CPSC 213 Lab 3

Dynamic Arrays & C Pointers

Slides available at randyzhu.com/cpsc213

Randy Zhu

Pointer Review

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- in general: `<type>* ptr;`

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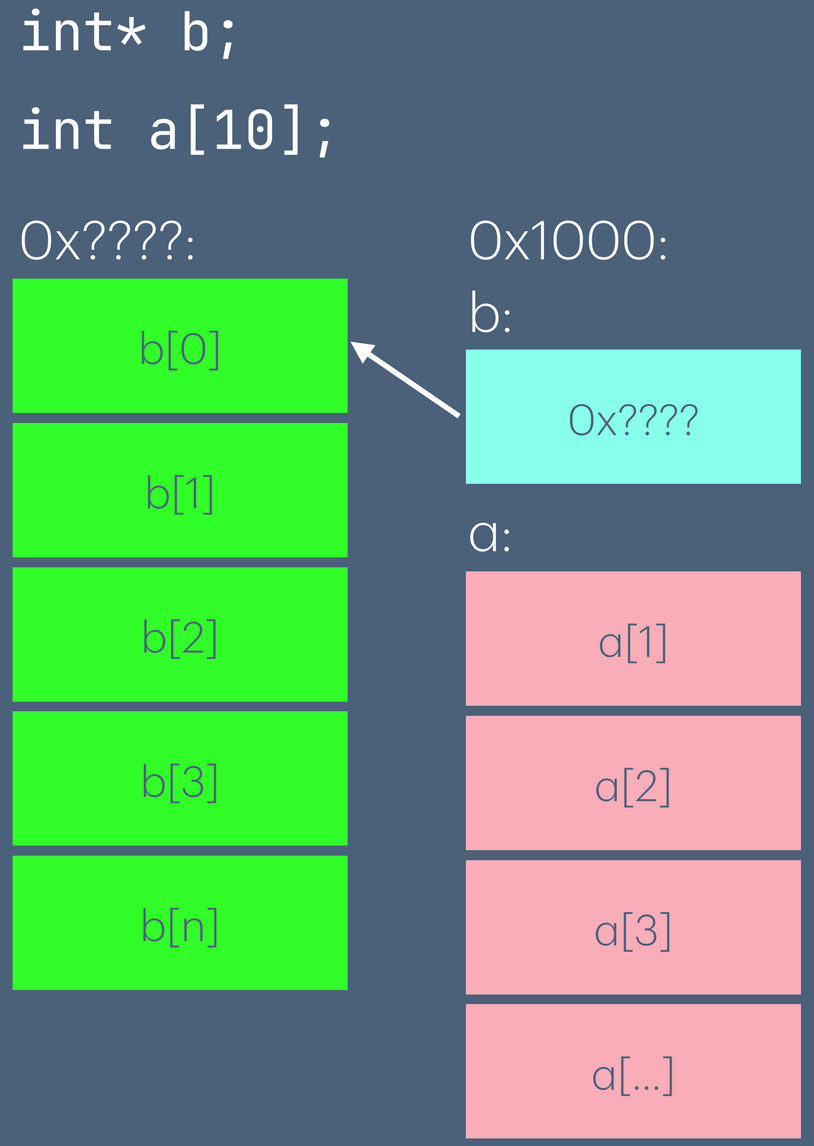
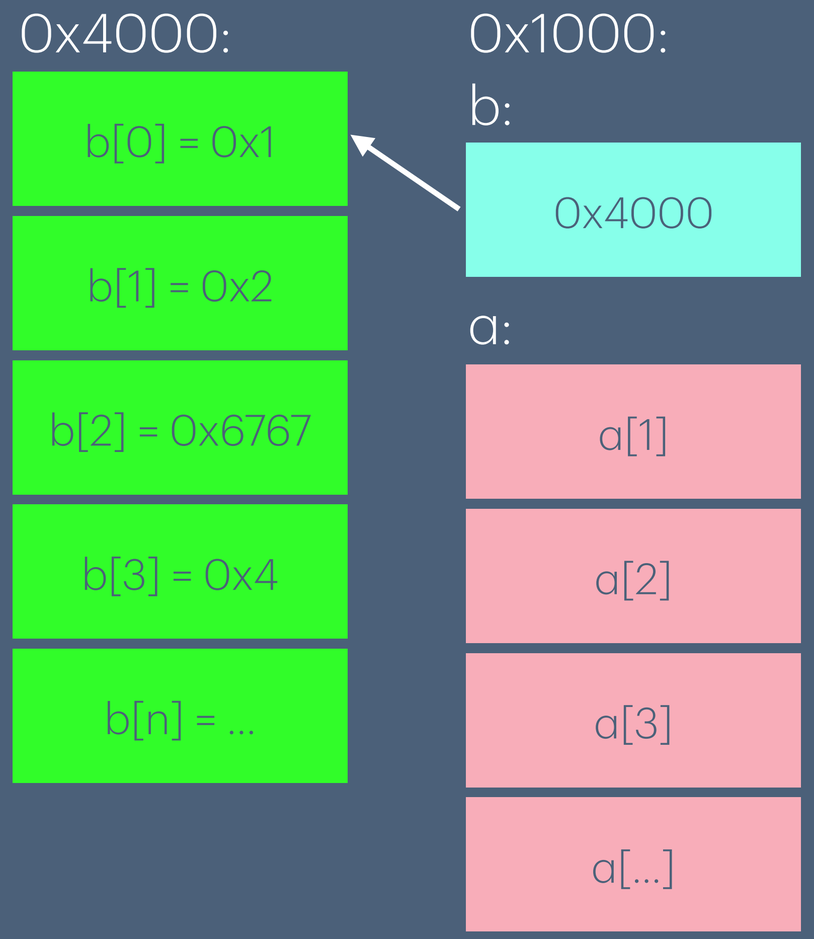


Pointer Review

Array-like; pointer arithmetic

```
int* b;
int a[10];
```



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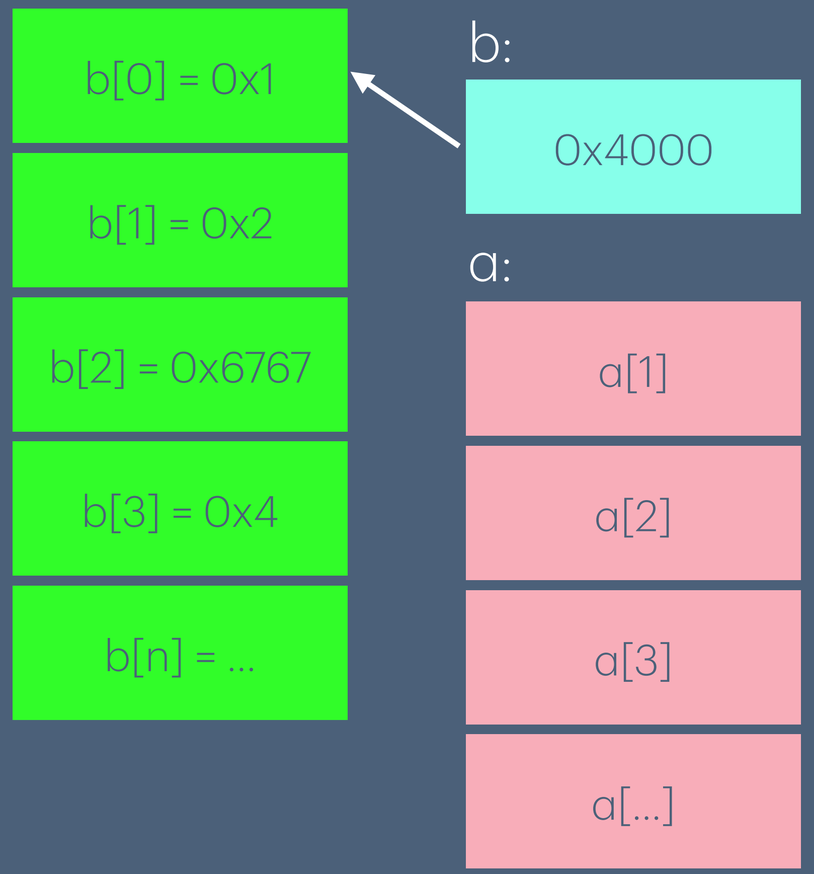

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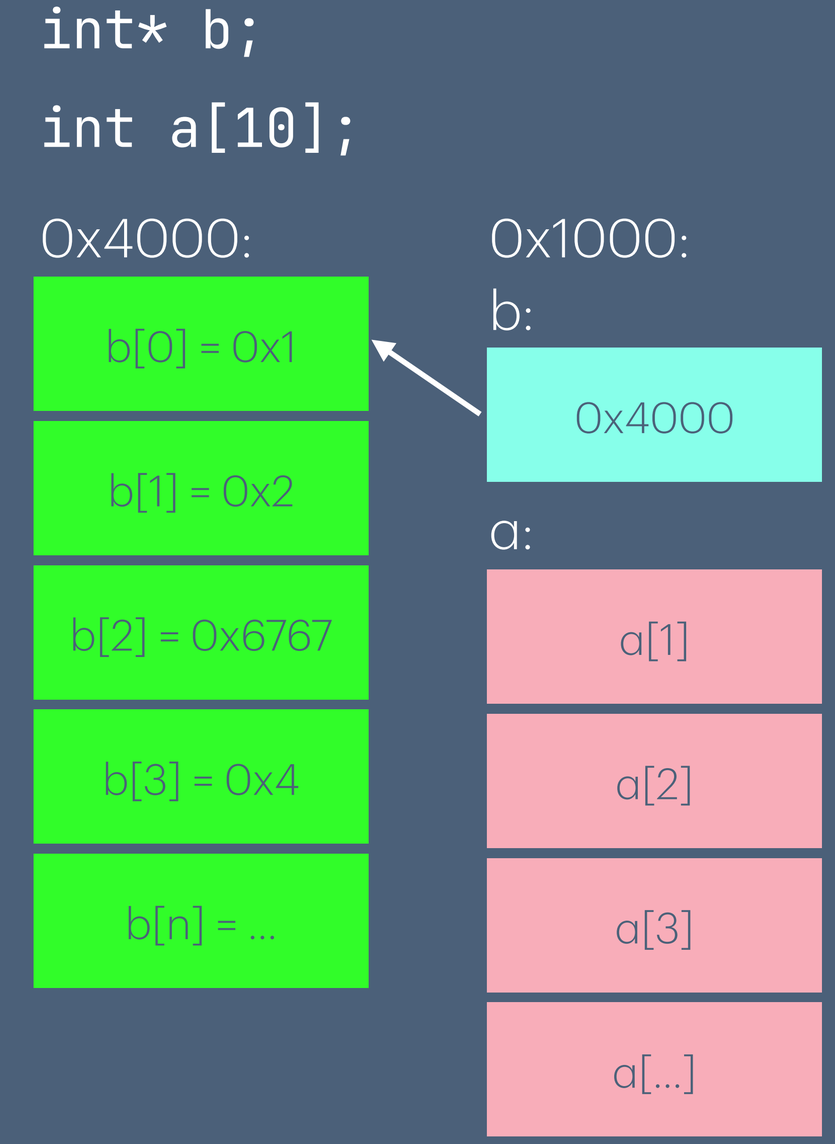

Pointer Review

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- `*b` gets the value a pointer points to
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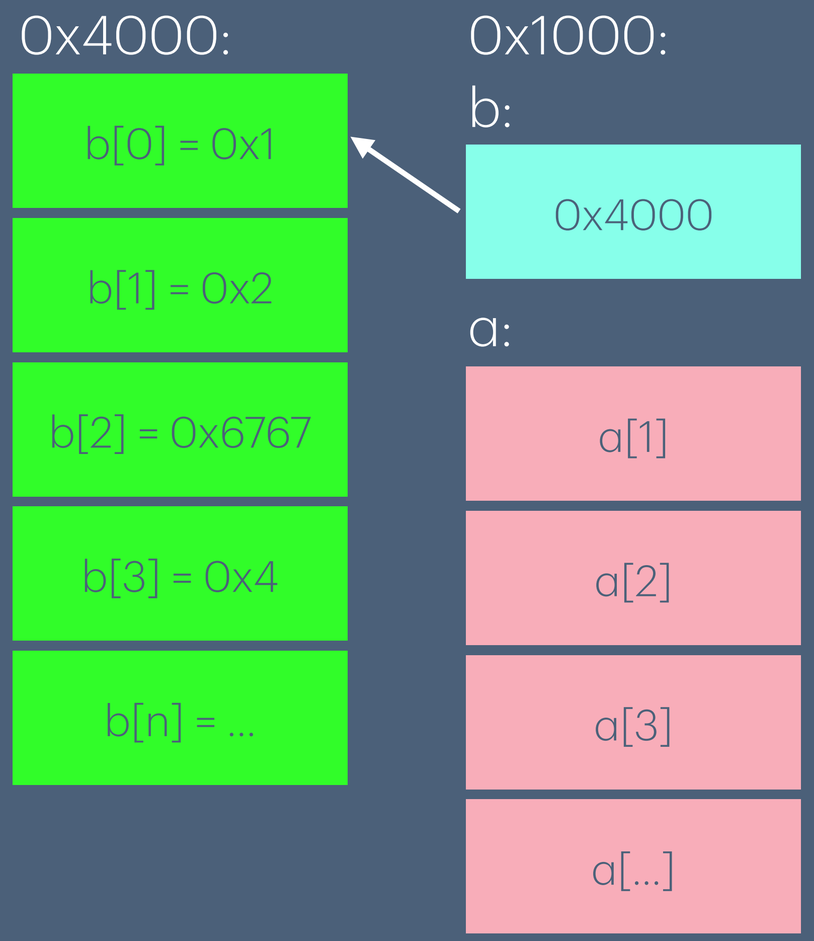

Pointer Review

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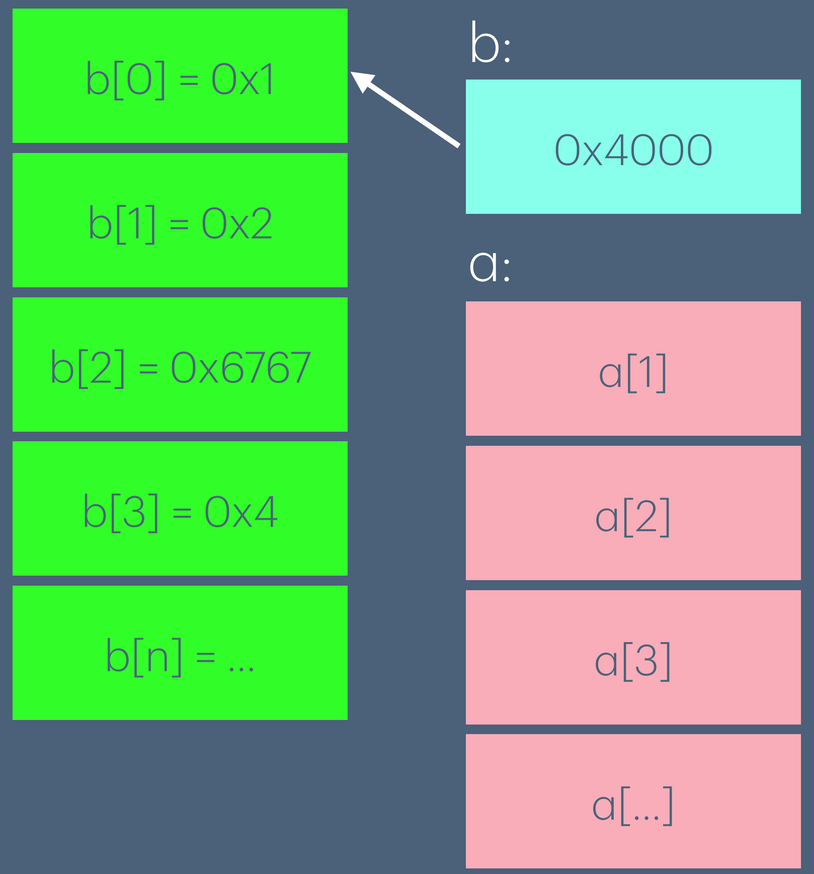

