Implementing Abstractions

Getting Storage Space

- How do the **`Vector`**, **`Stack`**, **`Queue`**, etc. get space to store all the elements that they hold?
- C++ code can request extra storage space as the program is running.
- This is called **dynamic memory allocation**.

Dynamic Allocation Demo

```
int main() {
   int numValues = getInteger("How many lines? ");

   string* arr = new string[numValues];
   for (int i = 0; i < numValues; i++) {
      arr[i] = getLine();
   }

   for (int i = 0; i < numValues; i++) {
      cout << i << ": " << arr[i] << endl;
   }
}
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numValues **7**

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numValues | 7 | arr | |

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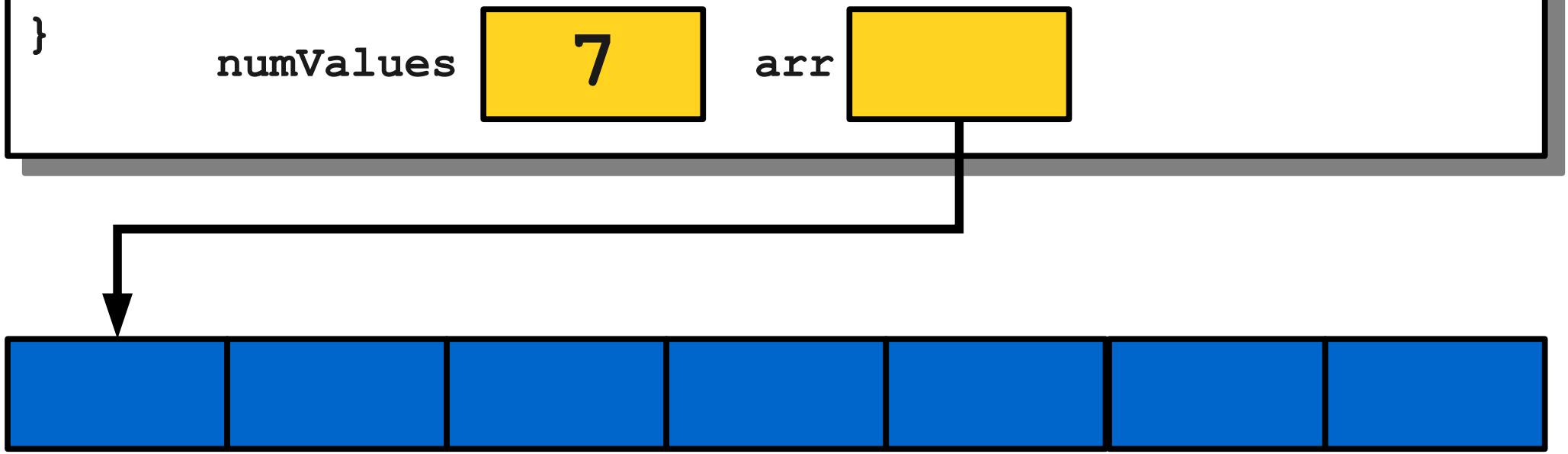

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   for (int i = 0; i < numValues; i++) {
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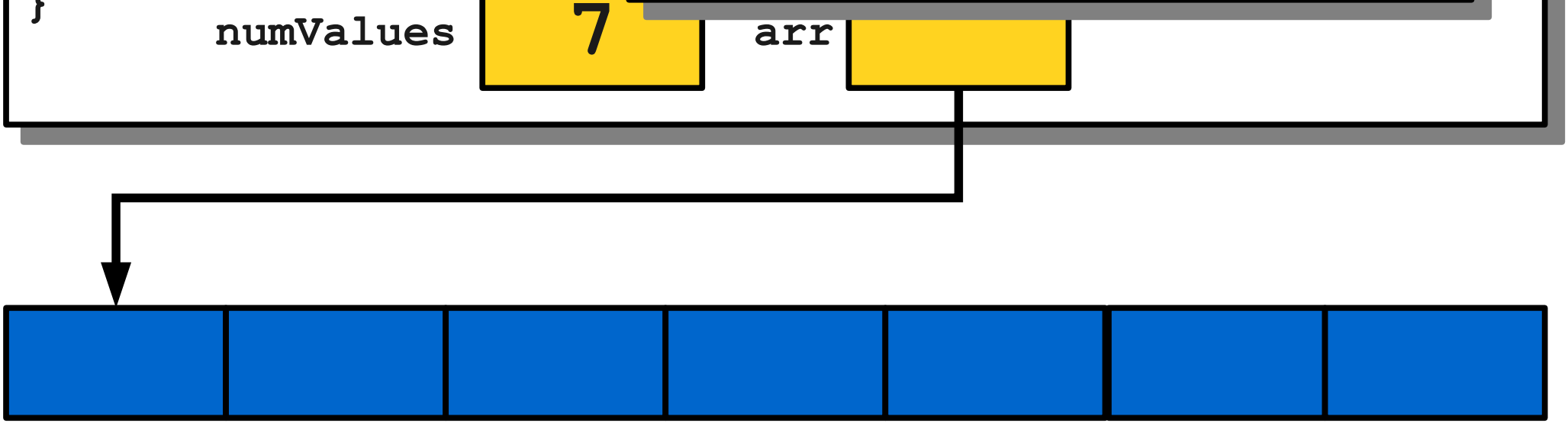
   for (int i = 0; i
      cout << i << ":
   }
}
```

Because the variable **arr** points to the array, it is called a *pointer*.



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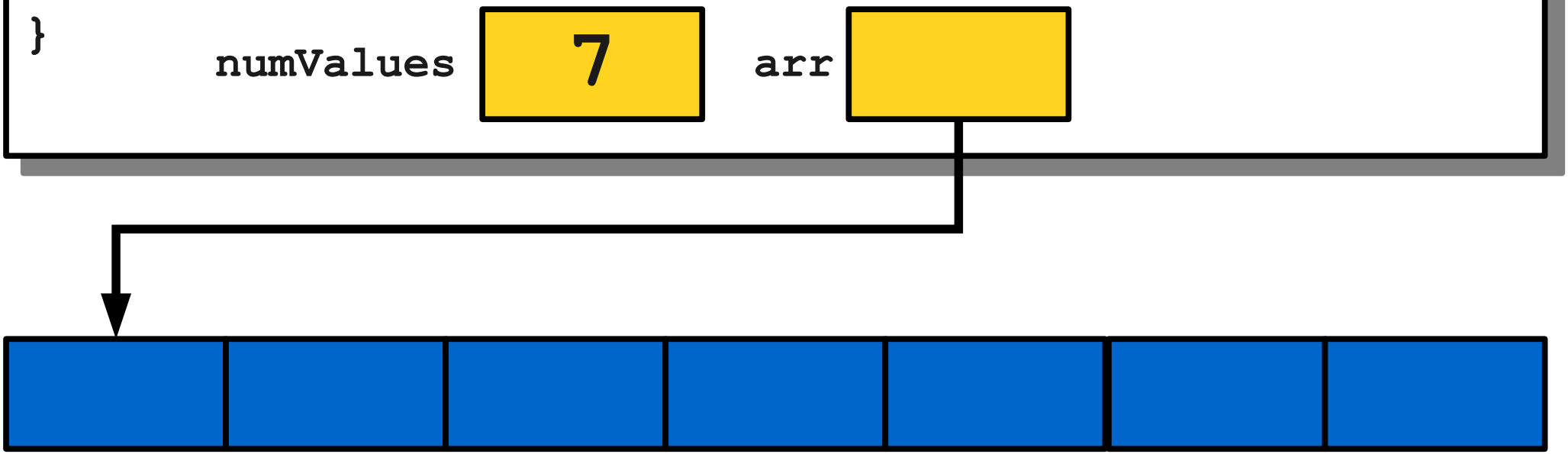

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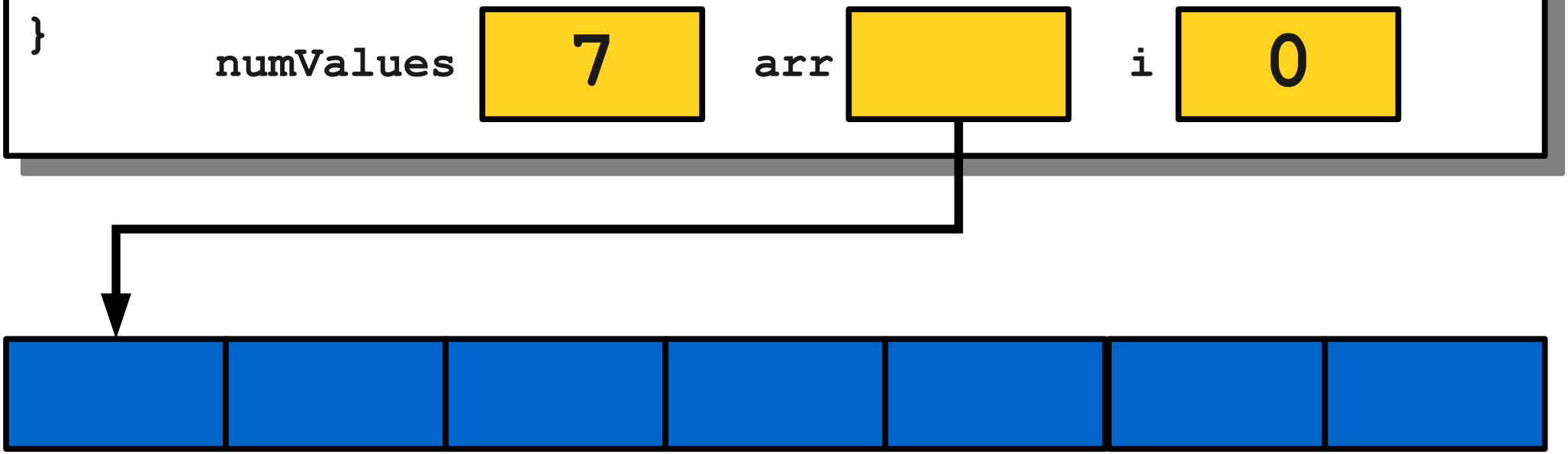

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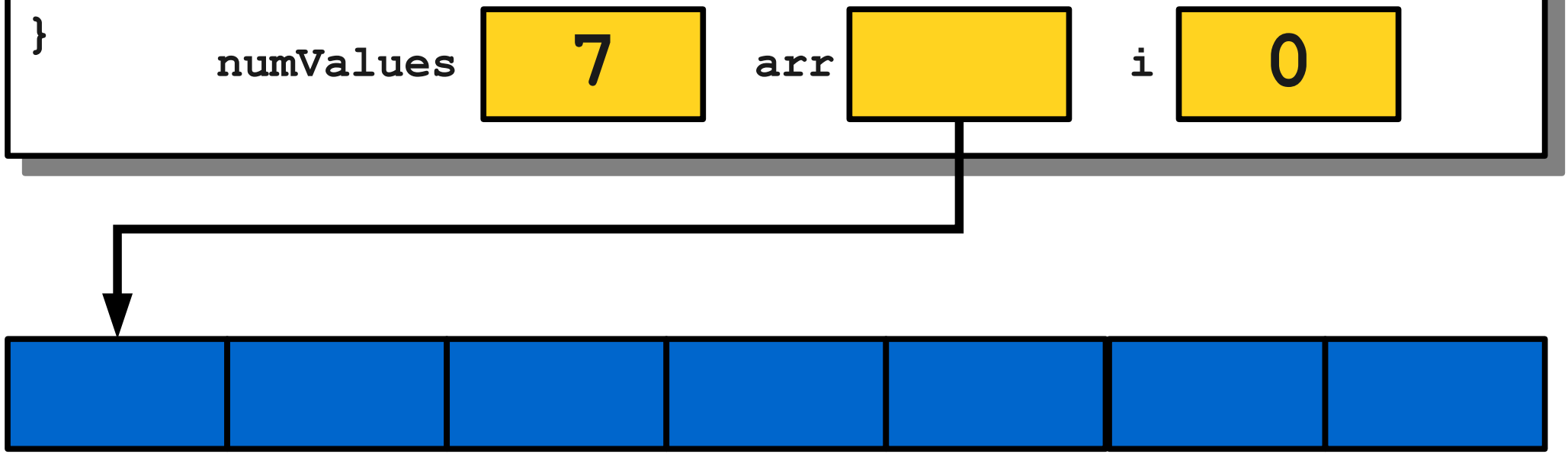

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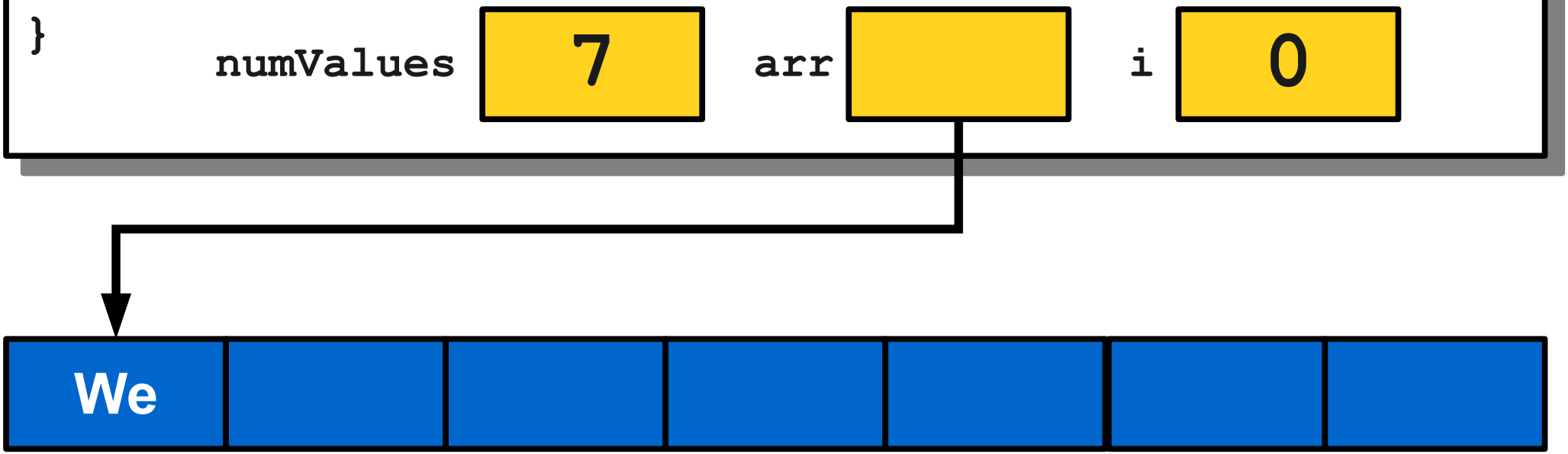

