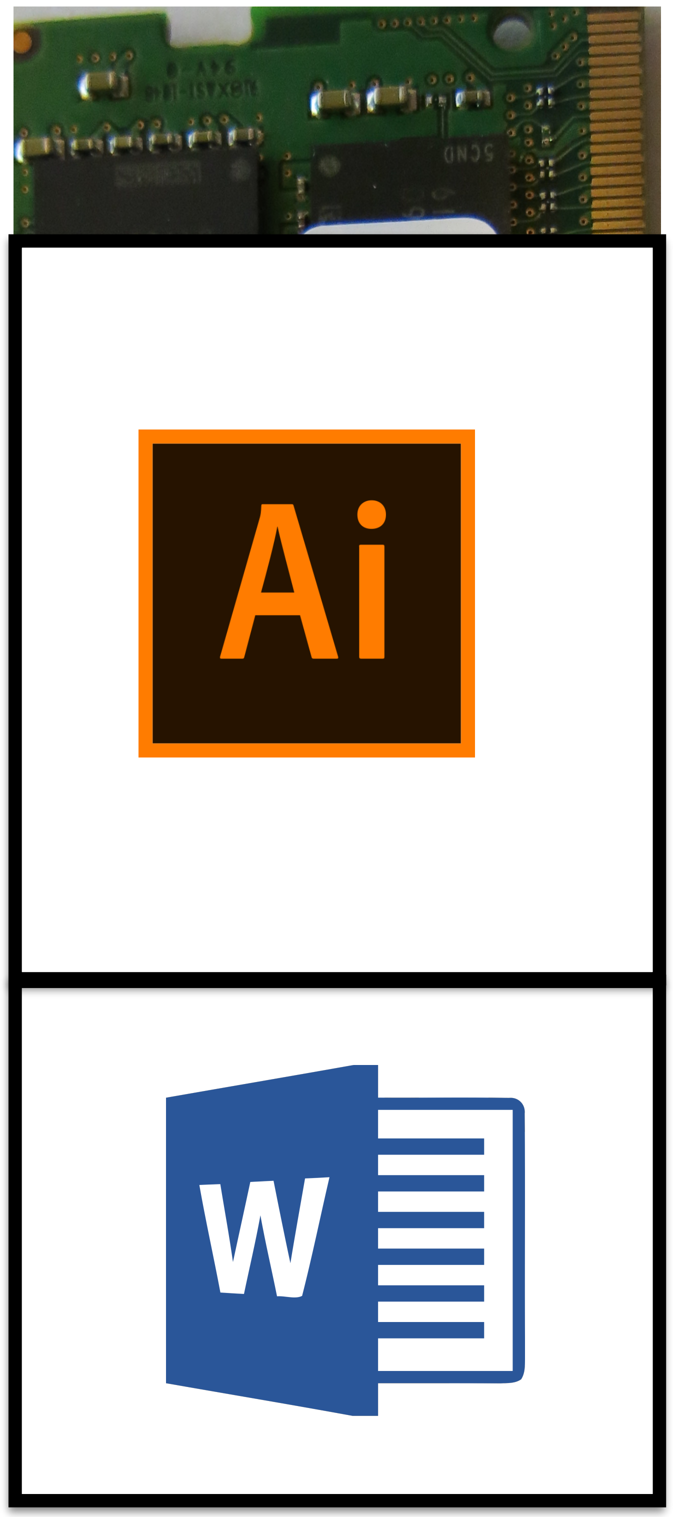

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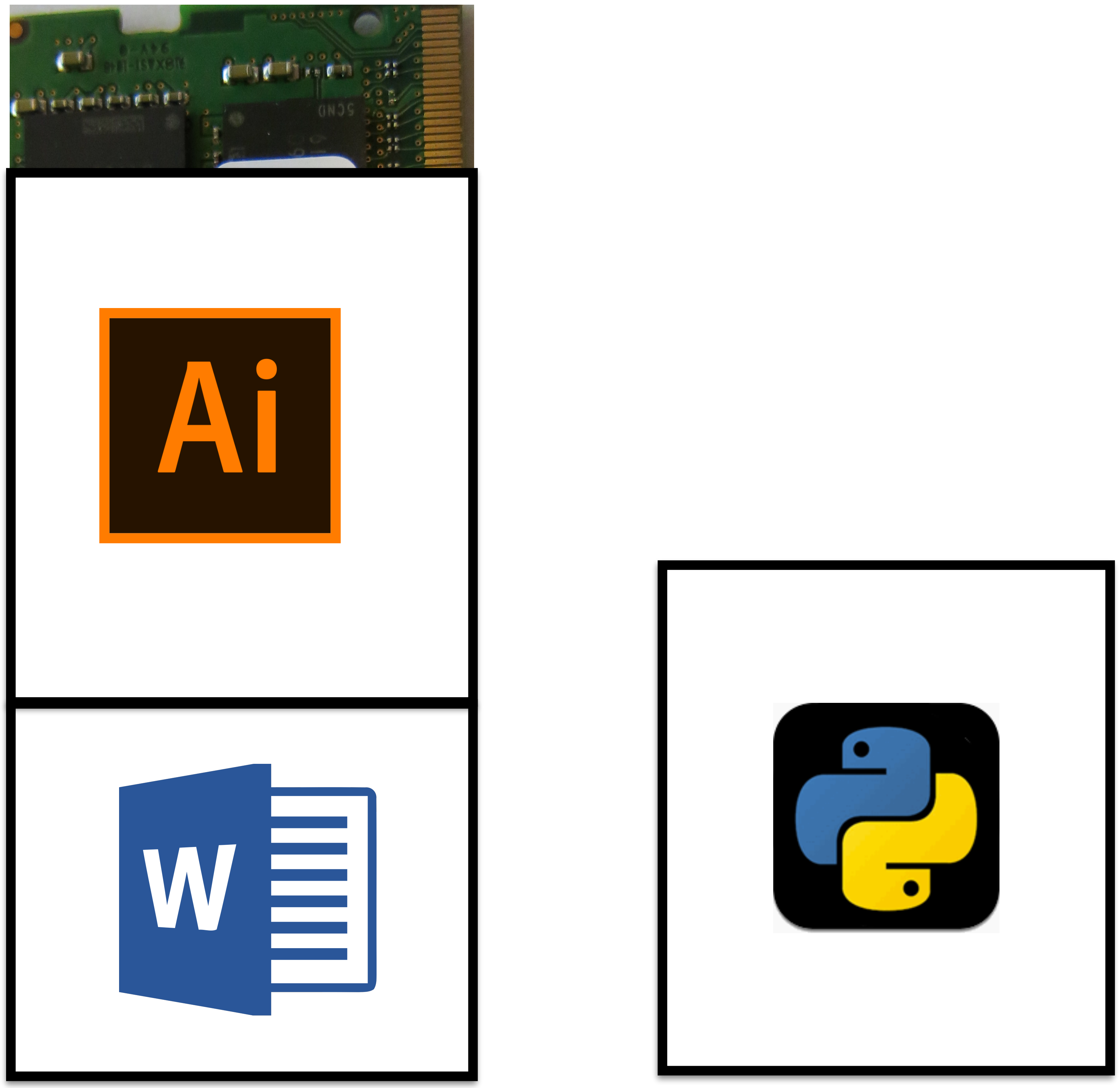
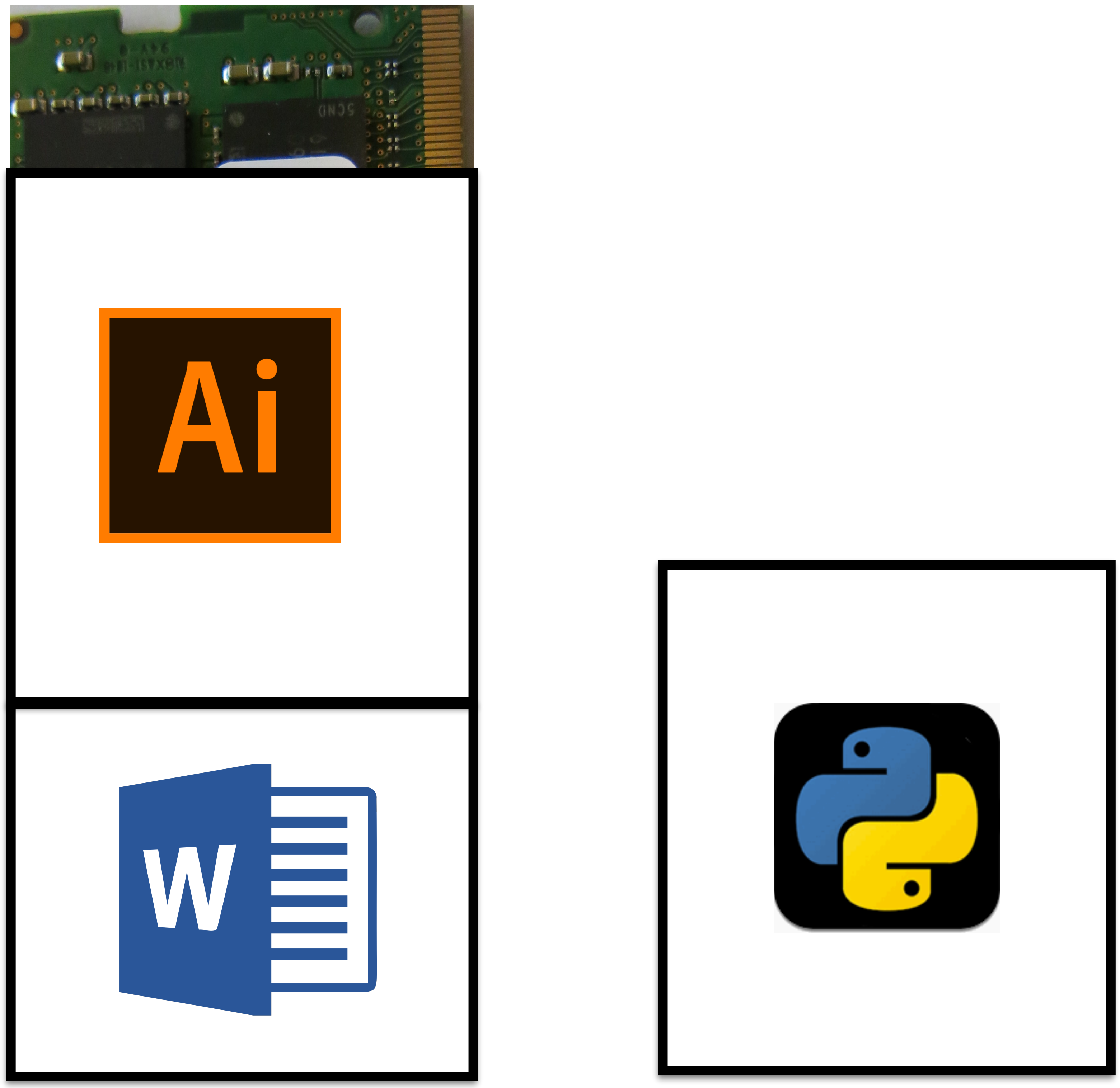


Direct Physical Memory Multiplexing

Limited to physical memory on the system



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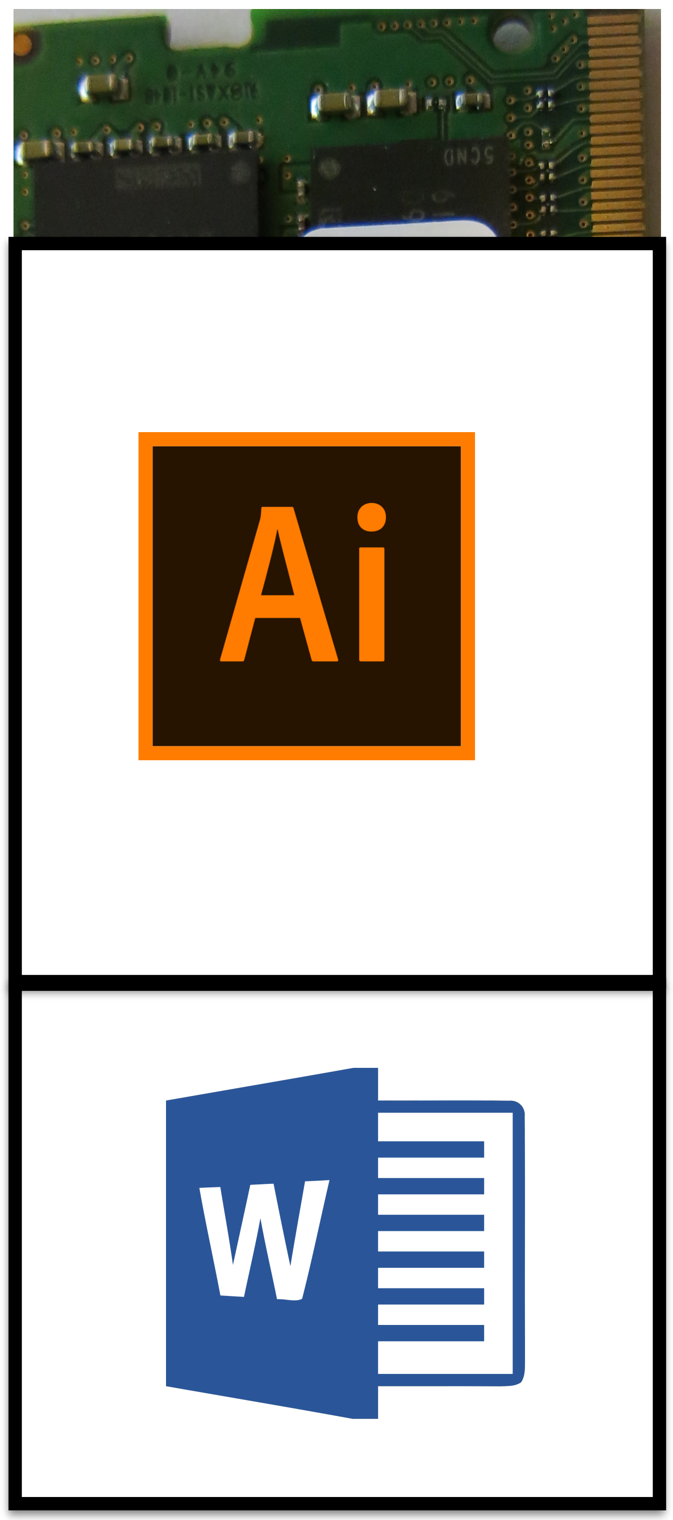

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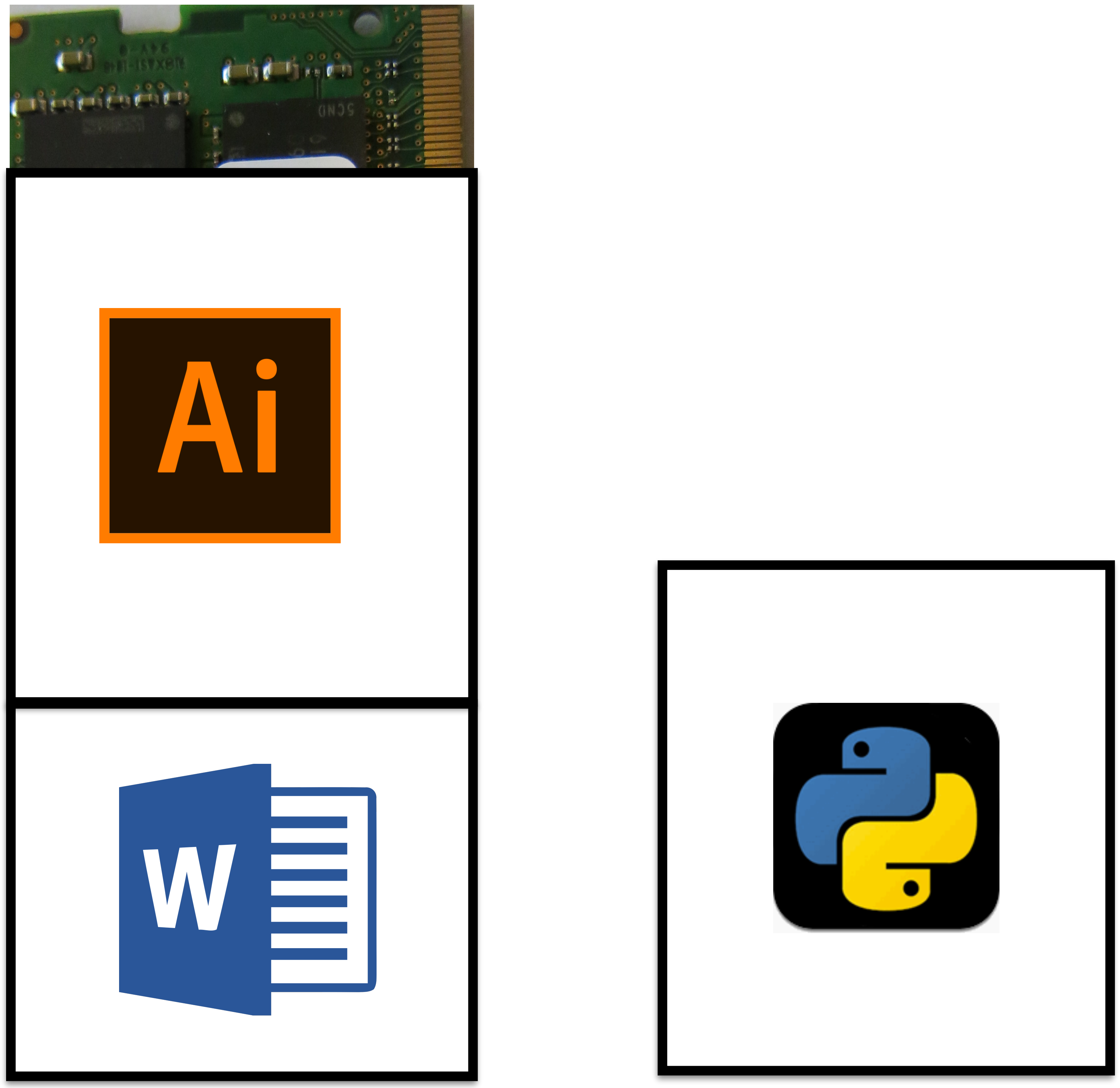

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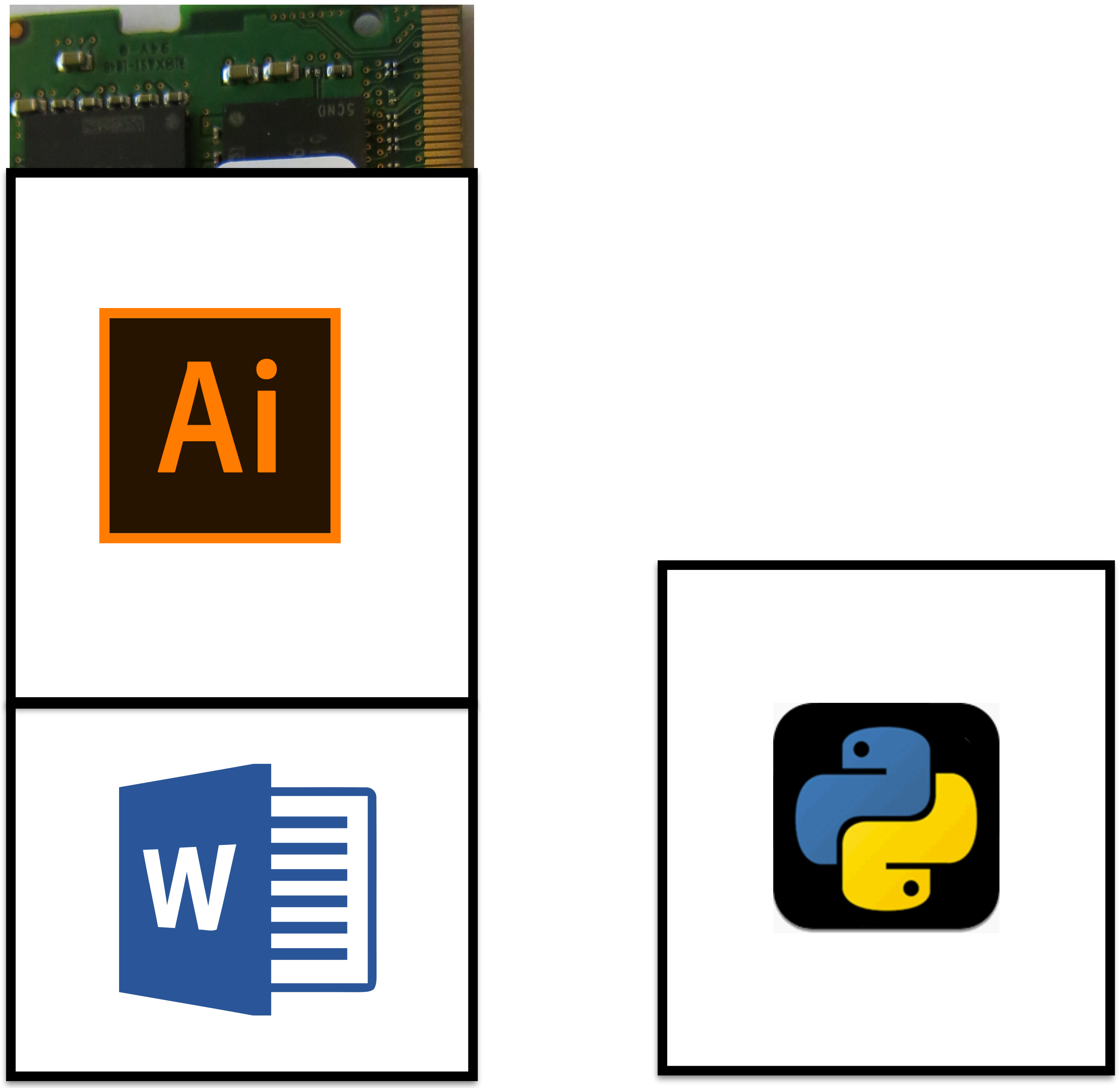

