Abstraction and OOP

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Today’s Plan

Announcements

Recap

Abstraction

OOP

Recap

Minimize software size and interactions

- Simplify complex program to manageable level
- Break down into smaller problems
- Isolate functionalities
- Minimize and control interactions

So how do we do this?

Abstraction

Abstraction Example

Abstraction Example

You always use them, switch from one to another seamlessly and probably don't think too much about them

Printers

Come in all shapes and sizes

Can have different complex mechanisms

(Laser, Laserjet, Inkjet, Dot matrix …)

Easy to use

- something common to all of them - abstraction

What is a printer?

What is a printer?

A printer reproduces graphics or text on paper

What is a printer?

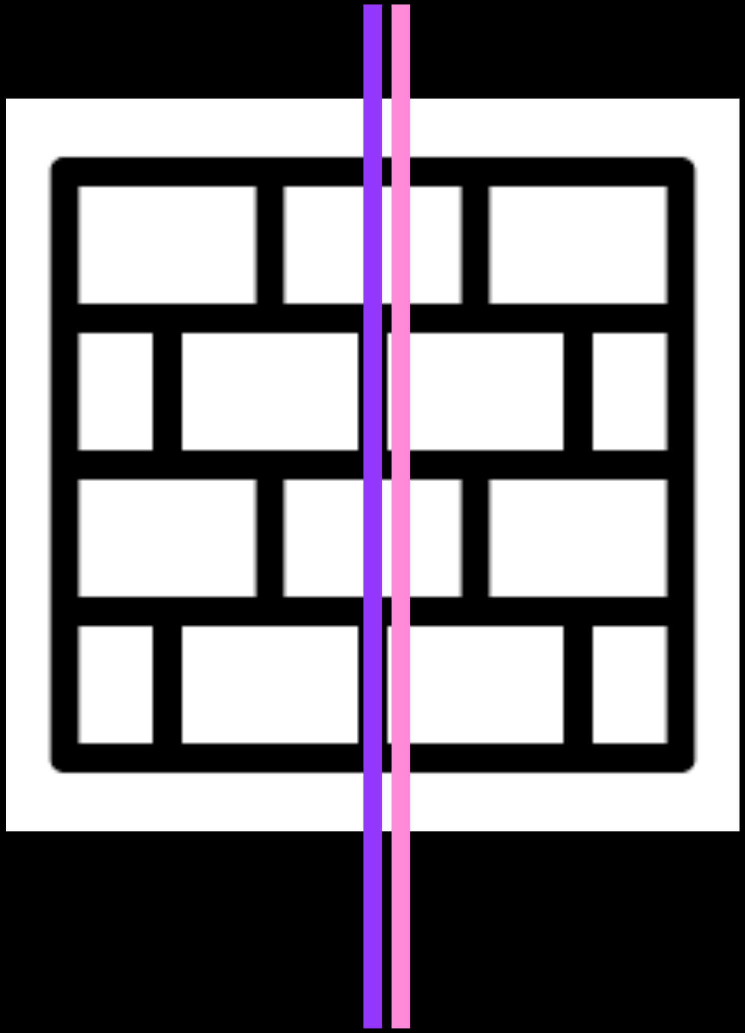
A printer reproduces graphics or text on paper

Separate functionality from implementation
(i.e. what can be done from how it's actually done)

Wall of Abstraction

Information barrier between device (program) use and how it works

Painstaking work to design technology and implement printers



Press button
Or
Send print job from application

Design and implementation

Usage

Abstractions are imprecise

A printer reproduces graphics or text on paper

Wall of abstraction between *implementer* and *client*

How does client know how to use it?

Abstractions are imprecise

A printer reproduces graphics or text on paper

Wall of abstraction between *implementer* and *client*

How does client know how to use it?

Provide an ***interface*** (what the user needs to interact)

In Software Engineering typically a set of ***attributes*** (data or properties) and a set of ***actions***

Lecture Activity

Designing the interface:
think about what the user needs to do / know about

Attributes (data):

Actions (operations):

Interface for Printer

Attributes (data):

- Ink level
- Paper level
- Error codes

Actions (operations):

- Print
- Rotate (landscape/portrait)
- Color / Black & White

How this is done is irrelevant to the client

Information Hiding

In this course it always means software

Interface —> ***client*** doesn't have to know about the inner workings

Actually client shouldn't know of or *have* access to implementation details

It is dangerous to allow clients to bypass interface

Safe Programming

Reasons for Information Hiding

Harmful for client to tamper with someone else’s implementation (*code*)