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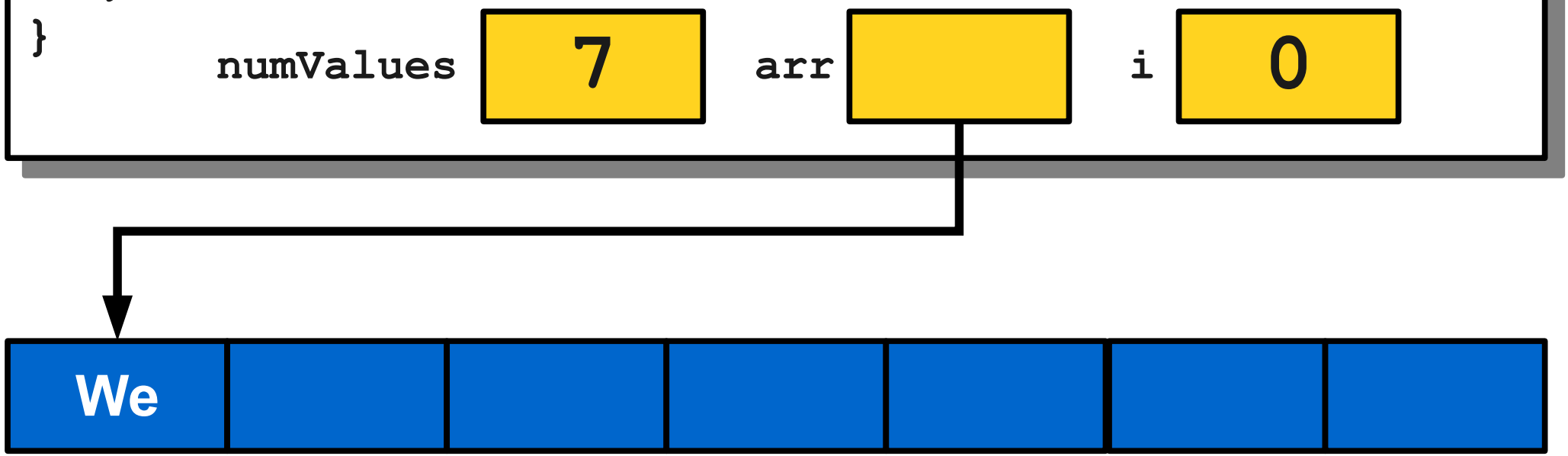

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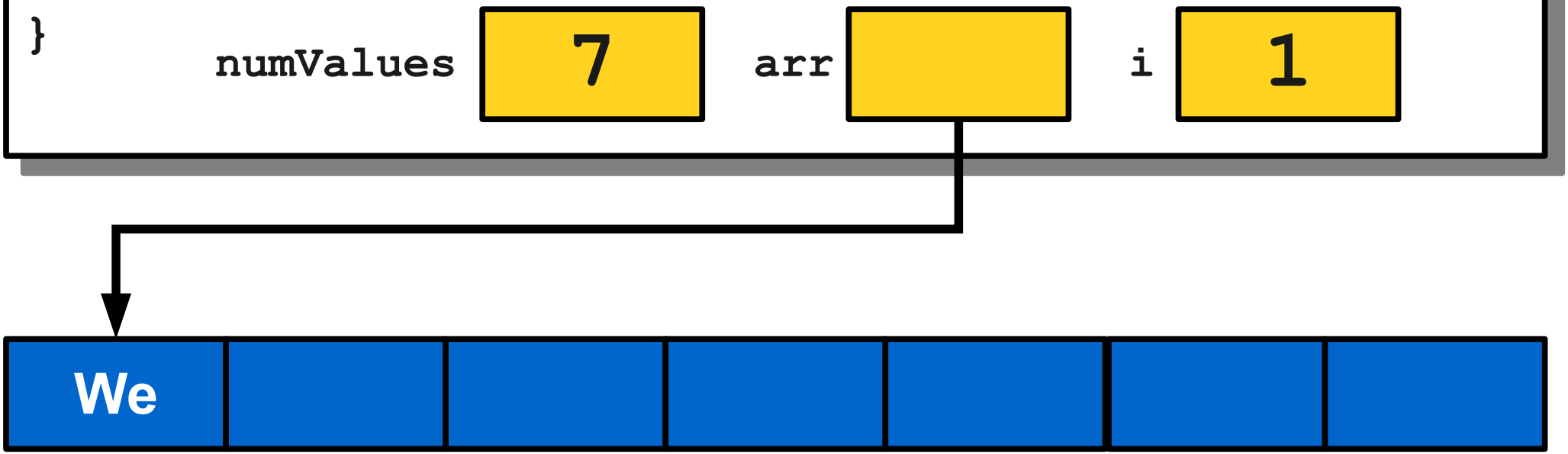

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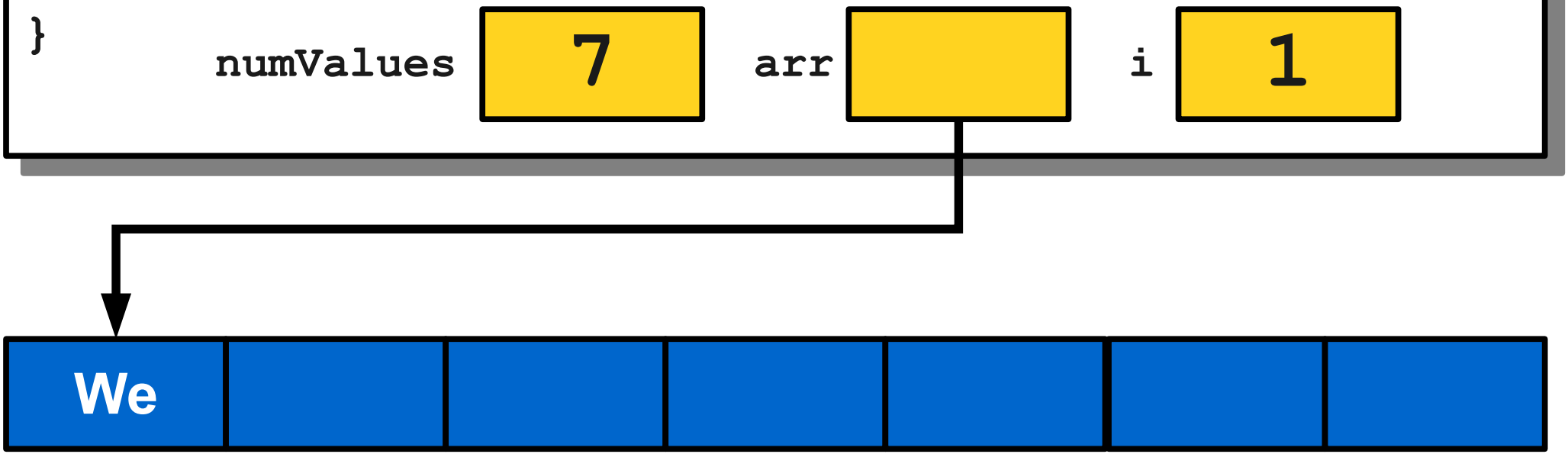

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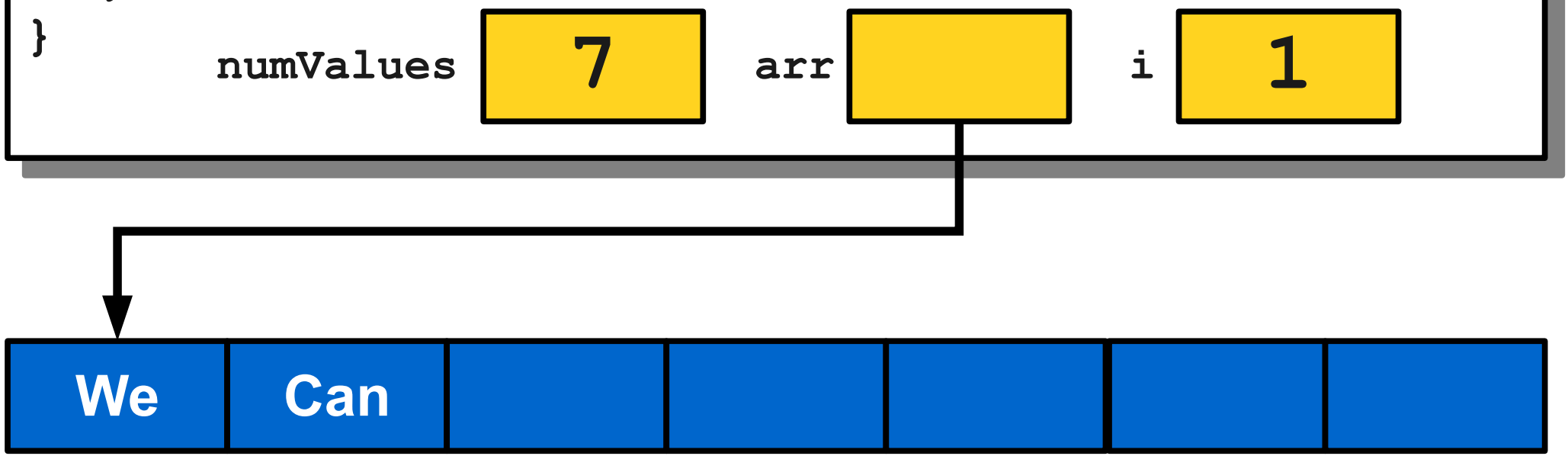

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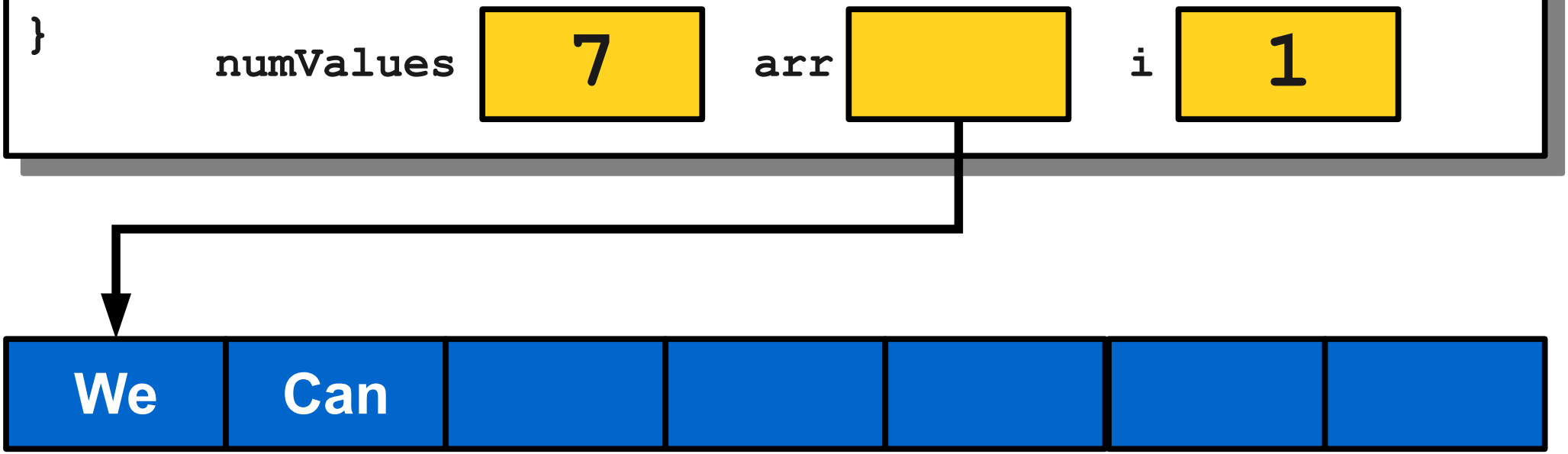

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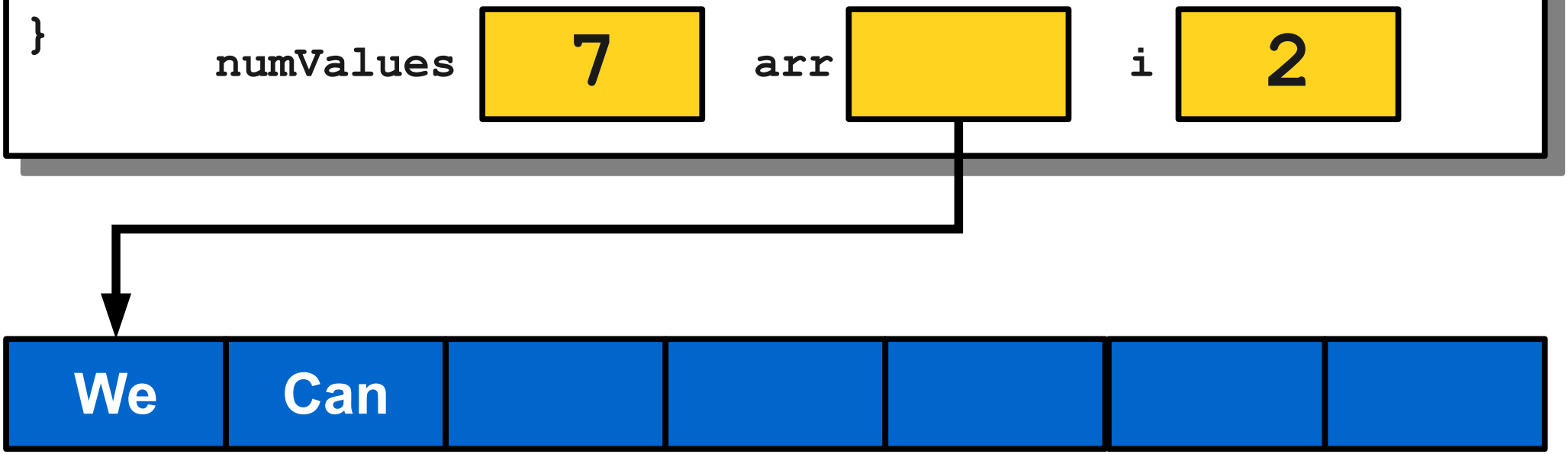