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    - 0x4000 + sizeof(int) * 1 = 0x4000 + 4 = **0x4004**

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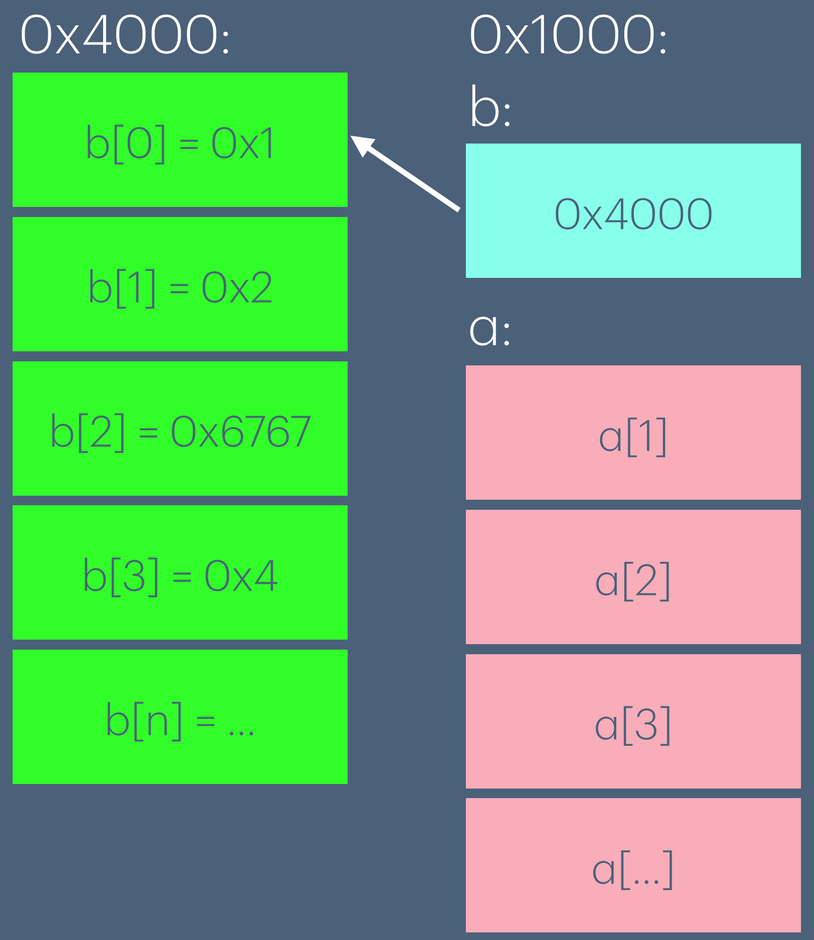

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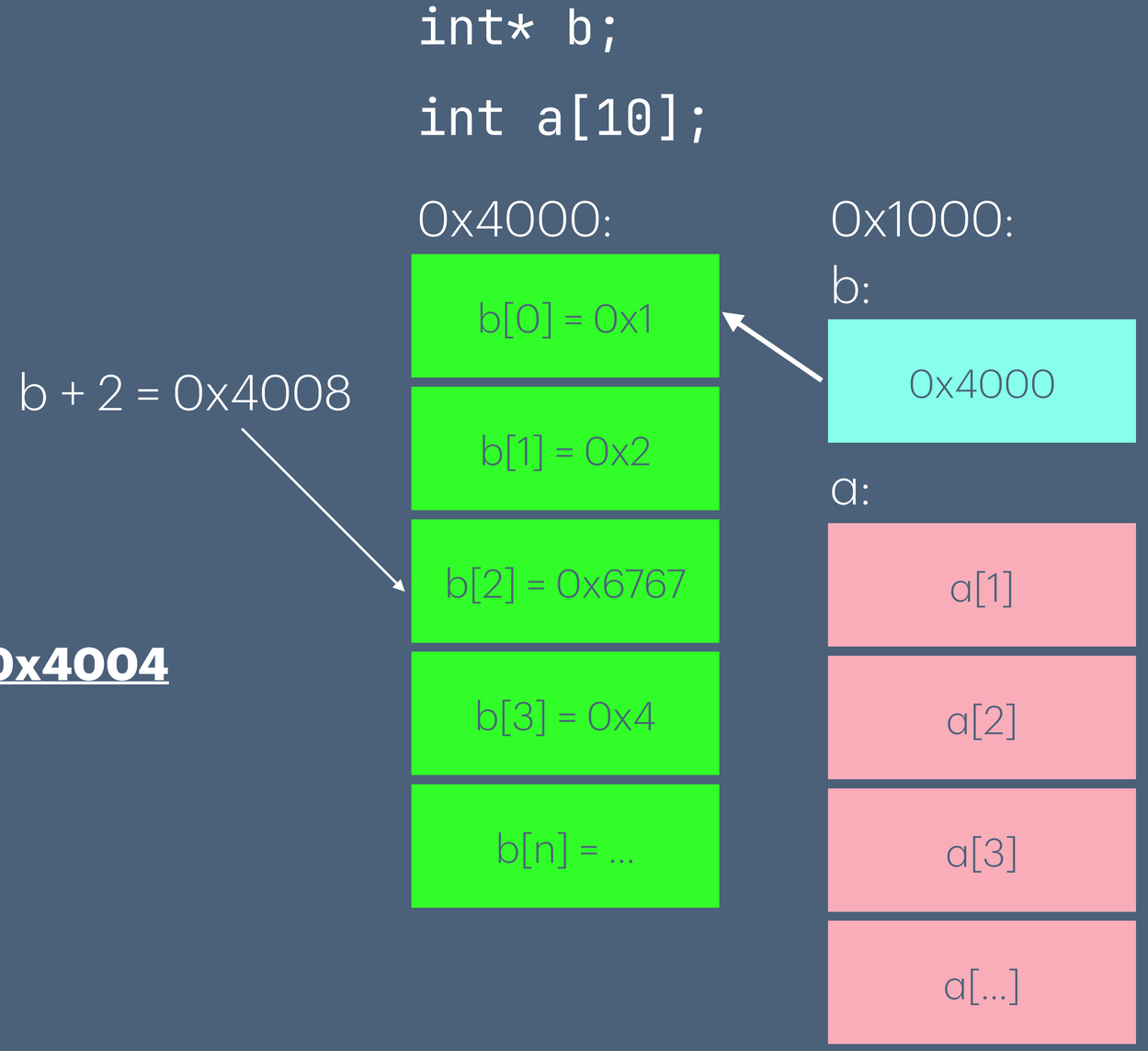

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- Here, `*b` → `0x1`
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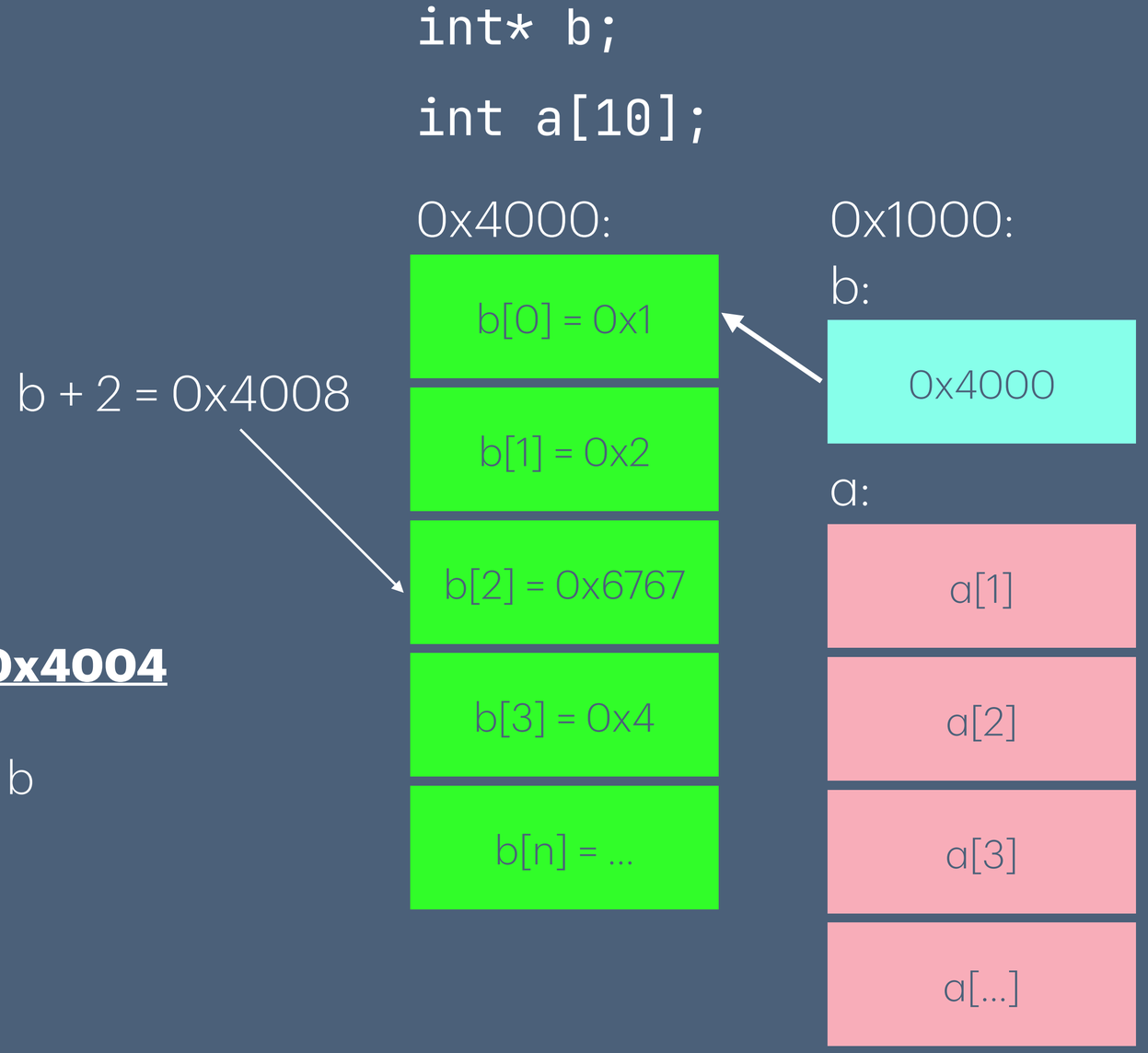
  - `*(b + 1)` gets the value of next int after b



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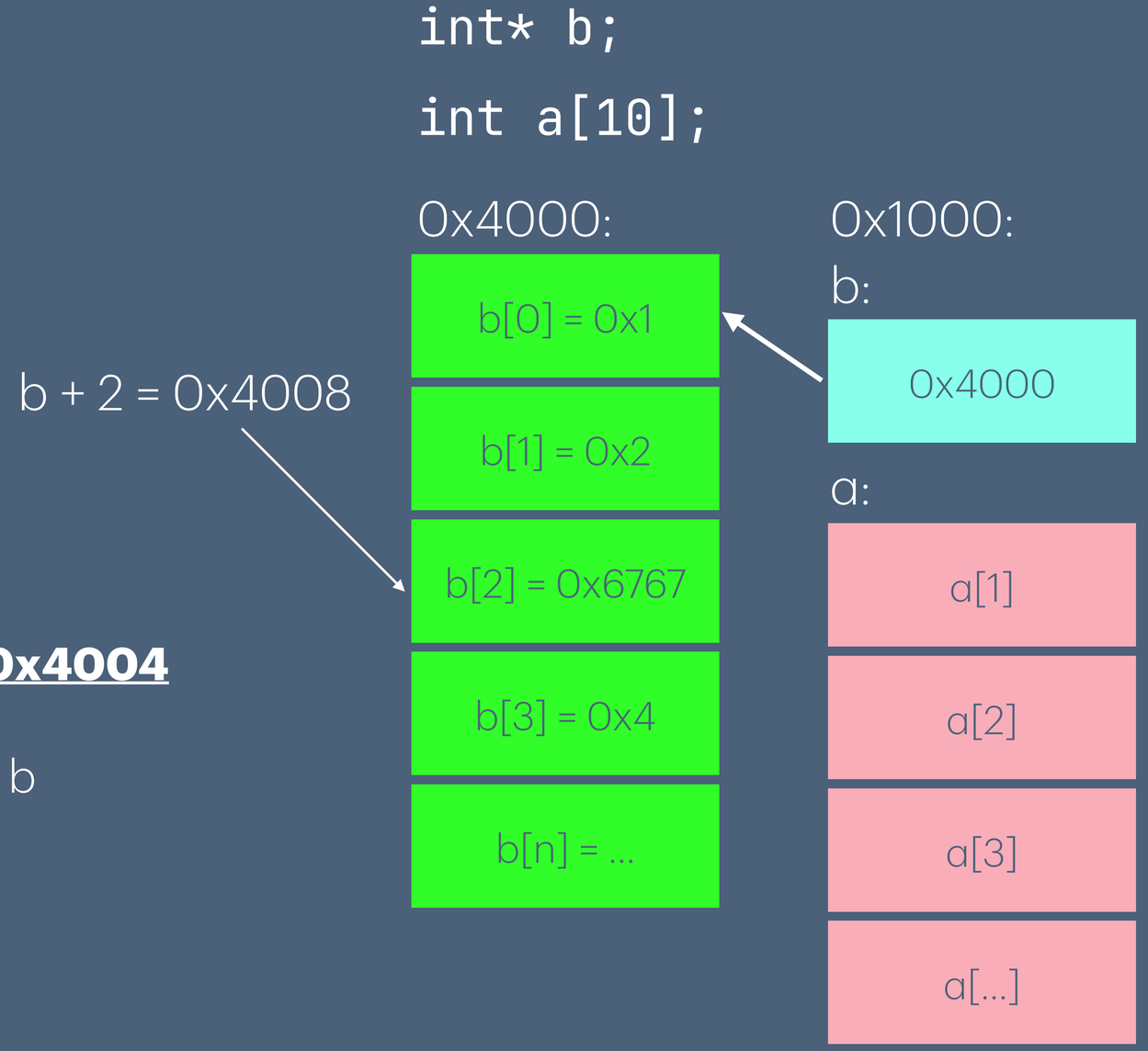

