Constructors and Assignment

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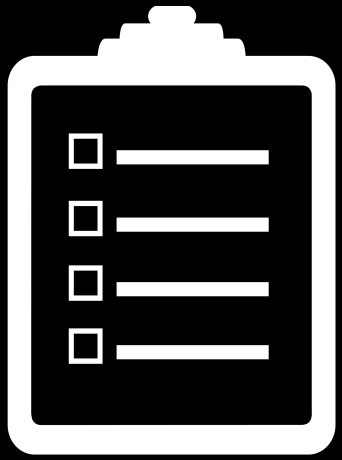
Game Plan



Recap

Const Correct Vector

Copy Constructor

Assignment Constructor

Rule of Three

Recap

Class Templates

The idea with class templates is the same.

A few more annoying nuances to watch out for.

```
template <typename ValueType>
class StrVector {

public:
    void push_back(const ValueType& elem);
    // rest of implementation
}
```

Tell compiler `ValueType` is a generic type.

Class Templates - Details

When we define a class template, we **only** use a .h file, and do not define member functions in a .cpp file.

Member functions are defined differently.

There's a bit of weird syntax for accessing nested types.

Class Templates - Details

Must announce that every method is templated

```
template <typename ValueType>
class Vector {

public:
    void push_back(const ValueType& elem);
    // rest of implementation
}

void Vector::push_back(const ValueType& val) {


}
```

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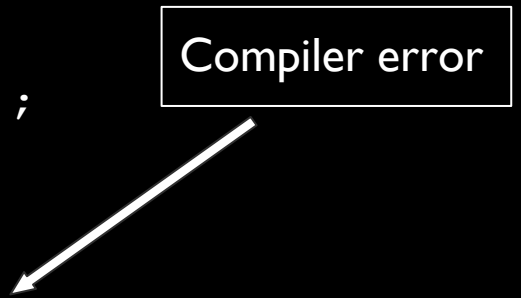

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class Vector {

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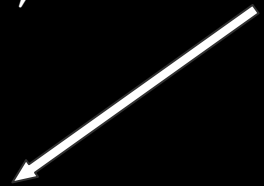
}
```

Compiler error



Class Templates - Details

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template <typename ValueType>
class Vector {

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Class Templates - Details

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class Vector {

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    void push_back(const ValueType& elem);
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}
```
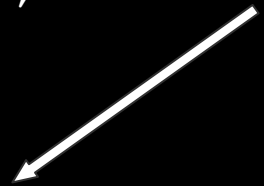

Class Templates - Details

Must announce that every method is templated

```
template <typename ValueType>
class Vector {

public:
    void push_back(const ValueType& elem);
    // rest of implementation
}

template <typename ValueType>
void Vector<ValueType>::push_back(const ValueType& val) {



}
```

All good!



Class Templates - Details II

Must use `typename` keyword for nested types:

```
template <typename ValueType>
Vector<ValueType>::iterator Vector<ValueType>::push_back(const
                                                ValueType& val) {


}
```

Class Templates - Details II

Must use `typename` keyword for nested types:

```
template <typename ValueType>
Vector<ValueType>::iterator Vector<ValueType>::push_back(const
                                                ValueType& val) {


}
```

```
missing 'typename' prior to dependent type name 'Vector<ValueType>::iterator'
Vector<ValueType>::iterator Vector<ValueType>::begin() {
^~~~~~~~~~~~~~~~~~~~~~~~~~~
typename
/Users/alimalik/Desktop/Programs/C++/StringVector/strvector.h
```

Class Templates - Details II

Must use `typename` keyword for nested types:

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template <typename ValueType>
Vector<ValueType>::iterator Vector<ValueType>::push_back(const
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}
```

Class Templates - Details II

Must use `typename` keyword for nested types:

```
template <typename ValueType>
typename Vector<ValueType>::iterator
           Vector<ValueType>::push_back(const ValueType& val) {