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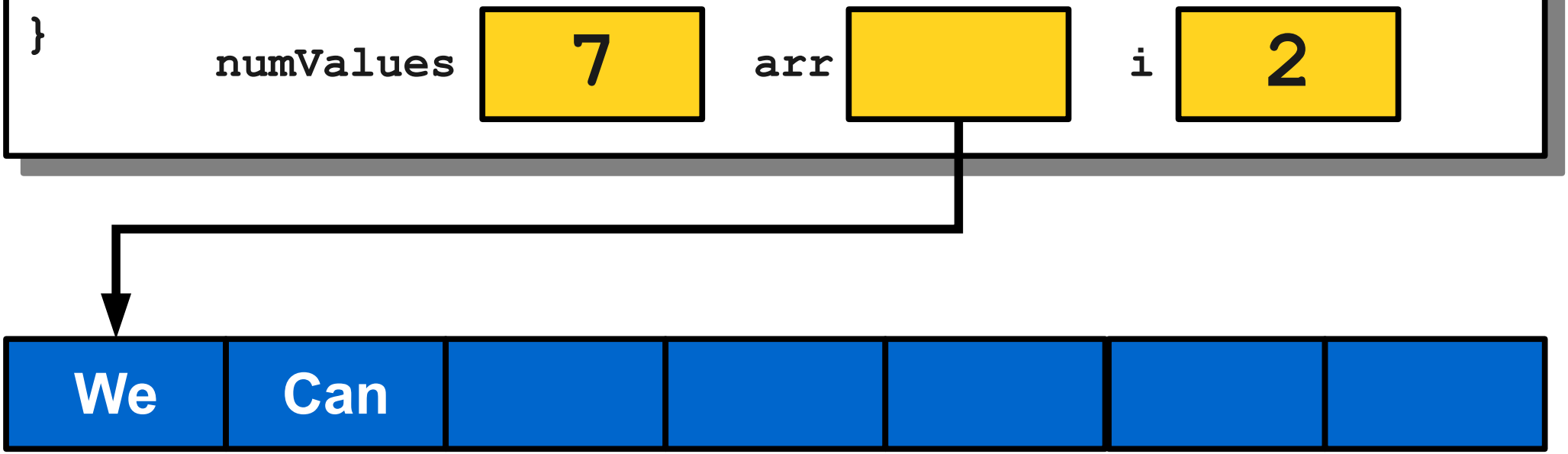

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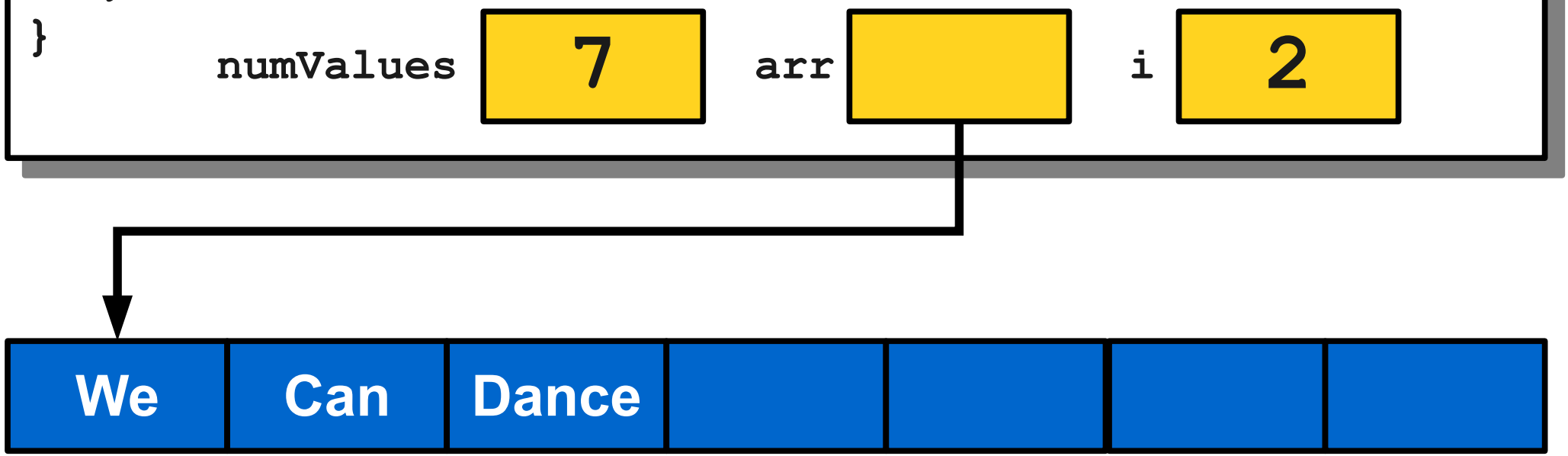

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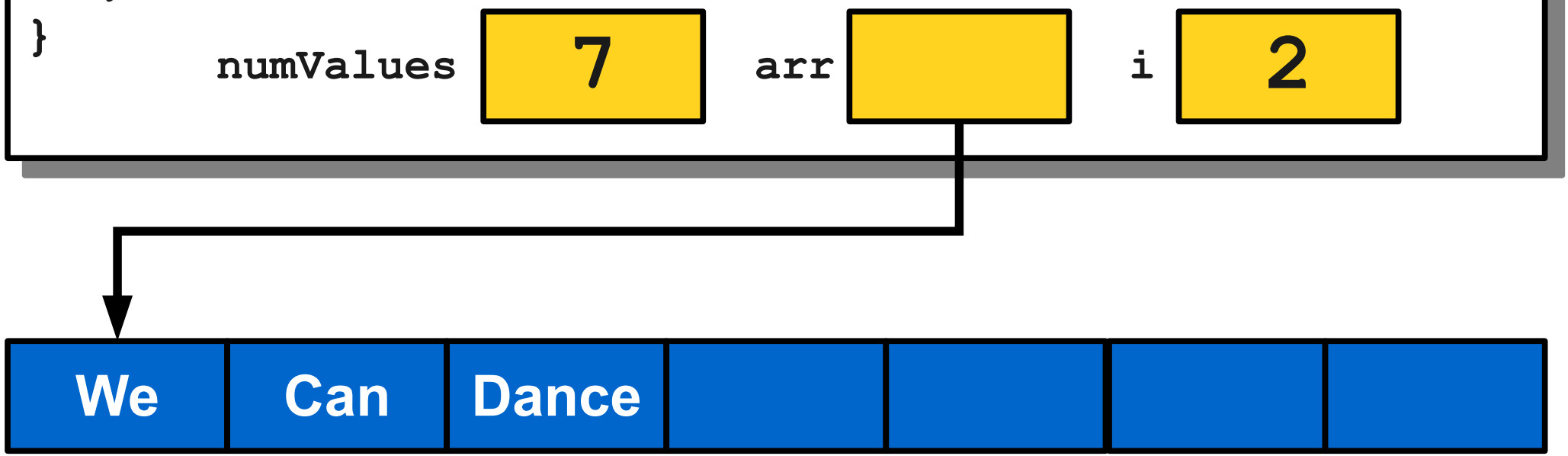

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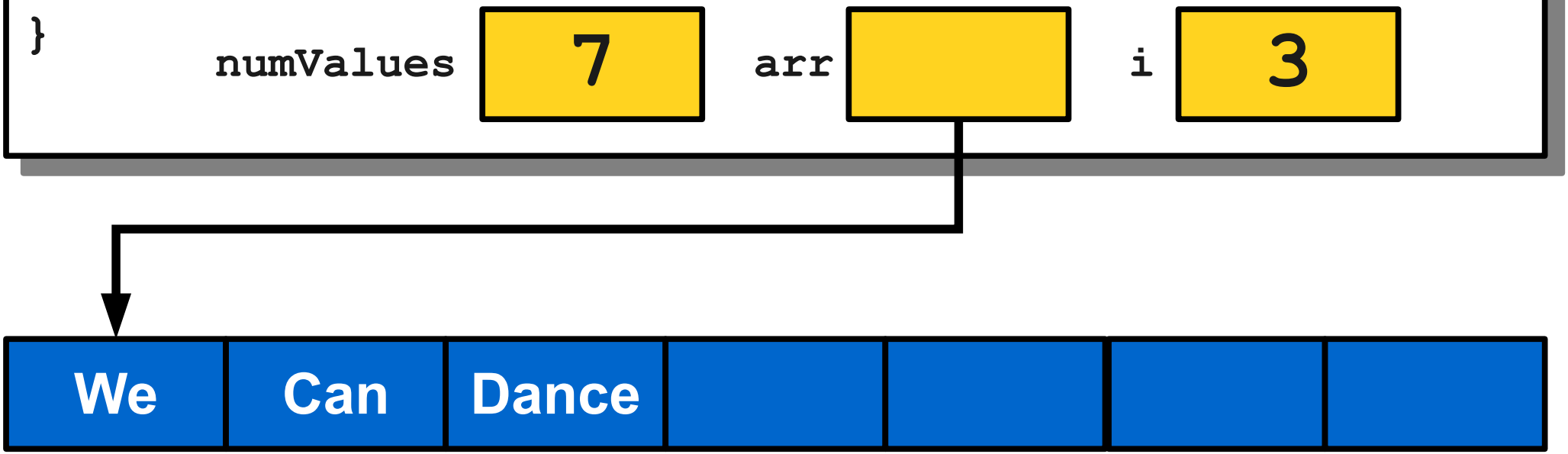

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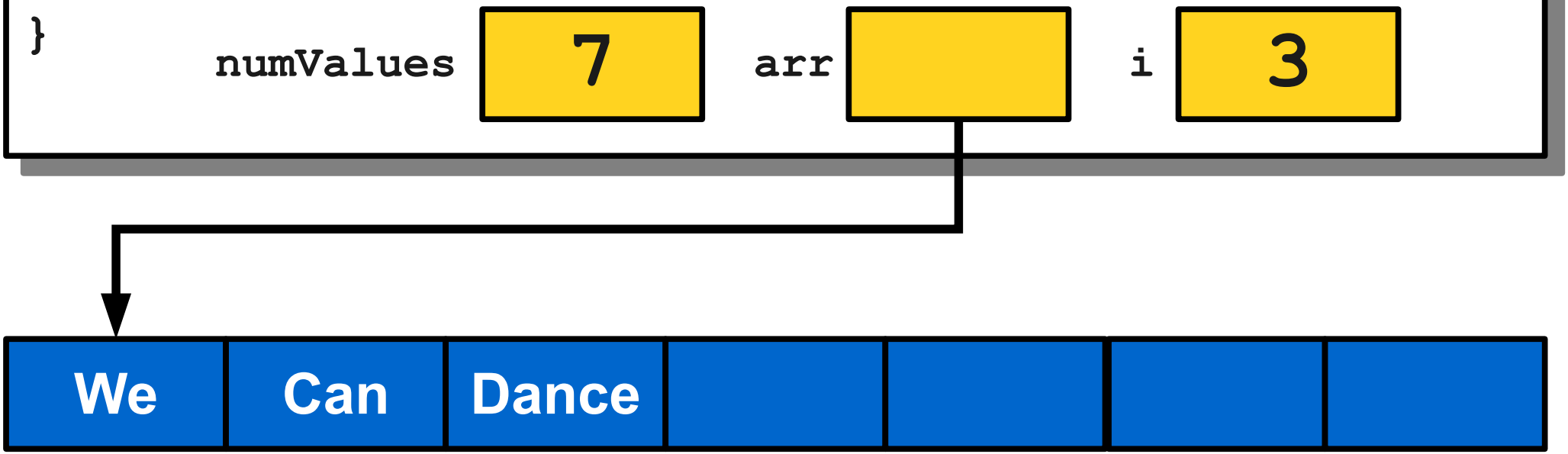

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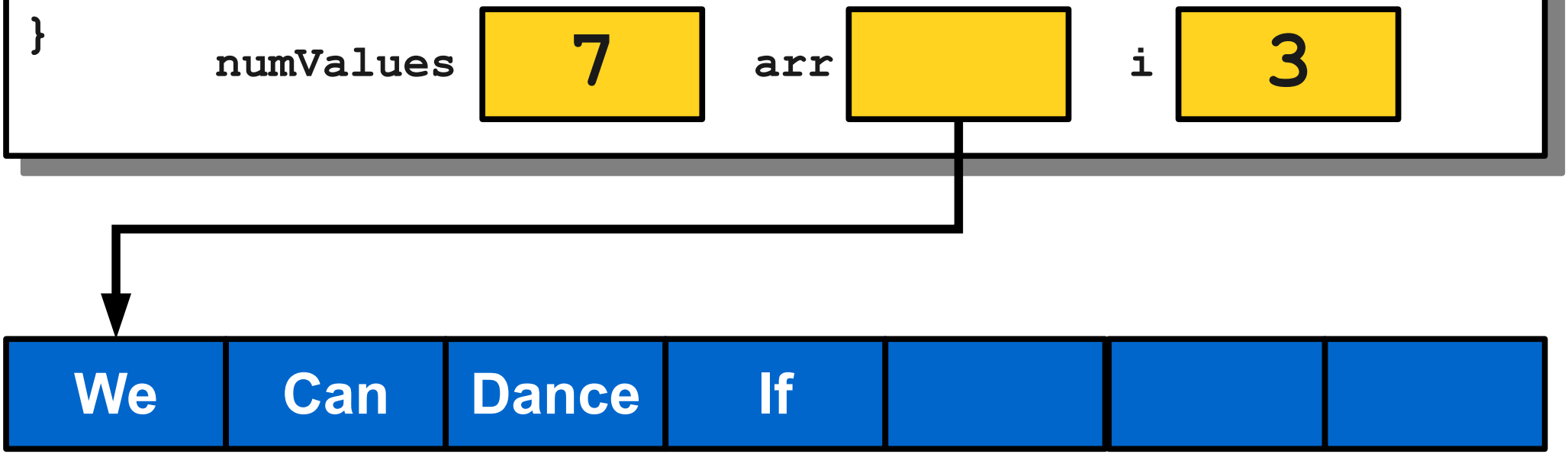