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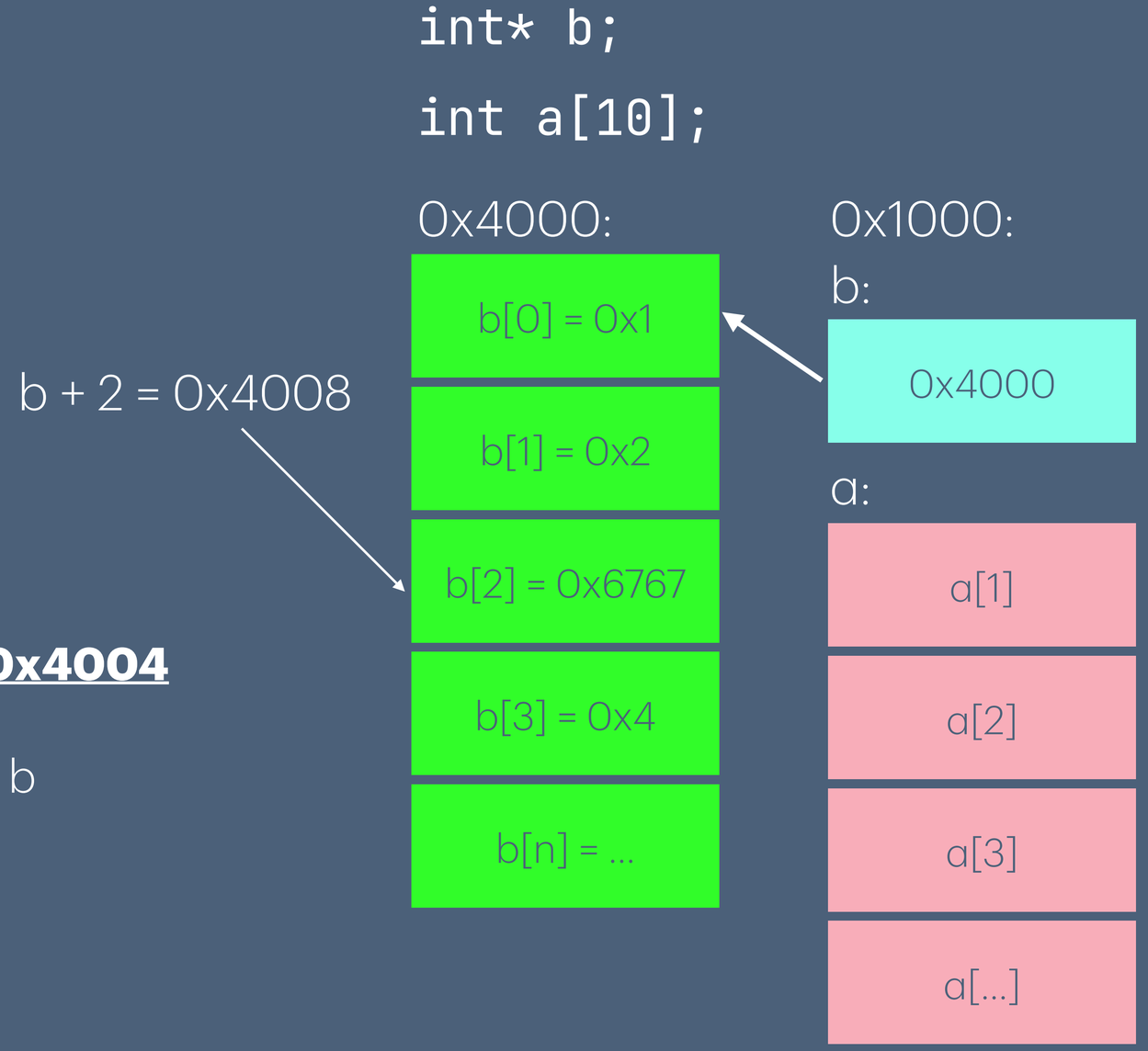

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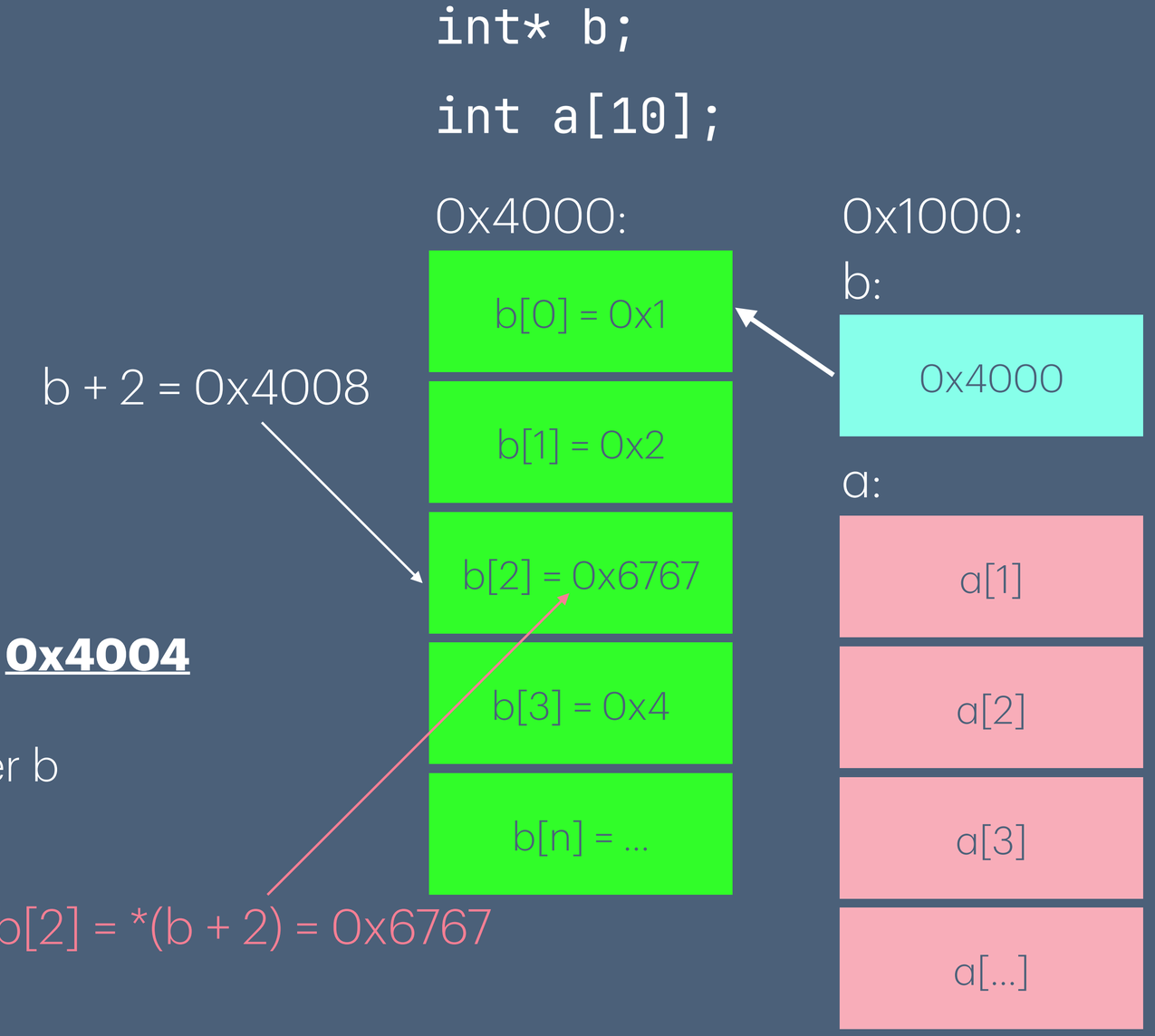


Approaches to counting memory reads

Q1: Static & Dynamic Arrays

- Translate C to ASM
  - Pros
    - Reliable
    - Good practice
  - Cons
    - Slower
    - ASM has to be correct
- Analyze the C code
  - Pros
    - Faster
    - Better understanding of C
  - Cons
    - Less flexible

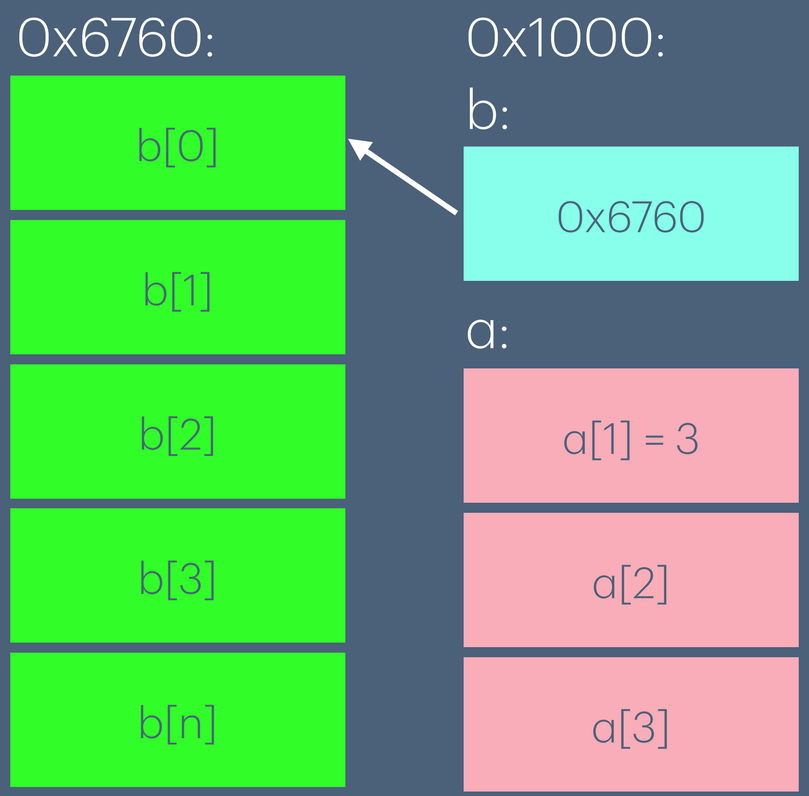
b[b[a[1]]] = b[1] + b[a[1]]

Dynamic vs Static Arrays

- Analysis approach
  - What do I need?
    - **Address** of RHS
    - **Value** of LHS
  - Values can be shared between RHS and LHS

$$b[b[a[1]]] = b[1] + b[a[1]]$$

b[b[a[1]]] = b[1] + b[a[1]]



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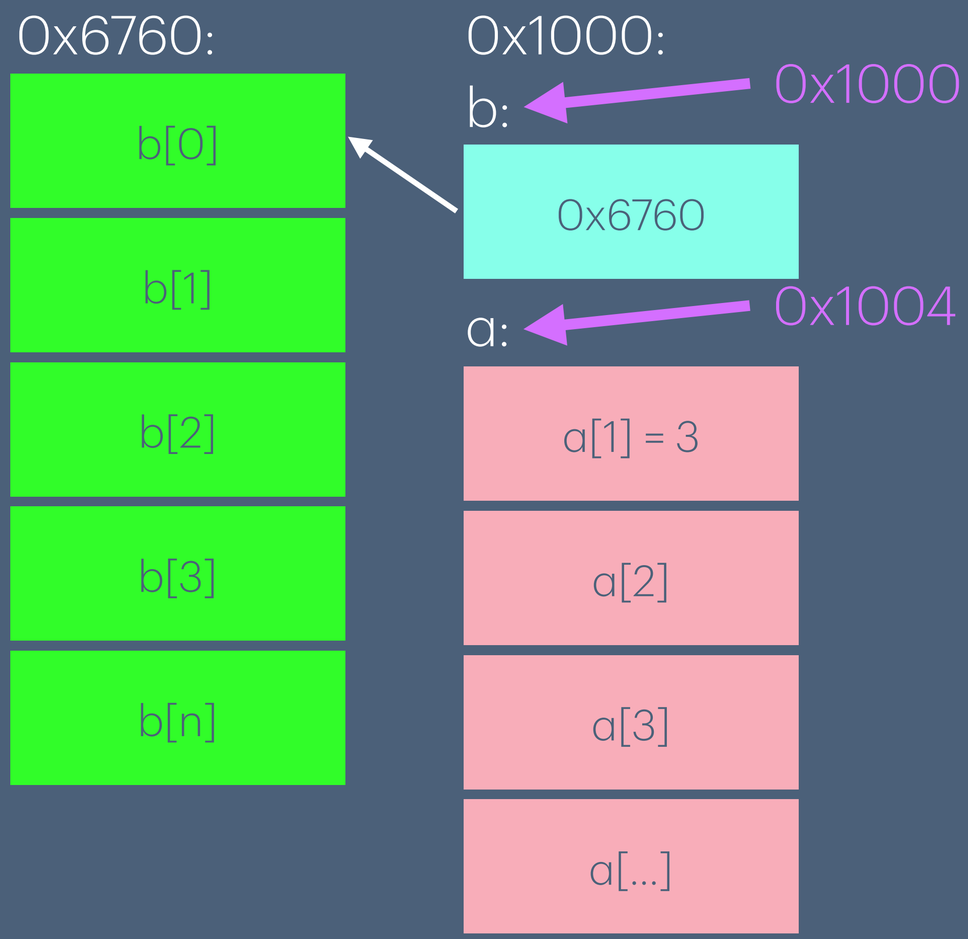

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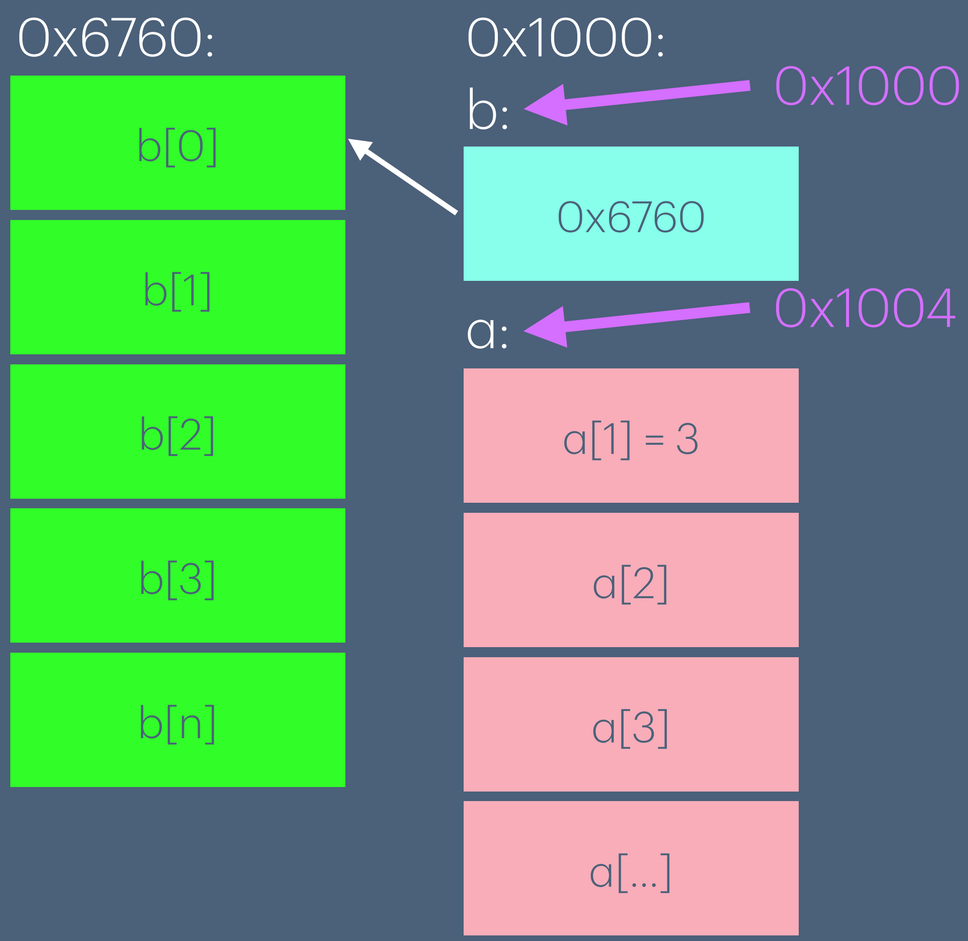