}
```

Const Correctness

Const Correctness

Lets us reason about whether a variable will change

What does constness mean for classes?

Const Interface

Classes have const and non-const interfaces

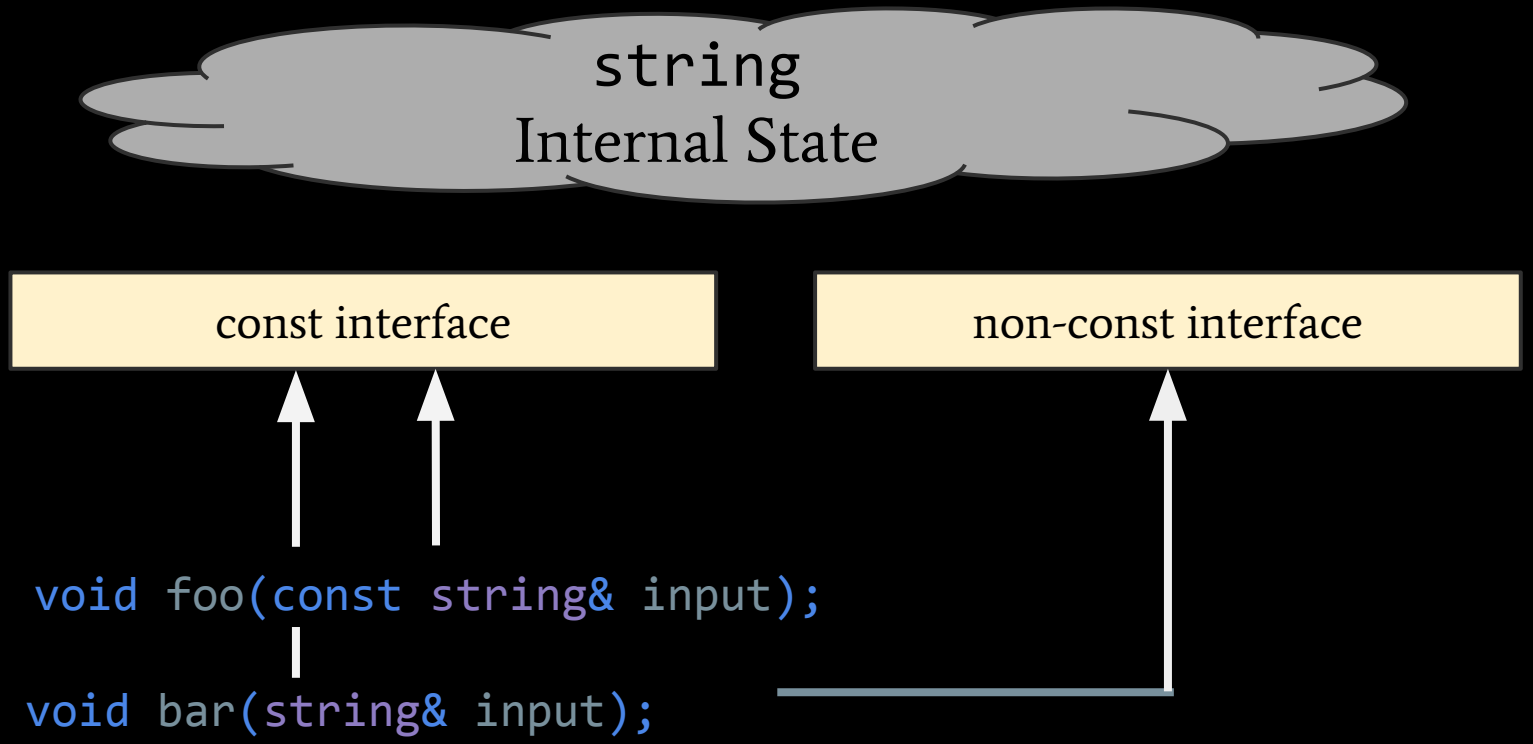
const instances of the class have to go through const interface

Non-const instance of the class can go through either

```
size_t string::size() const {
    // implementation
}

void string::clear() {
    // implementation
}
```

Const Interface



Const Pointers

Helpful to read right to left

```
// constant pointer to a non-constant int
int* const p;

// non-constant pointer to a constant int
const int* p;
int const* p;

// constant pointer to a constant int
const int* const p;
int const * const p;
```

Const Iterators

Similar to pointer constness

```
// acts like int* const it1;
const vector<int>::iterator it1;
*it1 = 10;      // totally fine!
++it;           // can't change iterator


// acts like const int* it2;
vector<int>::const_iterator it2;
*it2 = 10;      // can't change element
++it2;          // can move iterator
```

Const Summary

const on objects

Guarantees the object won’t change by only allowing you to call const functions. Helps catch bugs and allows for better optimisations.

const on functions

Guarantees function won’t call anything but other const functions and won’t modify and internal data members (unless marked mutable).

Const Correct Vector

Const Correctness

We need to write both `const` and non-`const` versions for some methods.

The method called depends on the `const`-ness of the object it is called on.

Examples:

- operator[]
- iterator begin() and end()

Refining Abstractions

Why Constructors?

Set up initial state of object:

- Make sure everything has a sensible starting value.
- Take information from user to set up object appropriately.

Initialisation vs Assignment

Initalisation vs Assignment

Initialisation:

Transforms an object's initial junk data into valid data.

Assignment:

Replaces existing valid data with other valid data.

Initalisation vs Assignment

Initialisation:

Defined by the constructor for a type.

Assignment:

Defined by the assignment operator for a type.

Initalisation vs Assignment