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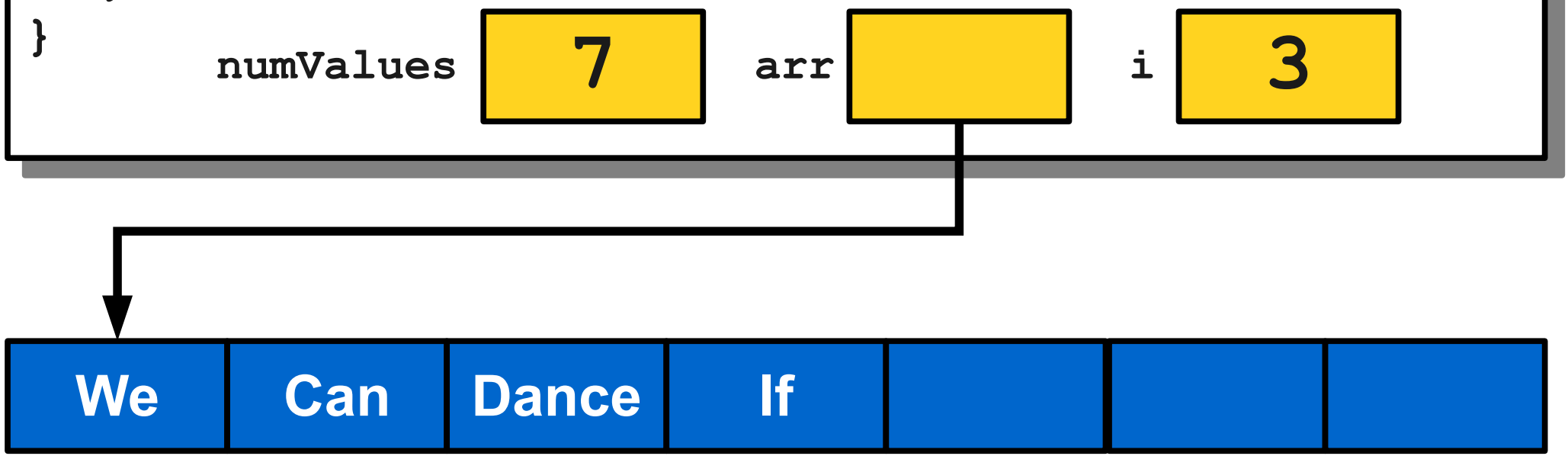

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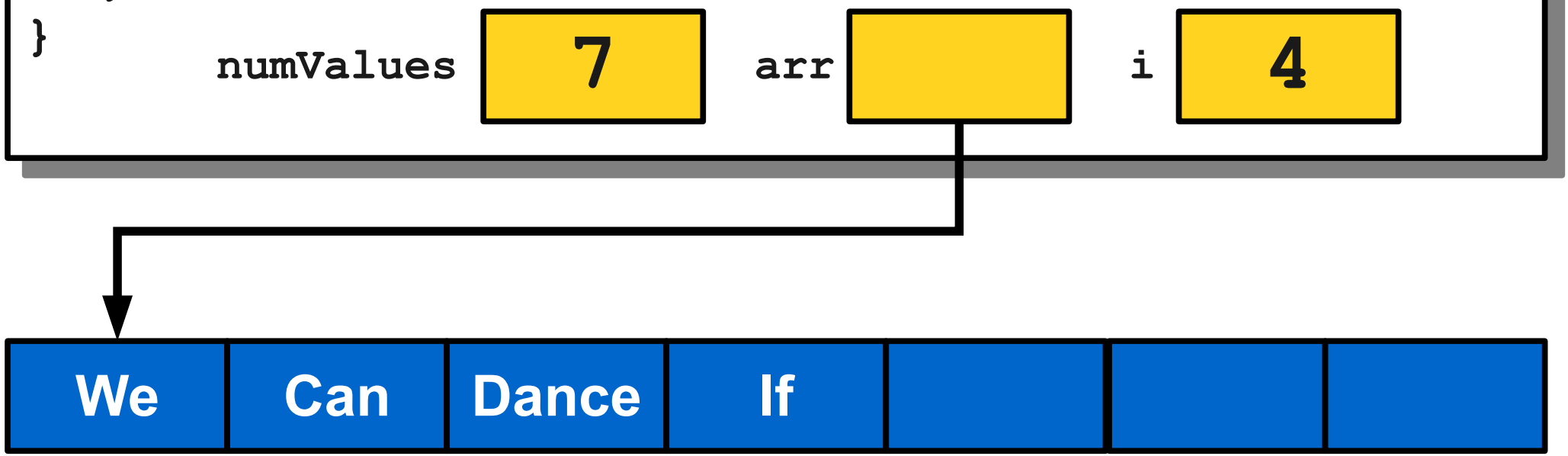

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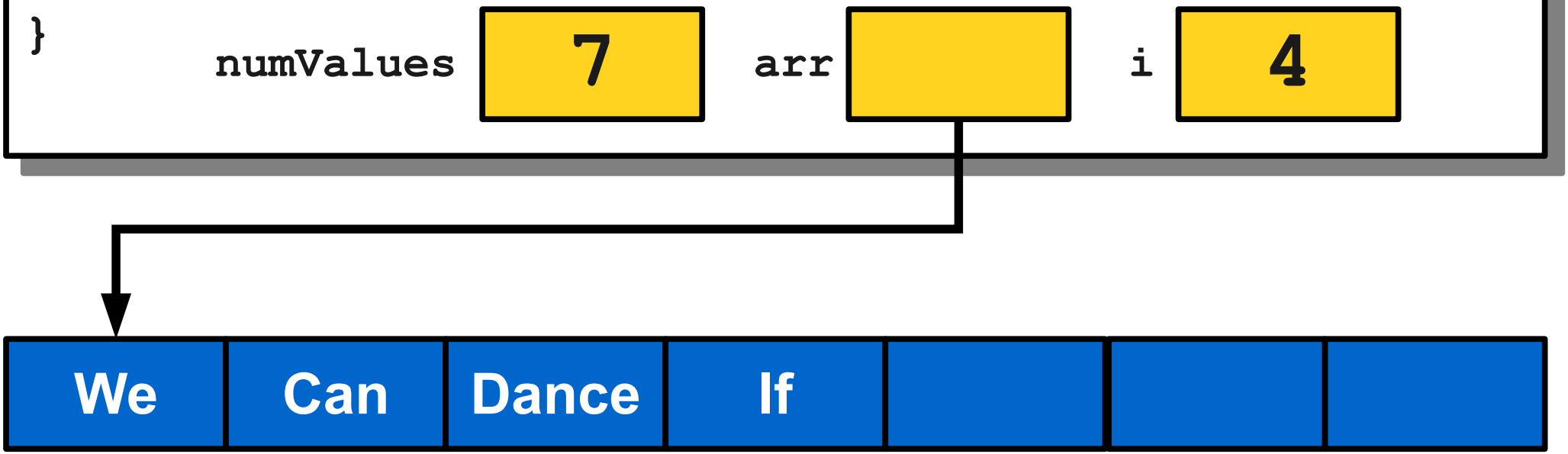

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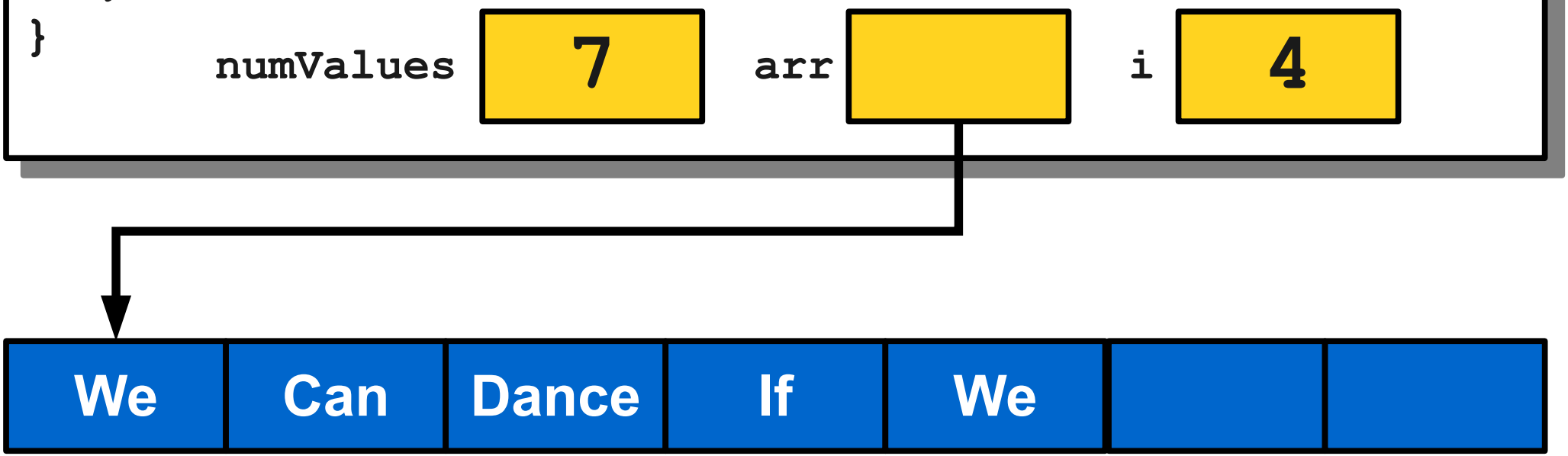

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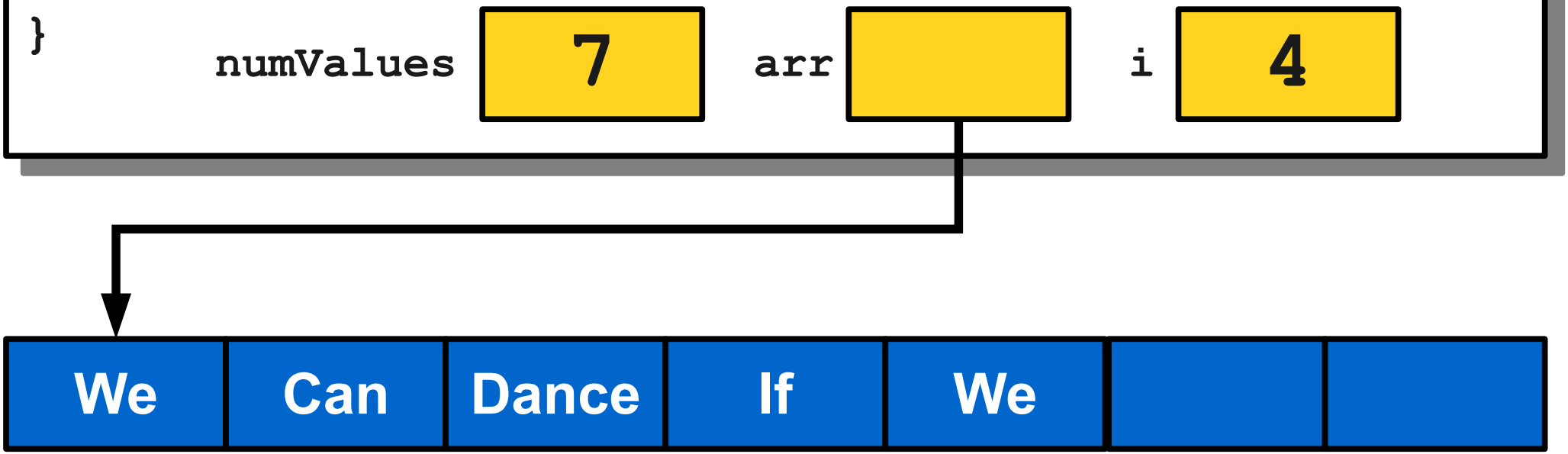

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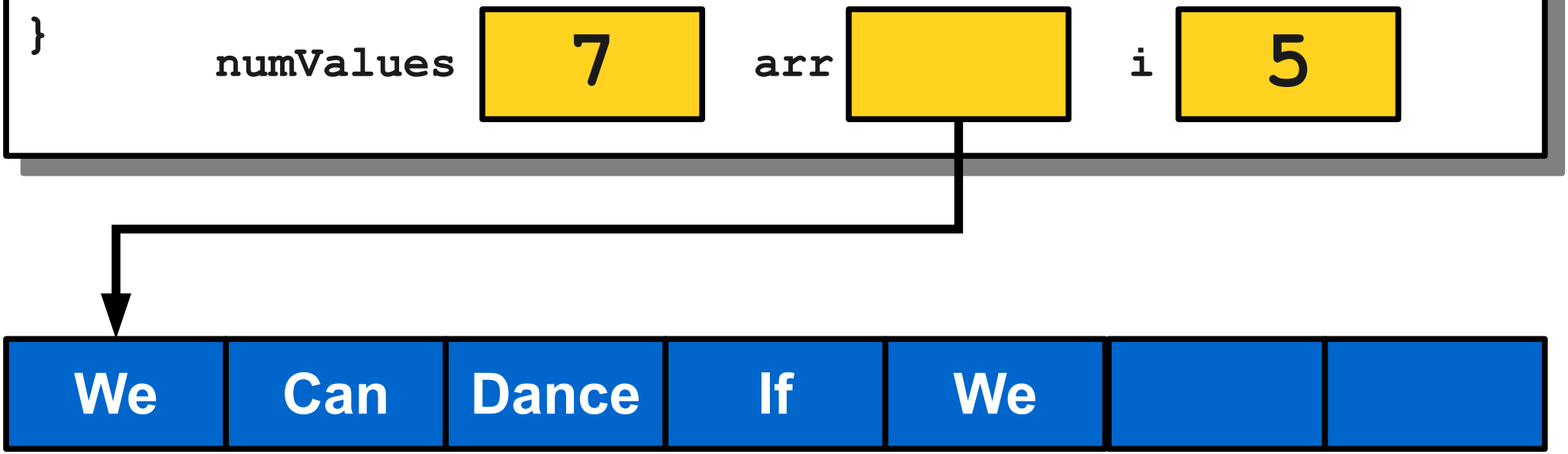