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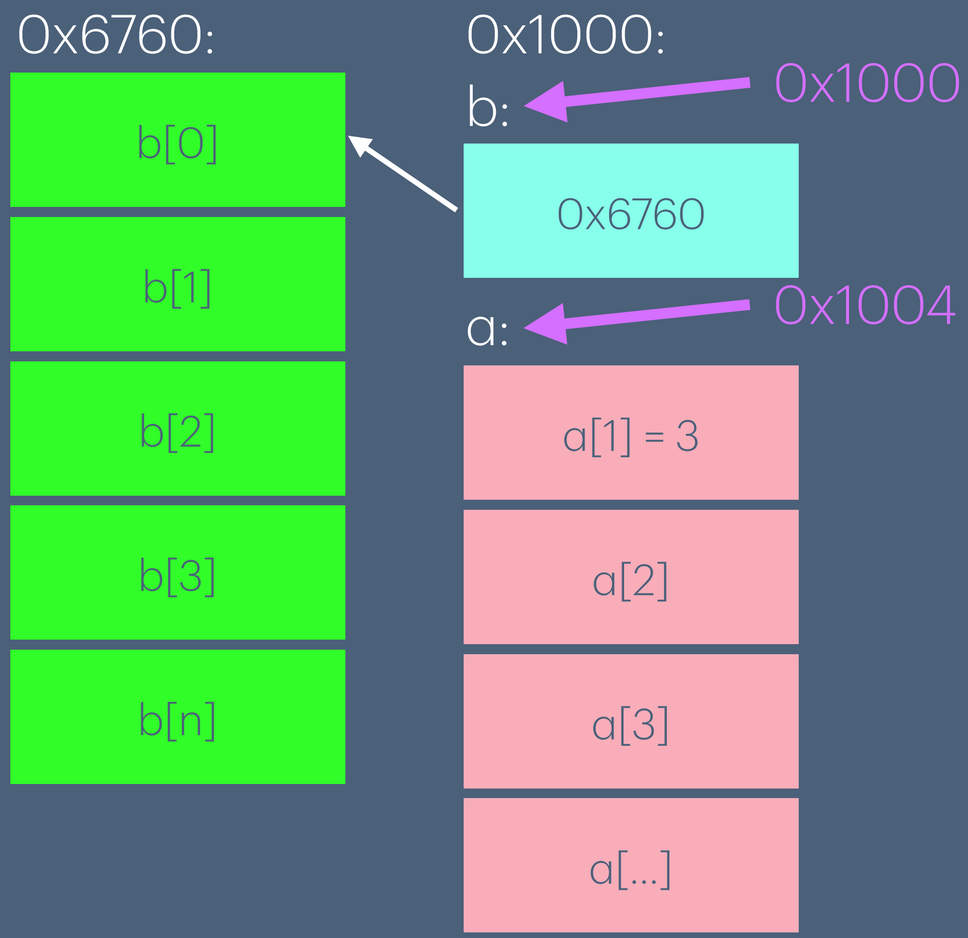

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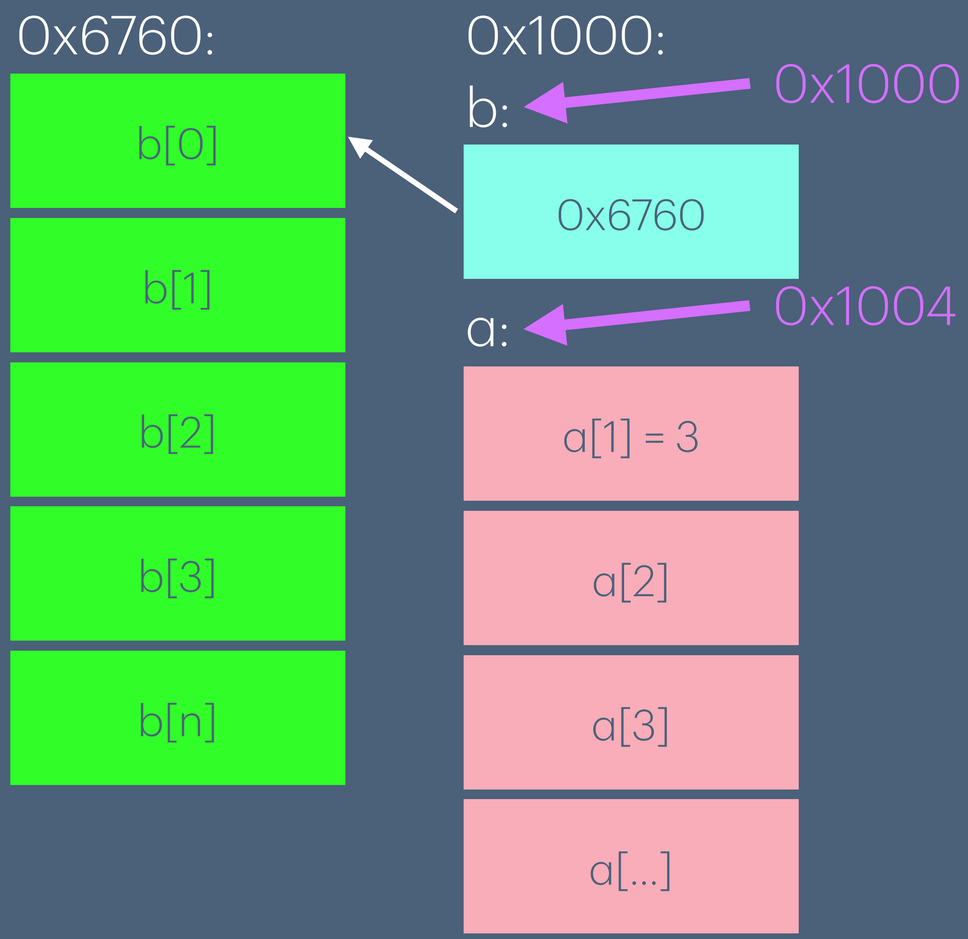

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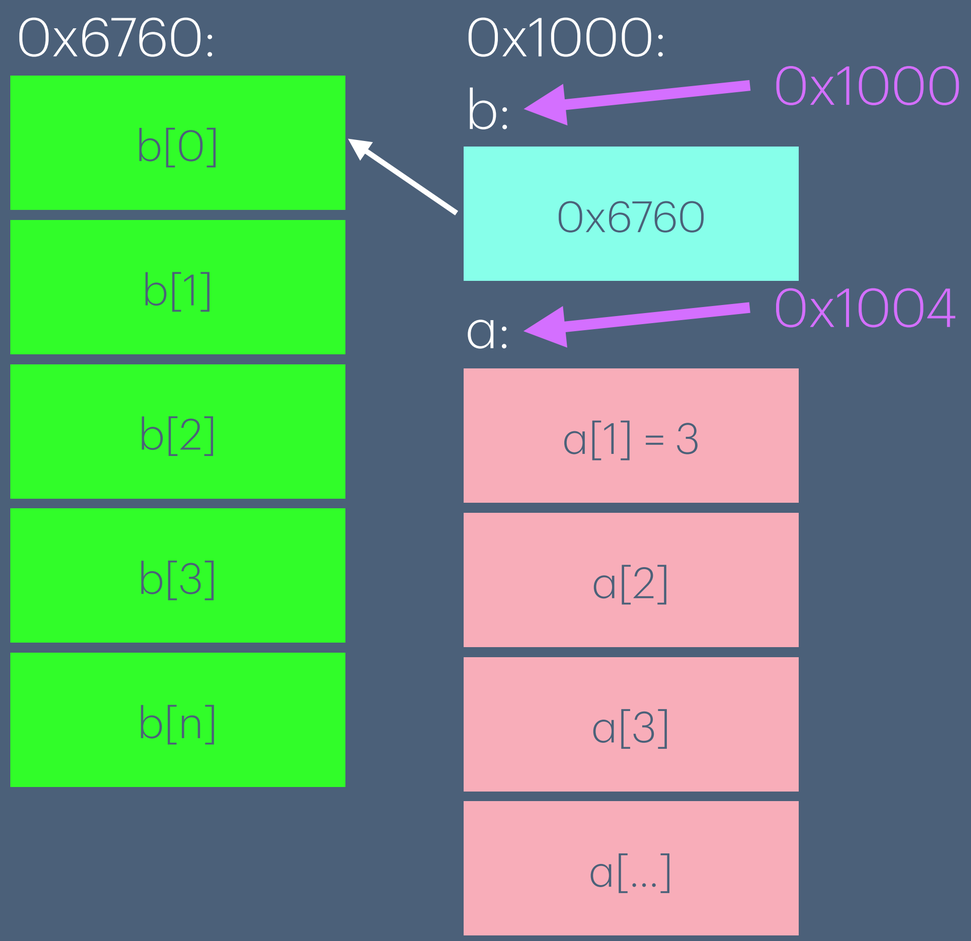

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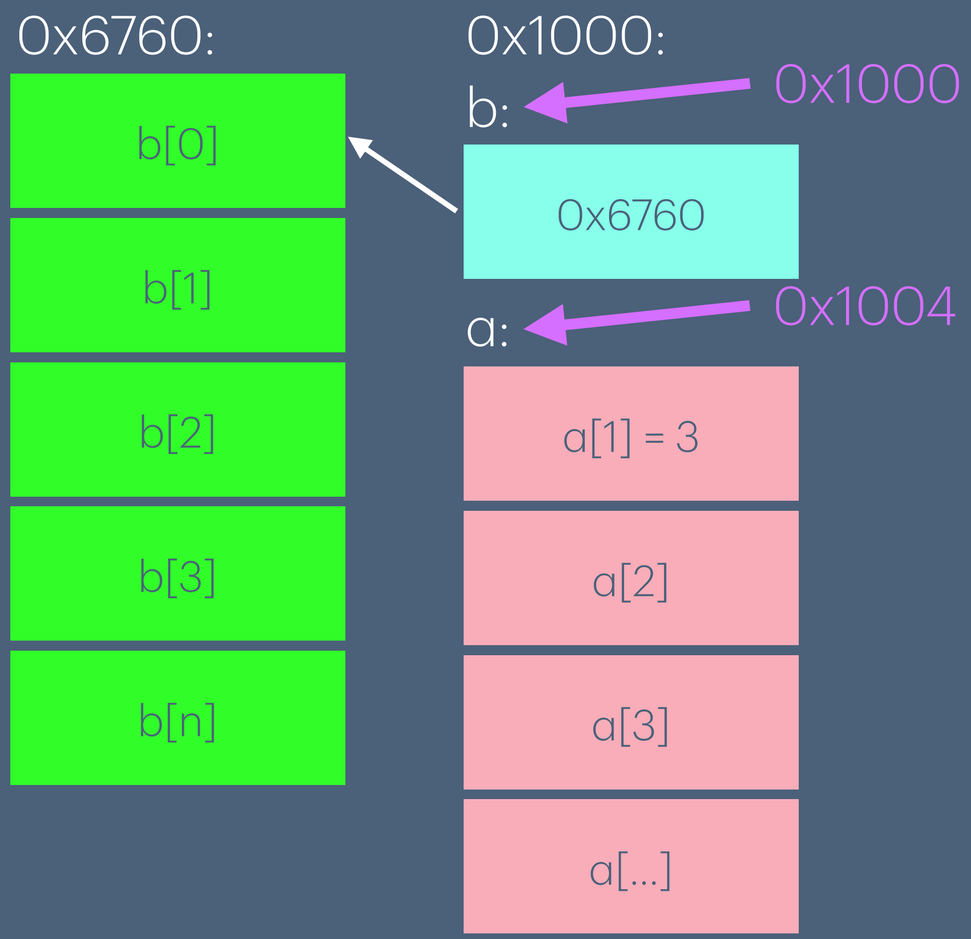

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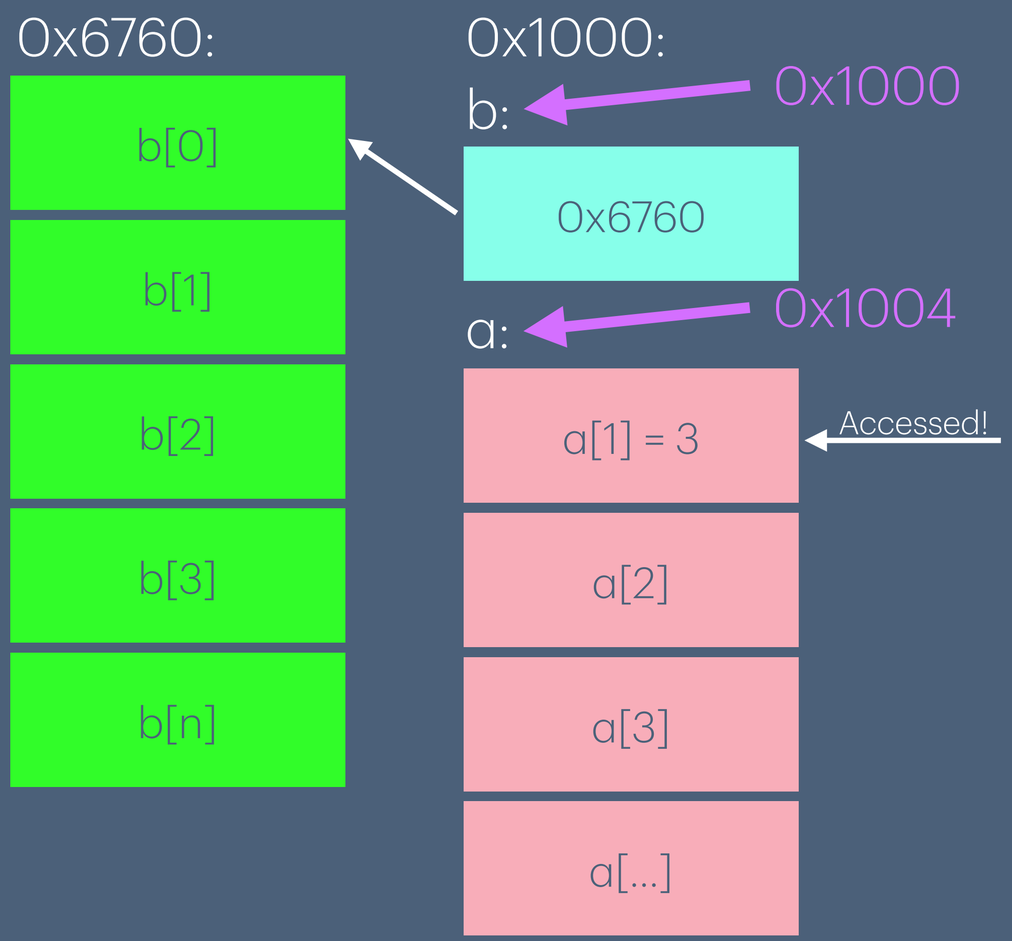