```
Vector<string> defV;
// initialisation

Vector<string> fillV(10, "hello");
// initialisation

Vector<string> copyV(defC);
// initialisation

Vector<string> v = defV;
// initialisation

v = fillV;
// assignment
```

Constructors

Normal Constructor:

- What you are used to!

Copy Constructor

- Initialise an instance of a type to be a copy of another instance

Copy Assignment

- Not a constructor
- Assign an instance of a type to be a copy of another instance

Constructors

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Vector<string> defV;
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Vector<string> v = defV;              // copy constructor
// initialisation

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Constructors - Quick Note

If you don’t define some of these constructors, the compiler will create default versions for you.

Constructors - Quick Note

If you don’t define some of these constructors, the compiler will create default versions for you.

This might not always do what you want

Default Constructor

Default Constructor

Takes no arguments.

Used to initialise members to sensible starting values.

```
class MyClass {

public:
    MyClass() {                 // default constructor
        privInt = 3;
    }

private:
    int privInt;
}
```

Default Constructor

Used as follows:

```
MyClass defC;           // calls default constructor

MyClass buggy();        // DOESNT WORK!
```

Default Constructor

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MyClass defC;              // calls default constructor

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Default Constructor

Used as follows:

```
MyClass defC;                   // calls default constructor

// Treated as function declaration
MyClass buggy();                // DOESNT WORK!
```

This is called C++'s Most Vexing Parse

Copy Constructor

Copy Constructor

Used to initialise an instance of a class from another existing instance.

Two ways it can be called:

```
// vector<string> v created earlier

// copy constructor called
vector<string> copyV(v);
vector<string> copyV2 = v;
```

Copy Constructor

Syntax is that of a constructor that takes a class object as its argument:

```
MyClass::MyClass (const MyClass& rhs) {

    // implementation

}
```

Copy Constructor

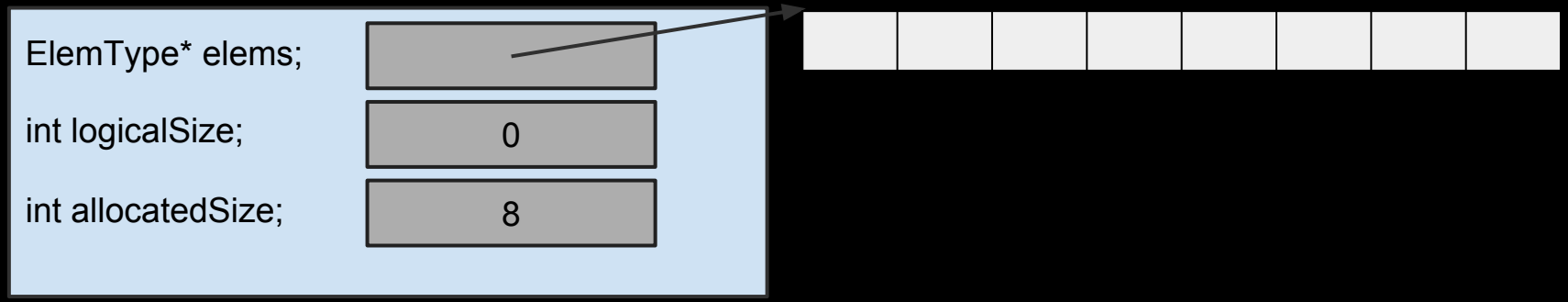
Let’s write a copy constructor for our Vector class!

First idea:

- Just copy all the member variables over.
- We’ll have the correct size and element pointer, so this works?
- This is what the default copy constructor does if you don’t write one.

Copy Constructor

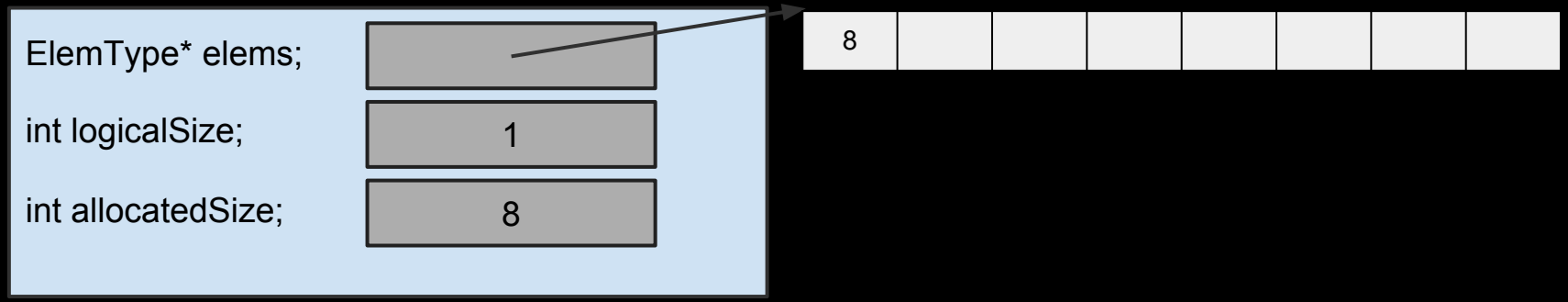
```
vector<int> a:
```