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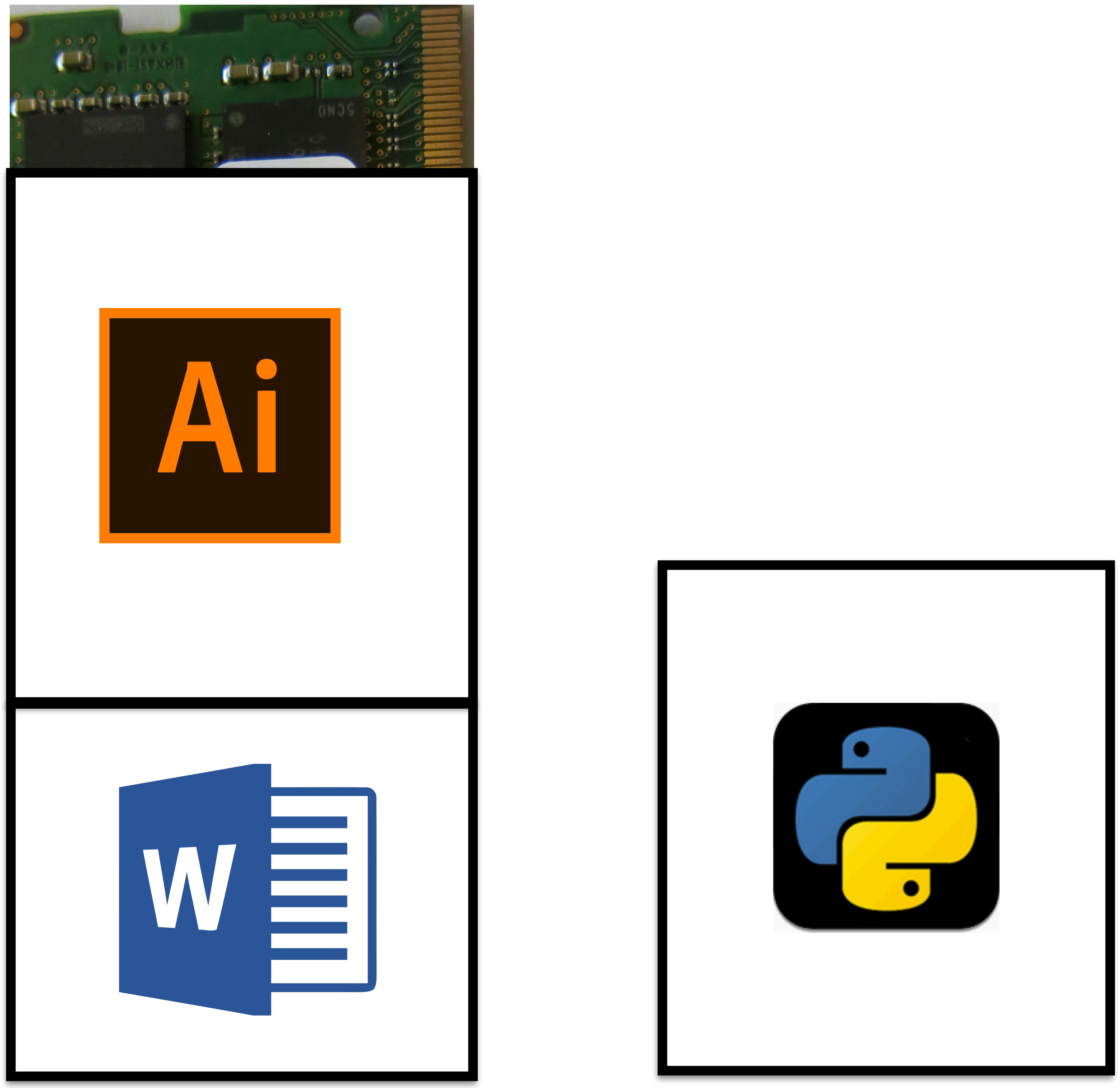
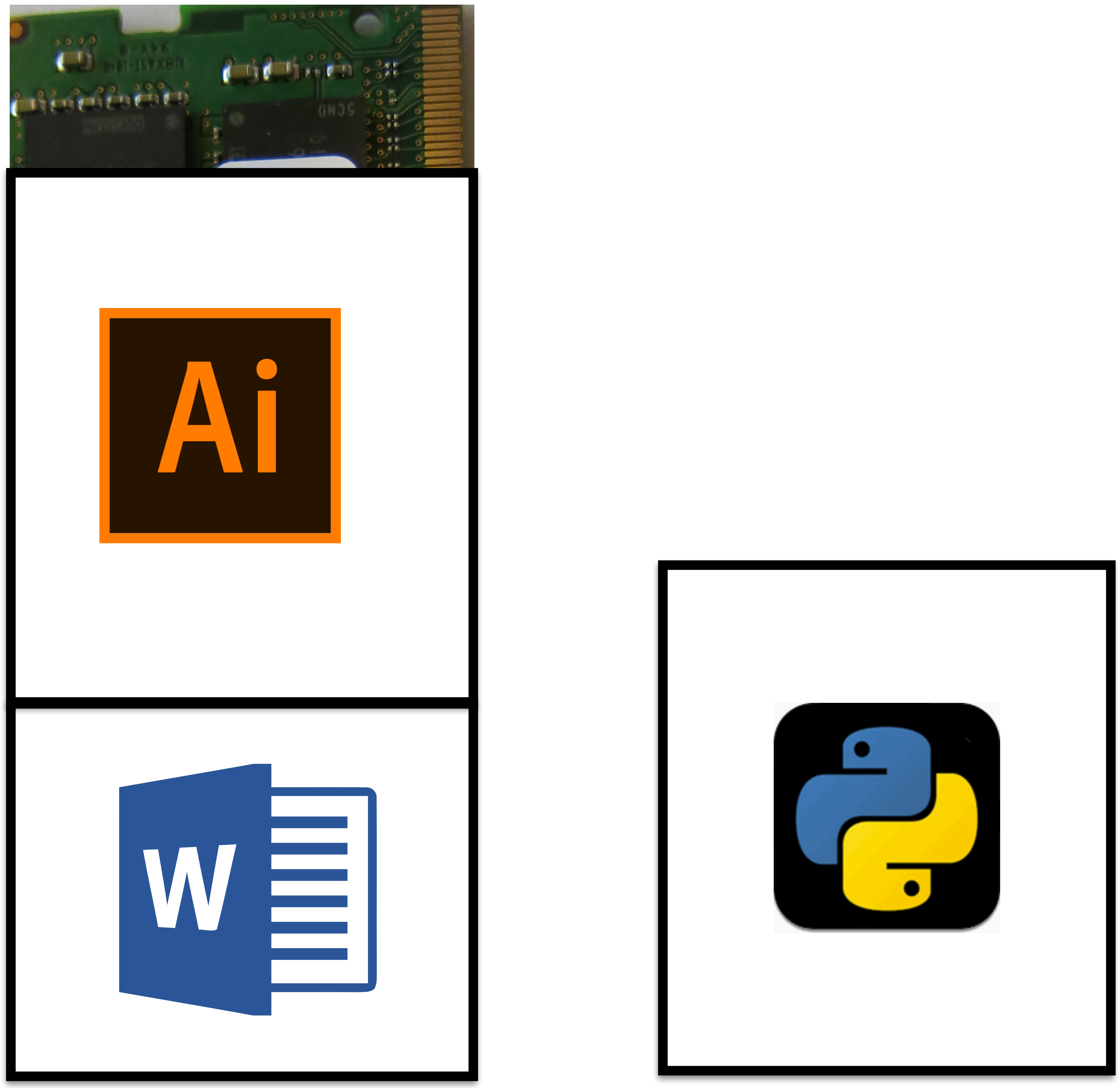


Direct Physical Memory Multiplexing

What if process says it wants full memory?



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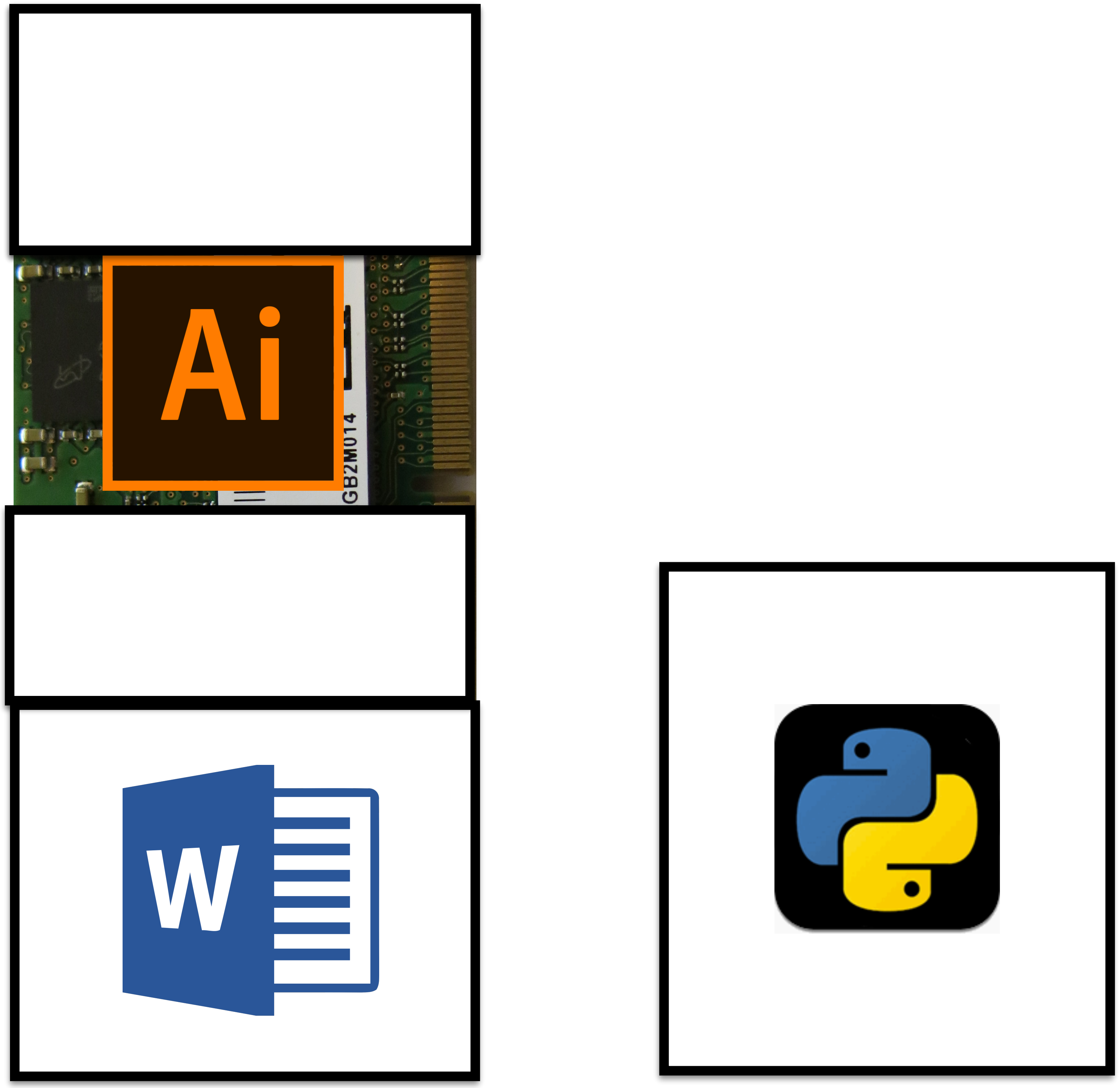

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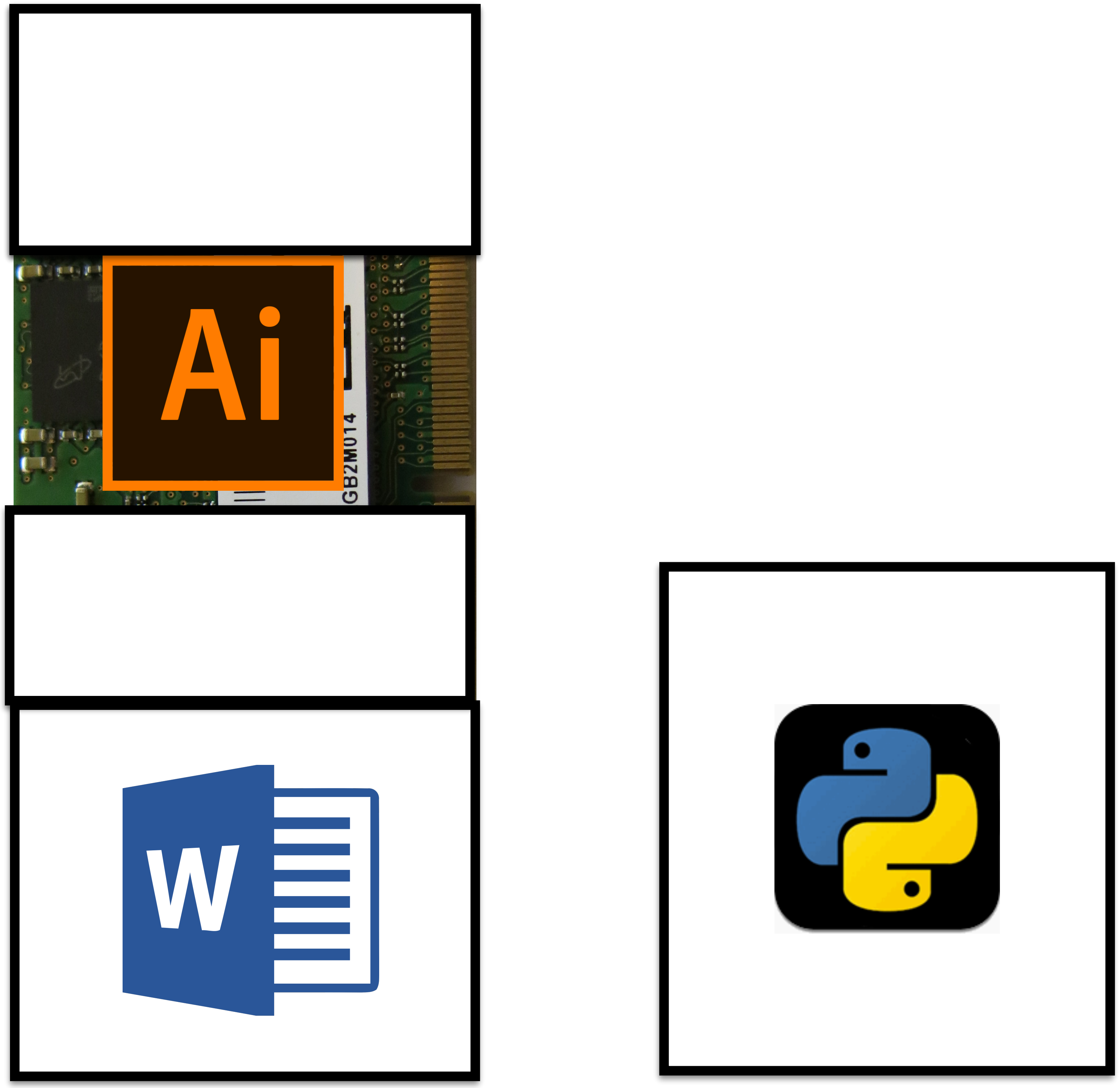
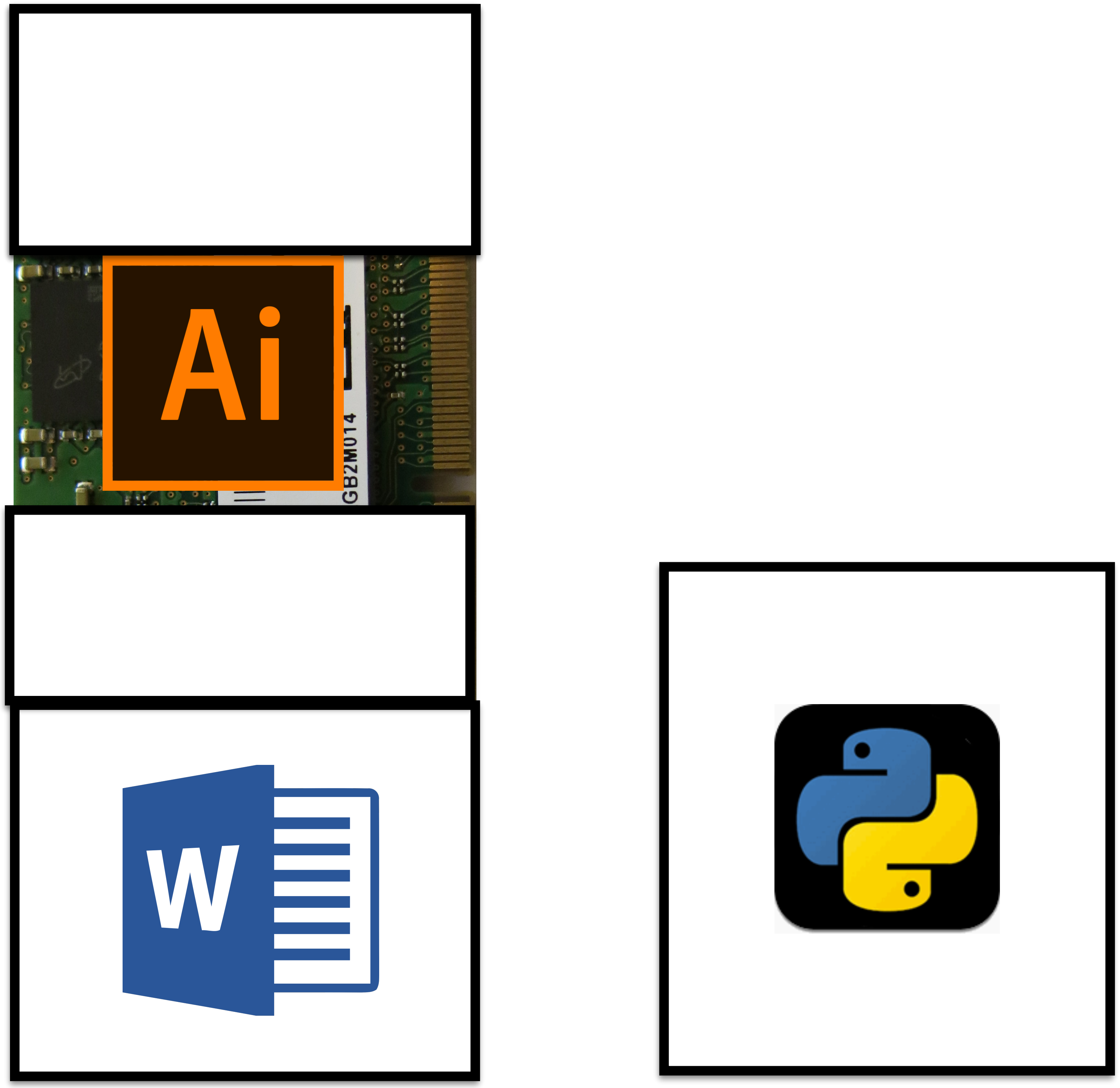


Direct Physical Memory Multiplexing

Internal Fragmentation

What if process says it wants full memory?