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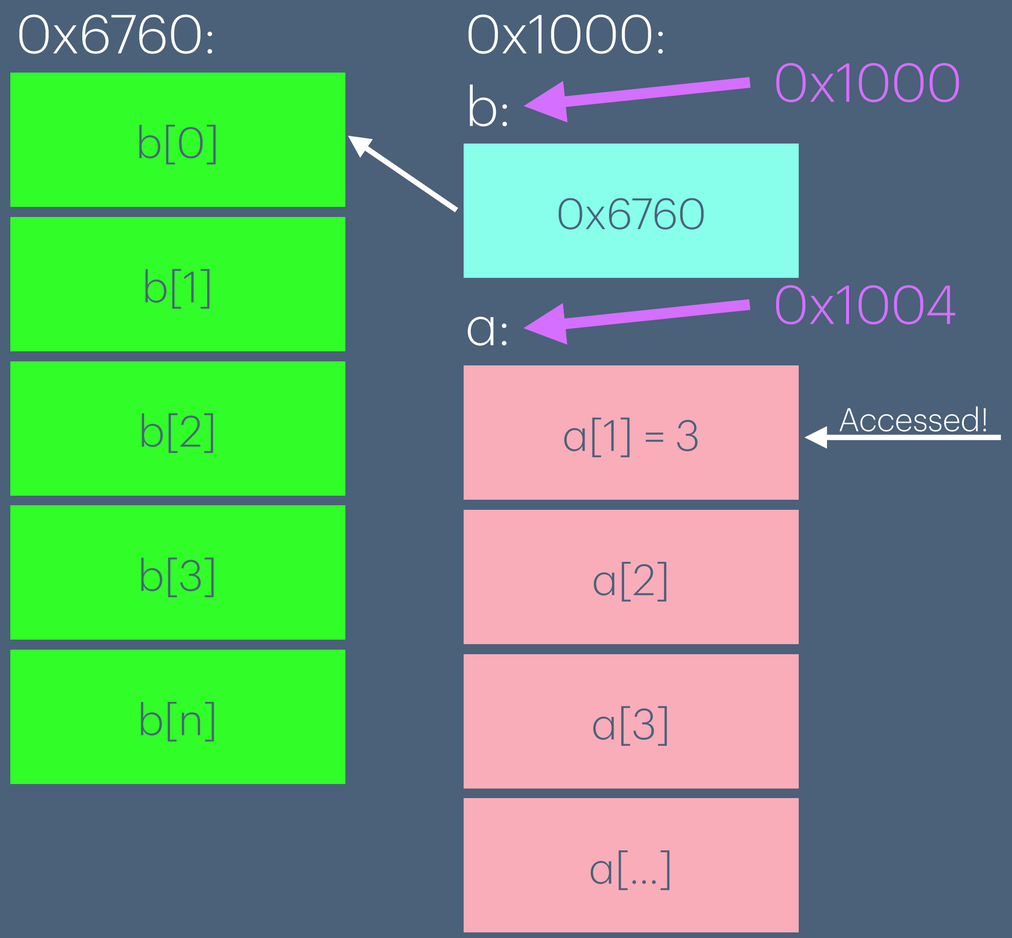

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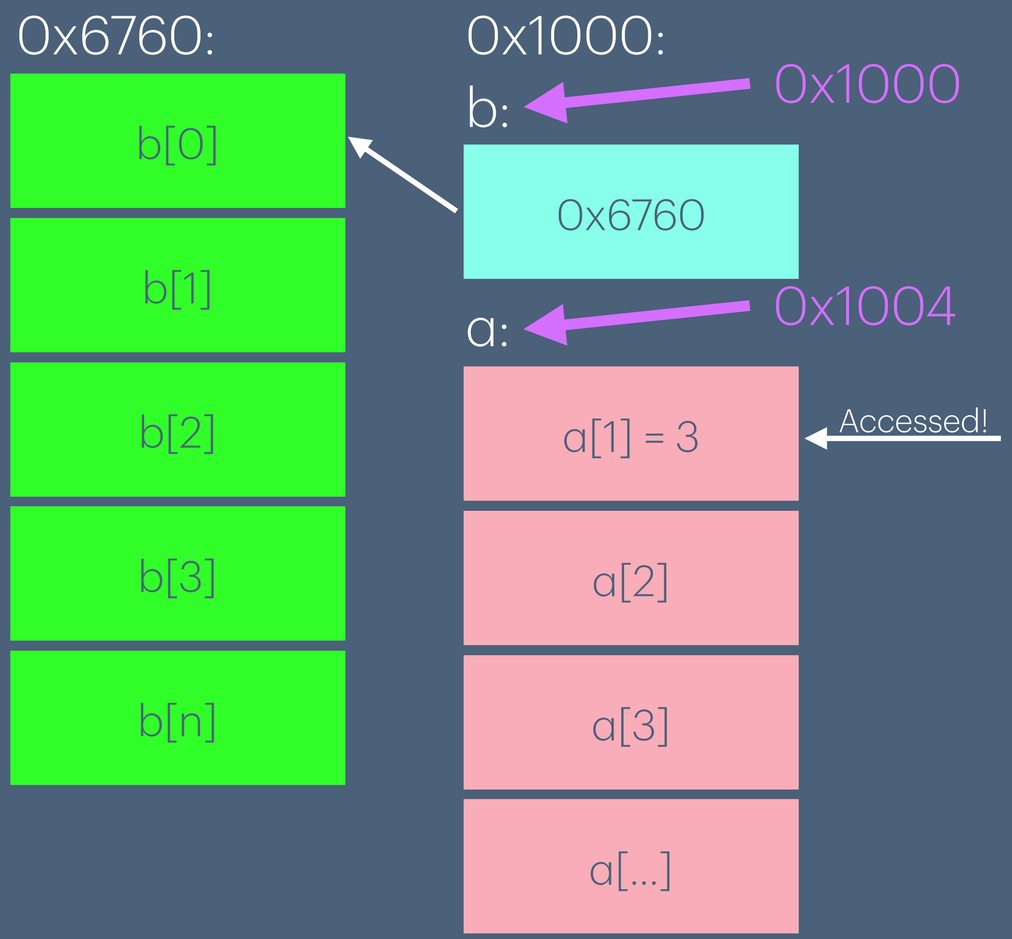

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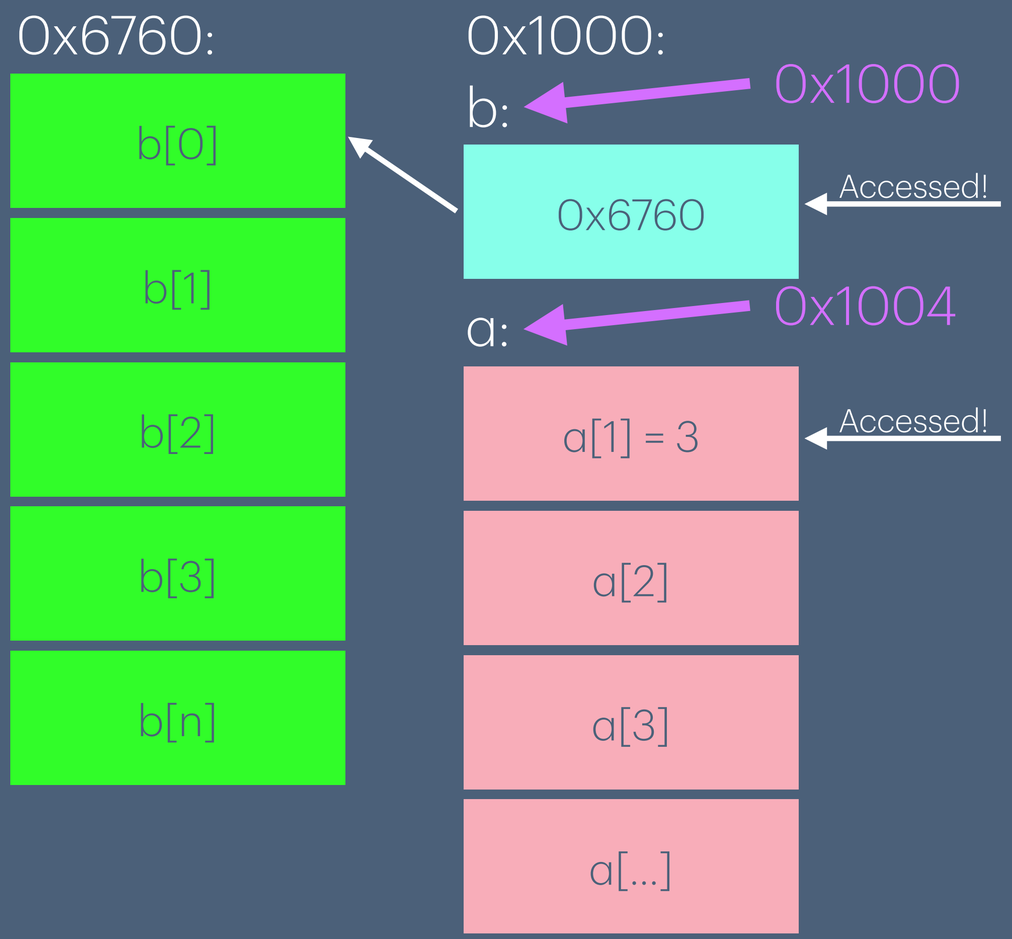

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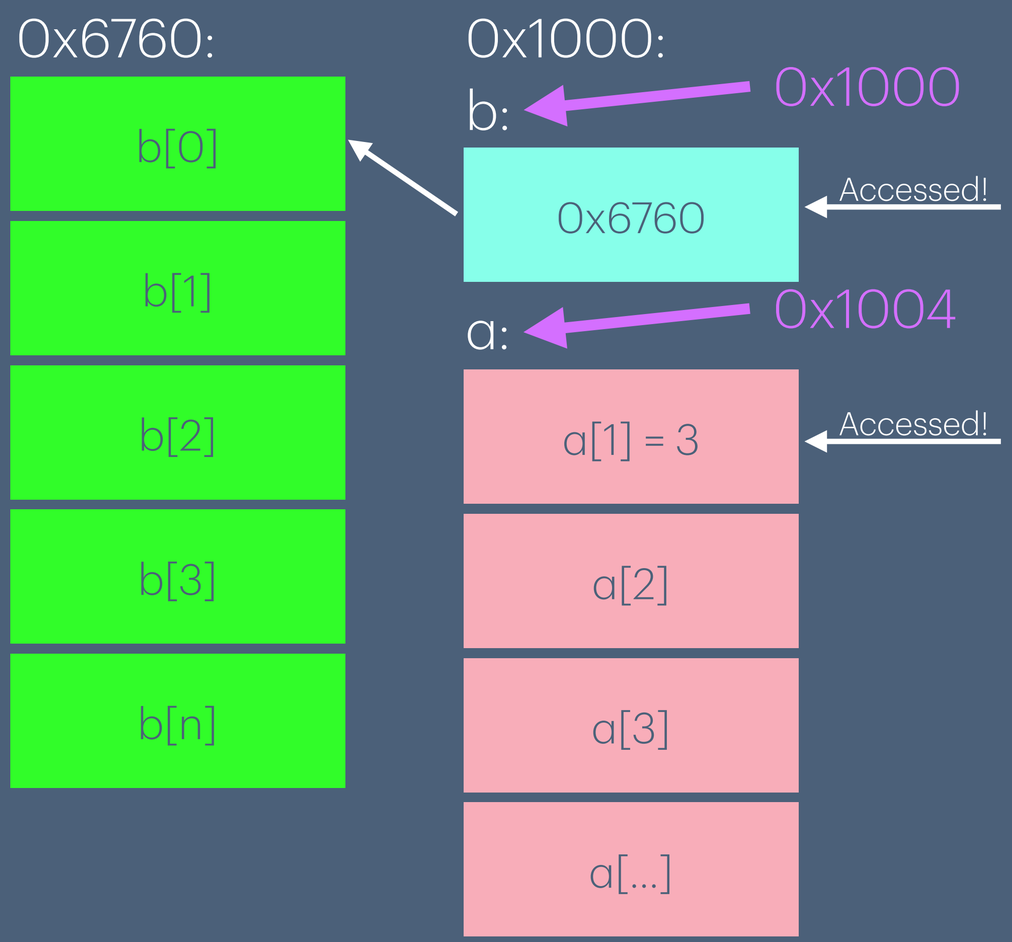

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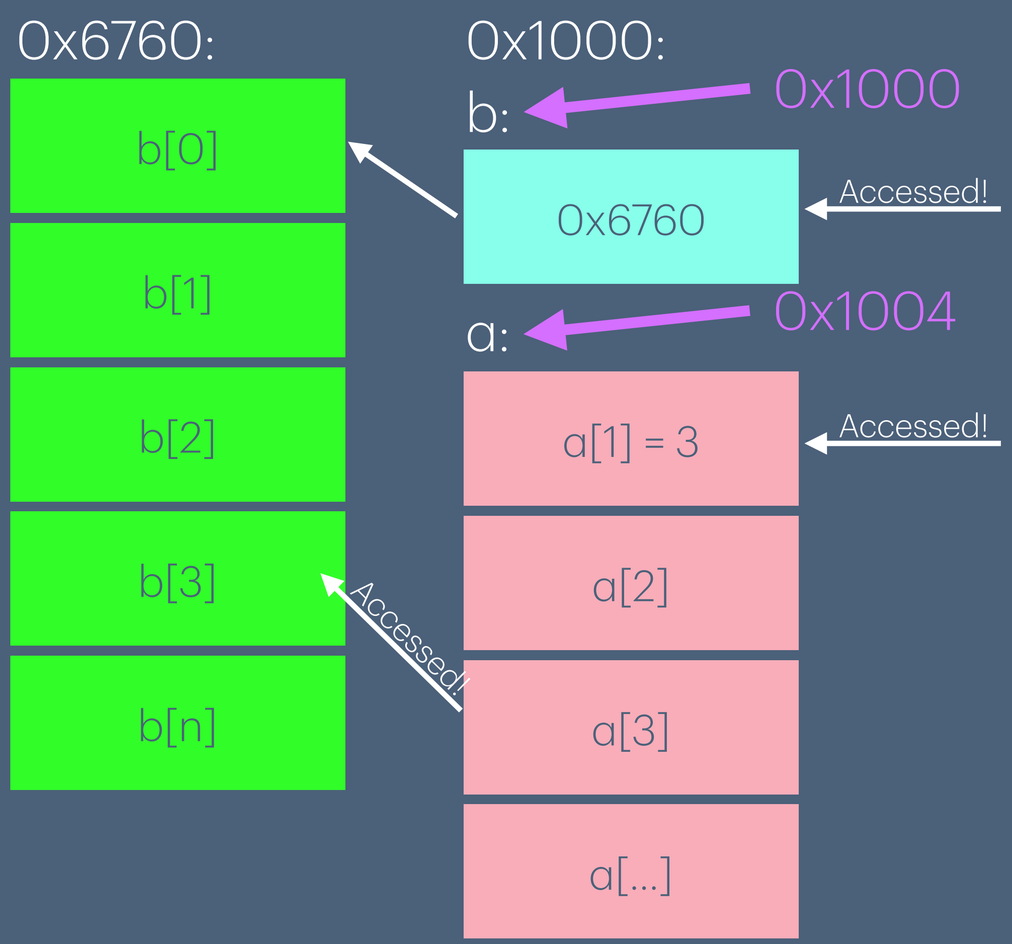