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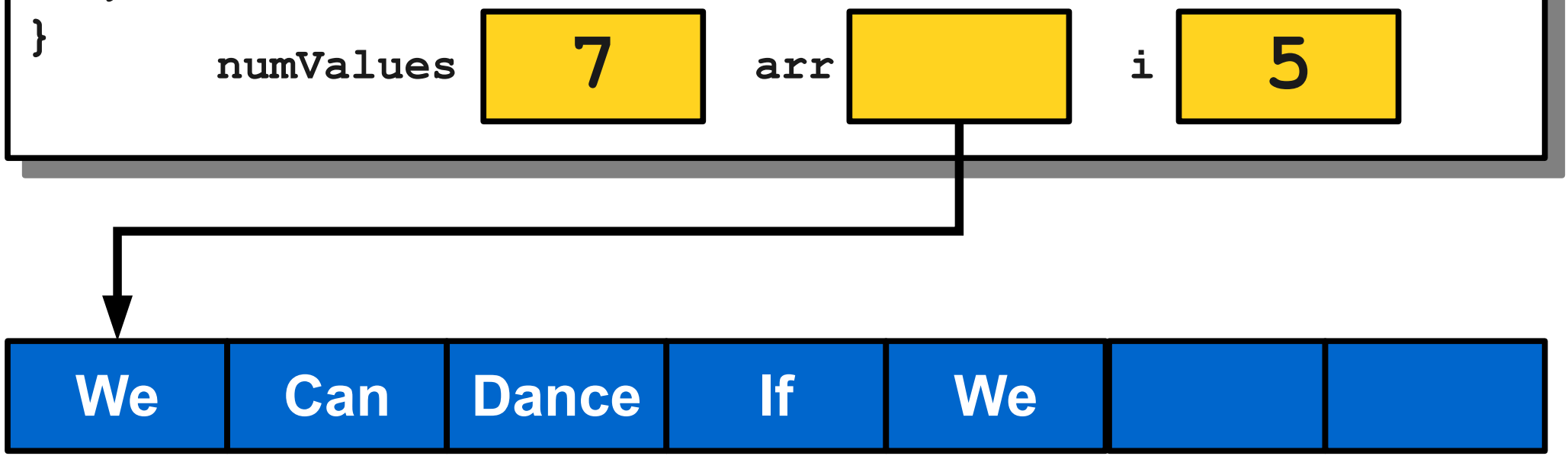

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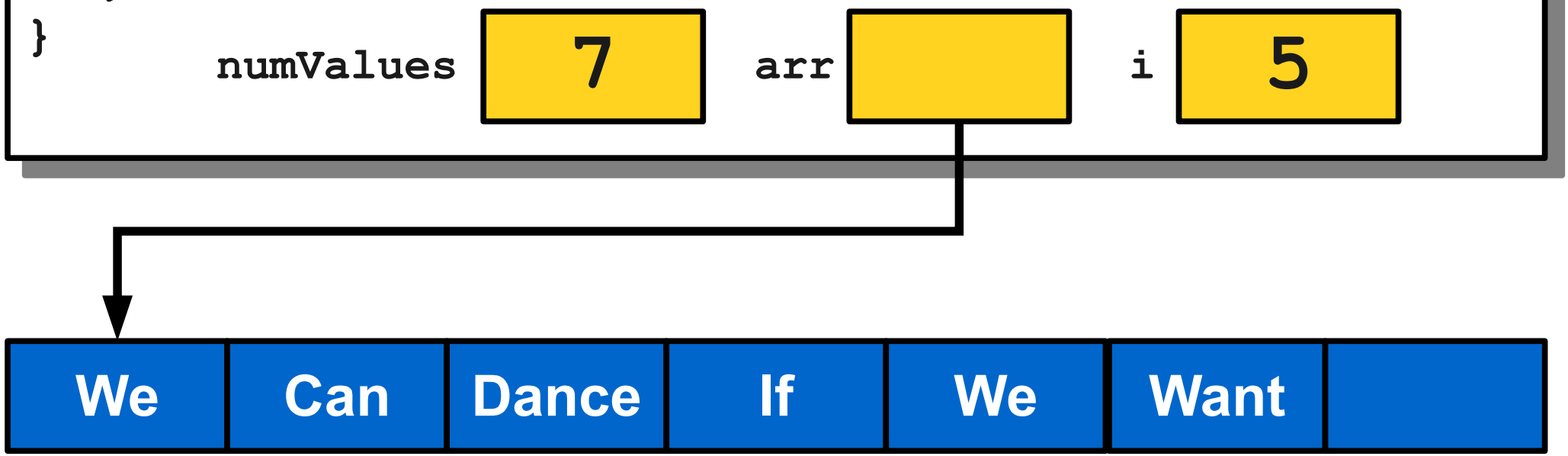

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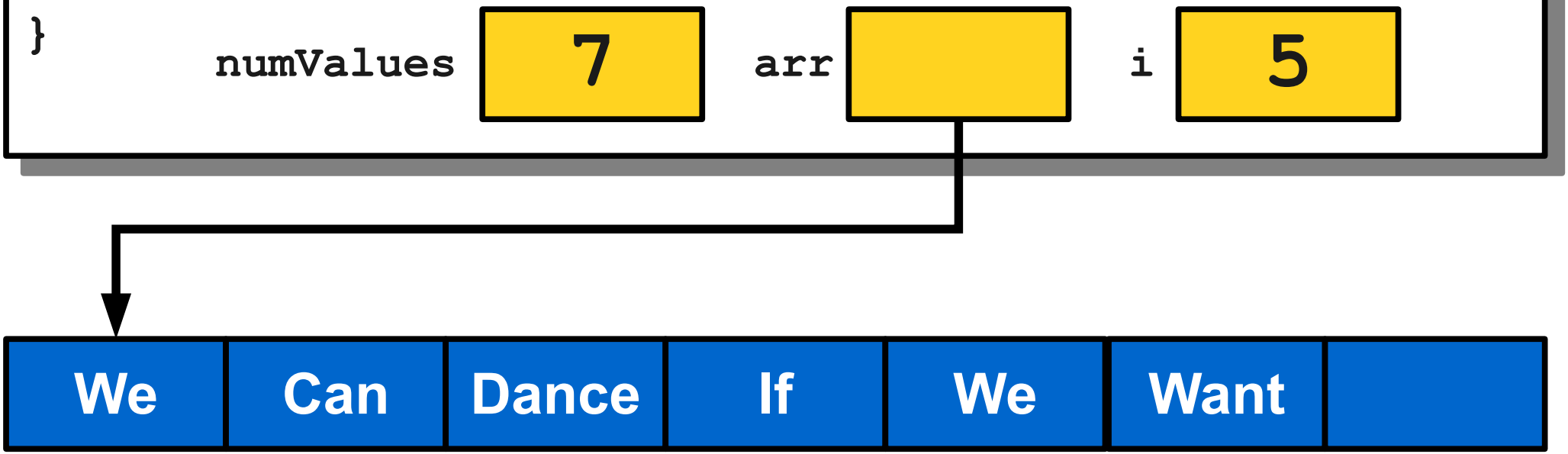

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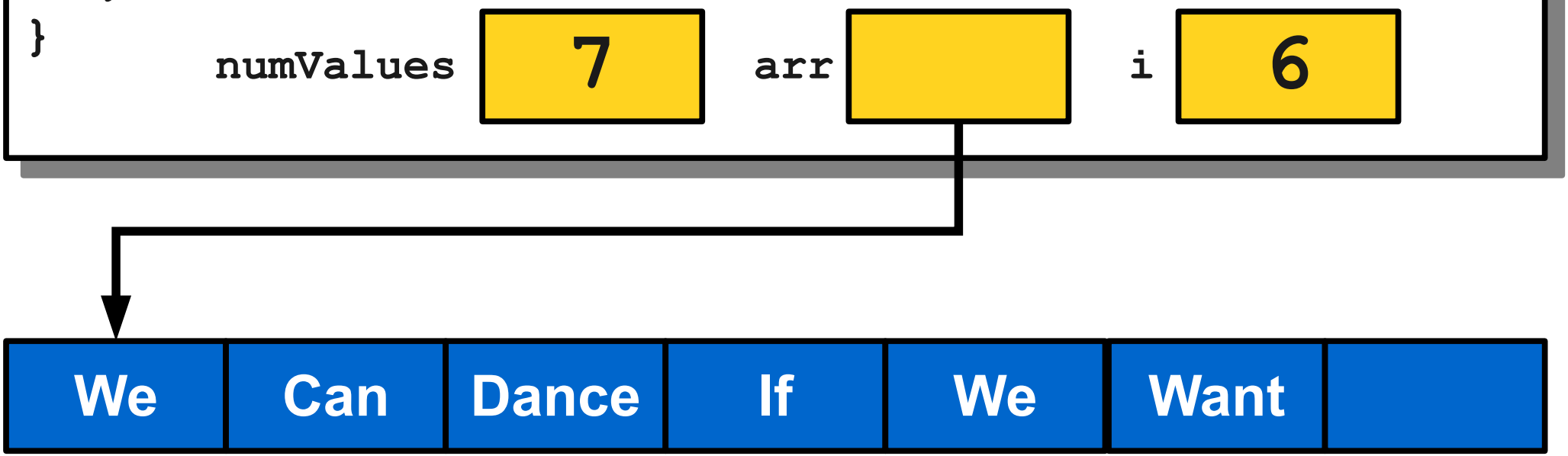

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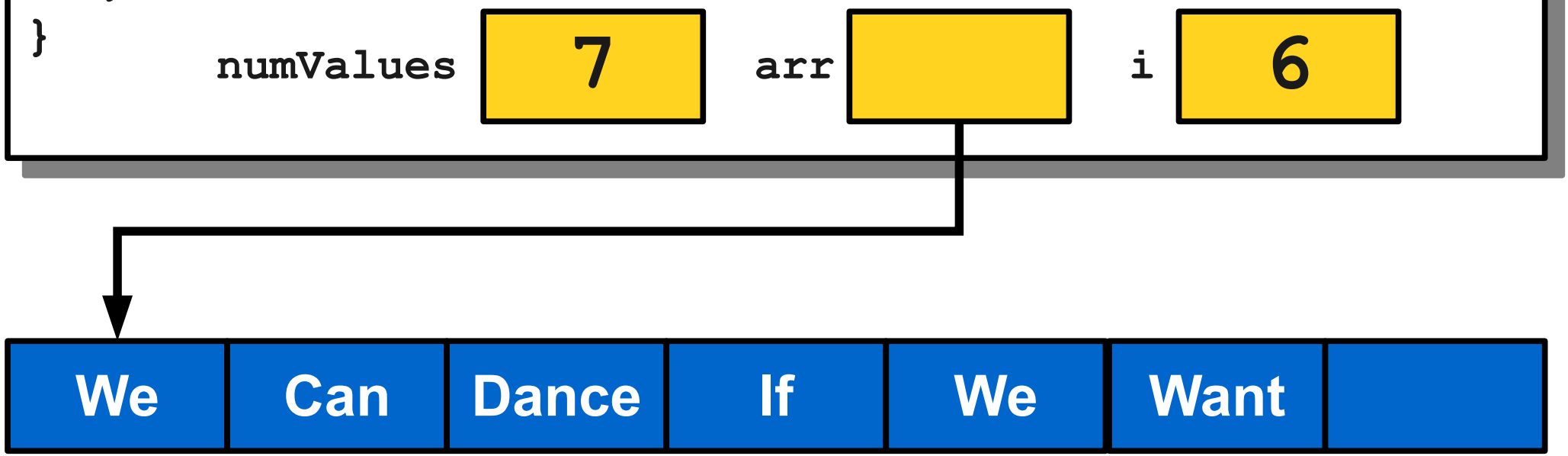

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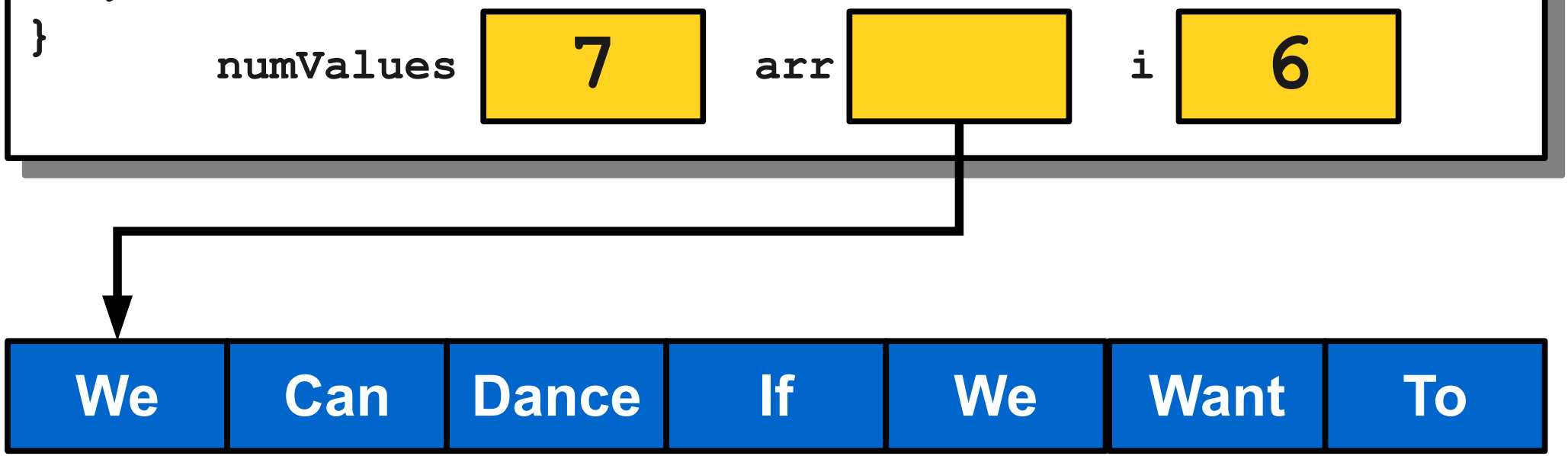