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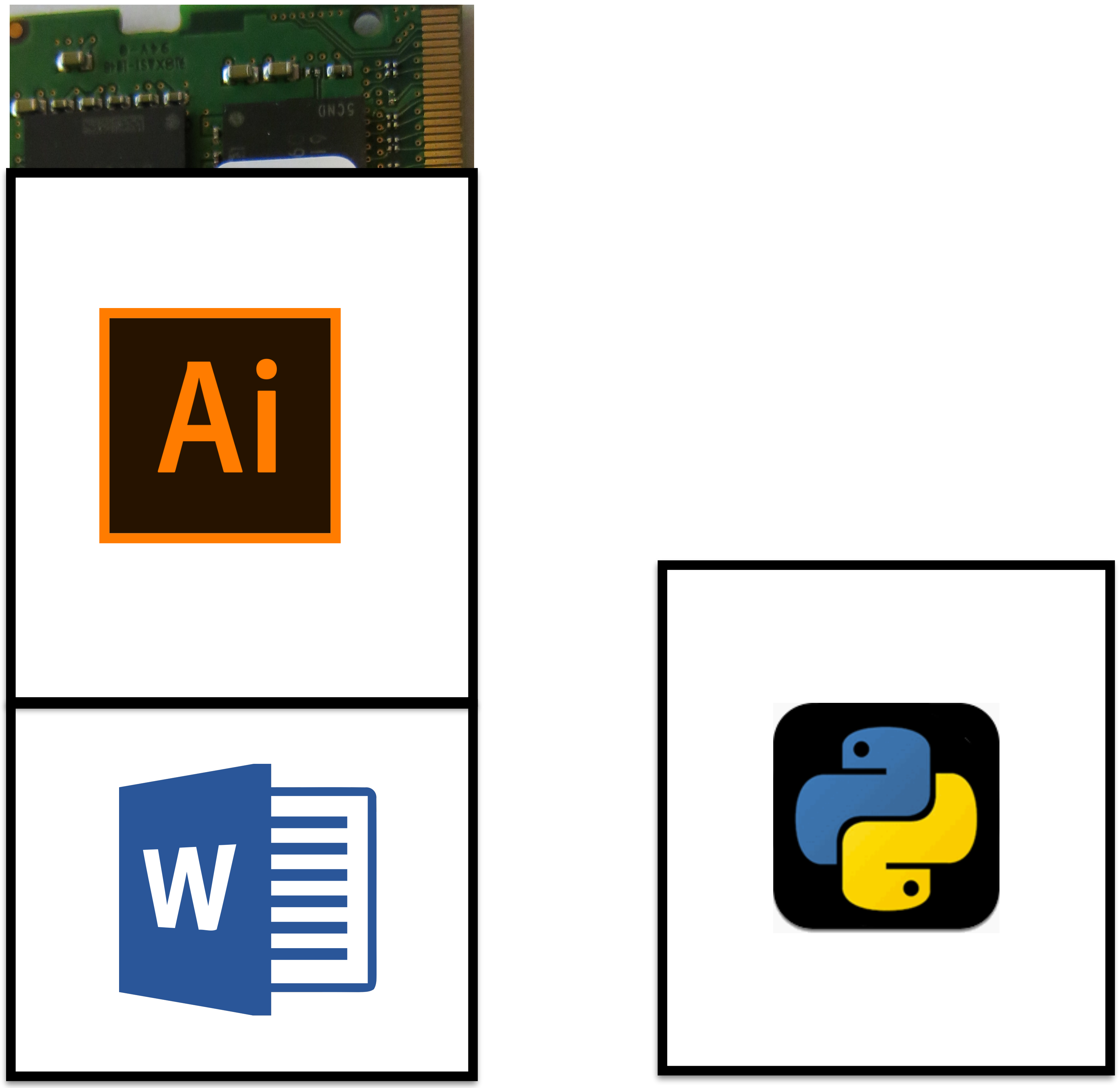
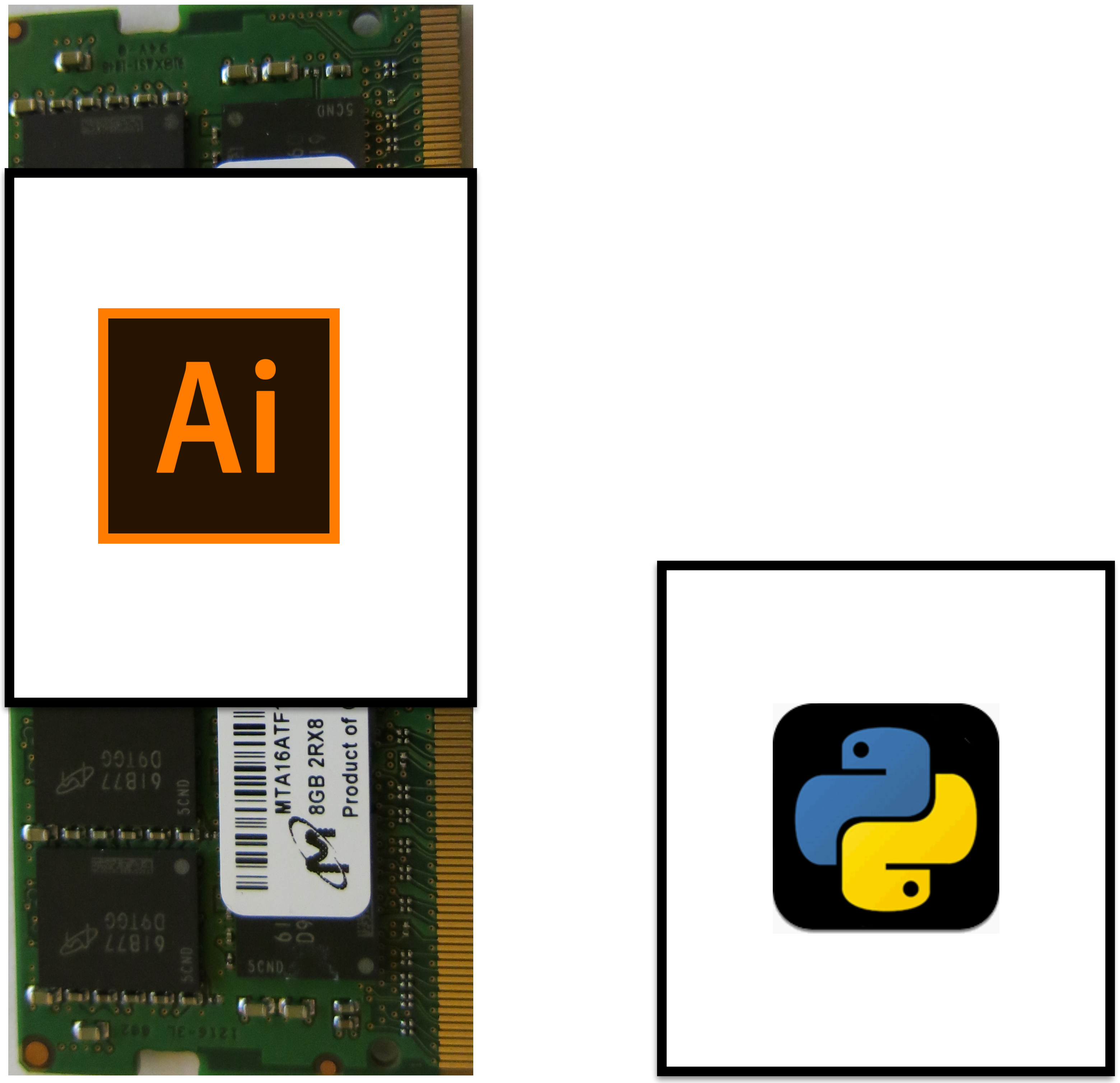


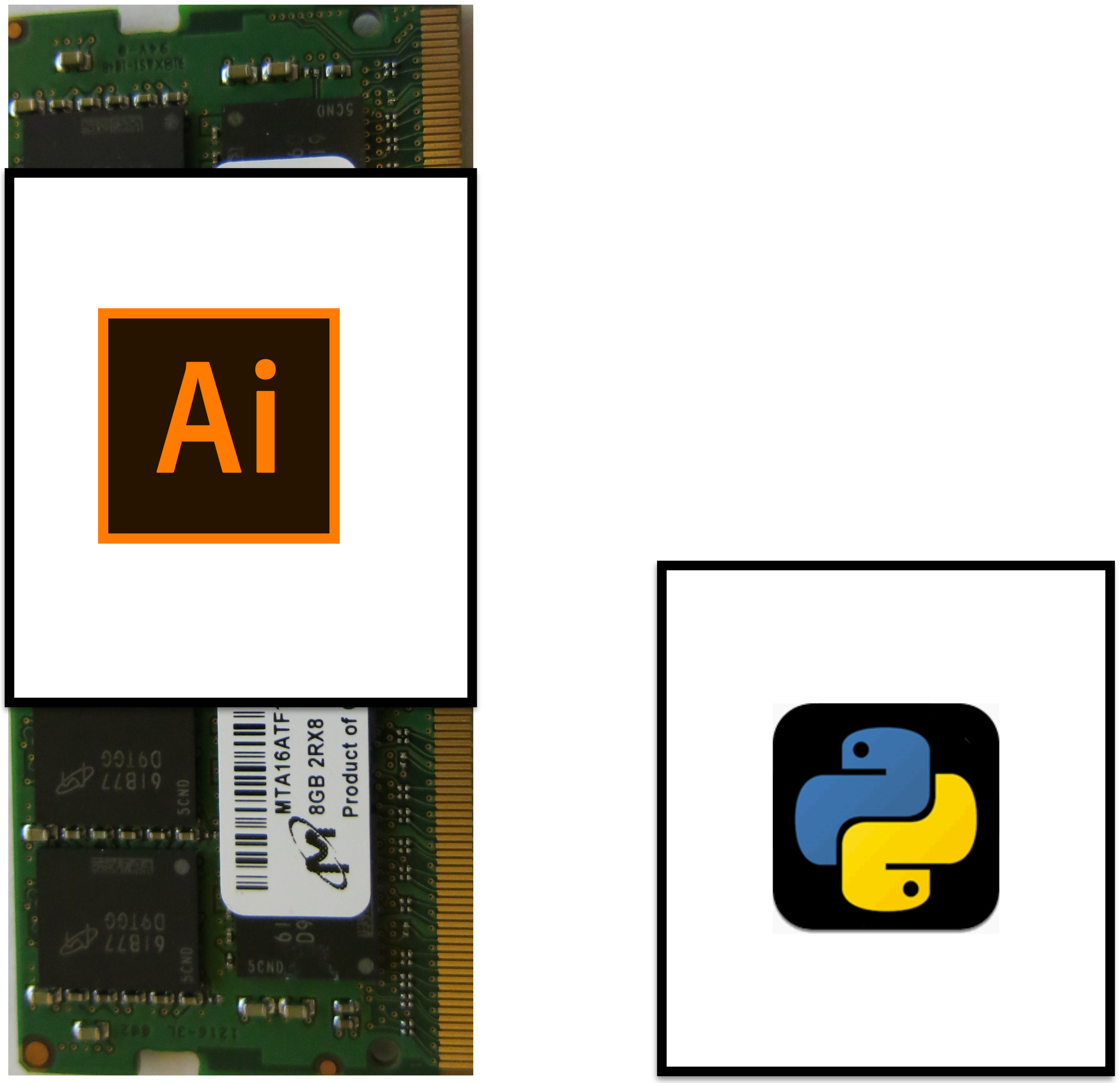
Direct Physical Memory Multiplexing



Direct Physical Memory Multiplexing

Can Python run now?

Total memory - Memory req for Illustrator > = Memory req for Python



Direct Physical Memory Multiplexing

External Fragmentation

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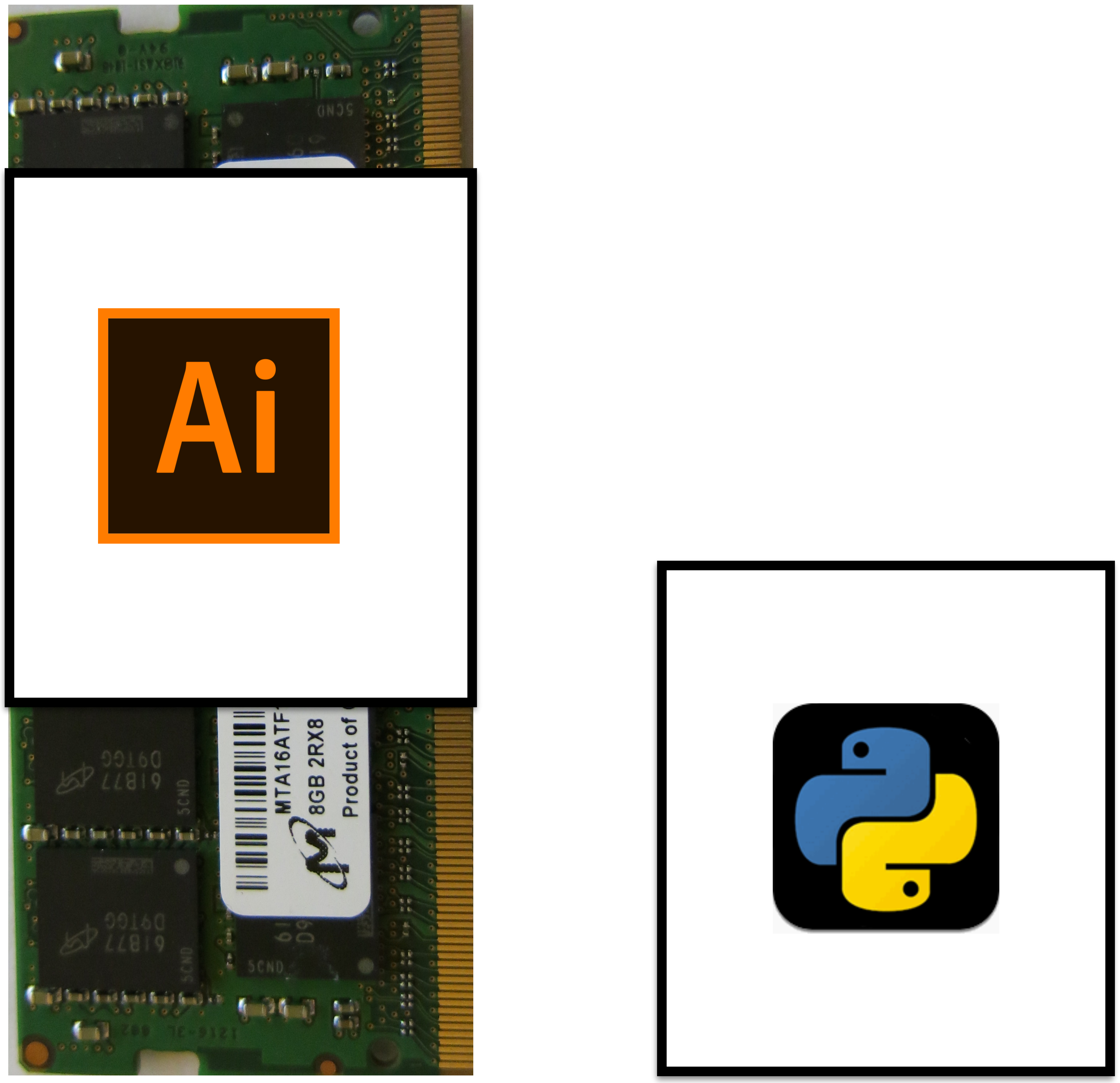
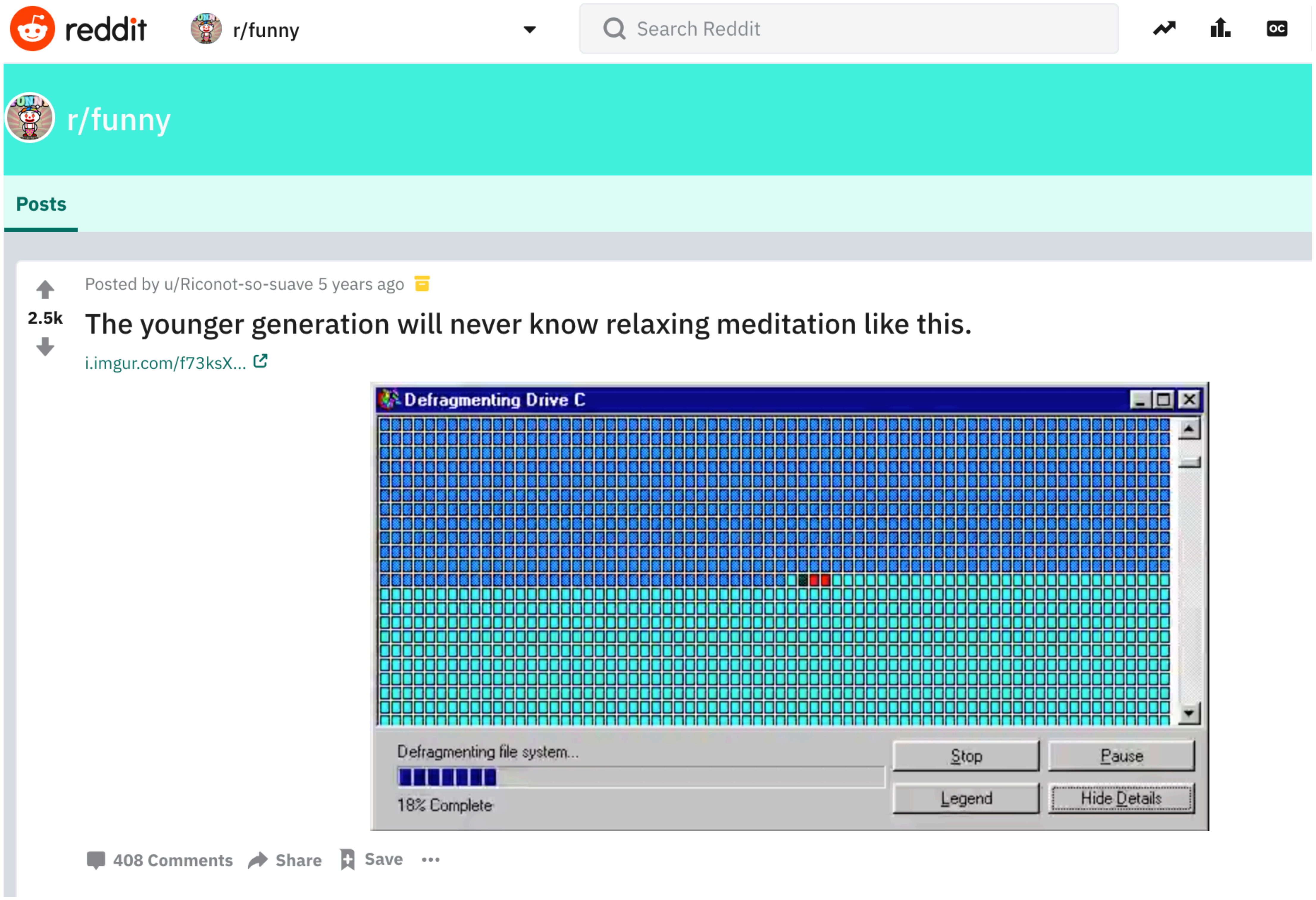


Defragmentation Memories …



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2.5k Posted by u/Riconot-so-suave 5 years ago

The younger generation will never know relaxing meditation like this.

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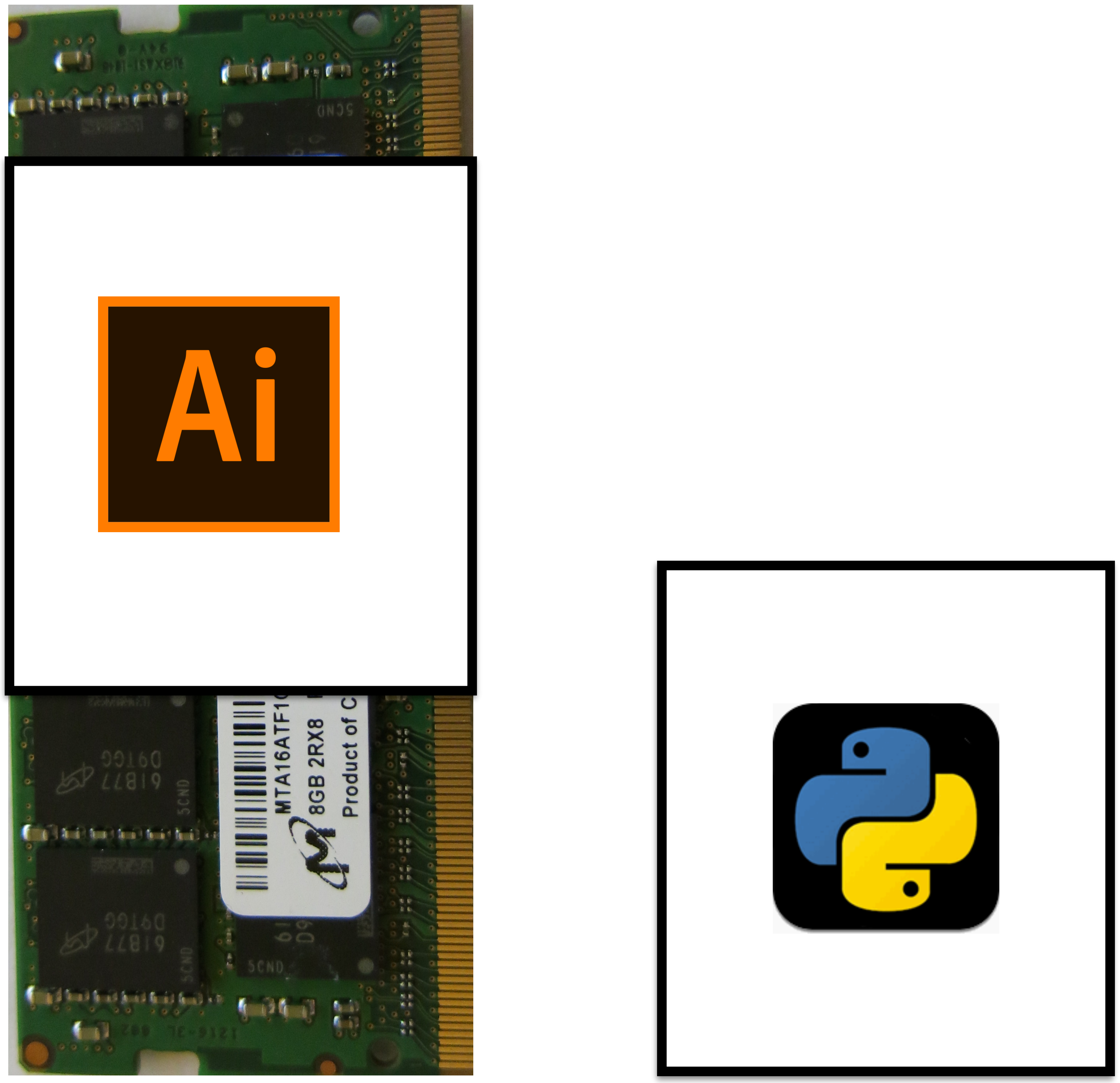
Direct Physical Memory Multiplexing

Defragmentation



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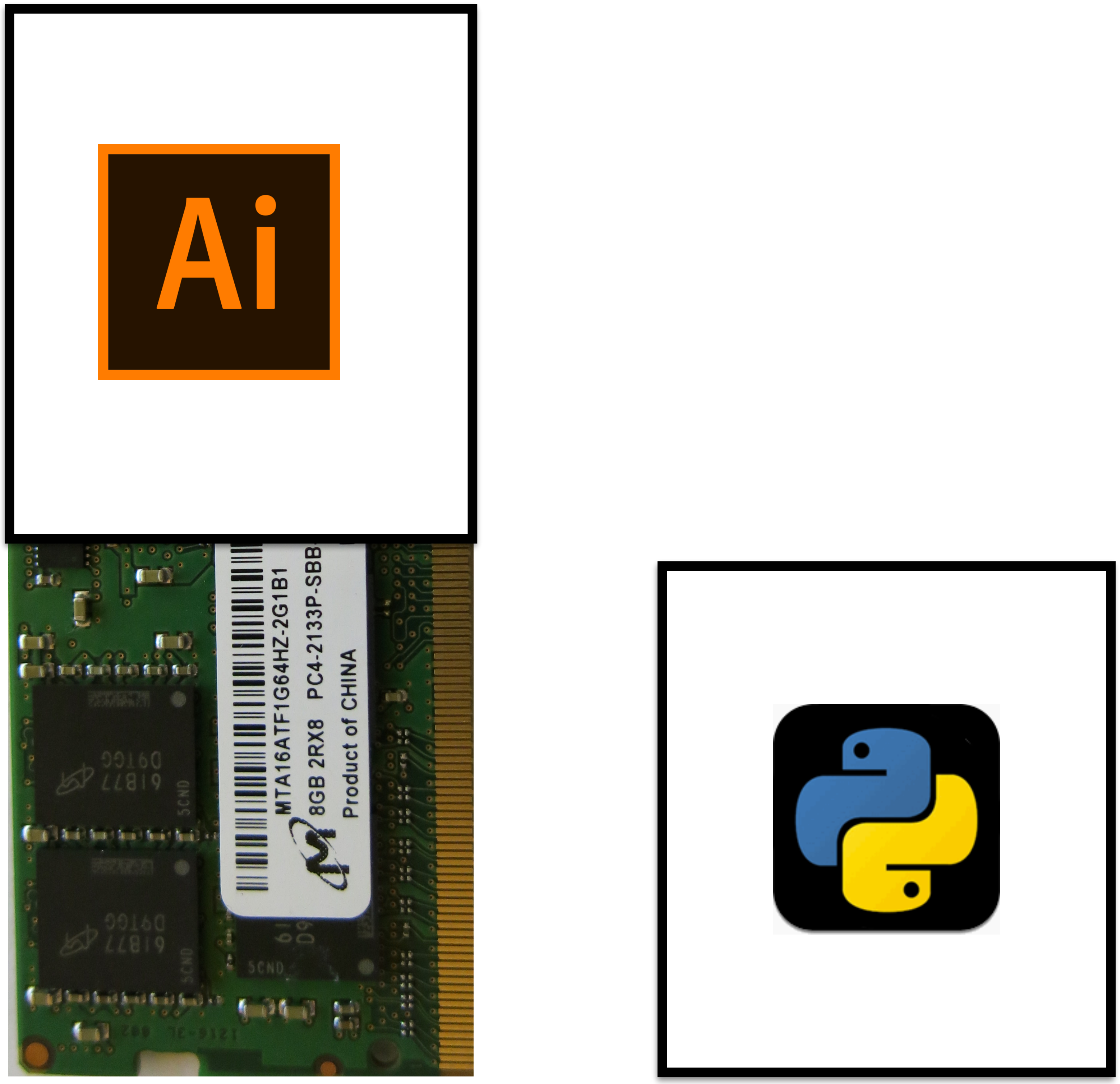