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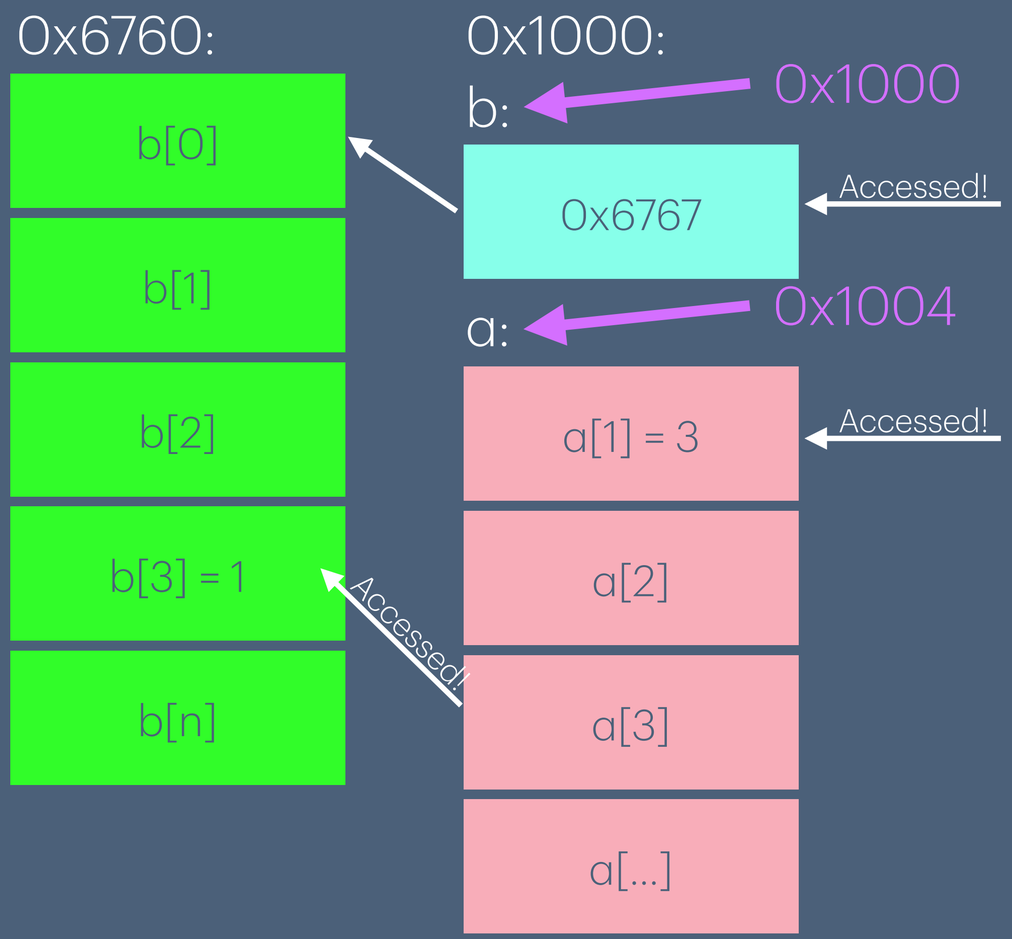

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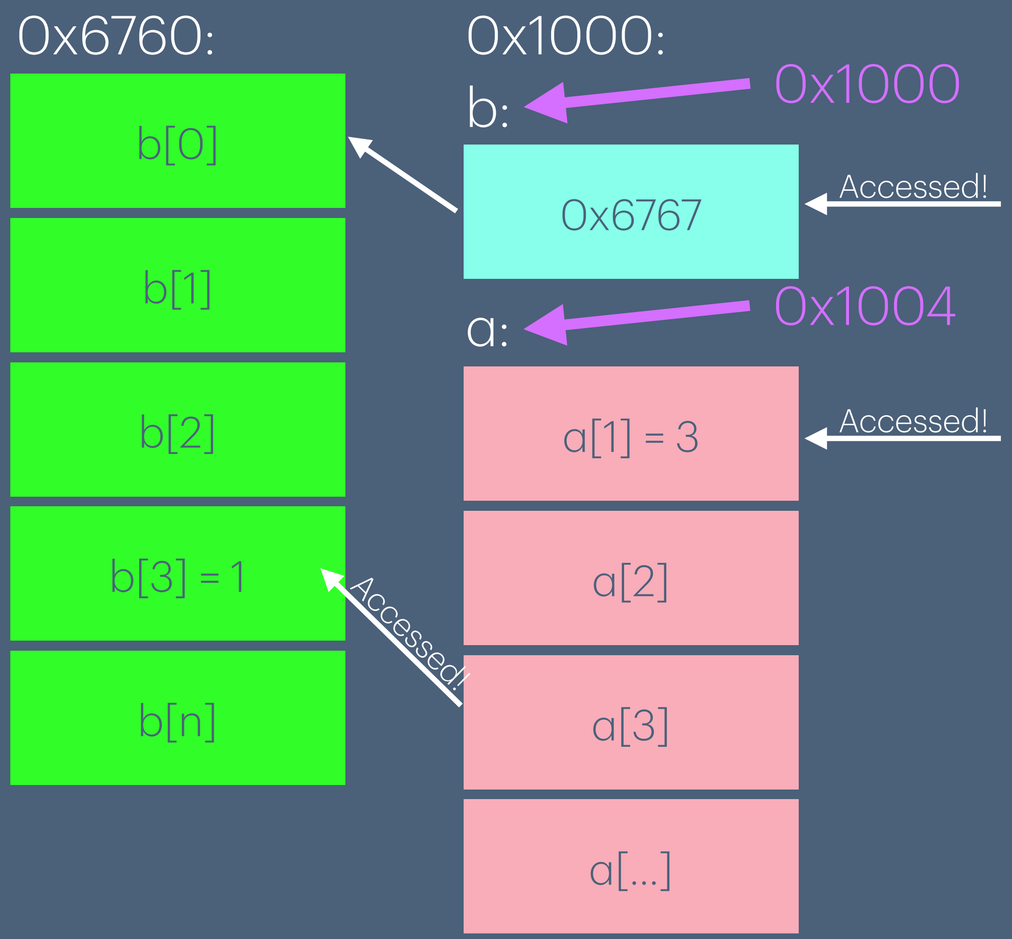

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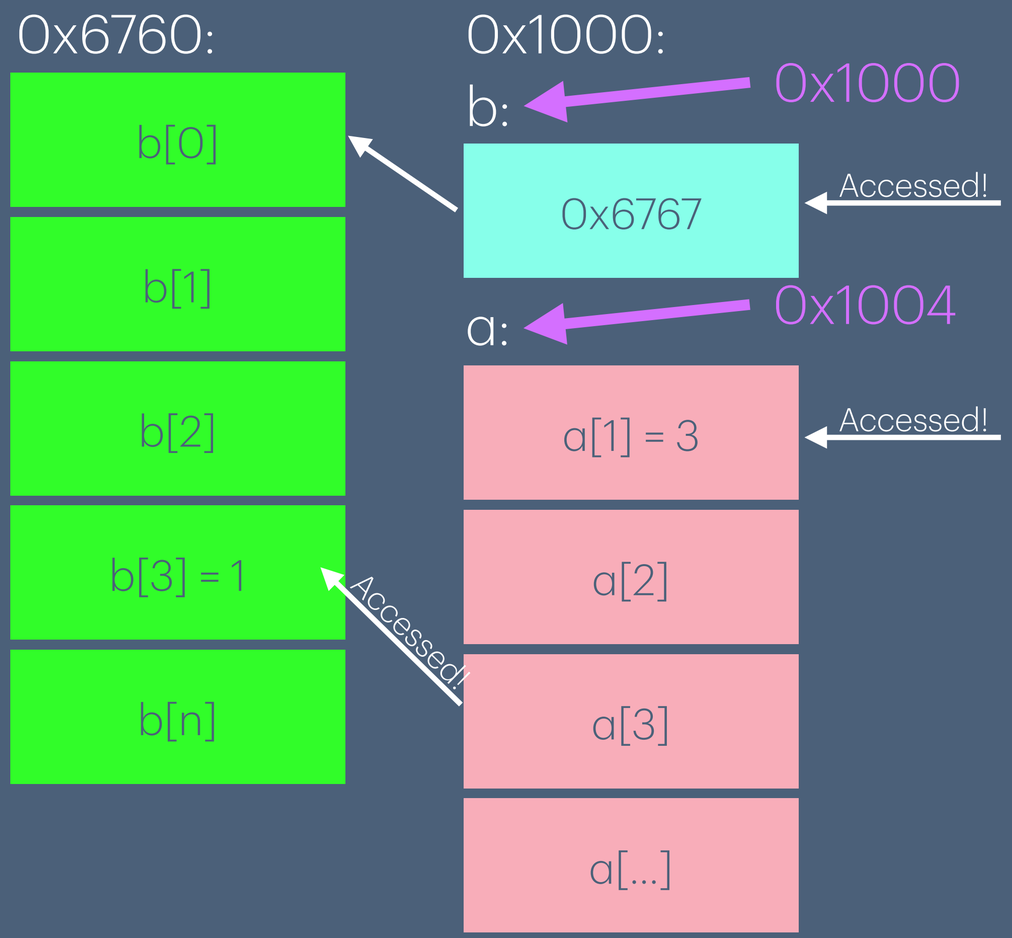

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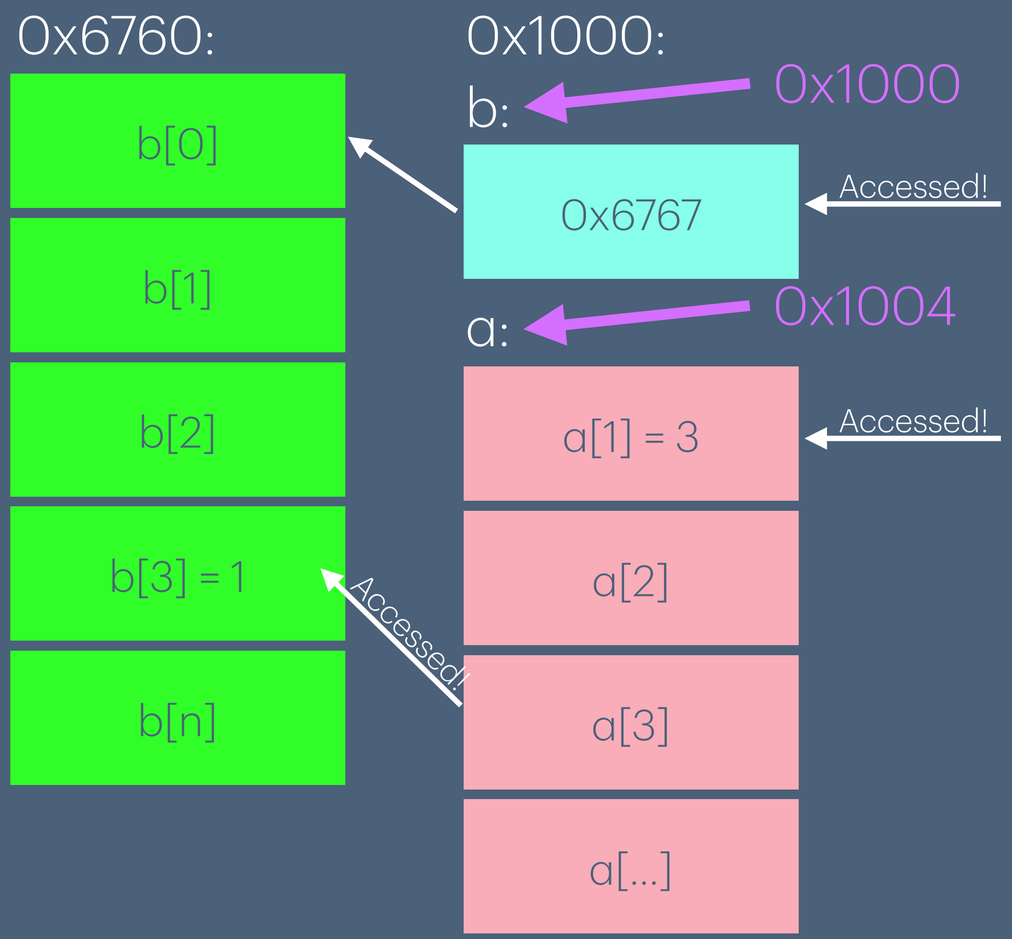

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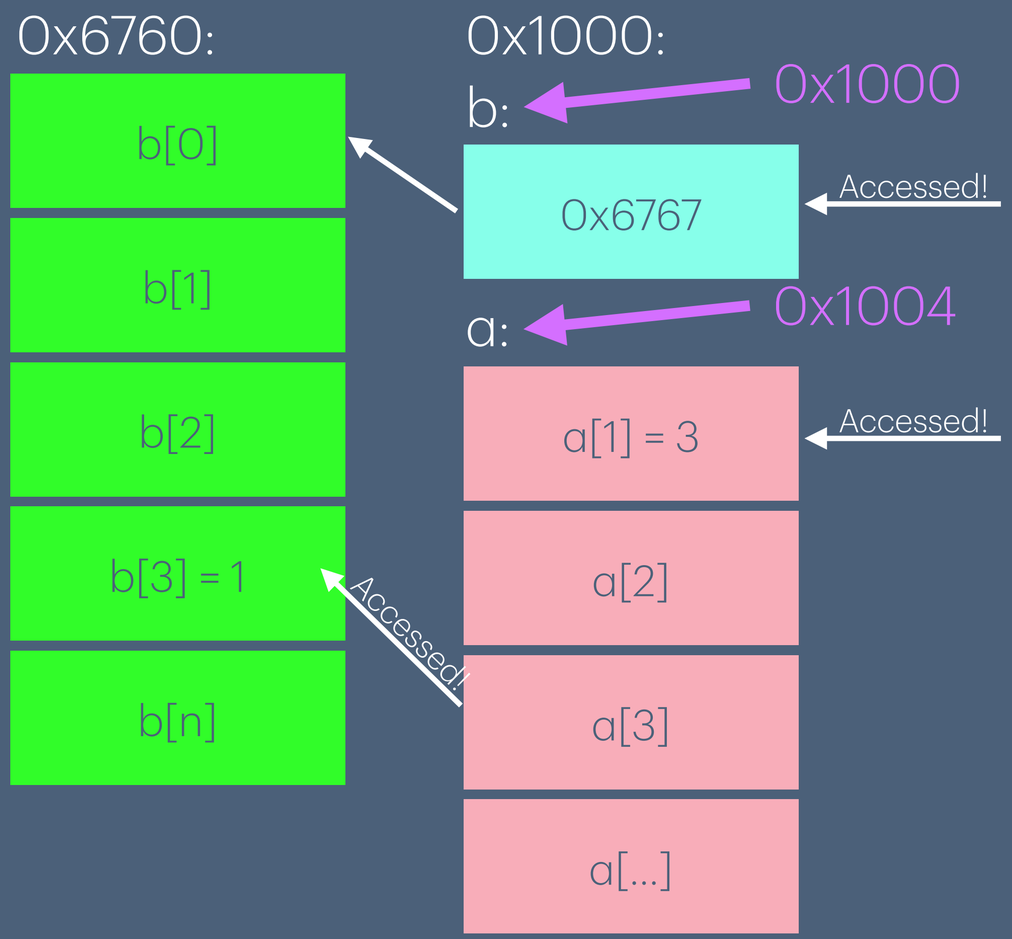