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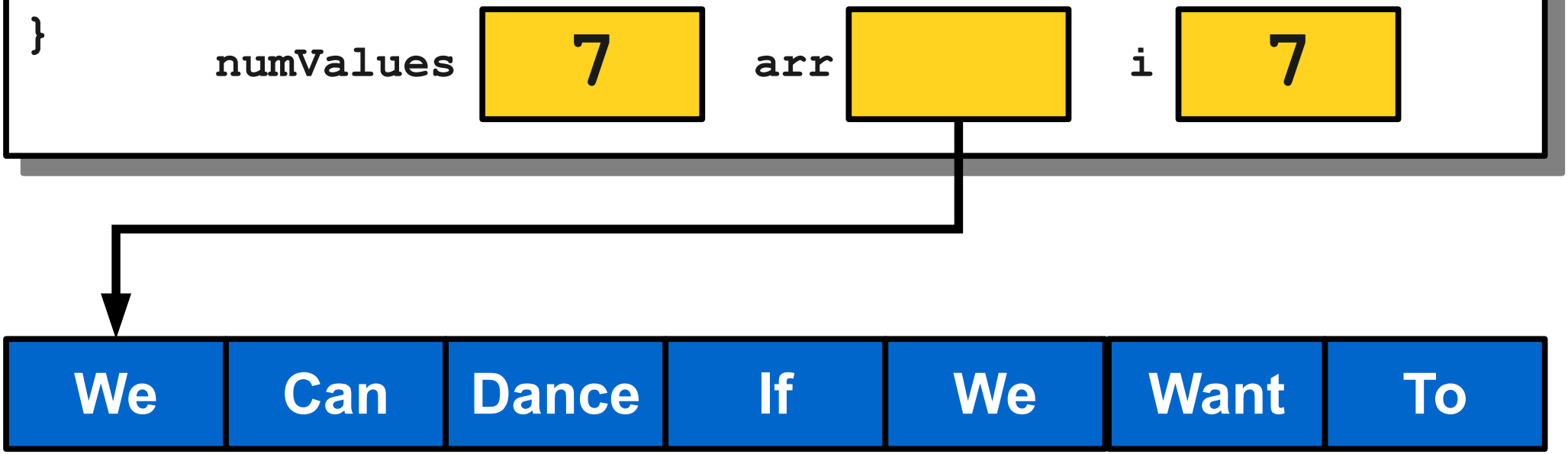
   for (int i = 0; i < numValues; i++) {
      cout << i << ": " << arr[i] << endl;
   }
}
```



```
int main() {
   int numValues = getInteger("How many lines? ");

   string* arr = new string[numValues];
   for (int i = 0; i < numValues; i++) {
      arr[i] = getLine();
   }

   for (int i = 0; i < numValues; i++) {
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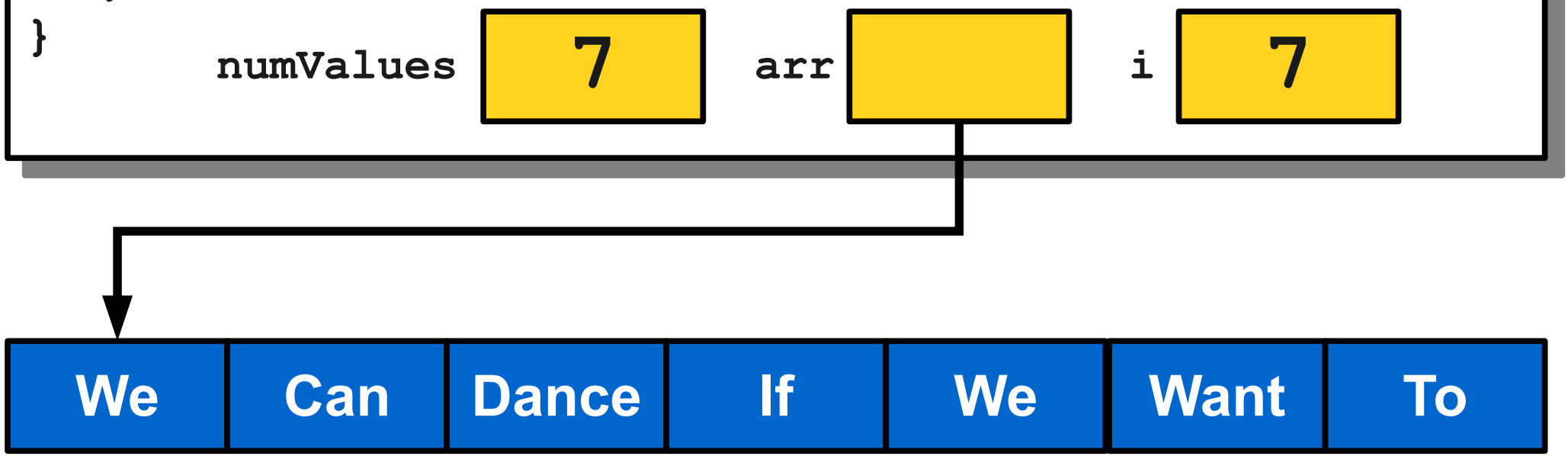

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```

numValues 7

arr

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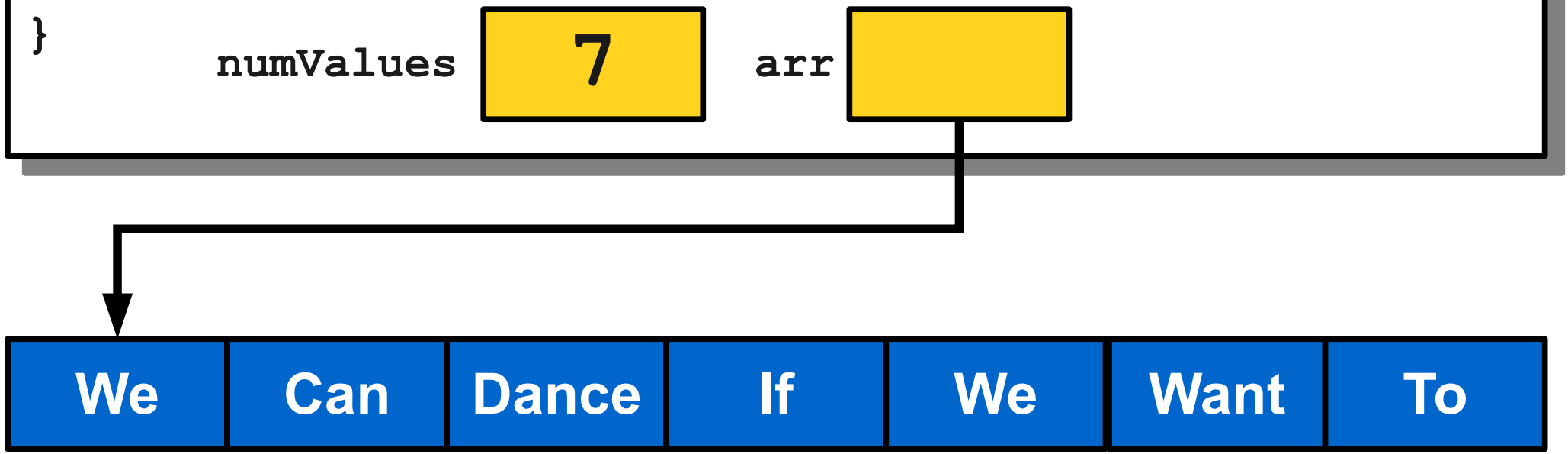

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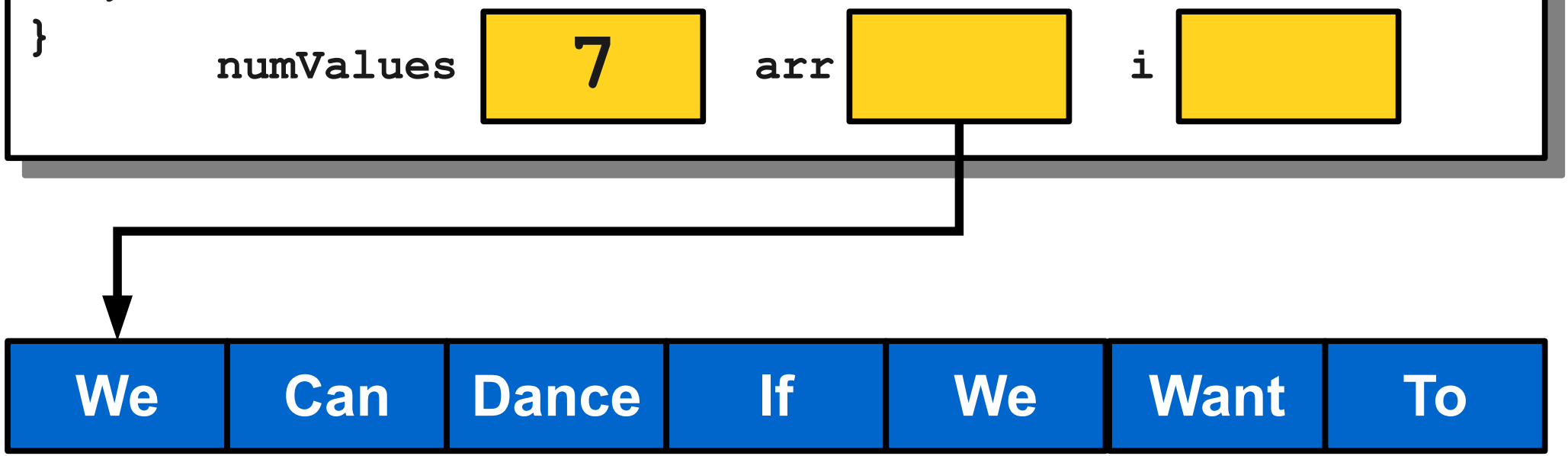

Dynamically Allocating Arrays

- First, declare a variable that will point at the newly-allocated array. If the array elements have type ***T***, the pointer will have type ***T****.
- Then, create a new array with the **new** keyword and assign the pointer to point to it.
- In two separate steps:

```
T* arr;
arr = new T[size];
```

- Or, in the same line:

```
T* arr = new T[size];
```

Cleaning Up

- When declaring global variables or local variables, C++ will automatically handle memory allocation and deallocation for you.
- When using `new`, you are responsible for deallocating the memory you allocate.
- If you don't, you get a **memory leak** and will slowly exhaust all of memory.
- Eventually, the program will crash when you ask for more memory with `new`, because the program thinks all of memory is in use.

Cleaning Up

- You can deallocate memory with the **`delete[]`** operator:

```
delete[] ptr;
```

- This destroys the array pointed at by the given pointer, not the pointer itself.

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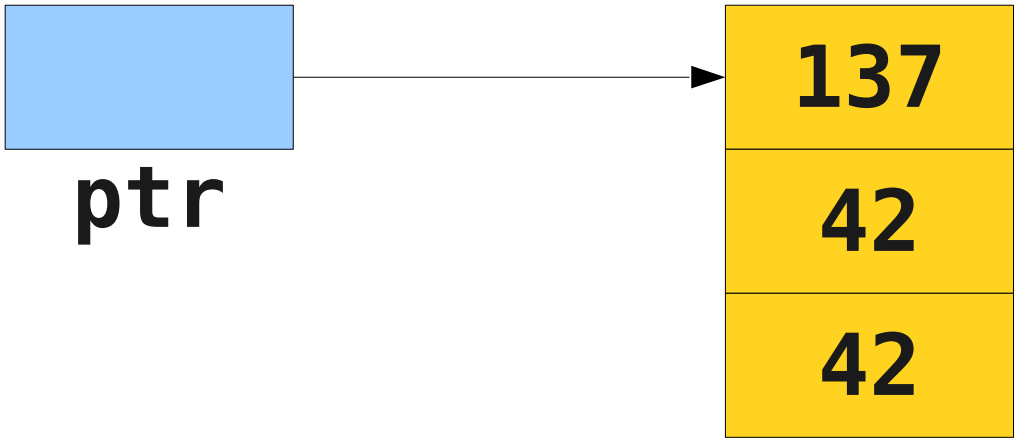

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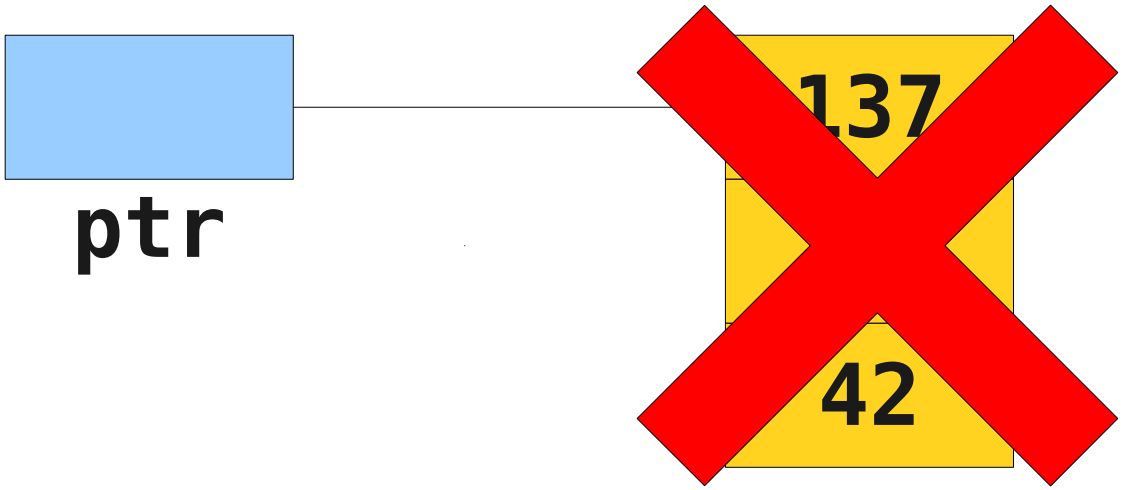