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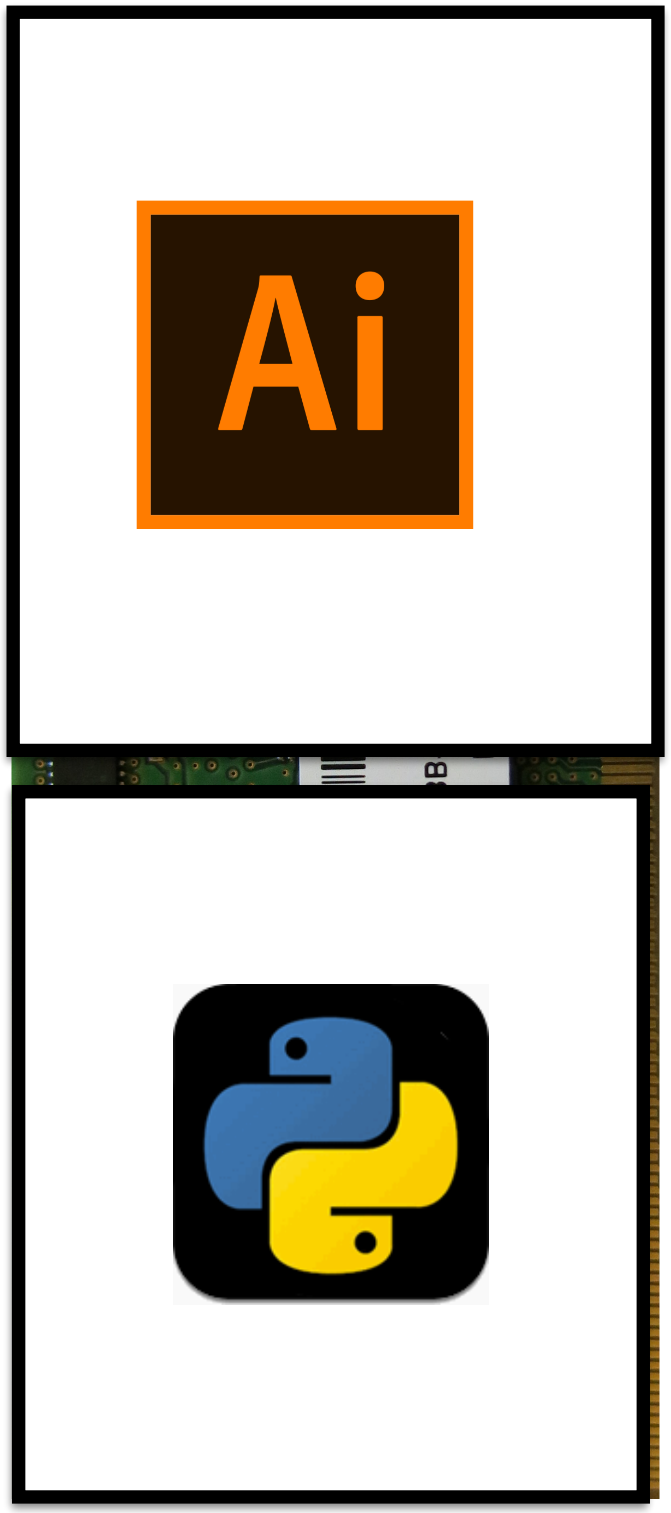

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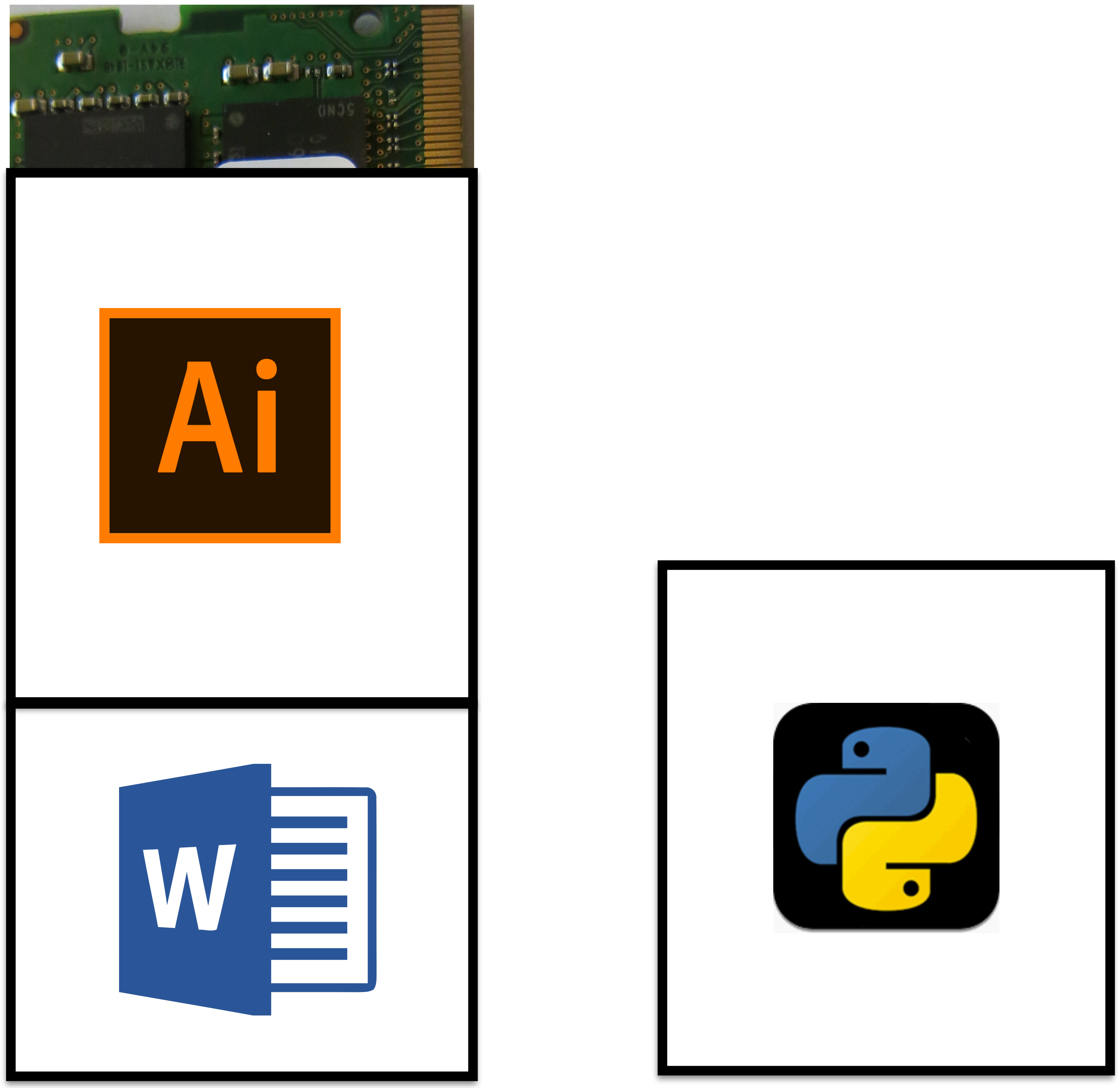

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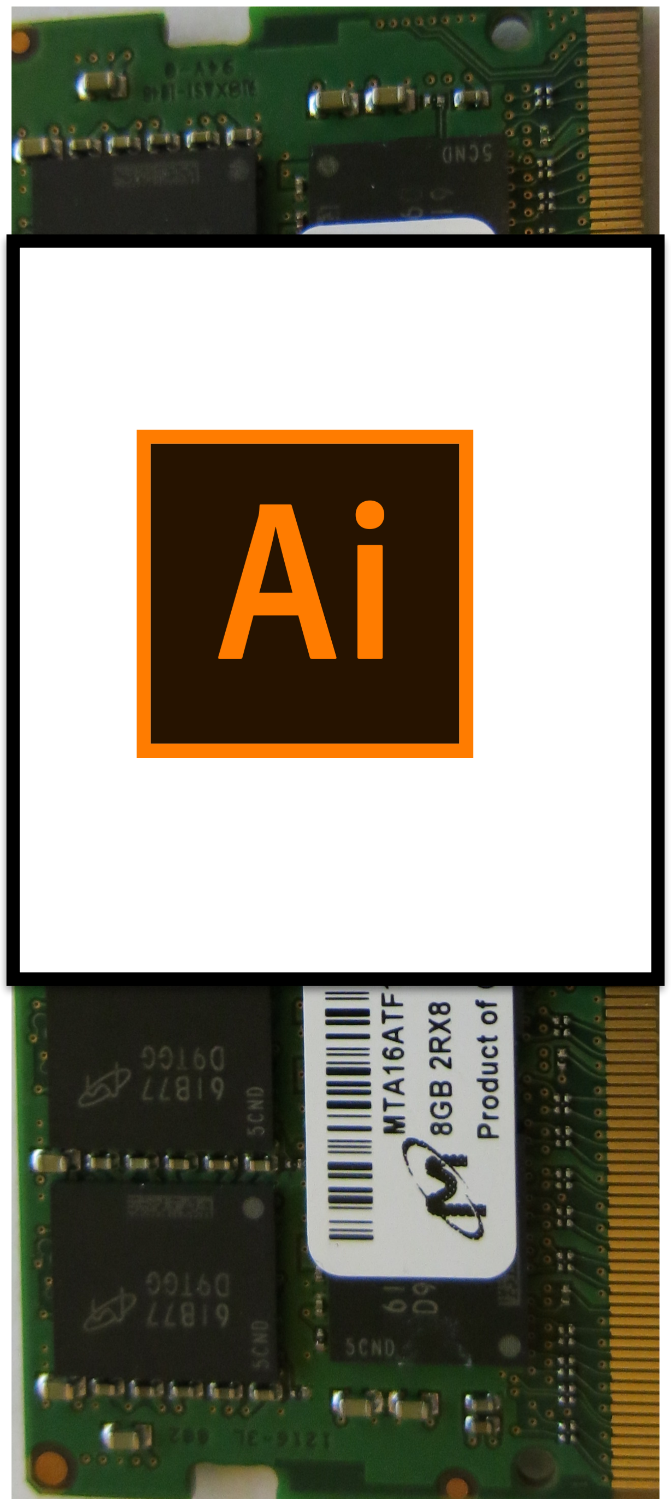

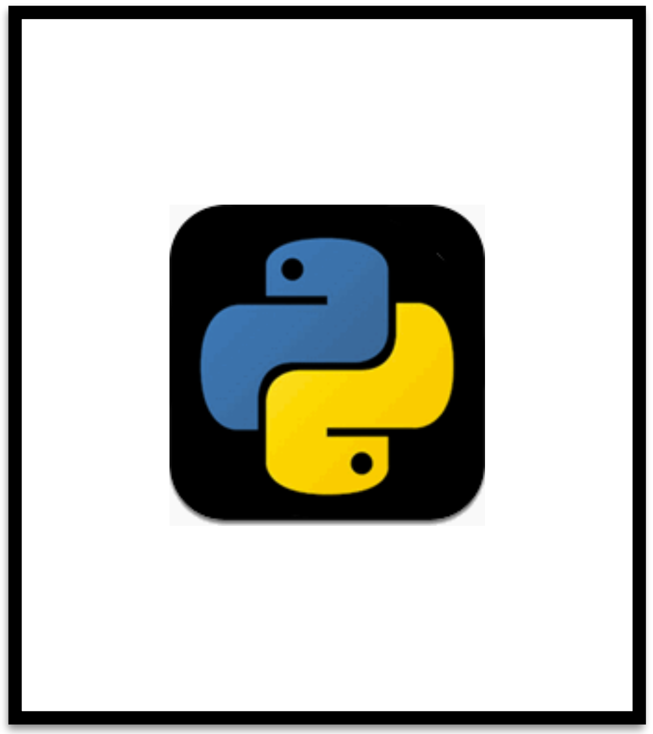

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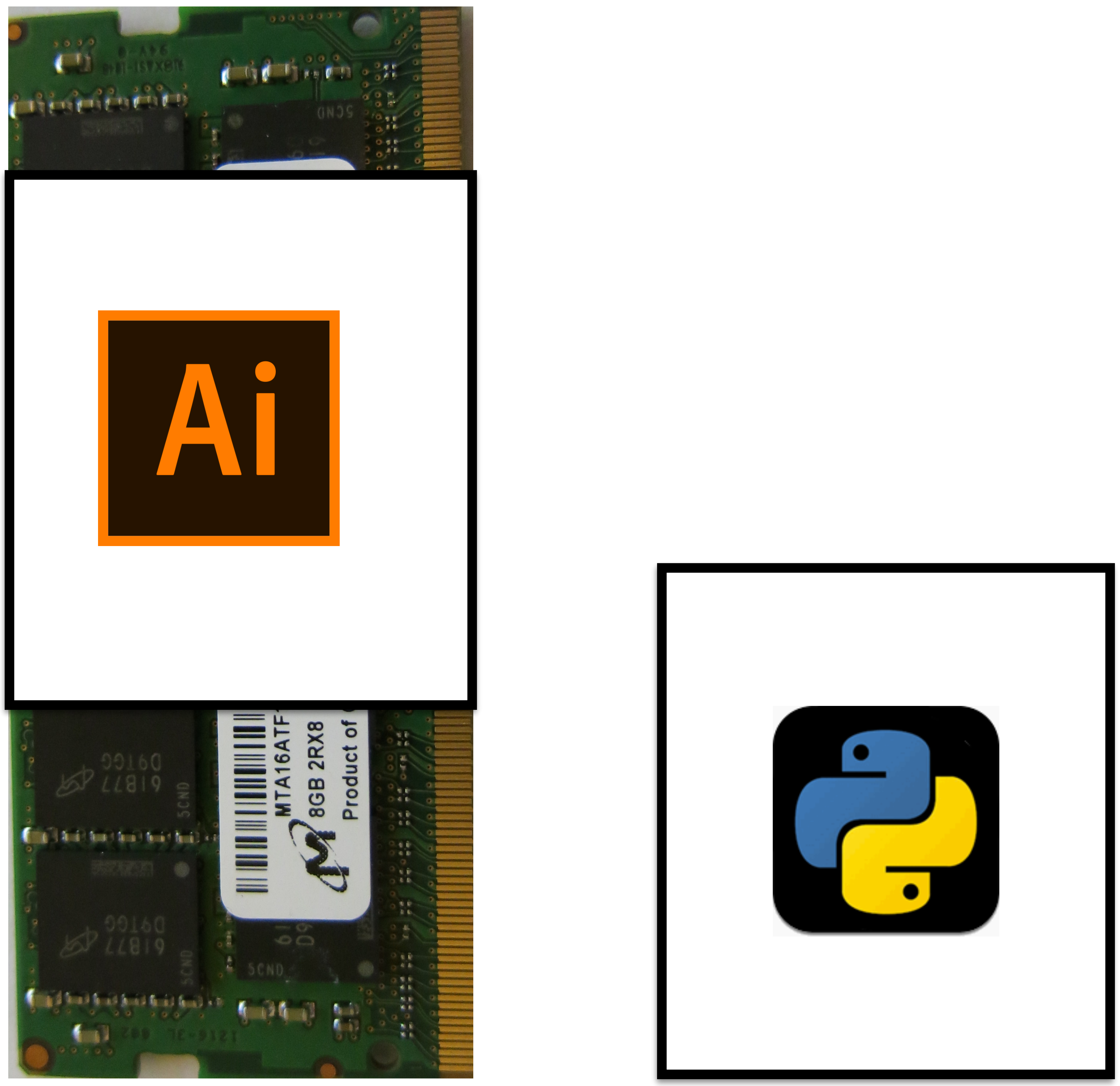

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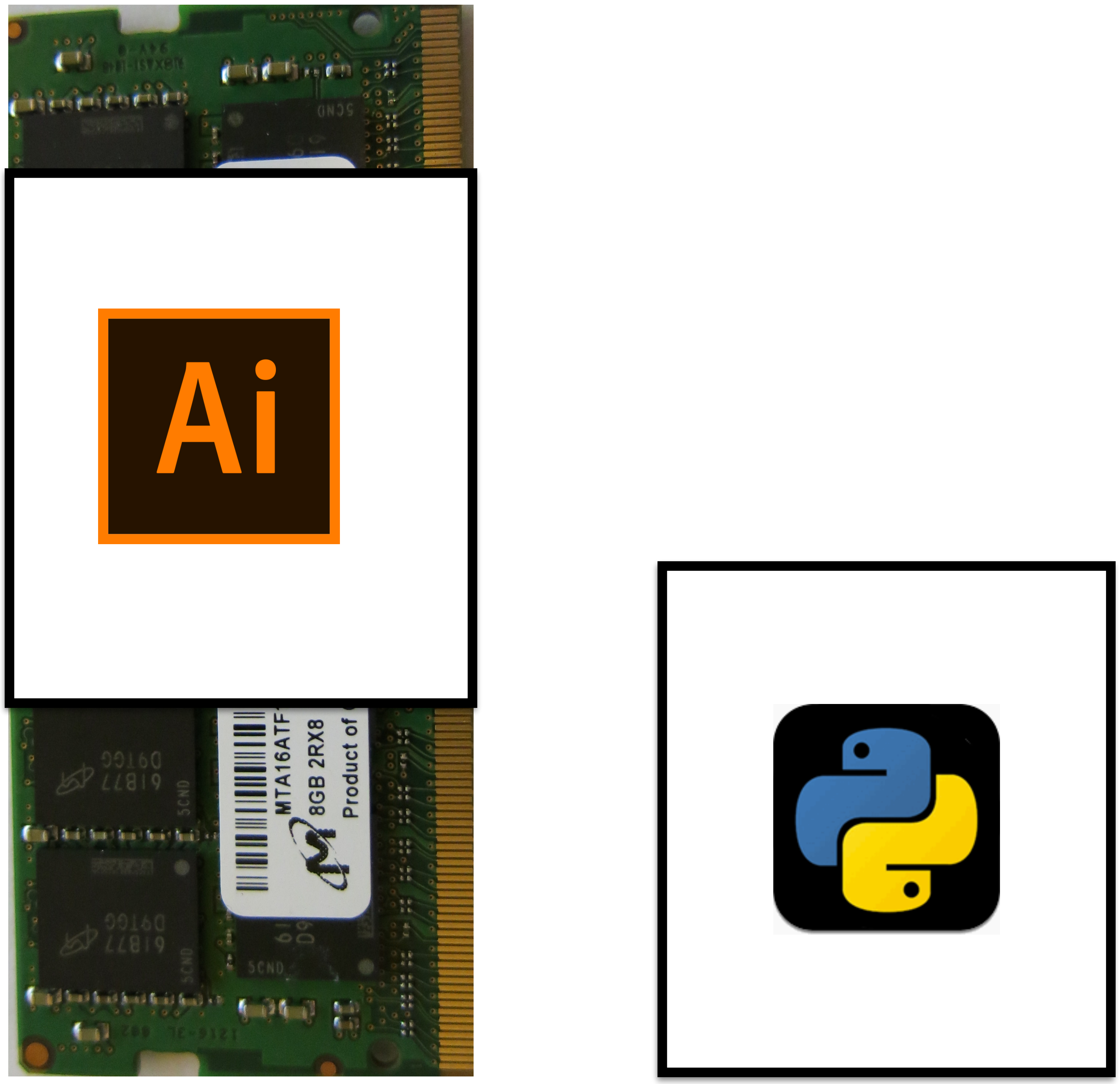

Goals of OS for Memory Virtualisation/ Management

1. Transparency
   1. Physical memory is invisible to user program
   2. Program thinks it has own private large (contiguous + plentiful) memory
2. Efficiency
   1. Not taking very long
   2. Not taking too much space
3. Protection/Isolation
   1. Protect processes from each other

Memory Interface

1. Load (address)
2. Store (address, value)

Physical v/s Virtual Memory

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1. Abstraction : Break the connection between physical memory and an address