```
Vector<int> a;
```

Copy Constructor

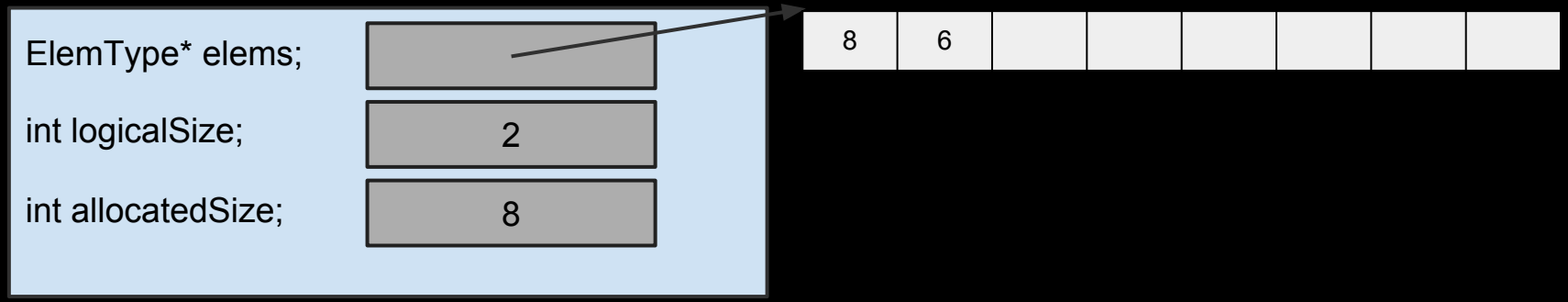
`vector<int> a:`




```
Vector<int> a;
a.push_back(8);
```

Copy Constructor

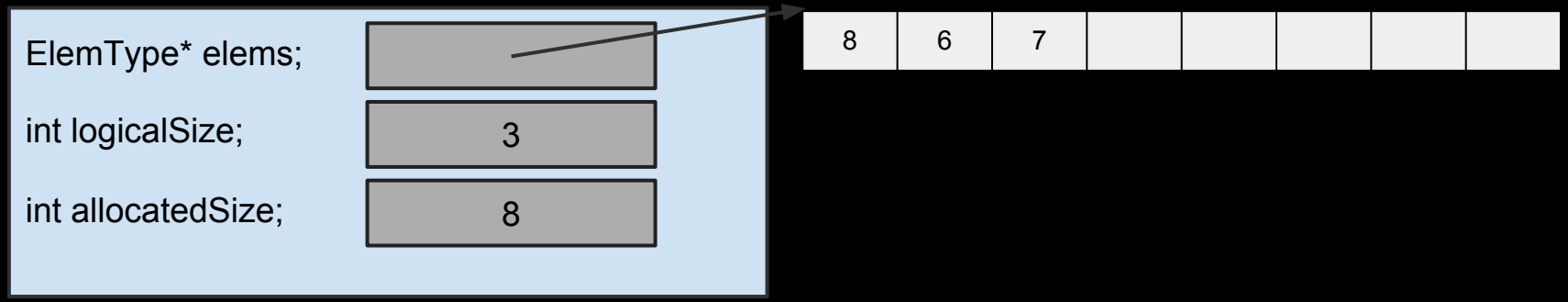
`vector<int> a:`