Cleaning Up

- You can deallocate memory with the **`delete[]`** operator:

```
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```

- This destroys the array pointed at by the given pointer, not the pointer itself.

Words of Caution

- C++ has few of the safety features present in Java.
- All of the following result in **undefined behavior** in C++:
  - Reading or writing through a pointer that you haven't initialized.
  - Reading or writing through a pointer to an array that you have deallocated.
  - Reading or writing off the end of an array.

Implementing **`Stack`**

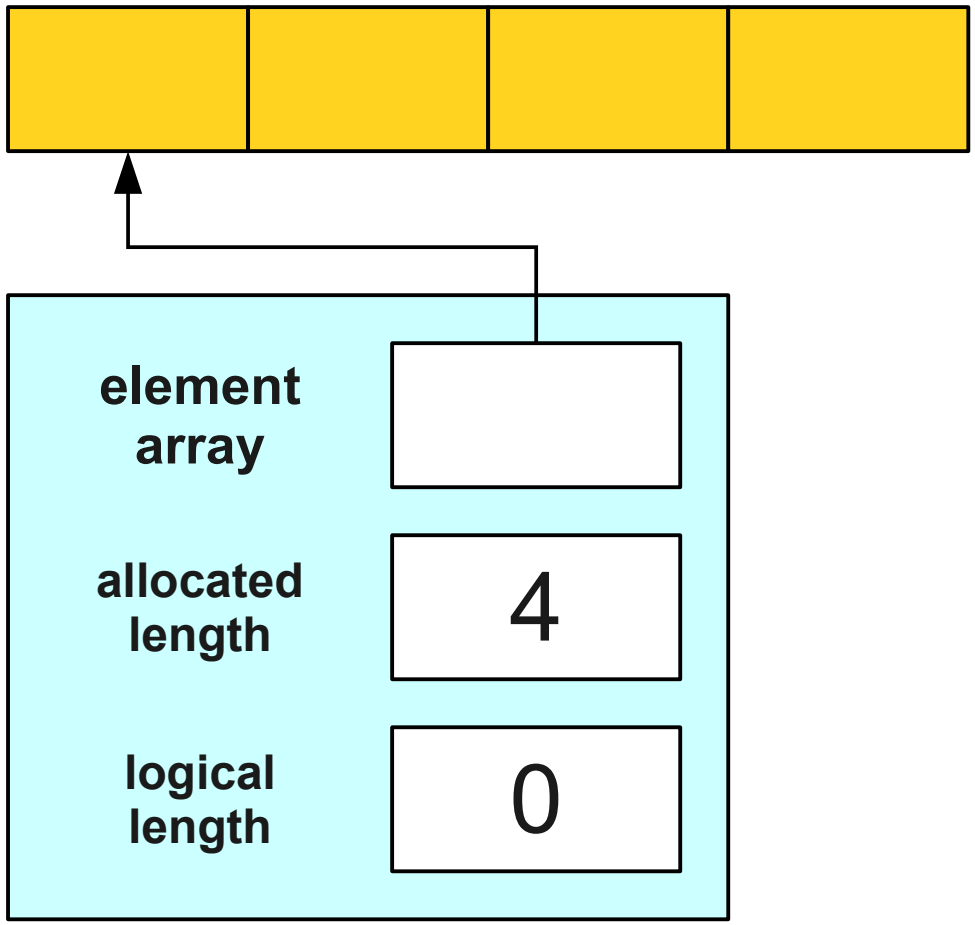
Implementing **`Stack`**

- Last time, we saw how to implement **`RandomBag`** in terms of **`Vector`**.
- We could also implement **`Stack`** in terms of **`Vector`**.
- What if we wanted to implement the **`Stack`** without relying on any other collections?
- Let's build the stack directly!

An Initial Idea

- **A bounded stack.**
- Allocate a fixed-size array for elements.
- Add elements to the array when they're pushed.
- Remove elements from the array when they're popped.
- Report an error if we exceed the size of the array.

An Initial Idea



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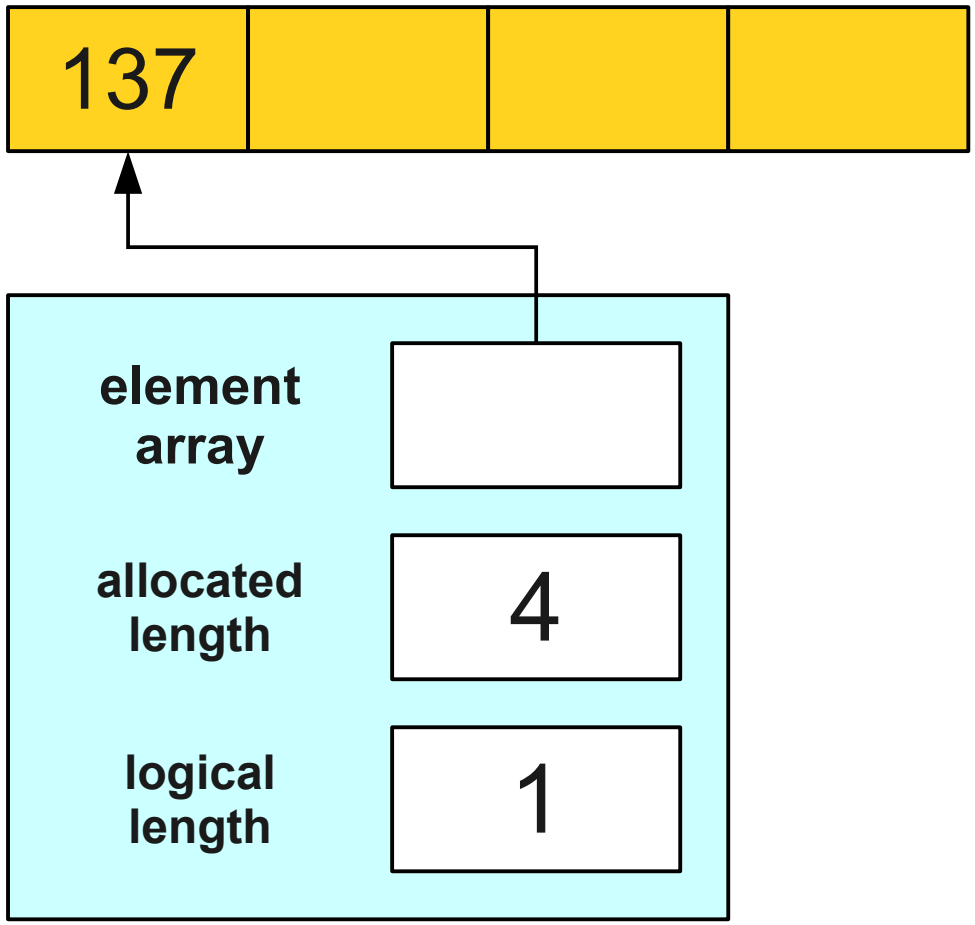

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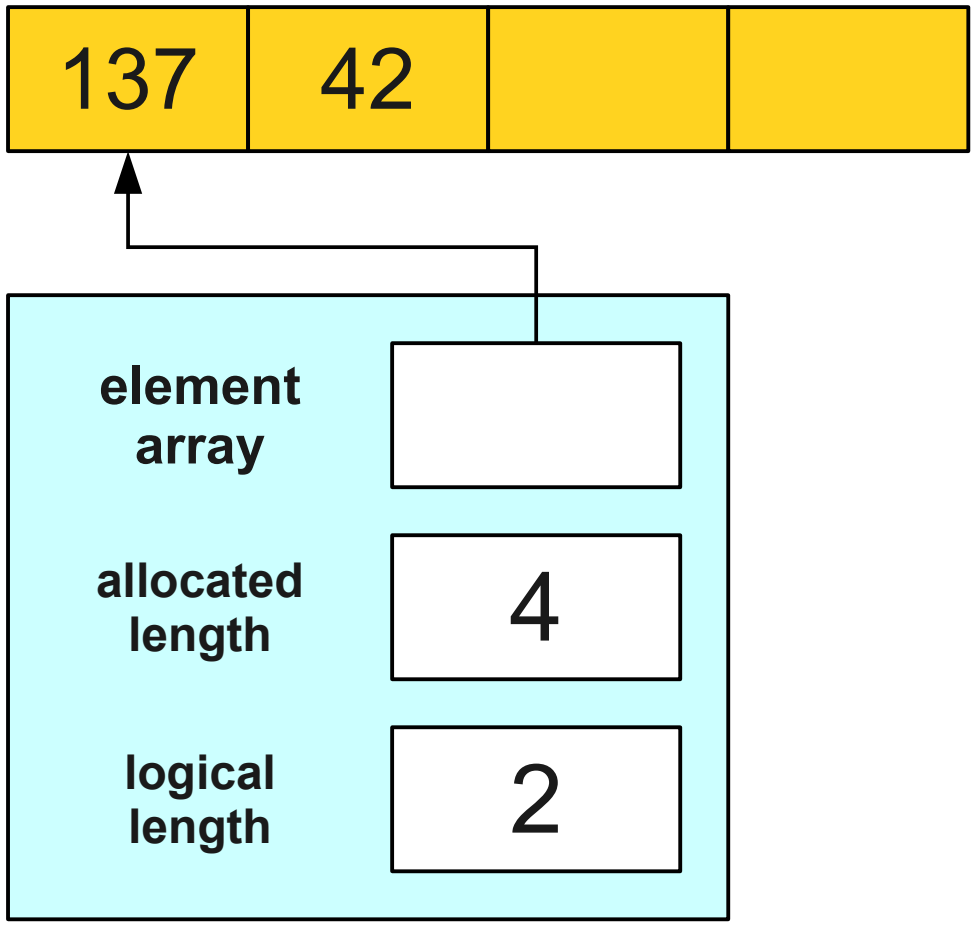