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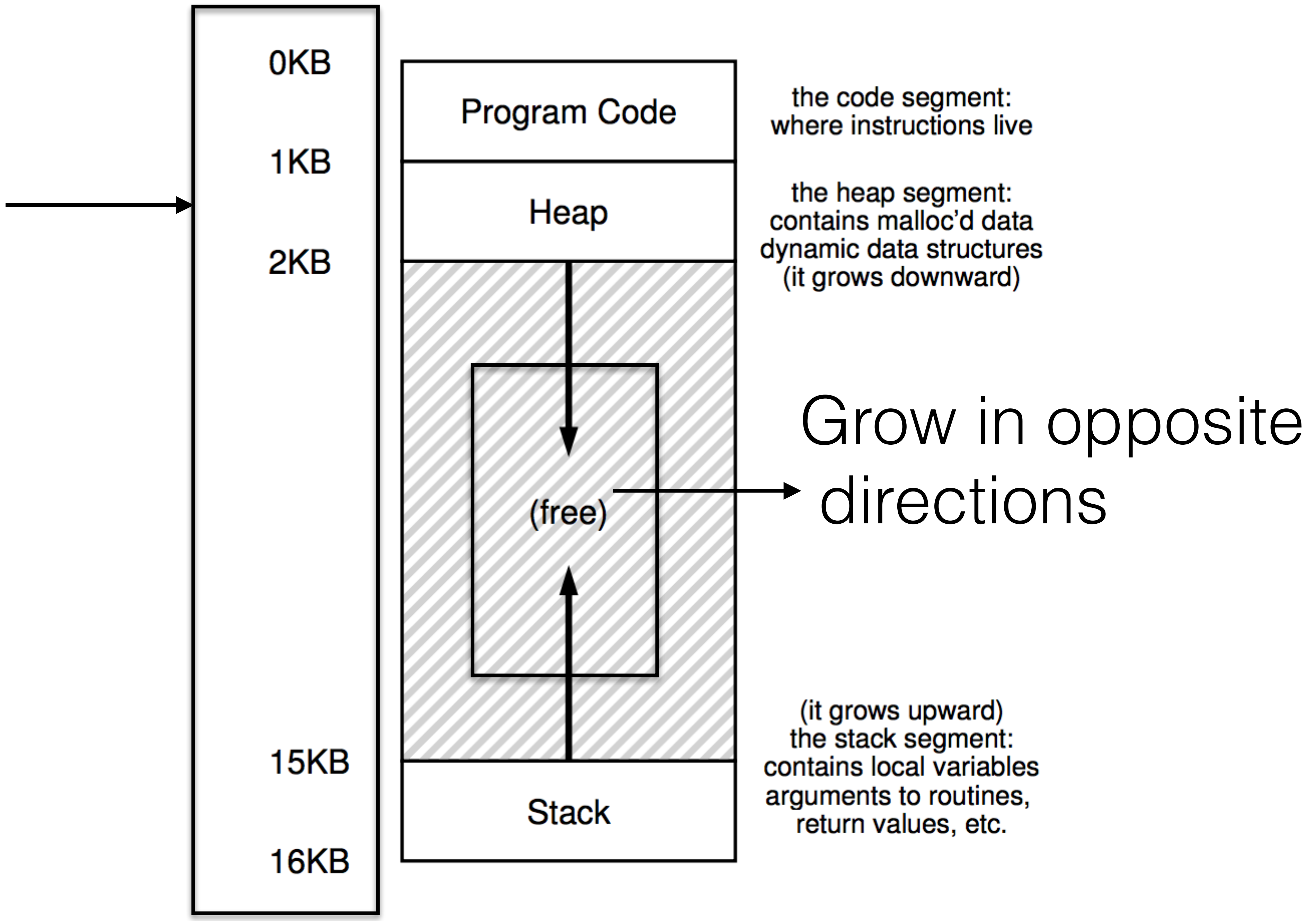
1. Abstraction : Break the connection between physical memory and an address
2. Data accessed using memory interface is virtual address
   1. Physical address points to memory
   2. Virtual address points to something *acting like memory*

Address Space

Virtual Address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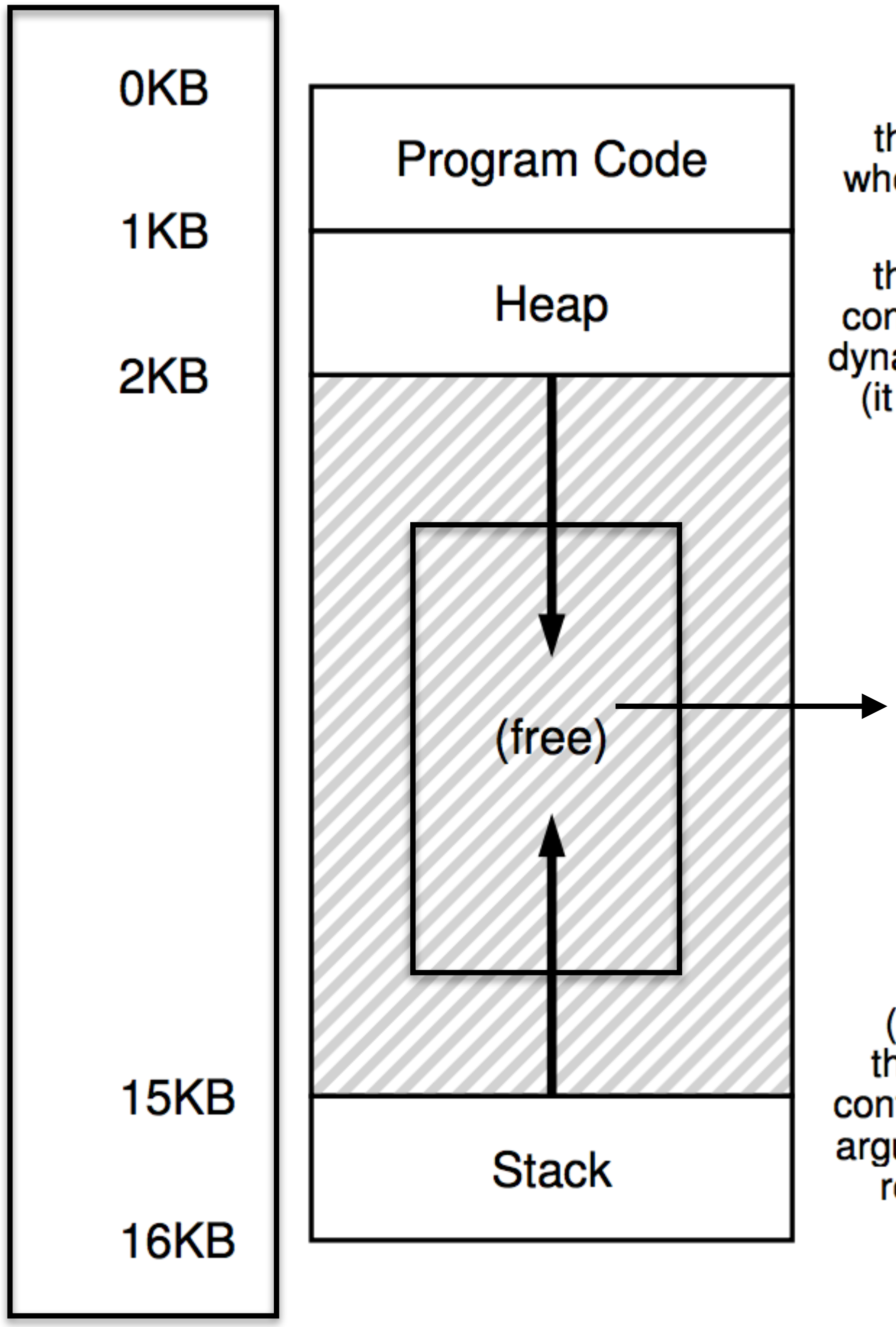
16KB
Program Code
the code segment: where instructions live
Heap
the heap segment: contains malloc'd data dynamic data structures (it grows downward)
(free)
Stack
(it grows upward) the stack segment: contains local variables arguments to routines, return values, etc.

Grow in opposite directions

Stack Overflow?!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Heap
(free)
Stack
the code segment: where instructions live
the heap segment: contains malloc'd data dynamic data structures (it grows downward)
(it grows upward) the stack segment: contains local variables arguments to routines, return values, etc.

What if they meet?

Self-study : what is stack overflow?

Stack Overflow?!

```
def fib(n):
    if n==1 or n==0:
        return 1
    else:
        return n*fib(n-1)
```

Exec Revisited

`fork_same_address.c`

Example

```
void func() {
    int x = 3000; //
    x = x + 3;    //
    ...
```

Example

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void func() {
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$\xrightarrow{\text{Compiler}}$

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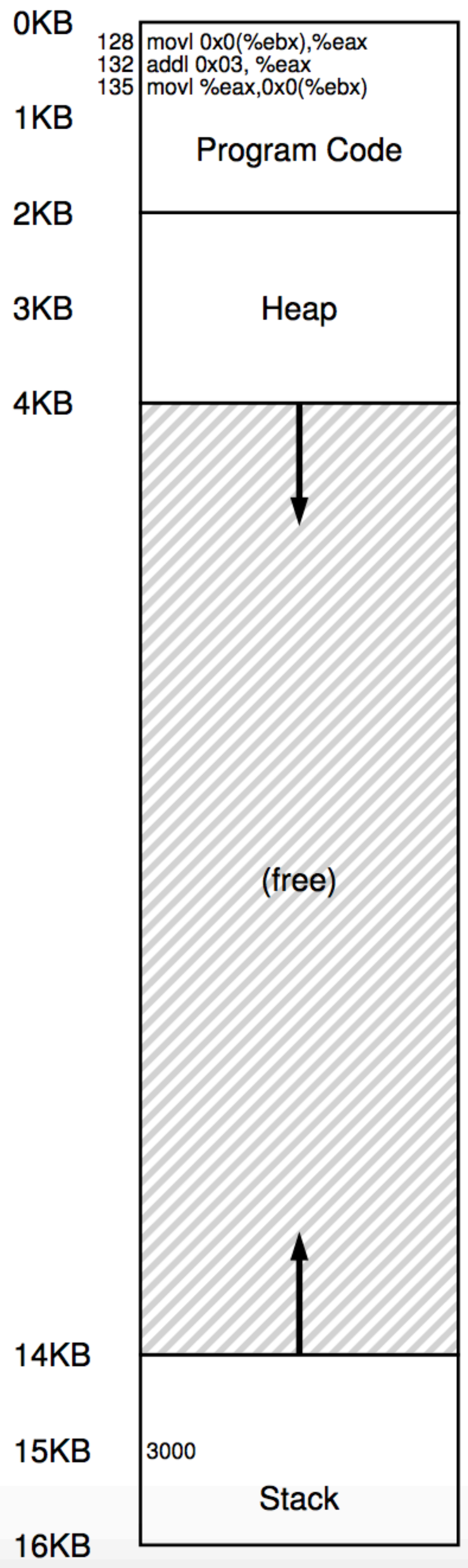

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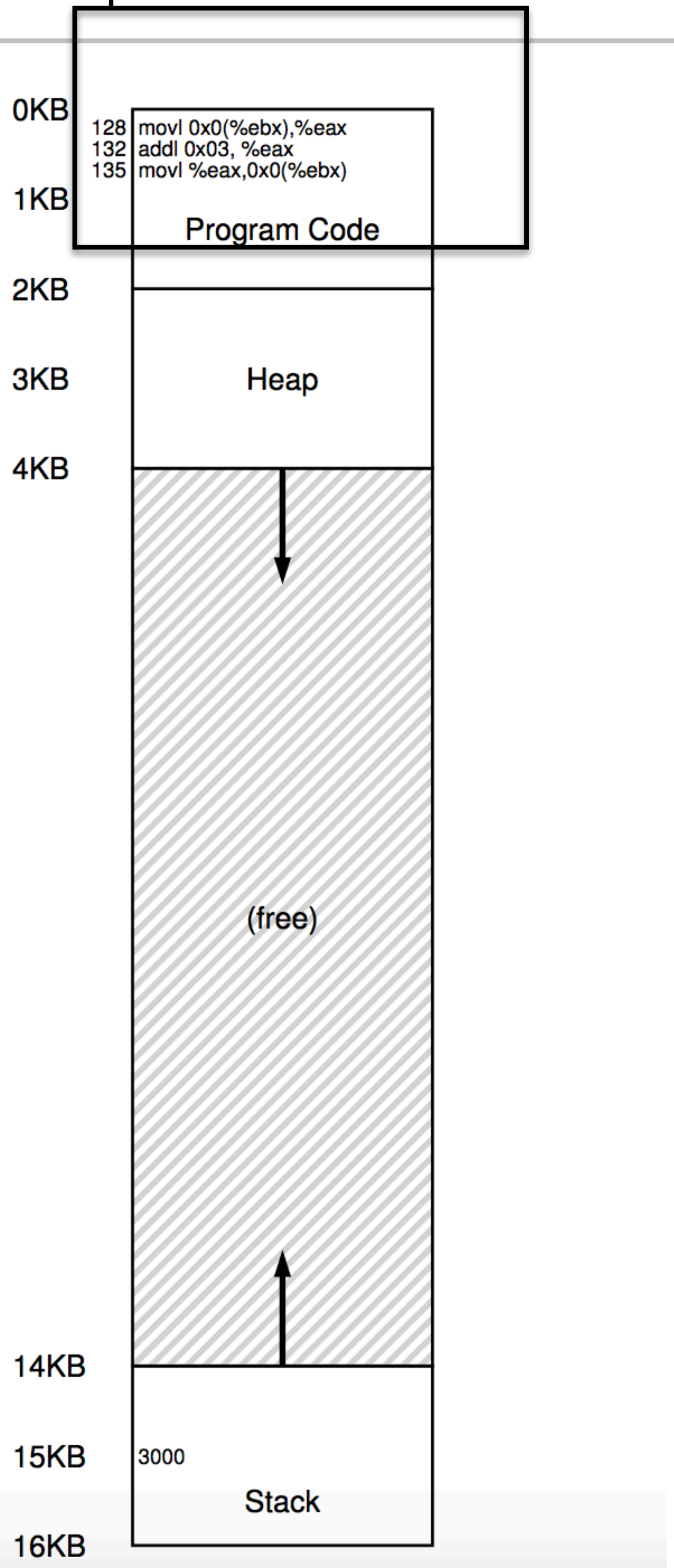

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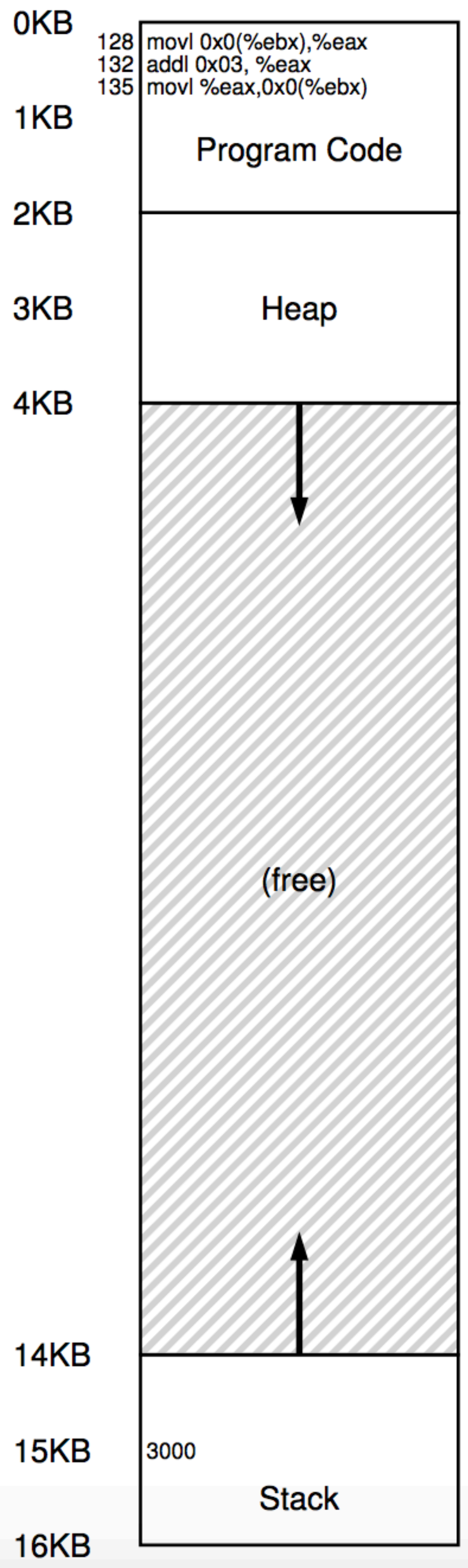

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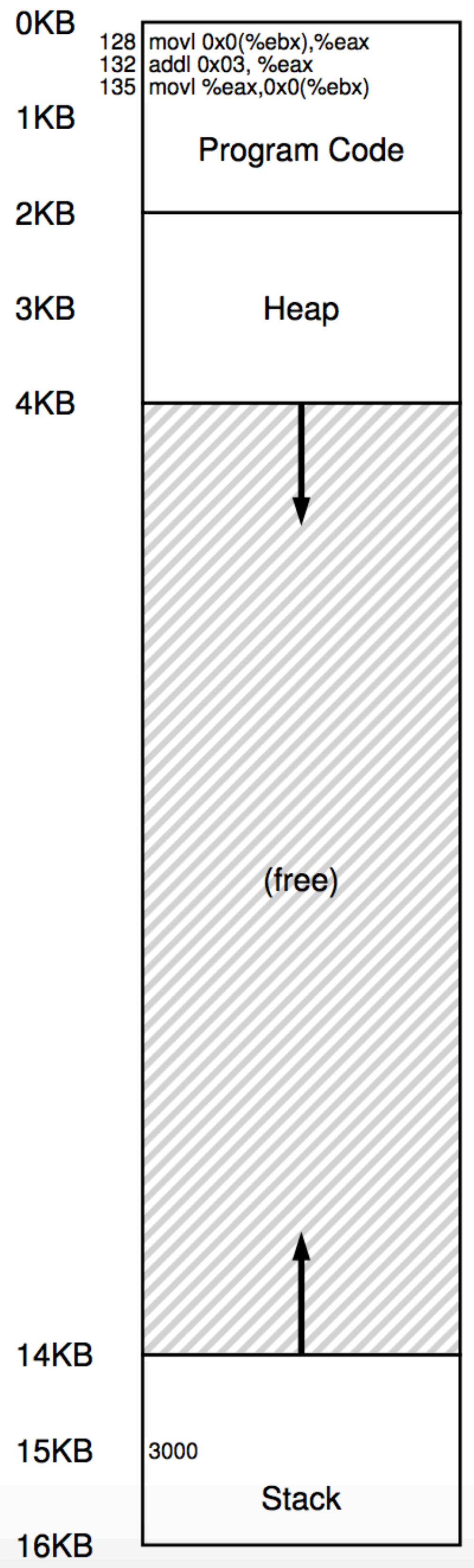
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4KB
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14KB
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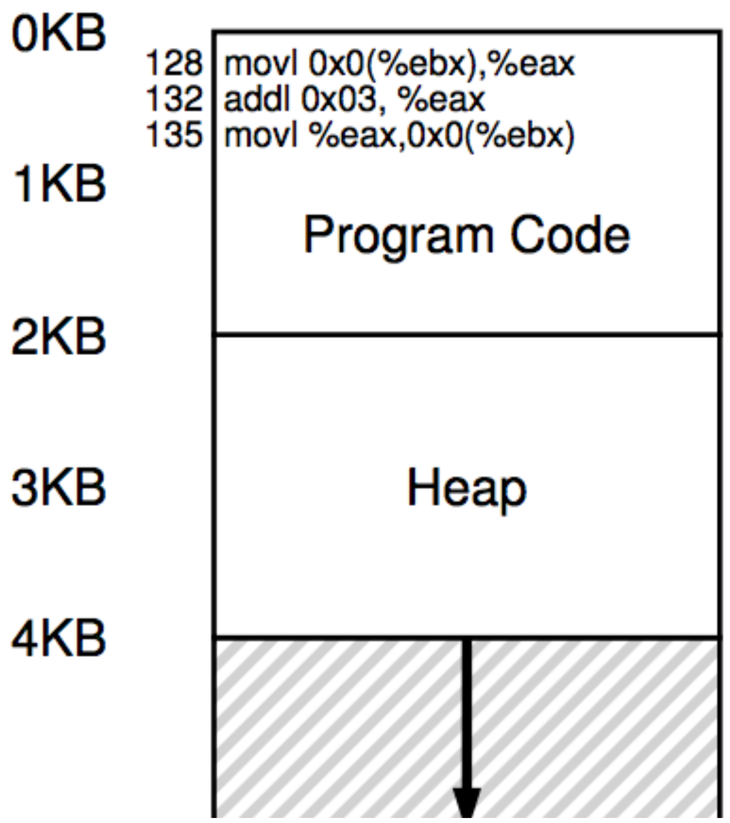
3000
Stack
16KB

Example



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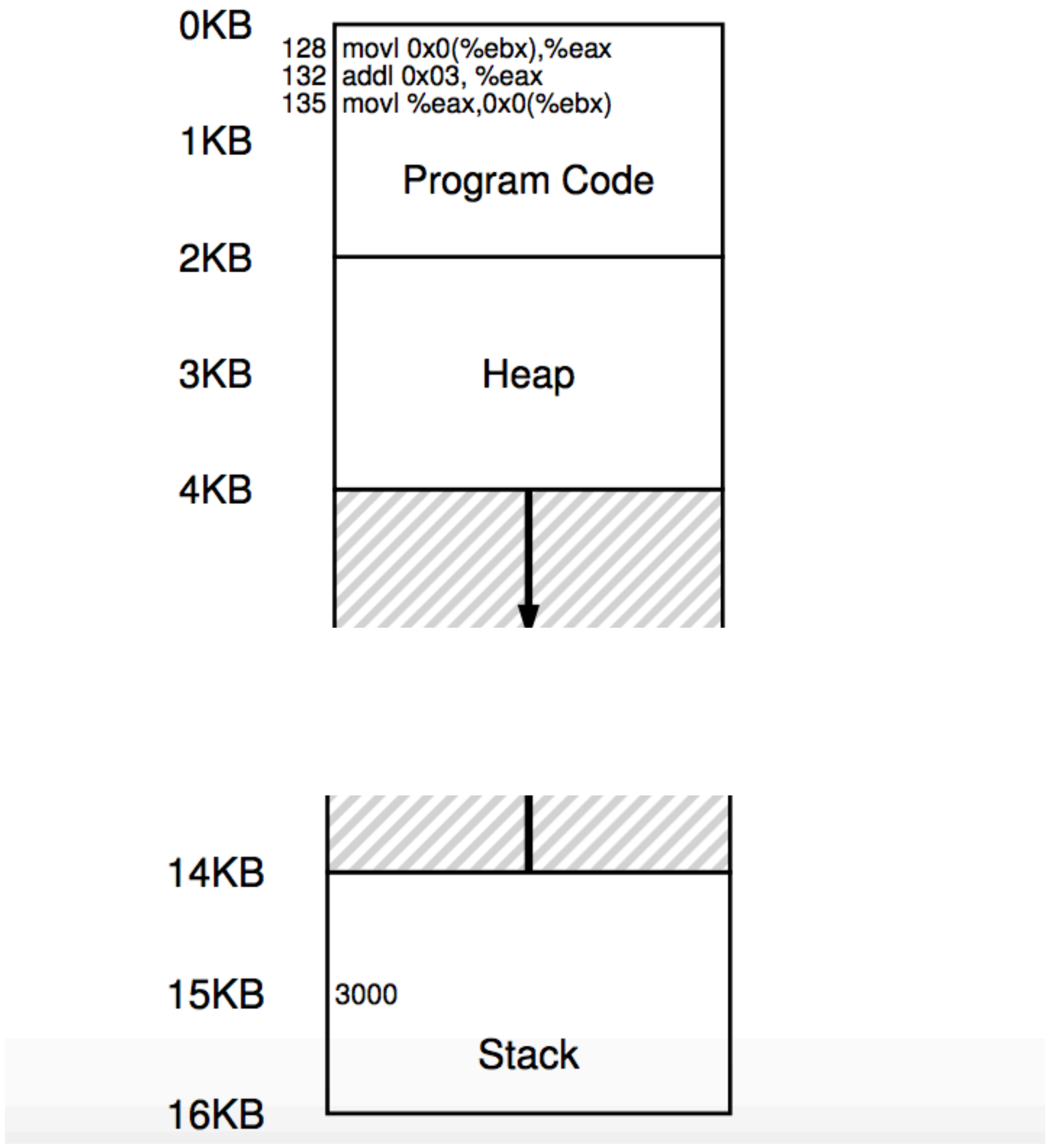
Fetch