```
Vector<int> a;
a.push_back(8);
a.push_back(6);
```

Copy Constructor

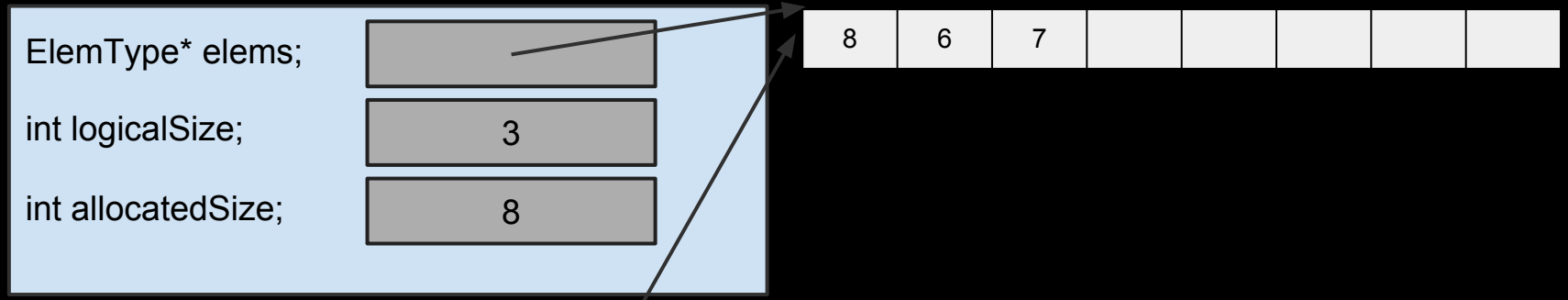
vector<int> a:



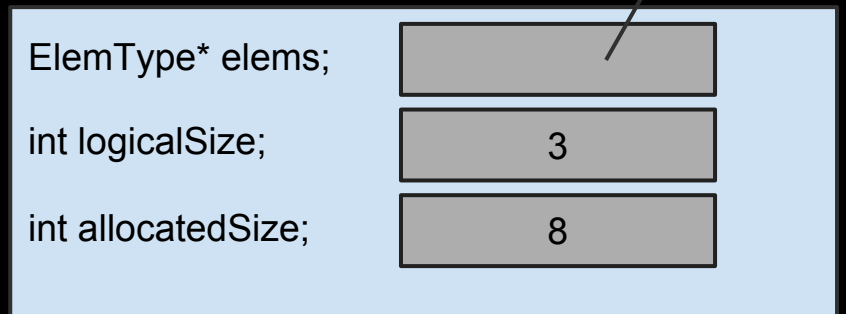

```
Vector<int> a;
a.push_back(8);
a.push_back(6);
a.push_back(7);
```

Copy Constructor

vector<int> a:



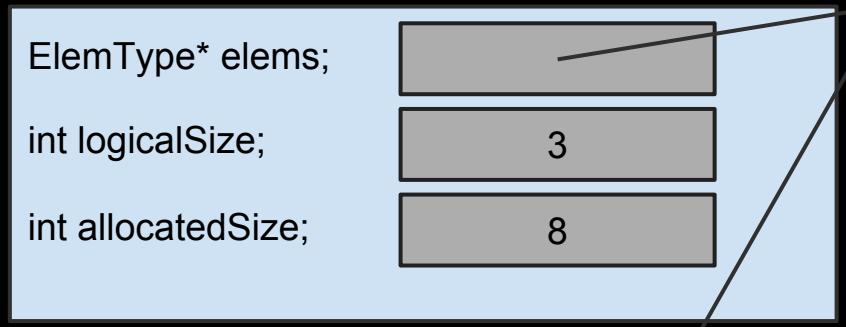
vector<int> b:




```
Vector<int> a;
a.push_back(8);
a.push_back(6);
a.push_back(7);
Vector<int> b = a;
```

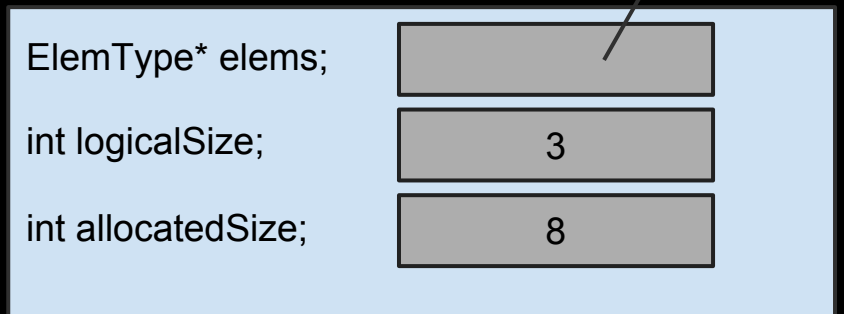
Copy Constructor

vector<int> a:



Changing the value of b also changed the value of a!

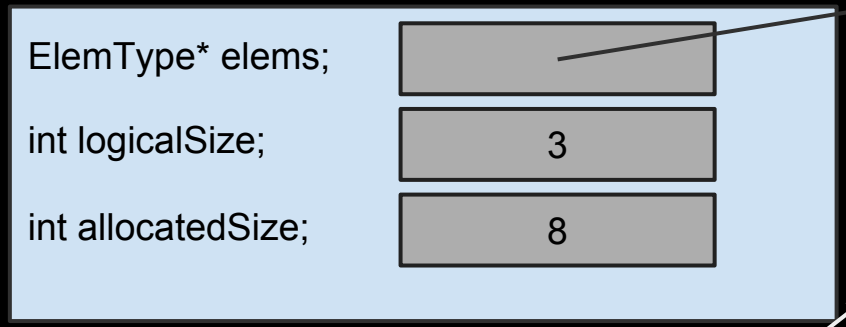
vector<int> b:

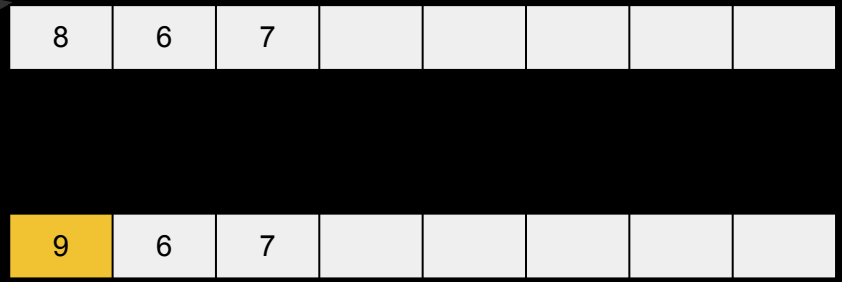



```
Vector<int> a;
a.push_back(8);
a.push_back(6);
a.push_back(7);
Vector<int> b = a;
b[0] = 9;
```

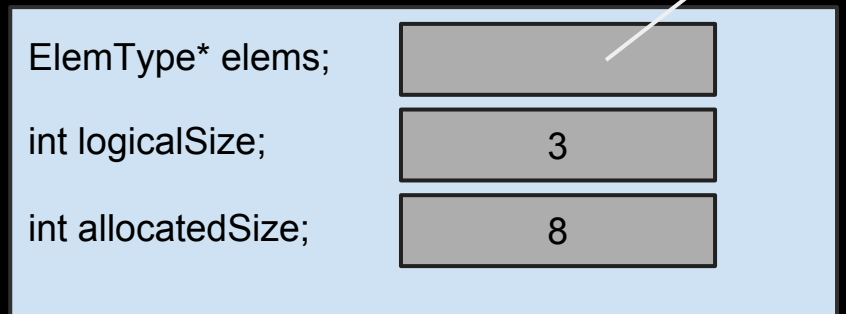
Copy Constructor

vector<int> a:





vector<int> b:

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Vector<int> a;
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a.push_back(7);
Vector<int> b = a;
b[0] = 9;
```

Copy Constructor - Deep copy

Lesson:

If you have pointer variables, you should always define a copy constructor.

Copy Constructor

Let’s add this to our vector class:

`MyVector.pro`

Copy Assignment

Copy Assignment

Takes already initialised object and gives it new values.

```
// vector<string> v, v2 created earlier

// copy constructor called
vector<string> copyV = v;

// copy assignment
copyV = v2;
```

Copy Assignment

Works by overloading the = operator.

Syntax is exact same as any other operator overload.

```
class MyClass {

public:
    MyClass& operator=(const MyClass& rhs) {

    }
private:
    int privInt;
}
```

Copy Assignment

Slightly more involved than copy constructor because object already contains valid data!

We need to watch out for:

- Catching memory leaks
- Handling self assignment
- Understanding the return value

The Rule of Three

The Rule of Three

If you implement a copy constructor, assignment operator, or destructor, you should implement the others, as well

Next Time

RAII