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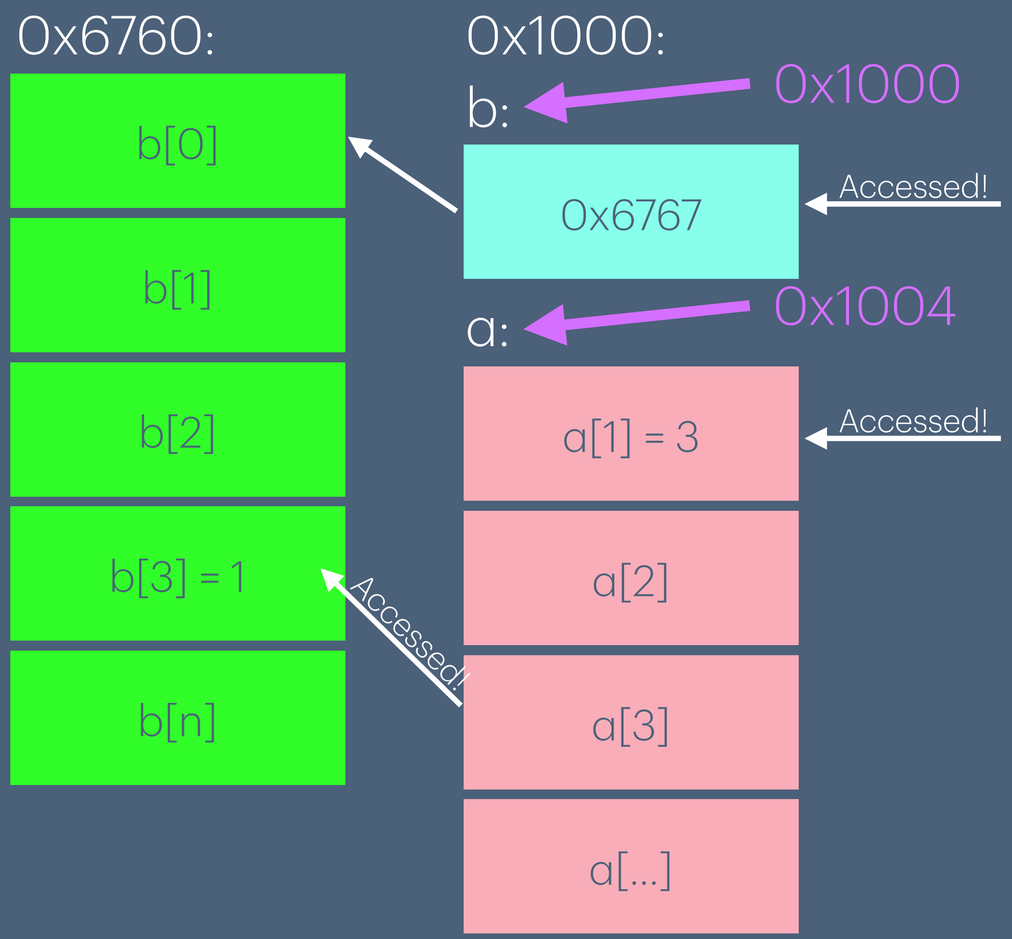

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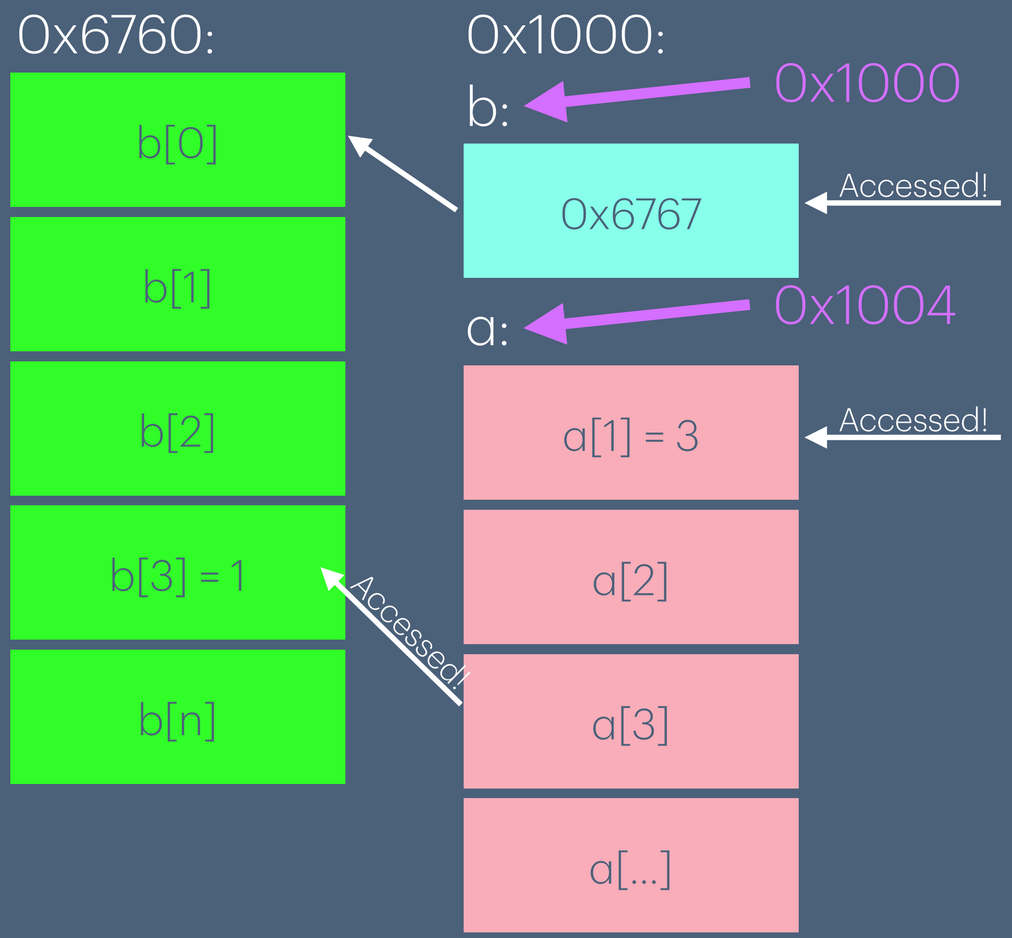

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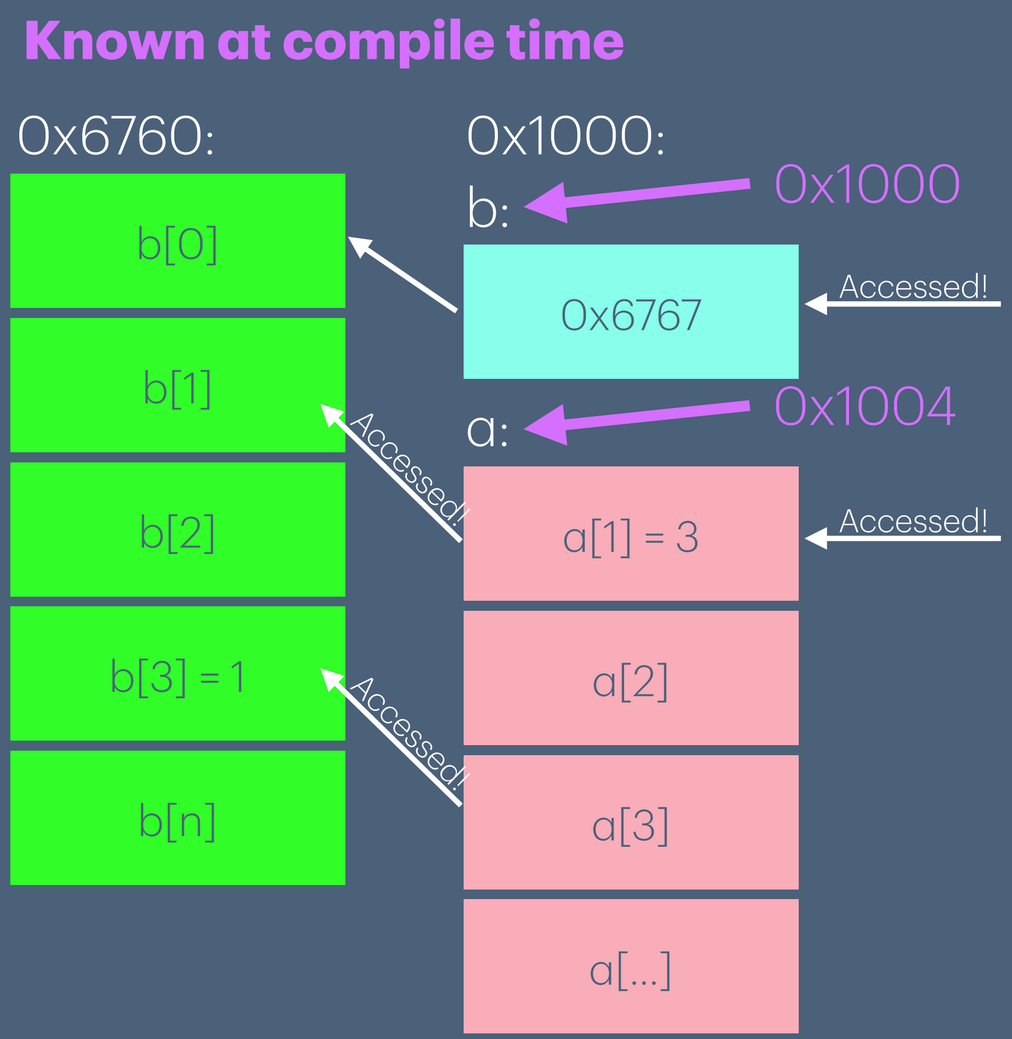

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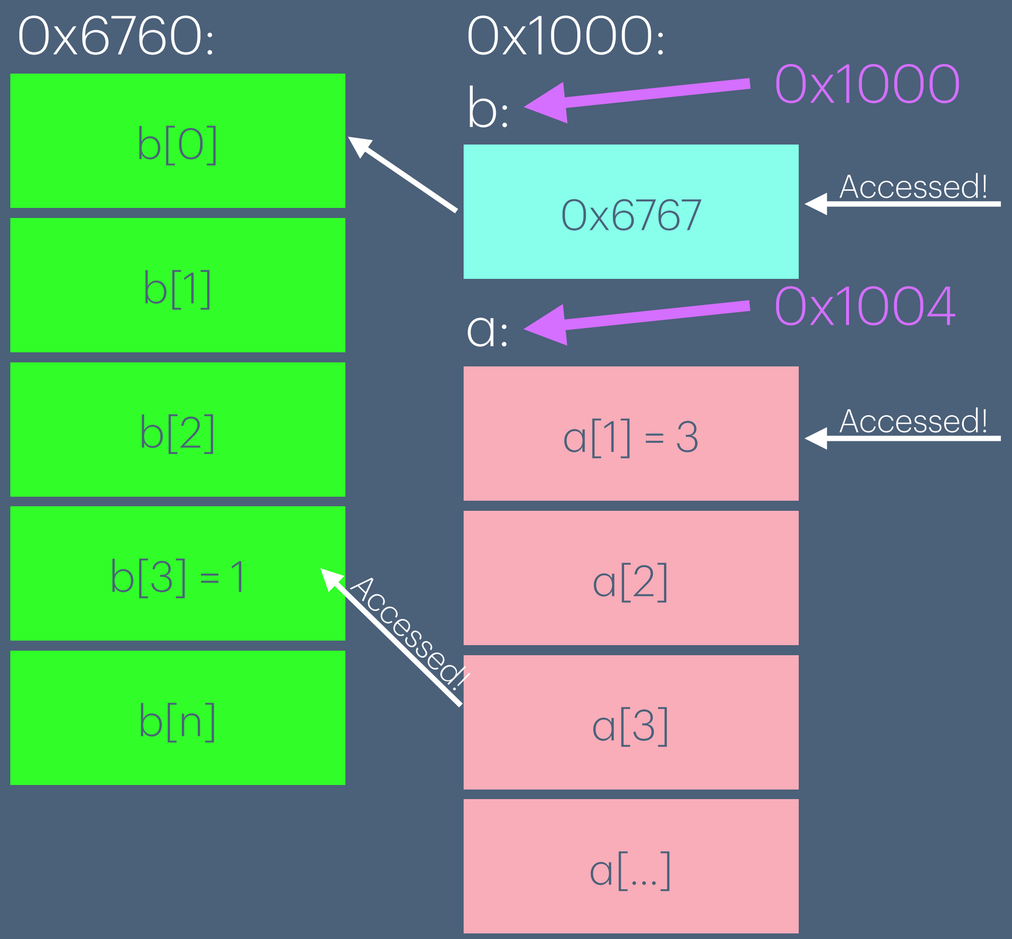

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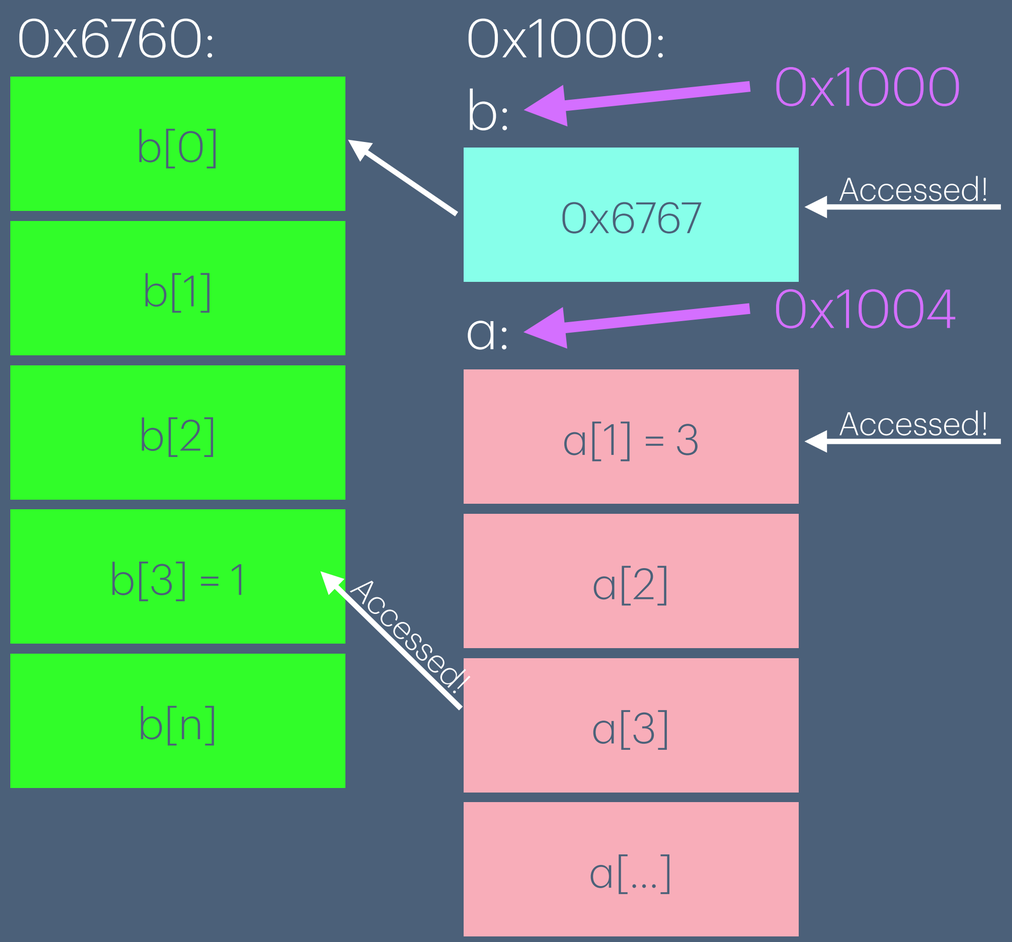