Example



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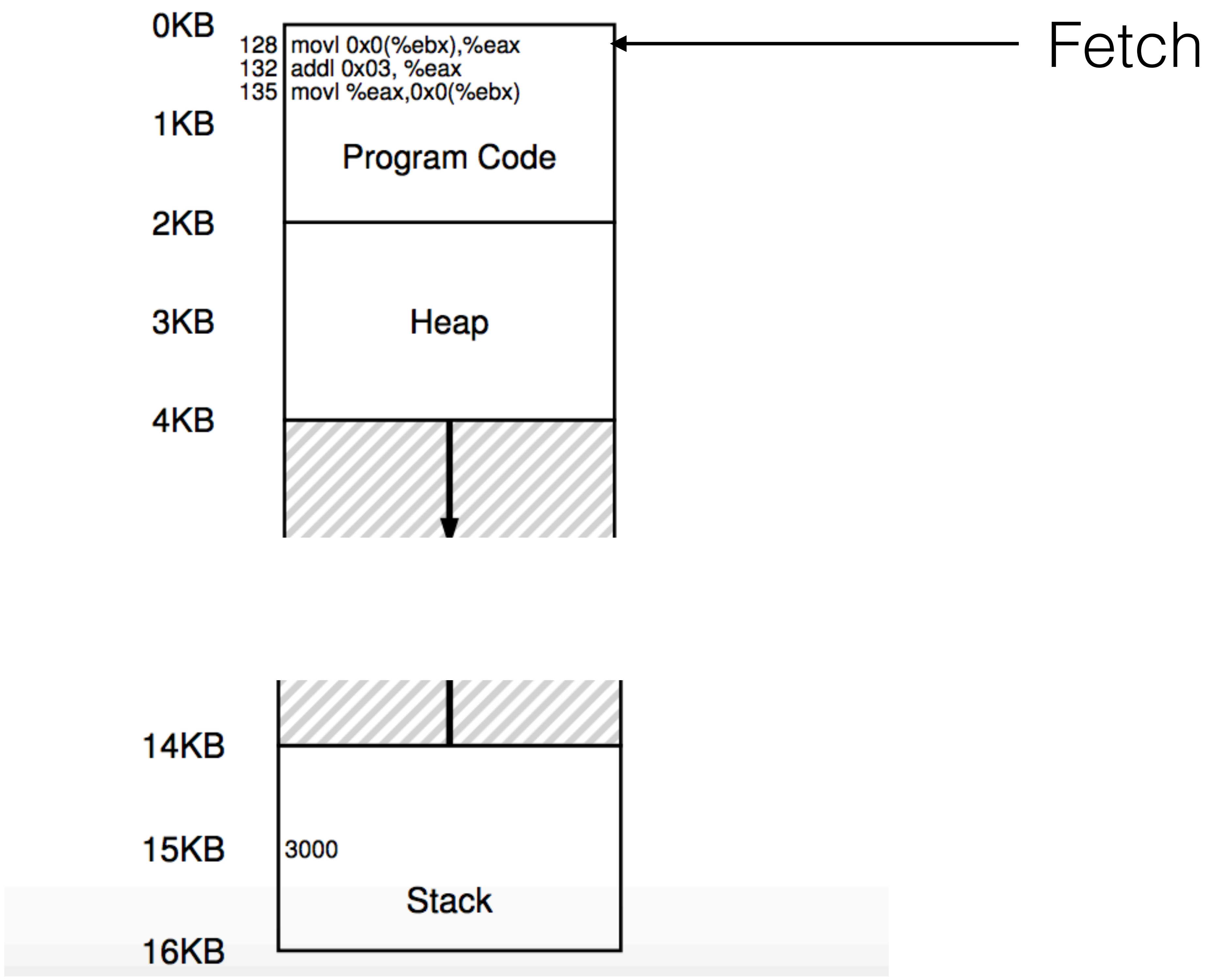
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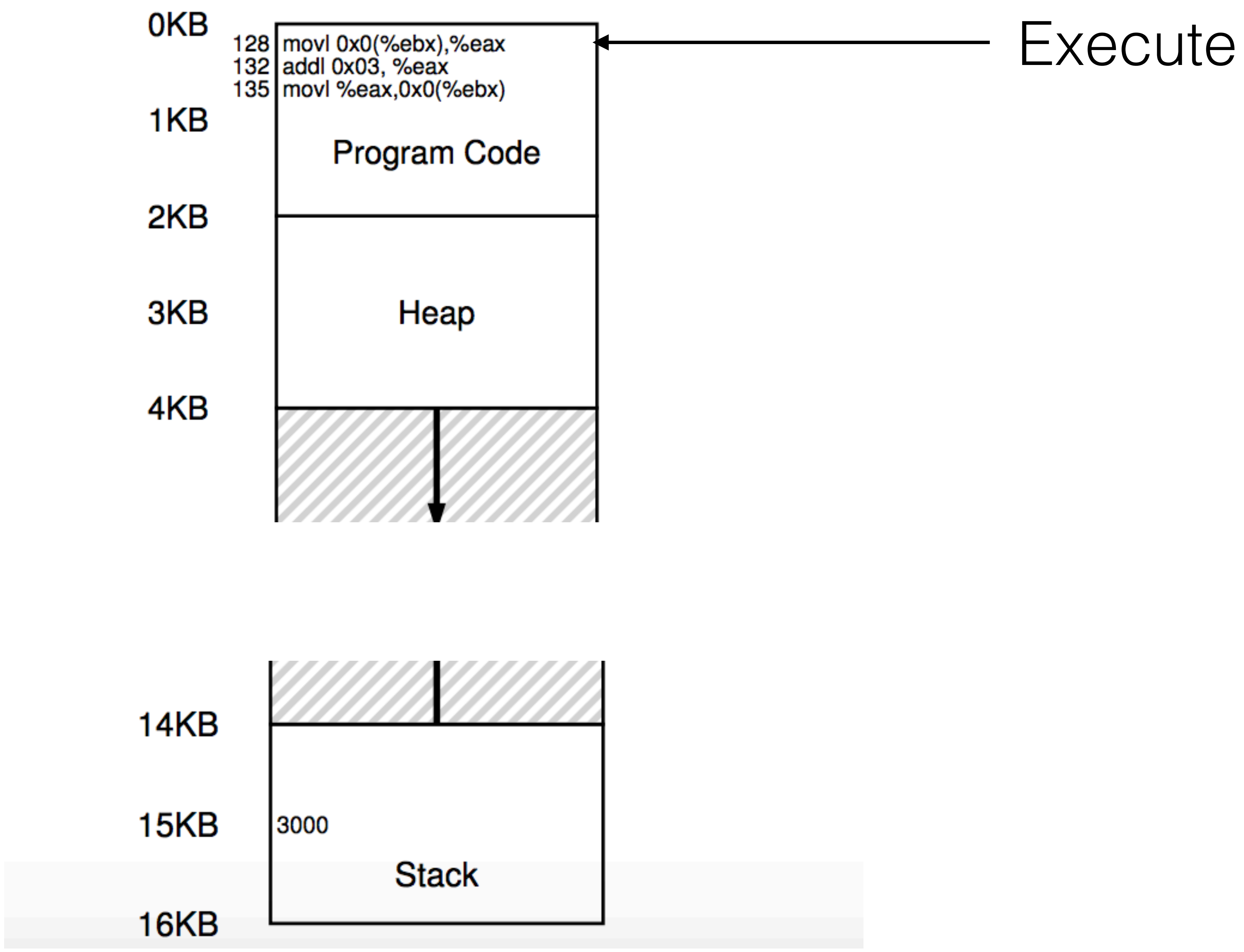
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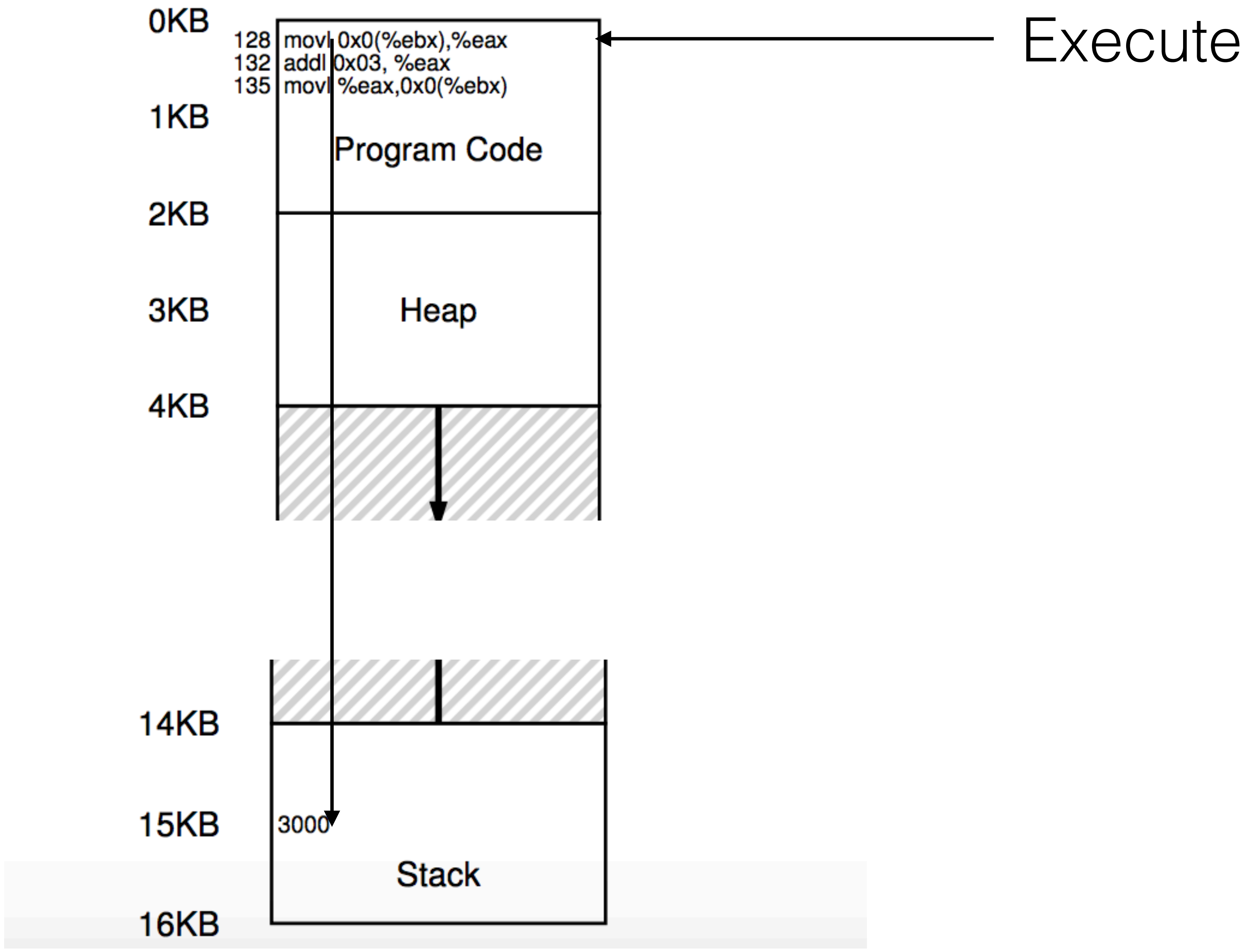

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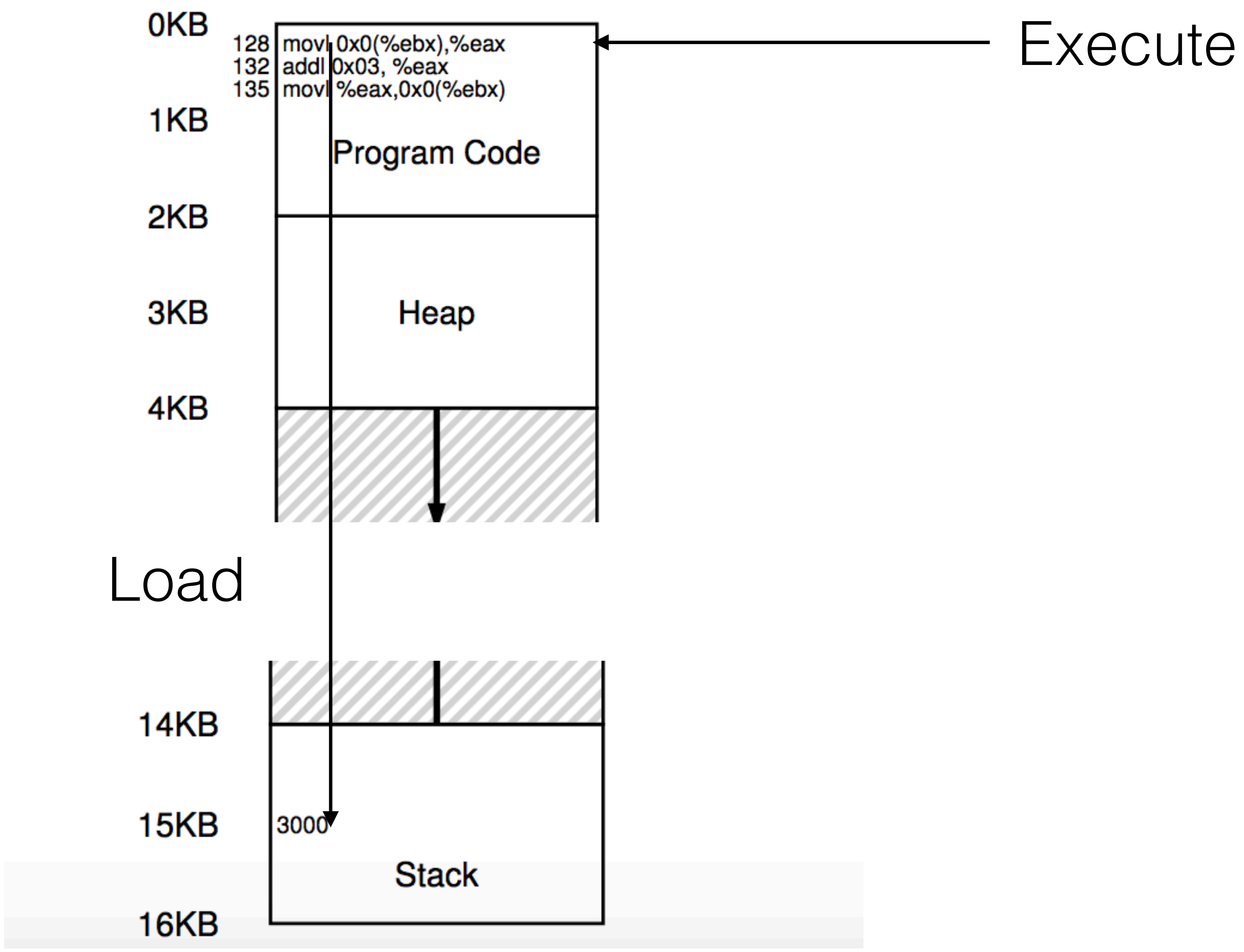
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Program Code
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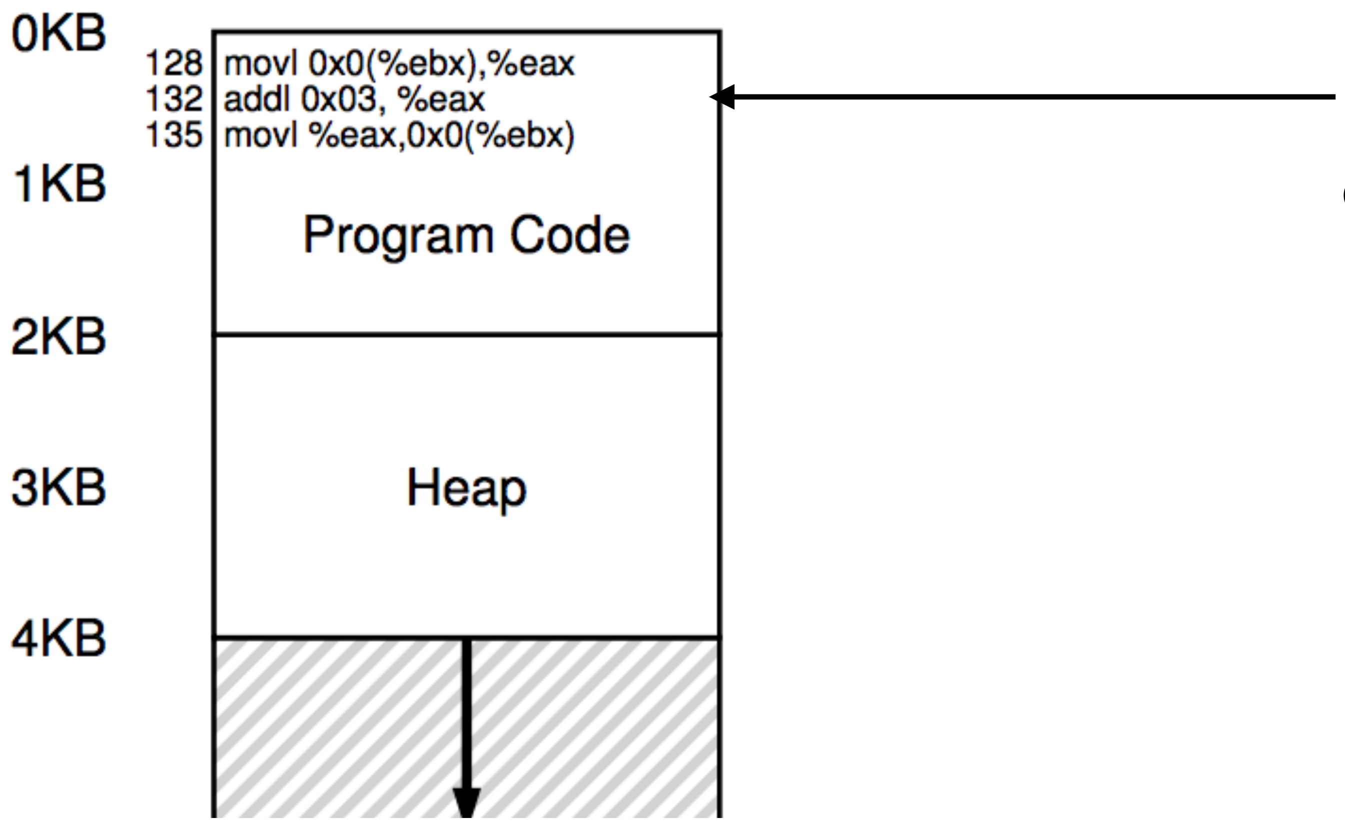
Execute
Load

Example



Fetch
& Execute

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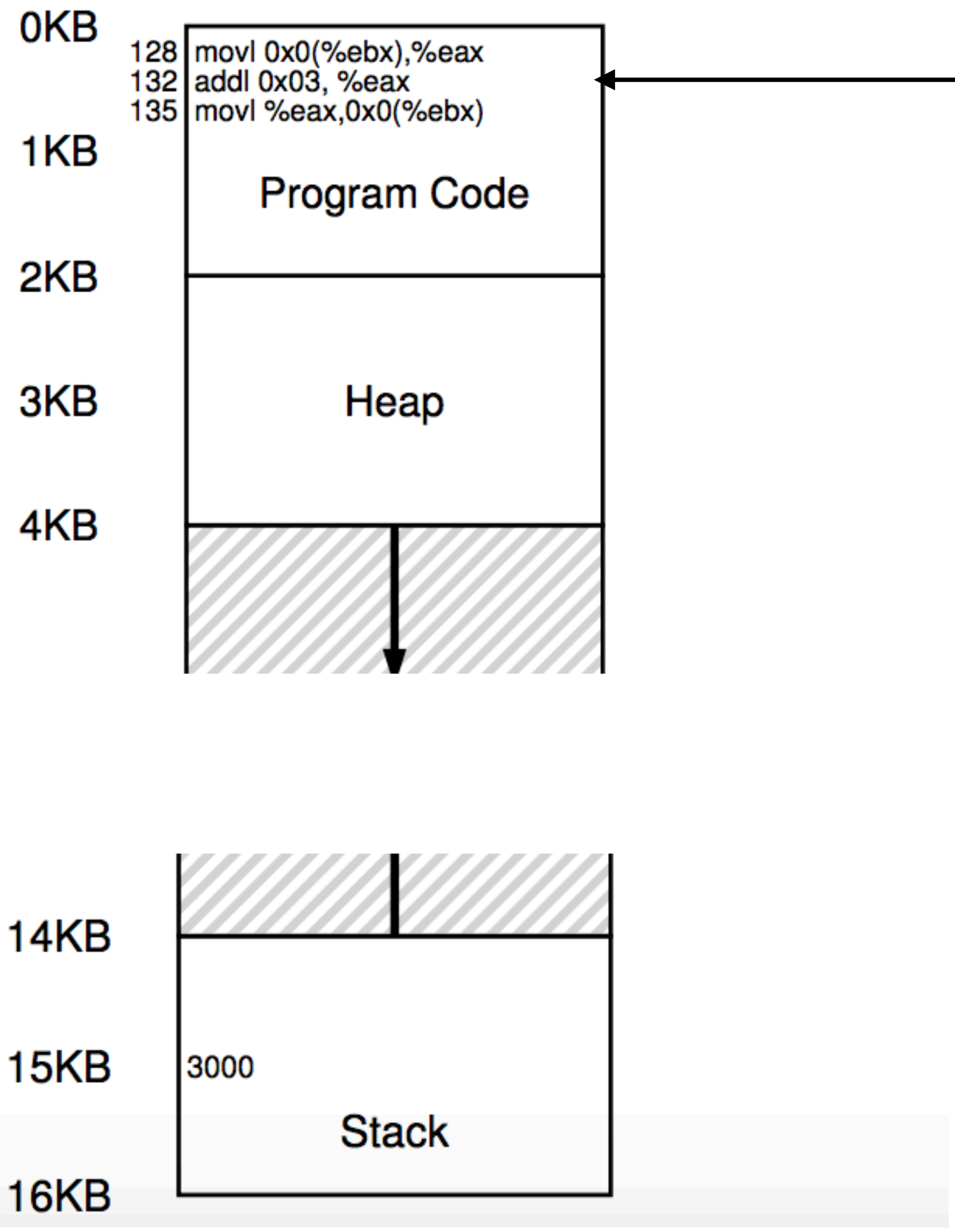