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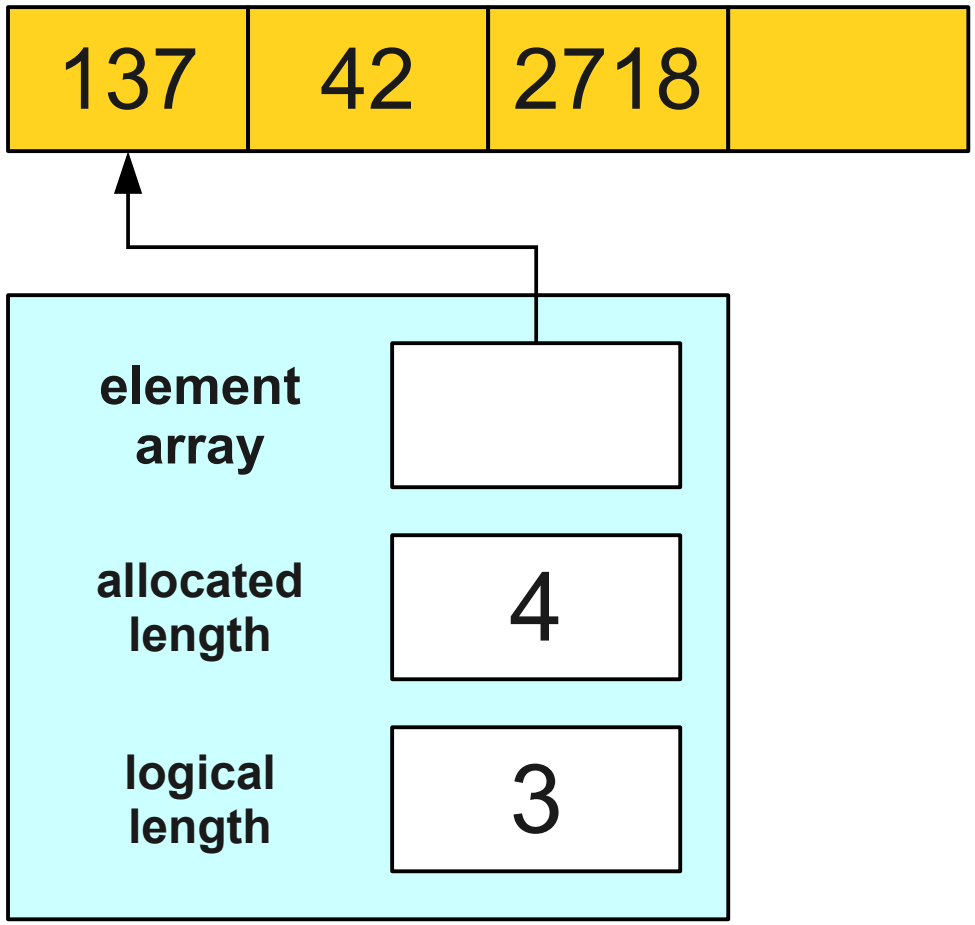

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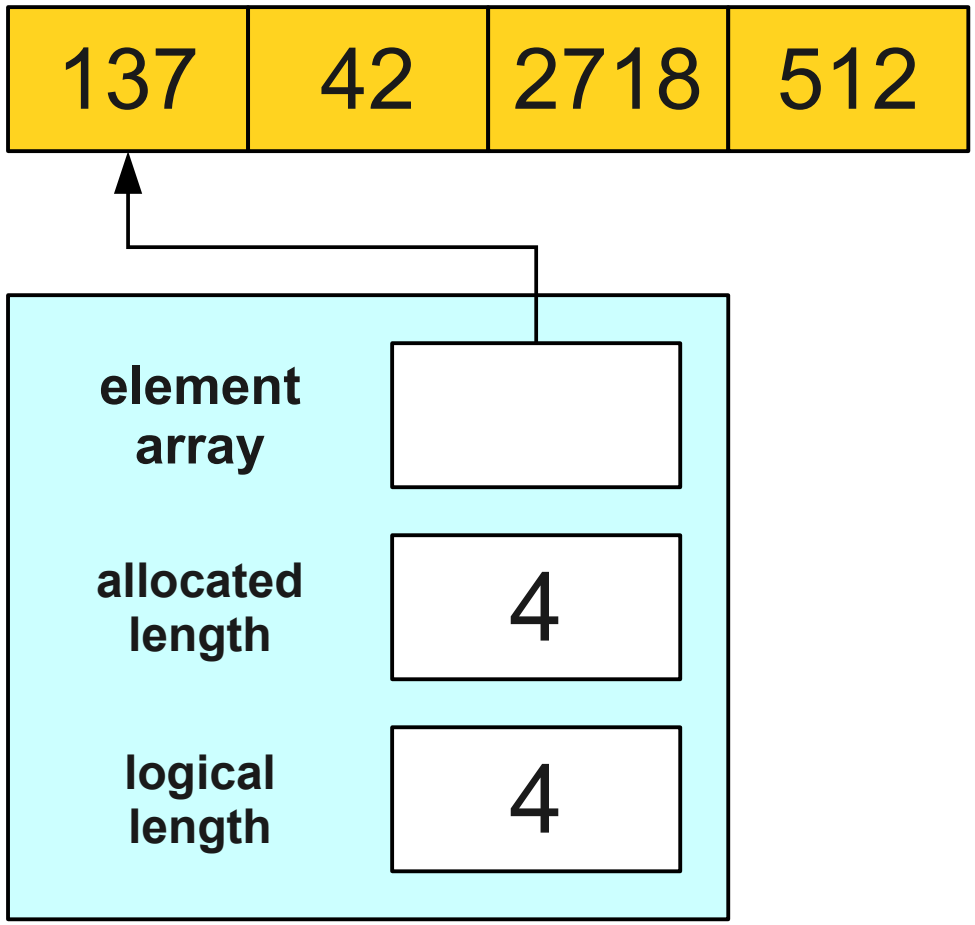

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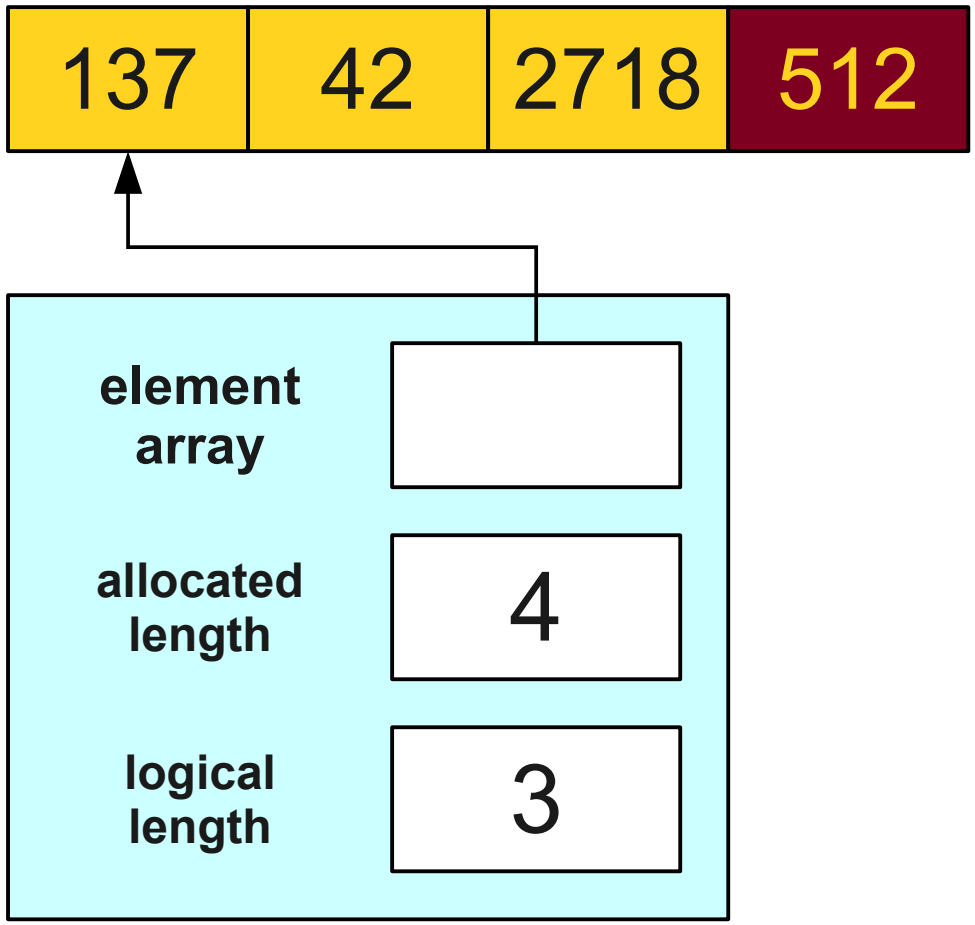

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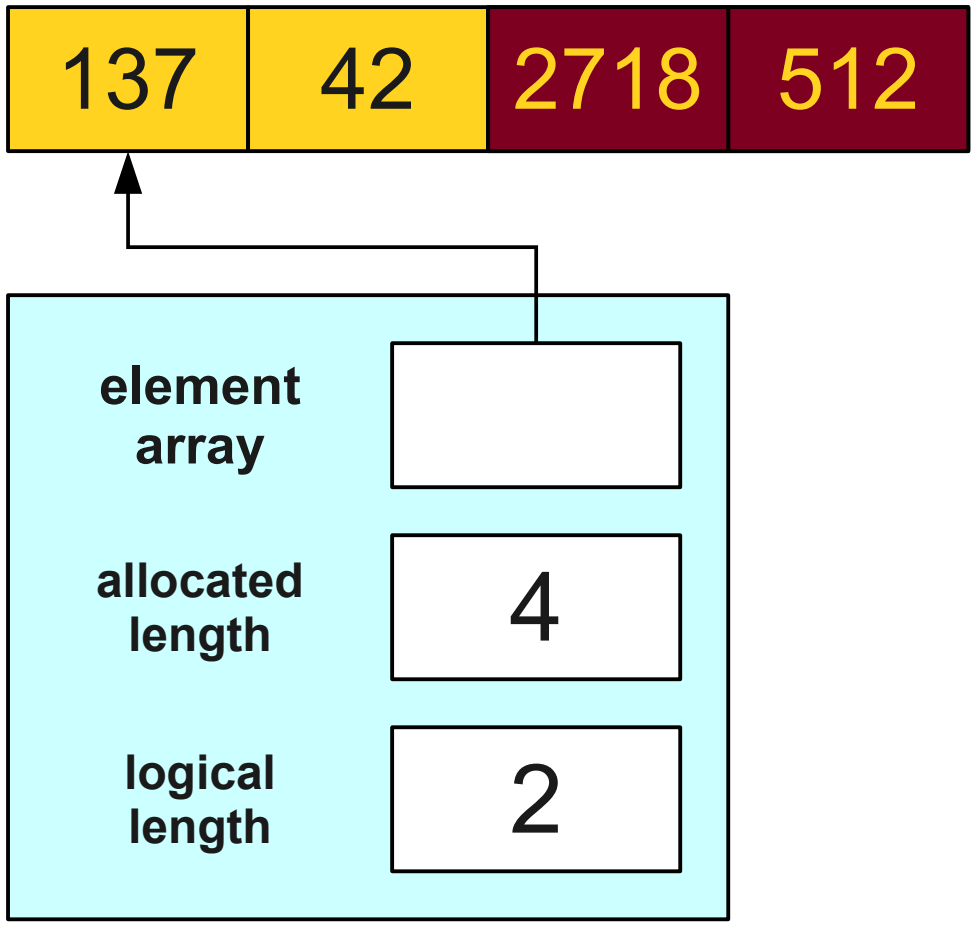

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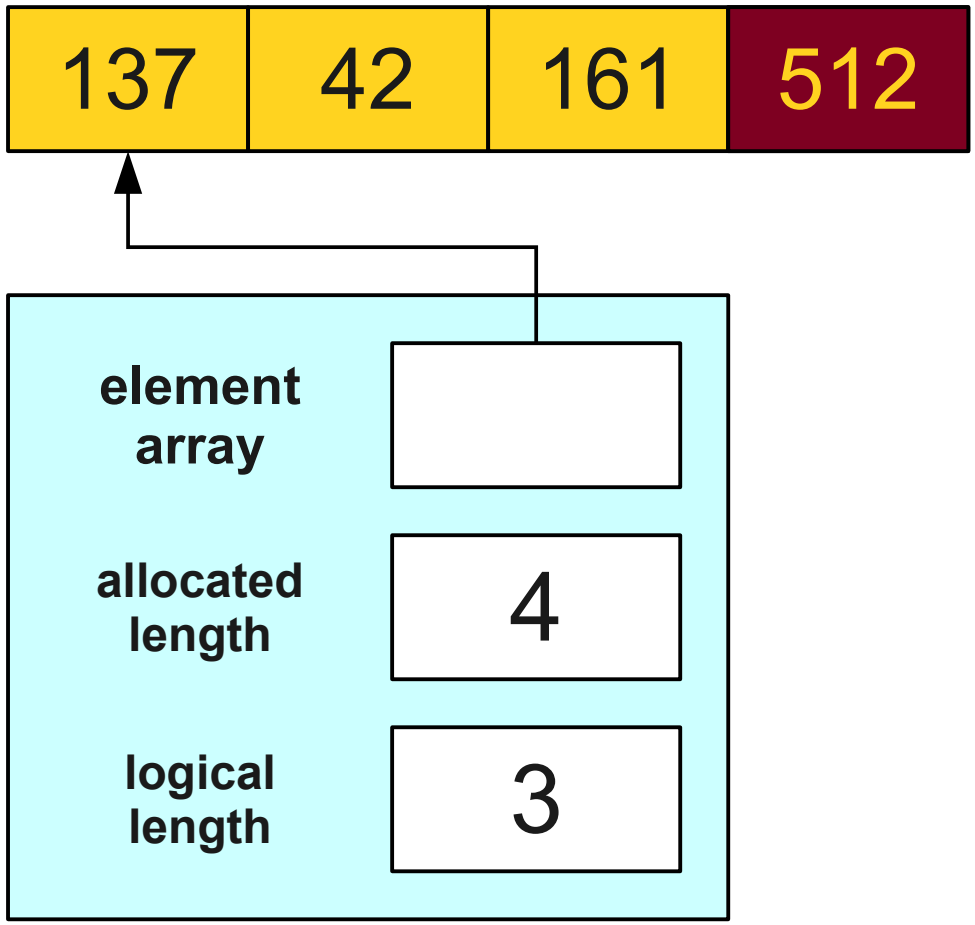

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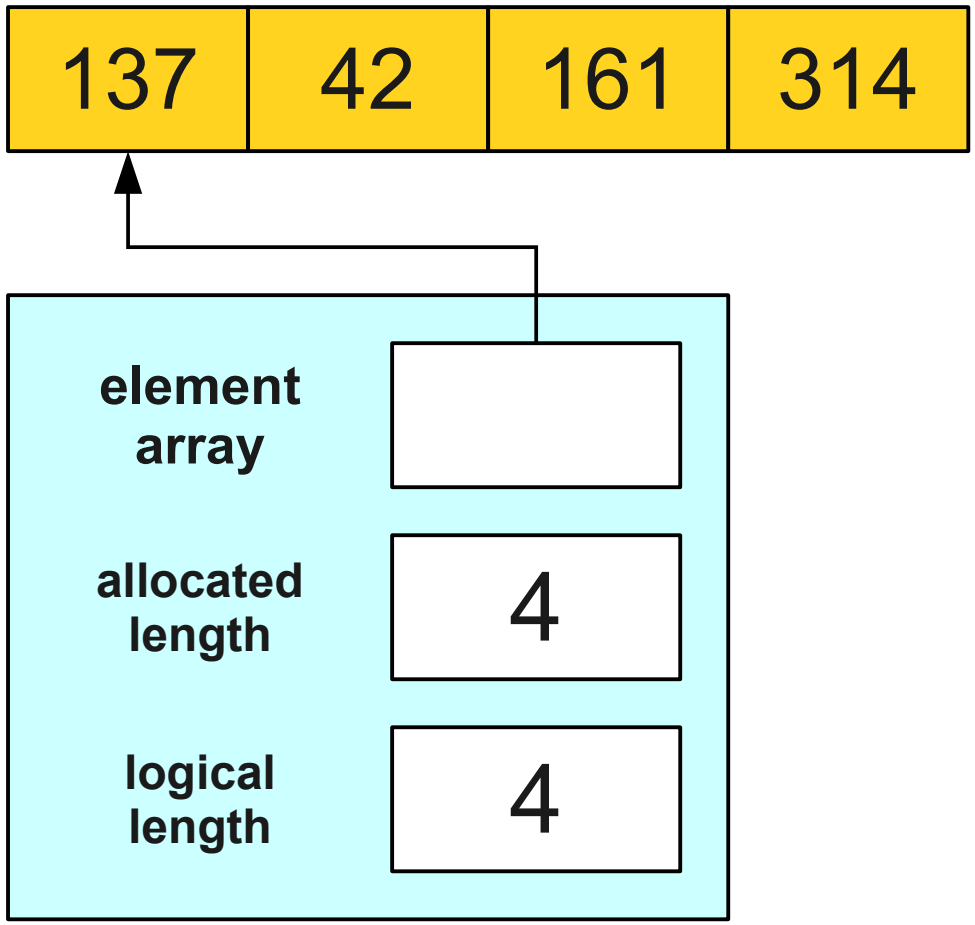

Let's Code it Up!

Constructors

- A **constructor** is a special member function used to set up the class before it is used.
- The constructor is automatically called when the object is created.
- Syntax: The constructor for a class named ***ClassName*** has signature

***ClassName*(*args*);**

Destructors

- A **destructor** is a special member function responsible for cleaning up an object's memory.
- Automatically called when a local variable goes out of scope.
- Automatically called if you `delete` a pointer to an object.
- Syntax: The destructor for a class named ***ClassName*** has signature

~*ClassName*();

Next Time

- **Making `Stack` Grow!**
  - Different approaches to **`Stack`** growth.
  - Analysis of these approaches.
  - The reality: *everything is a tradeoff!*