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b[b[a[1]]] = b[1] + b[a[1]]

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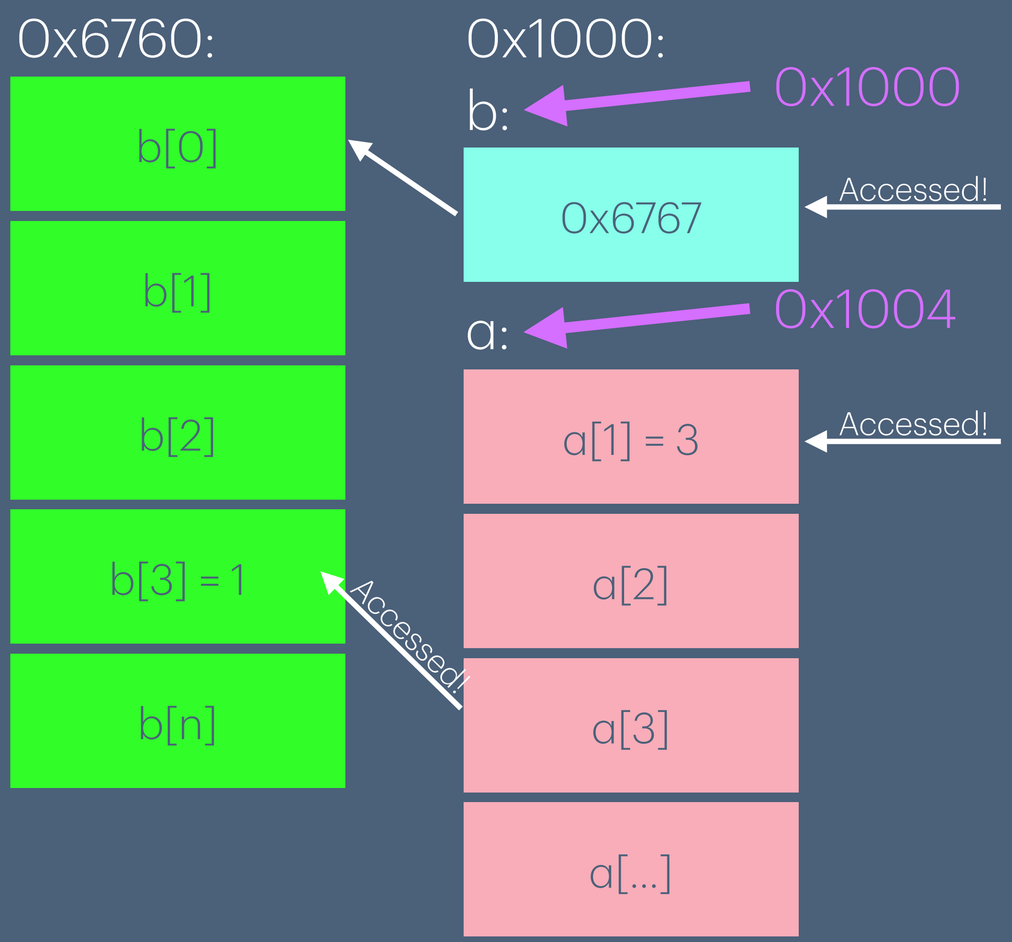

- Total memory reads
- 4

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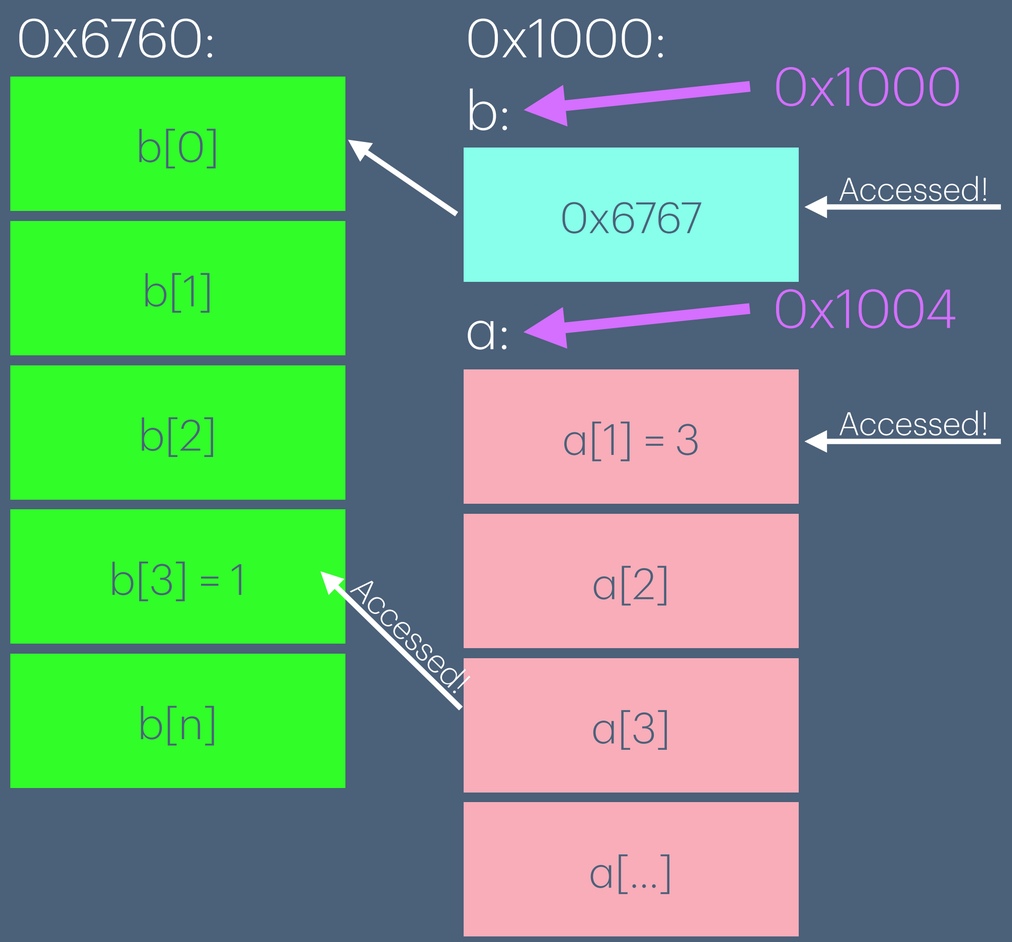
Known at compile time



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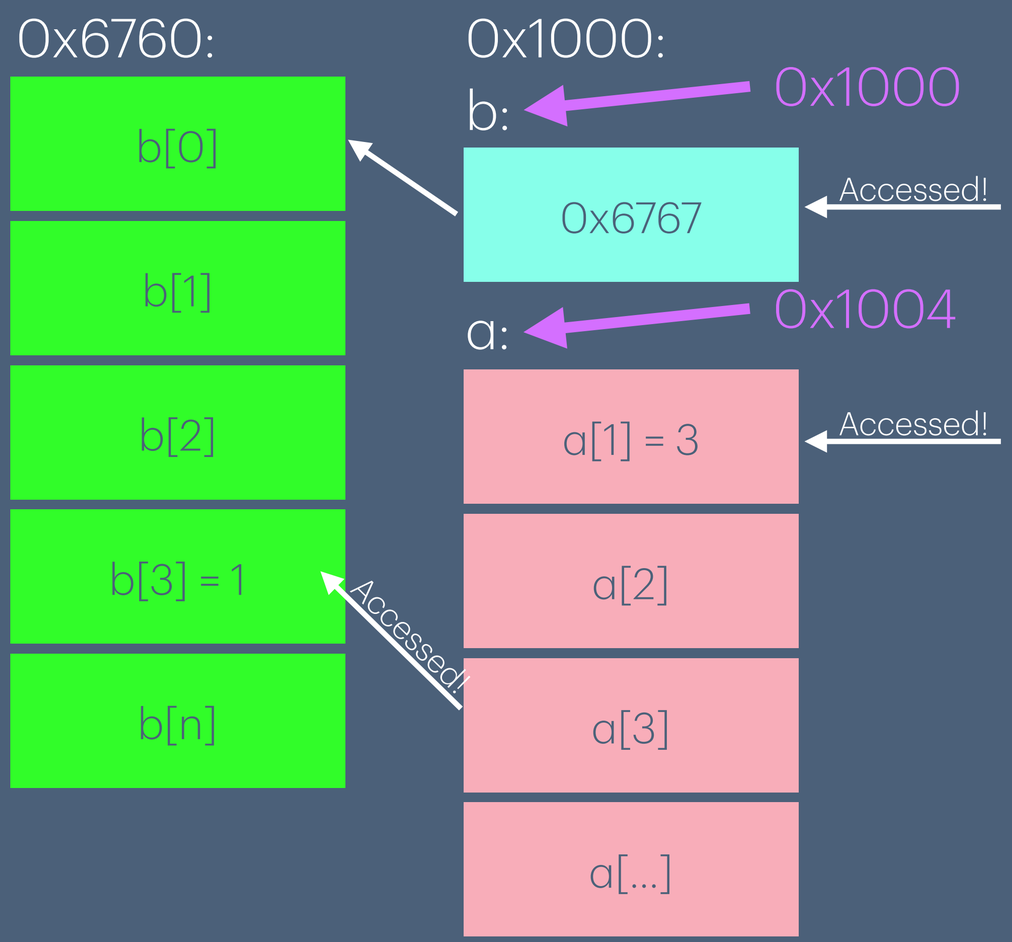

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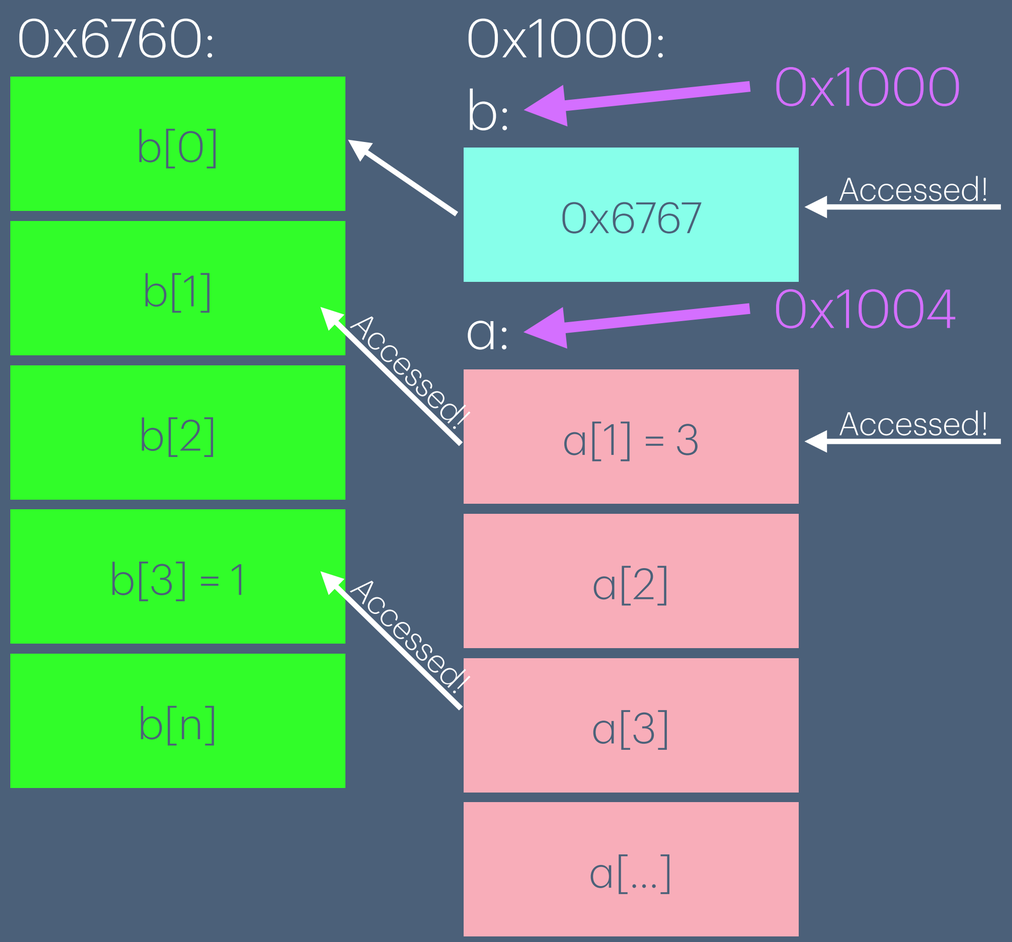

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Q2: Pointers

WTF?

```
arr[3][0] = arr[0][2 - arr[1][4]]
```

Q2: Pointers

An algorithm

- Apply this rule:
- `*(a + i) = a[i]`
- Work from right to left
- Simplest first
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Q2: Pointers

RHS continued

Q2: Pointers

RHS continued

- `arr[0][2 - *(*(arr + 1) + 4)]`

Q2: Pointers

RHS continued

- `arr[0][2 - *(*(arr + 1) + 4)]`
  - `*(arr[0] + 2 - *(*(arr + 1) + 4))`

Q2: Pointers

RHS continued

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  - `*(arr[0] + 2 - *(*(arr + 1) + 4))`
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Q2: Pointers

RHS continued

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- `*(arr[0] + 2 - *(*(arr + 1) + 4))`
  - `*(*(arr + 0) + 2 - *(*(arr + 1) + 4))`

Q2: Pointers

RHS continued

- `arr[0][2 - *(*(arr + 1) + 4)]`
  - `*(arr[0] + 2 - *(*(arr + 1) + 4))`
- `*(arr[0] + 2 - *(*(arr + 1) + 4))`
  - `*(*(arr + 0) + 2 - *(*(arr + 1) + 4))`
  - `*(*arr + 2 - *(*(arr + 1) + 4))`

Q2: Pointers

RHS continued

- `arr[0][2 - *(*(arr + 1) + 4)]`
  - `*(arr[0] + 2 - *(*(arr + 1) + 4))`
- `*(arr[0] + 2 - *(*(arr + 1) + 4))`
  - `*(*(arr + 0) + 2 - *(*(arr + 1) + 4))`
  - `*(*arr + 2 - *(*(arr + 1) + 4))`
- DONE!

Q2: Pointers

LHS

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LHS

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LHS

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- Convert `arr[3][0]`
  - `arr[3][0]`
    - `*(arr[3] + 0)`
    - `*(arr[3])`
    - `*(*(arr + 3))`

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LHS

- Our original expression: `arr[3][0] = arr[0][2 - arr[1][4]]`
- Convert `arr[3][0]`
  - `arr[3][0]`
    - `*(arr[3] + 0)`
    - `*(arr[3])`
    - `*(*(arr + 3))`
    - `**(arr + 3)`

Q2: Pointers

Grand finale

- `**(arr + 3) = *(*arr + 2 - *(*(arr + 1) + 4))`
- Part 2?
  - Apply the algorithm in reverse