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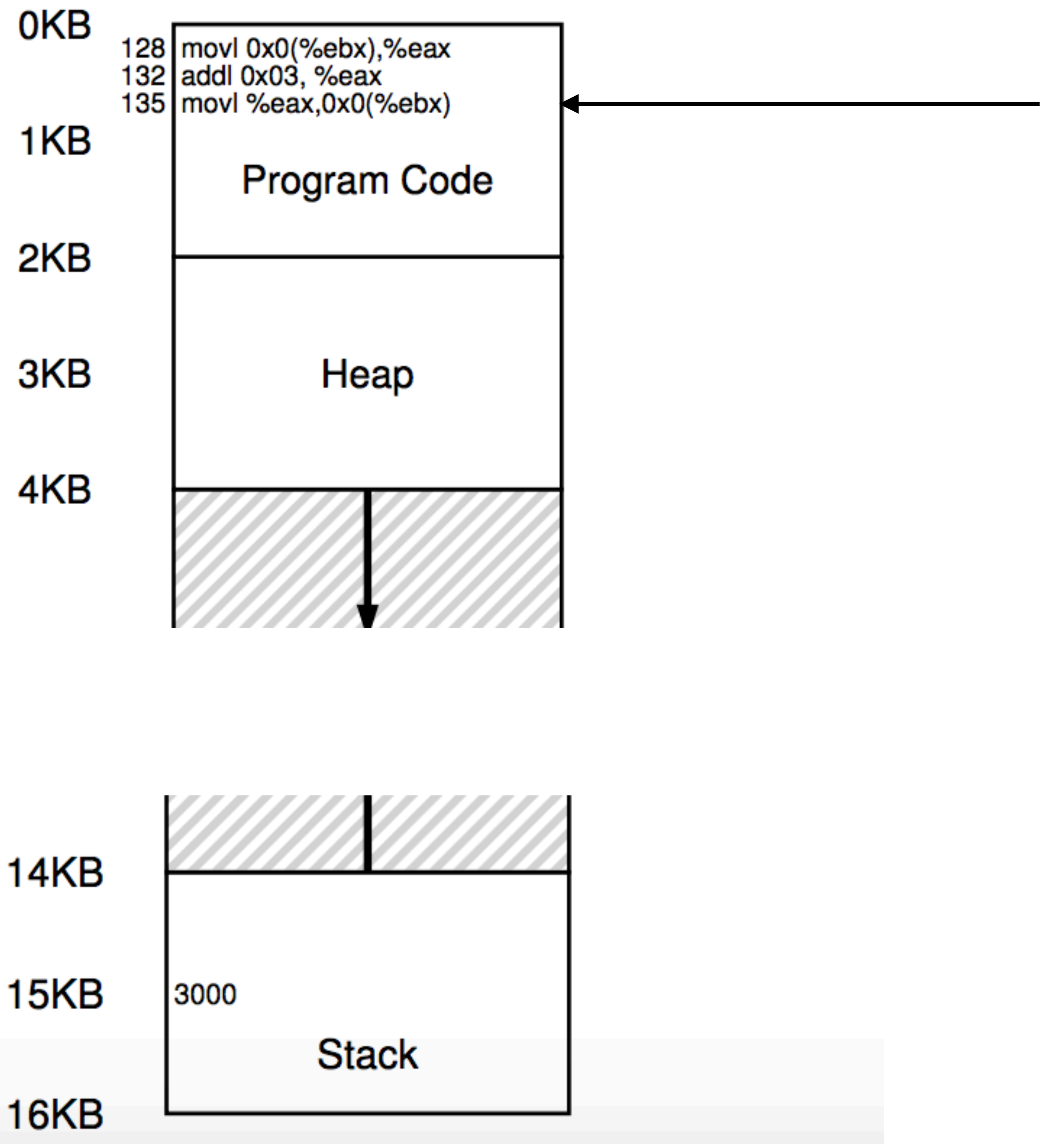

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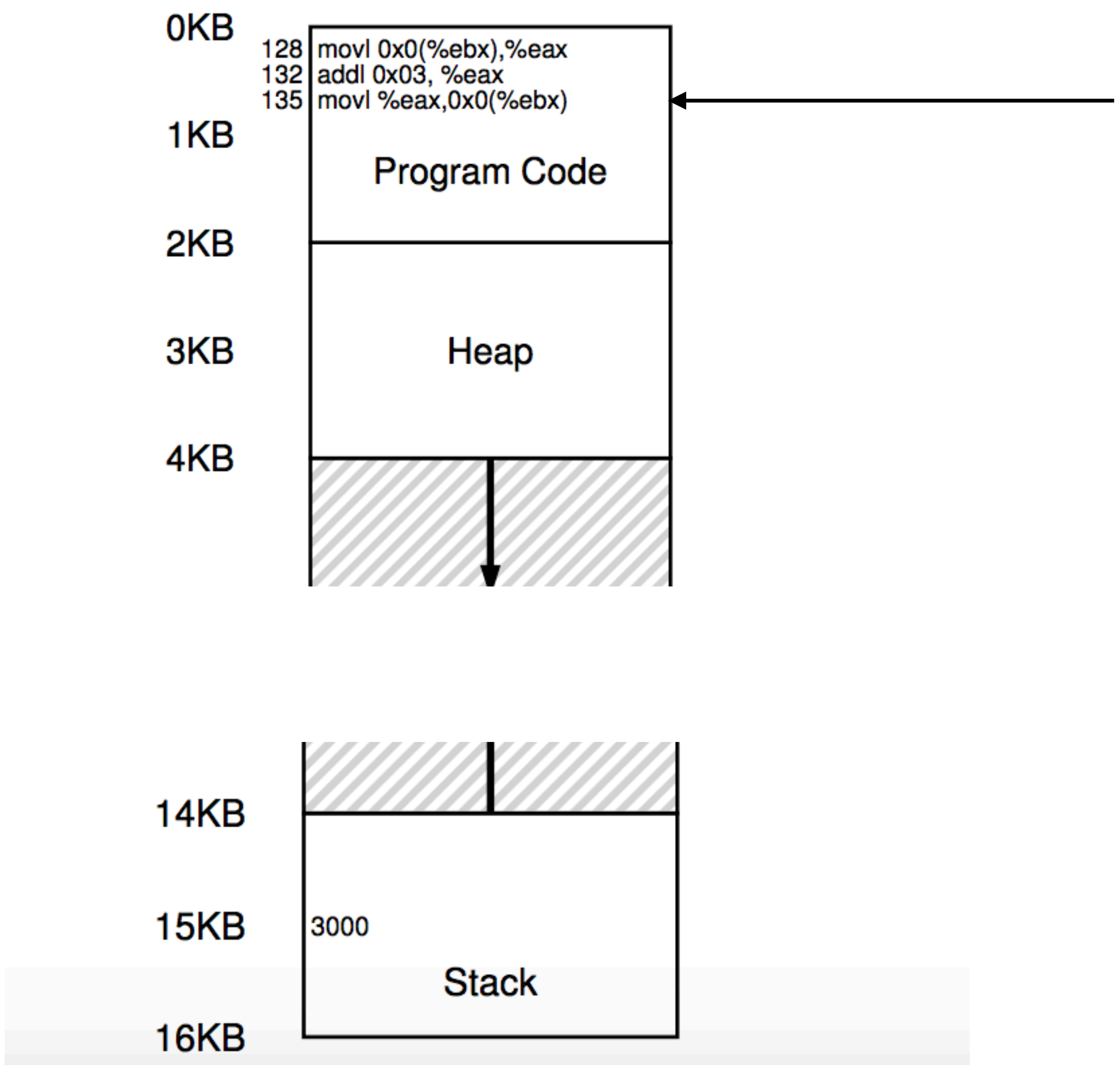
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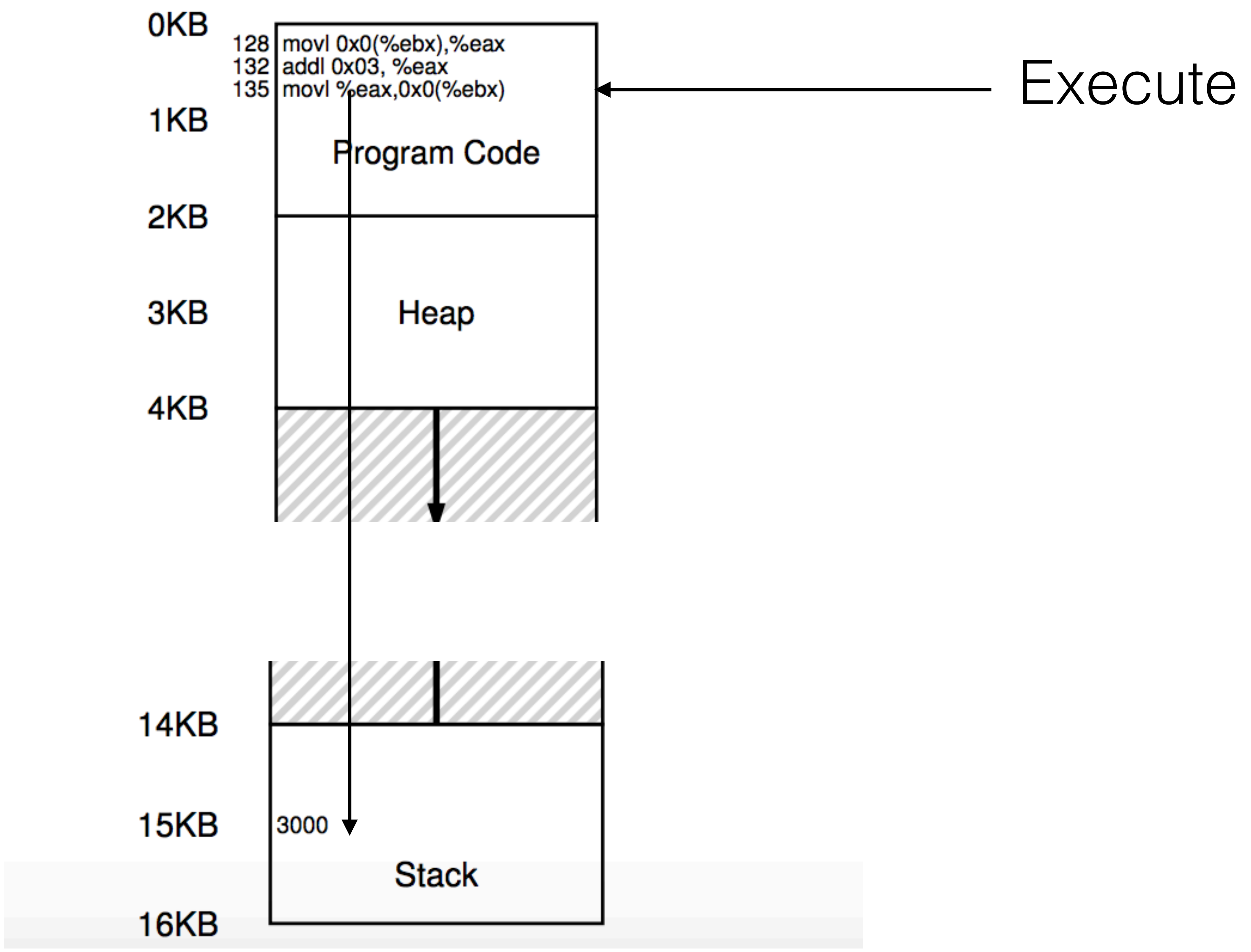
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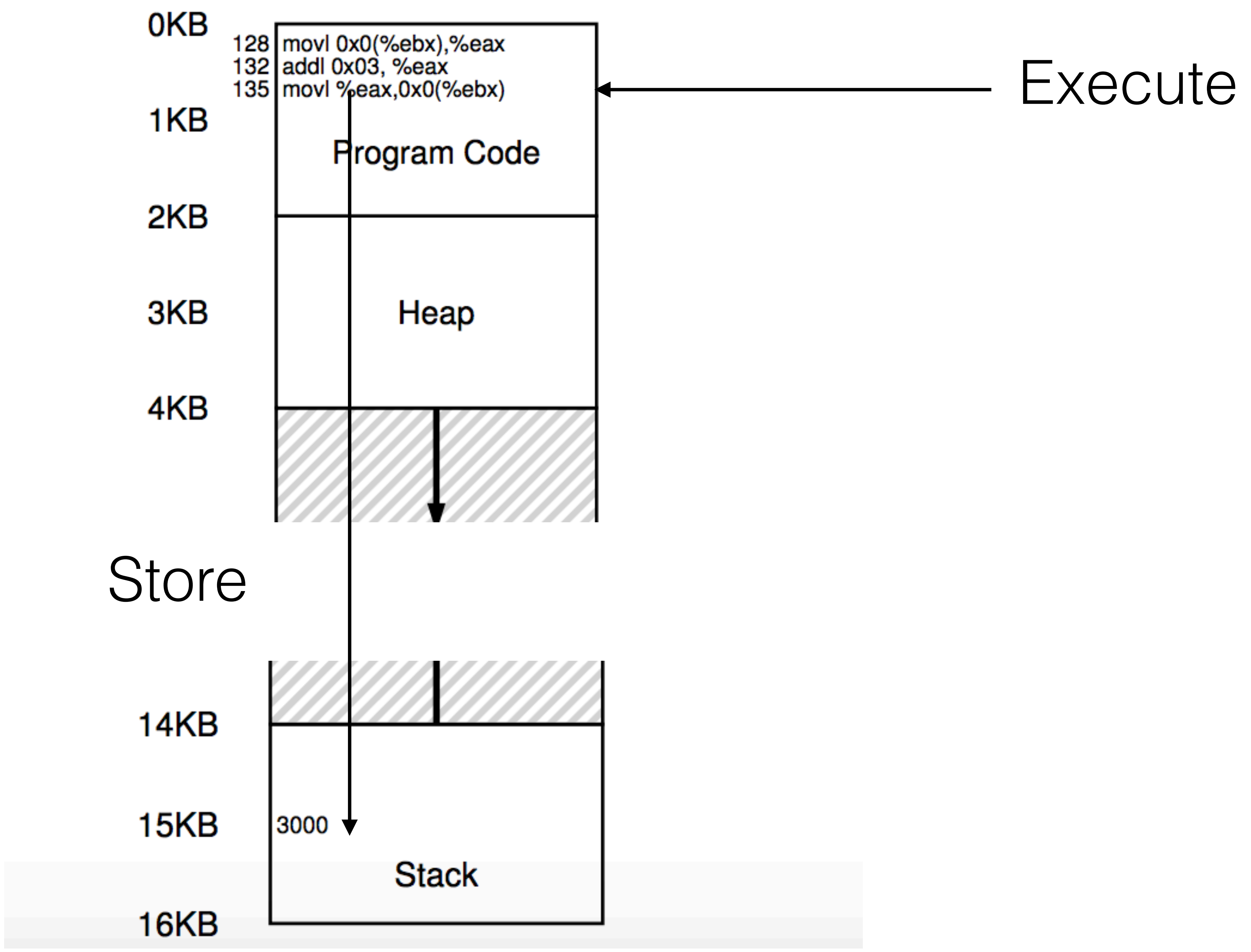

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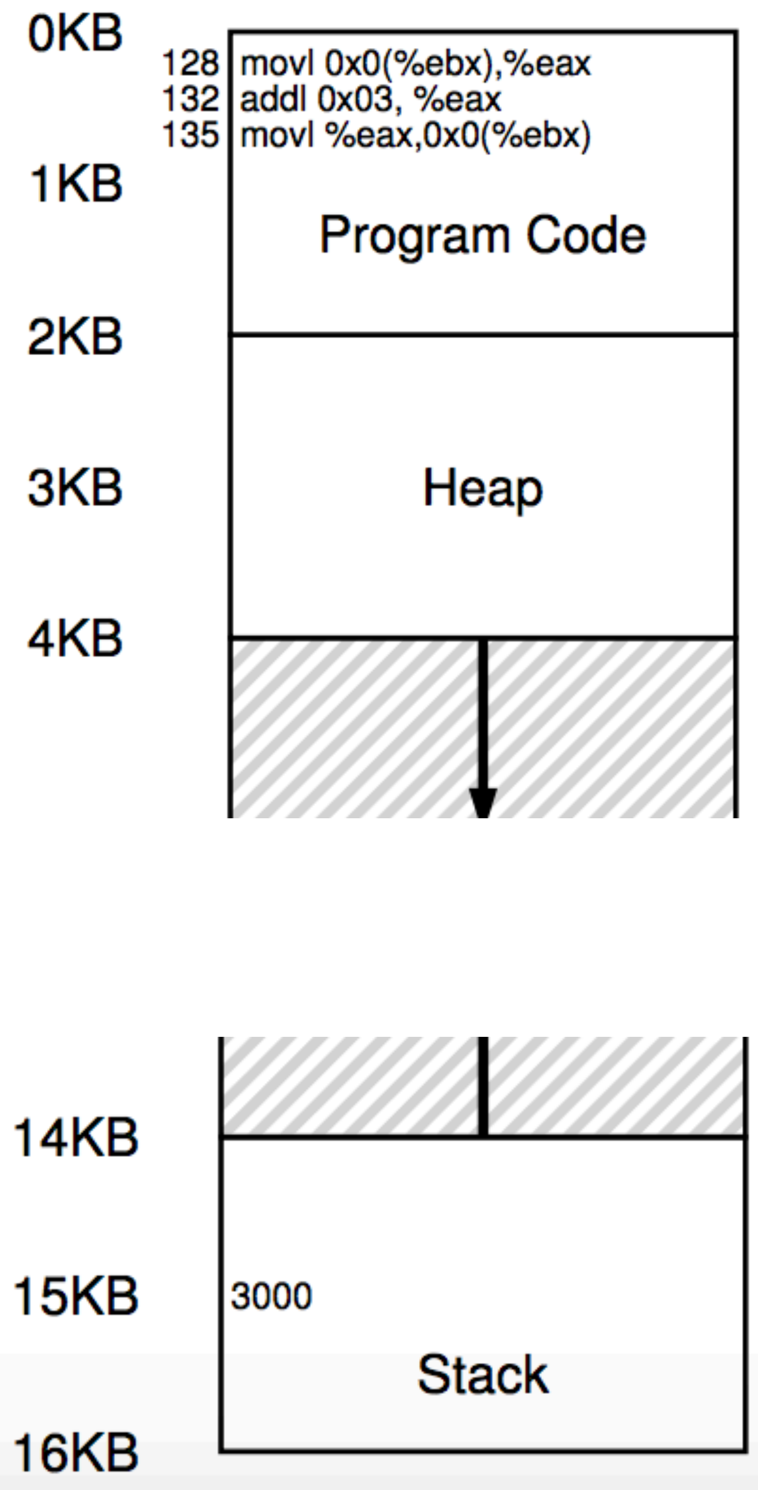
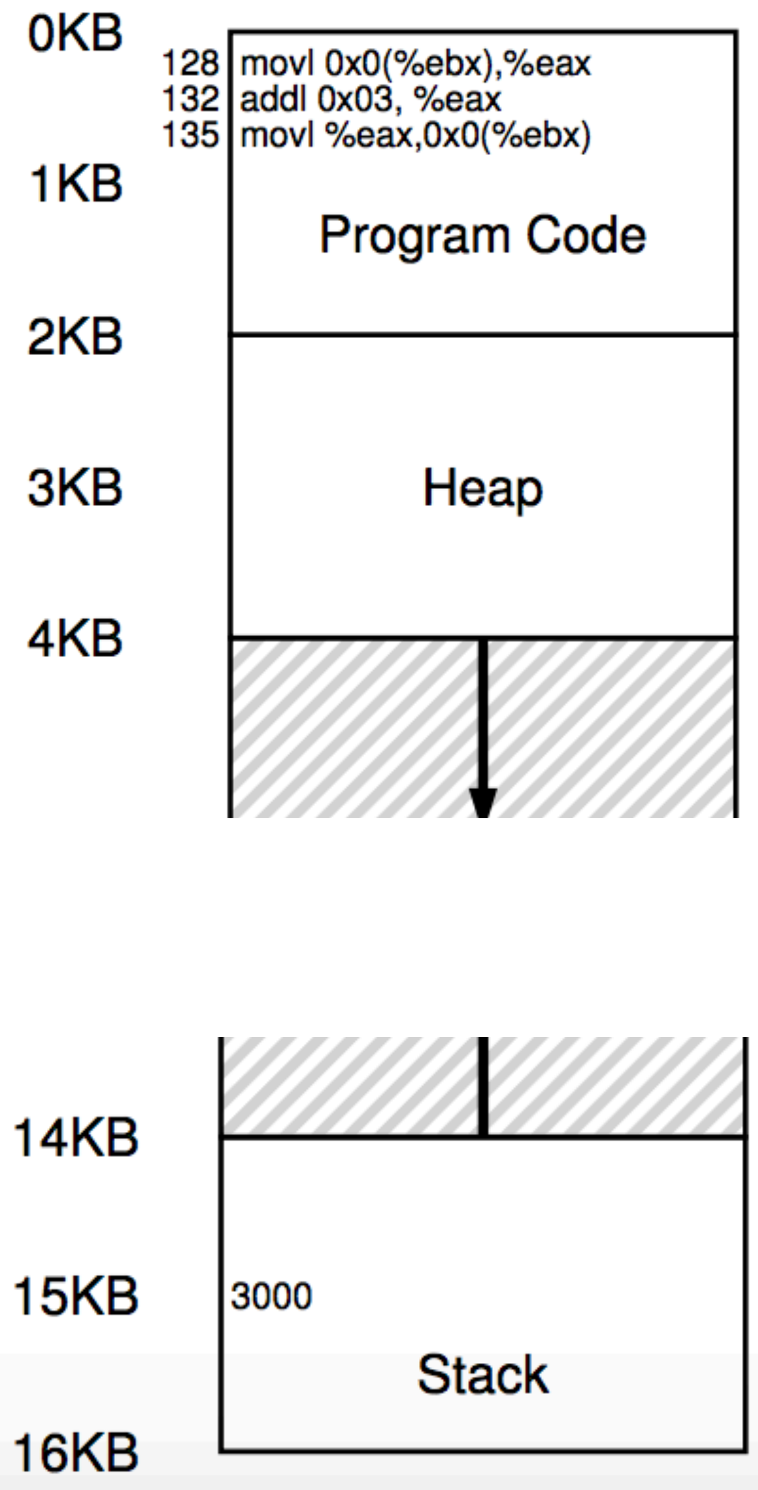
135 movl %eax,0x0(%ebx)
Program Code
Heap
Execute
Store
3000
Stack

Pop Quiz



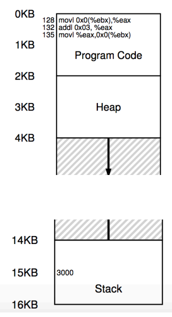
Do all process start and end from 0 KB and 16 KB?

Relocation



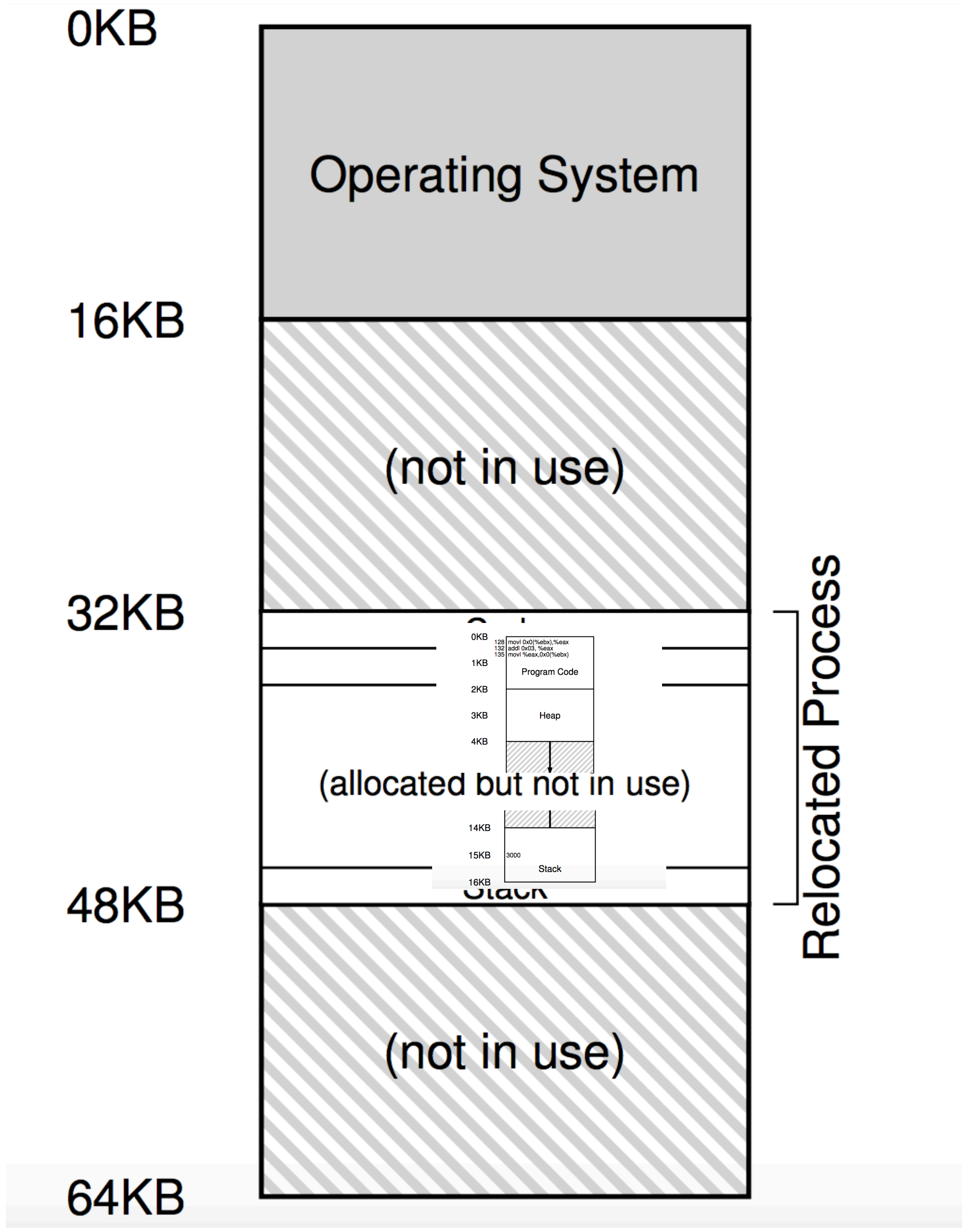
0KB
128 movl 0x0(%ebx),%eax
132 addl 0x03, %eax
135 movl %eax,0x0(%ebx)
1KB
Program Code
2KB
3KB
Heap
4KB
14KB
15KB
3000
Stack
16KB

Relocation



```
128 movl 0x0(%ebx),%eax
132 addl 0x03, %eax
135 movl %eax,0x0(%ebx)
```

Relocation



0KB
Operating System
16KB
(not in use)
32KB
0KB
128 movl 0x0(%ebx),%eax
132 addl 0x03, %eax
135 movl %eax,0x0(%ebx)
1KB
Program Code
2KB
3KB
Heap
4KB
(allocated but not in use)
14KB
15KB
3000
Stack
16KB
Stack
48KB
(not in use)
64KB
Relocated Process

General Address Translation

Kernel

CPU

MMU

Physical Memory

General Address Translation

Kernel

CPU

MMU

Physical Memory

General Address Translation

Kernel

CPU

MMU

Physical Memory

Virtual Address

General Address Translation

Kernel

CPU

MMU

Physical Memory

Virtual Address

0x10102030

General Address Translation

Kernel

CPU

MMU

Physical Memory

Virtual Address
0x10102030

General Address Translation

Kernel

CPU

MMU

Physical Memory

Virtual Address

0x10102030

$$\begin{tikzcd} & \text{Kernel} & \\ \text{CPU} & \text{MMU} \arrow[u] & \text{Physical Memory} \\ \text{Virtual Address 0x10102030} \arrow[ur] & & \end{tikzcd}$$

General Address Translation

$$\begin{tikzcd}
 & \text{Kernel} \arrow[d, bend left] & \\
\text{CPU} & \text{MMU} \arrow[u, bend left] & \text{Physical Memory} \\
\text{Virtual Address } \texttt{0x10102030} \arrow[ur] & &
\end{tikzcd}$$

General Address Translation

$$\begin{tikzcd}
 & \text{Kernel} \arrow[d, bend left] & \\
\text{CPU} & \text{MMU} \arrow[u, bend left] & \text{Physical Memory} \\
\text{Virtual Address 0x10102030} \arrow[ur] & \text{Physical Address} &
\end{tikzcd}$$

General Address Translation

Kernel

CPU

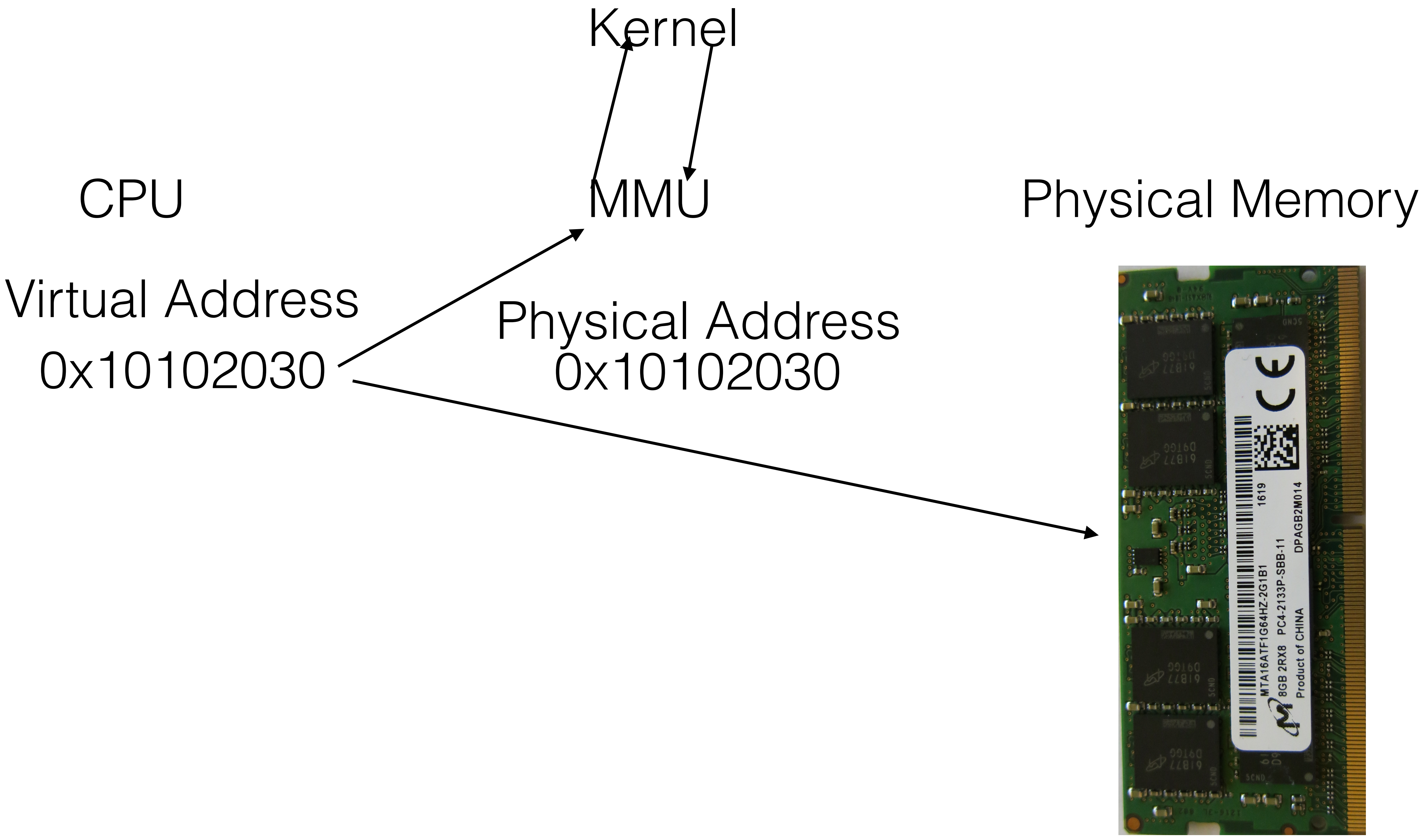
MMU

Physical Memory

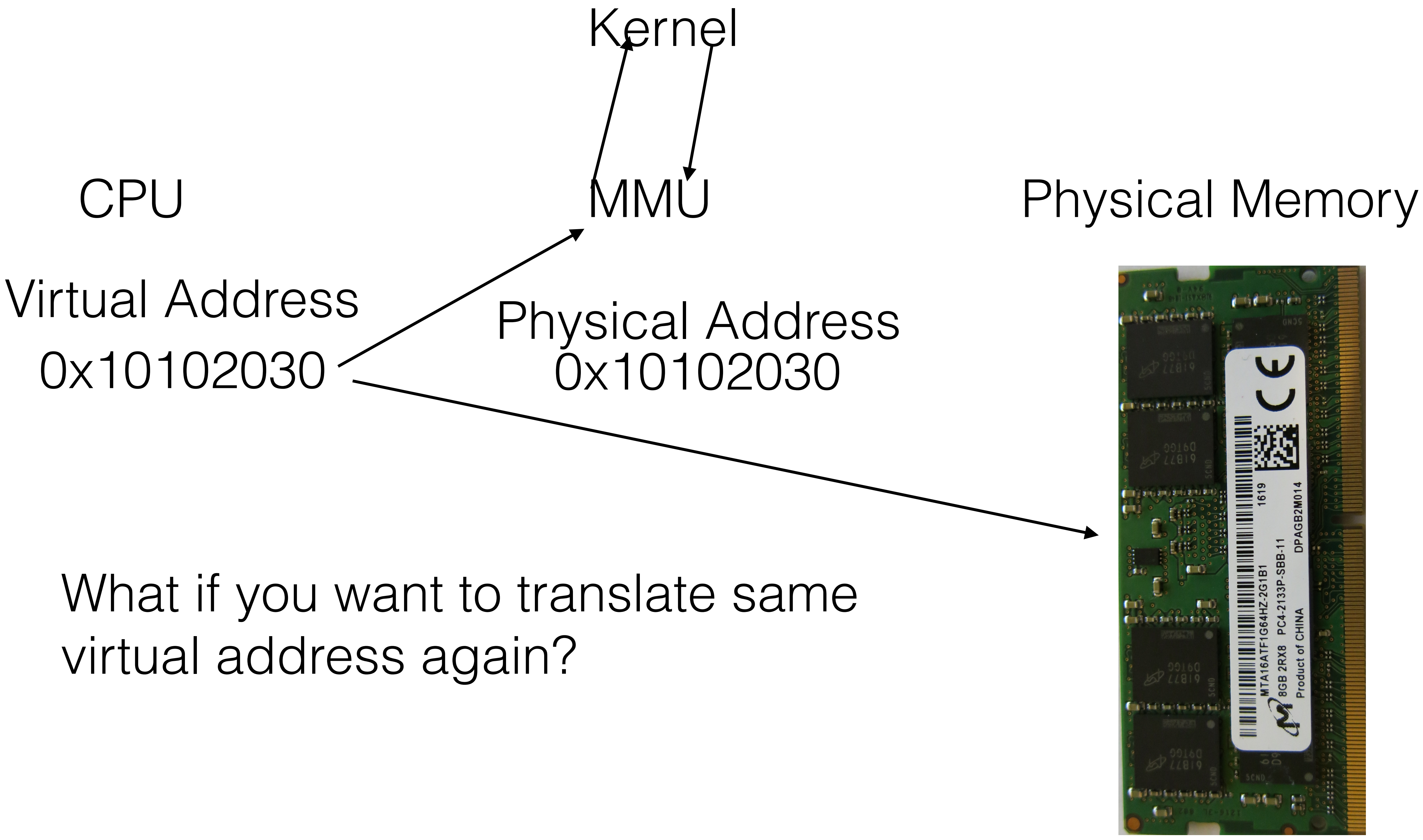
Virtual Address
0x10102030

Physical Address
0x10102030

General Address Translation

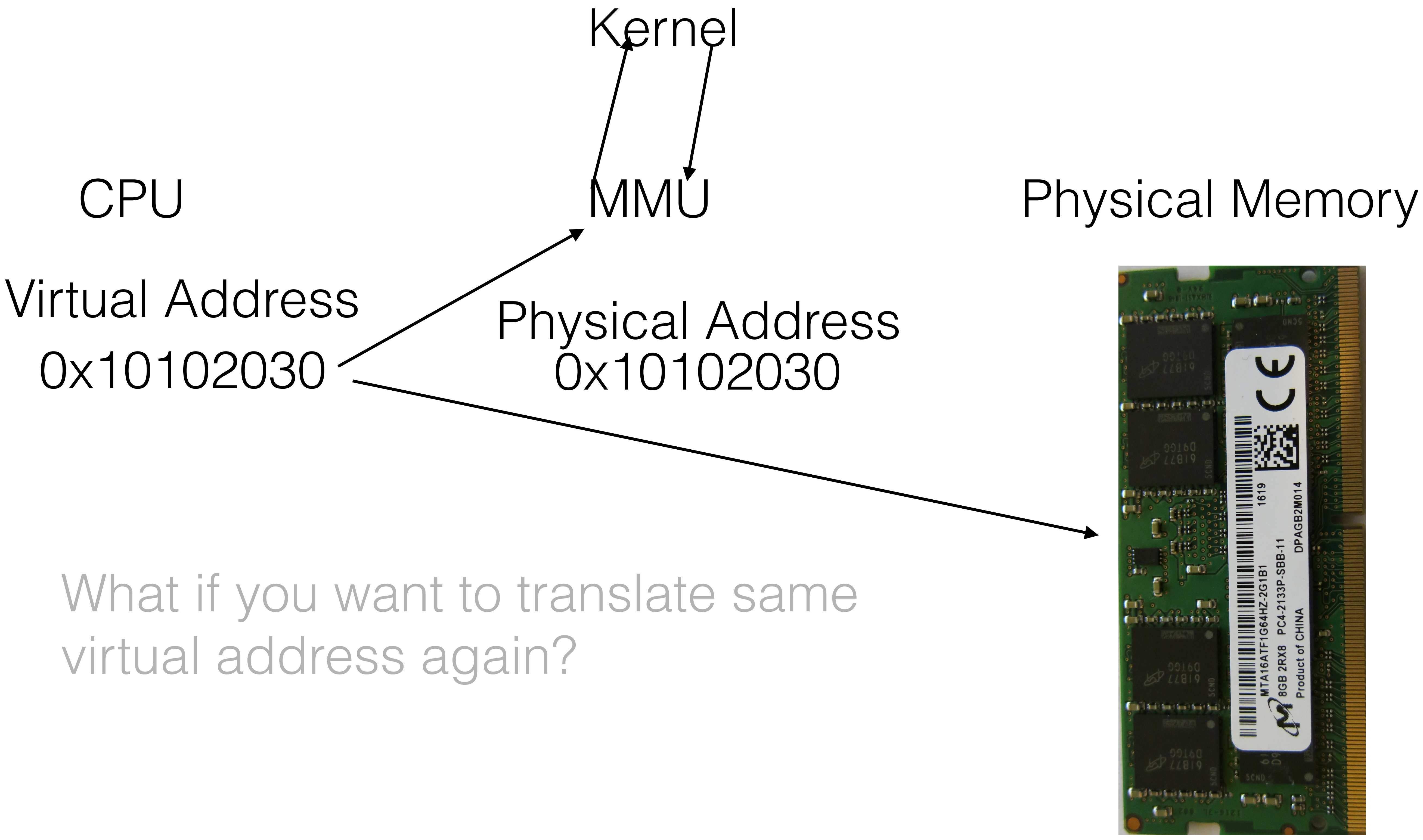


General Address Translation



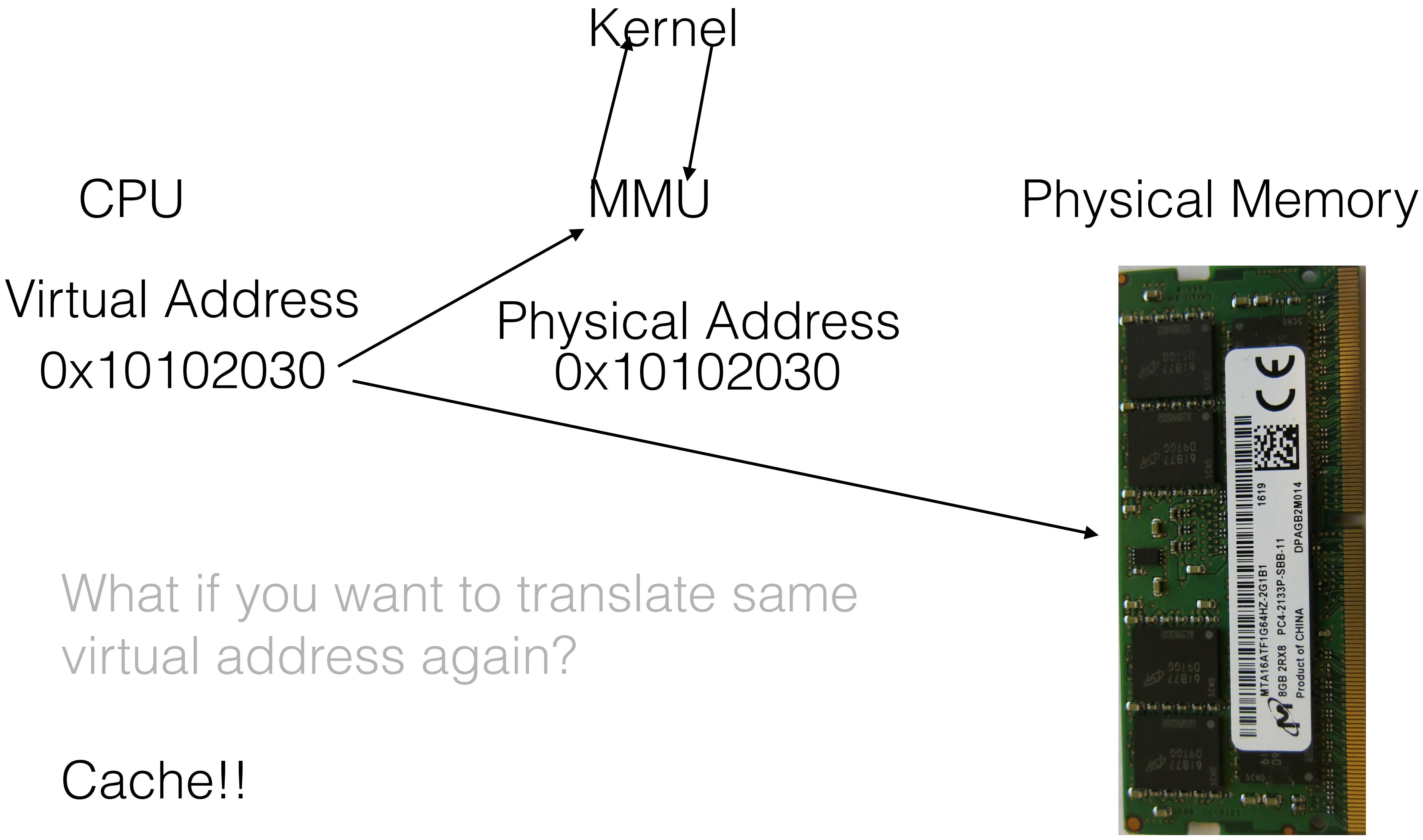
What if you want to translate same virtual address again?

General Address Translation



What if you want to translate same virtual address again?

General Address Translation



What if you want to translate same virtual address again?

Cache!!

General Address Translation

Kernel

CPU

MMU

Physical Memory

Virtual Address
0x10102030

Physical Address
0x10102030

What do you do with cache if there is a context switch?