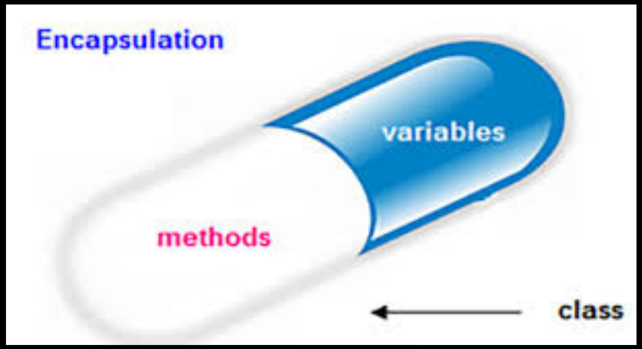
- Voluntarily/involuntarily break it - misuse it

- Reduces flexibility and modifiability by locking implementation in place

- Increases number of interactions between modules

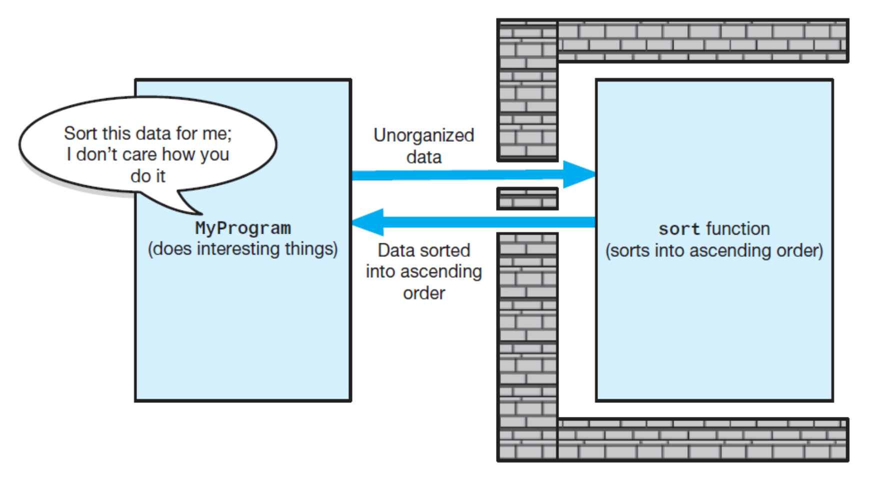
Object Oriented Design

Principles of Object Oriented Programming (OOP)



Encapsulation

Objects combine data and operations


Sort this data for me; I don't care how you do it
MyProgram
(does interesting things)
Unorganized data
Data sorted into ascending order
sort function
(sorts into ascending order)

Information Hiding

Objects hide inner details

Inheritance

Objects inherit properties from other objects

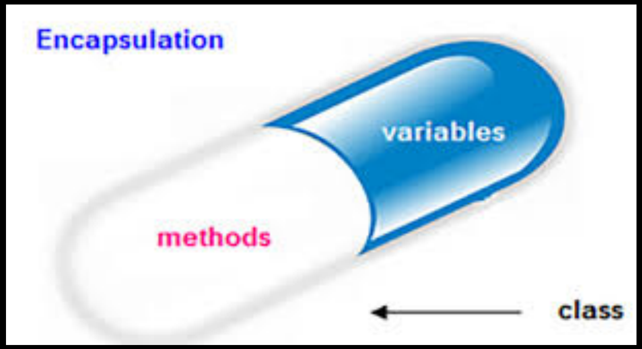
Polymorphism

Objects determine appropriate operations at execution

Principles of Object Oriented Programming (OOP)

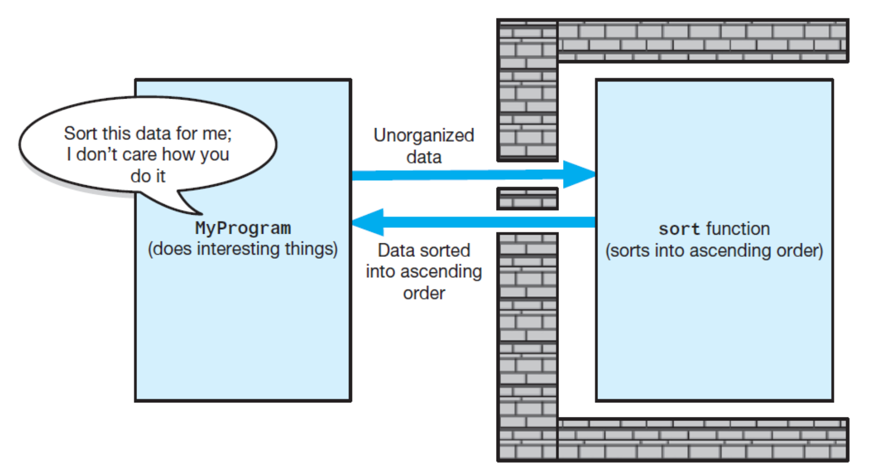
Encapsulation

Objects combine data and operations



Information Hiding

Objects hide inner details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Inheritance

Objects inherit properties from other objects

Polymorphism

Objects determine appropriate operations at execution

Coming soon

Object-Oriented Solution

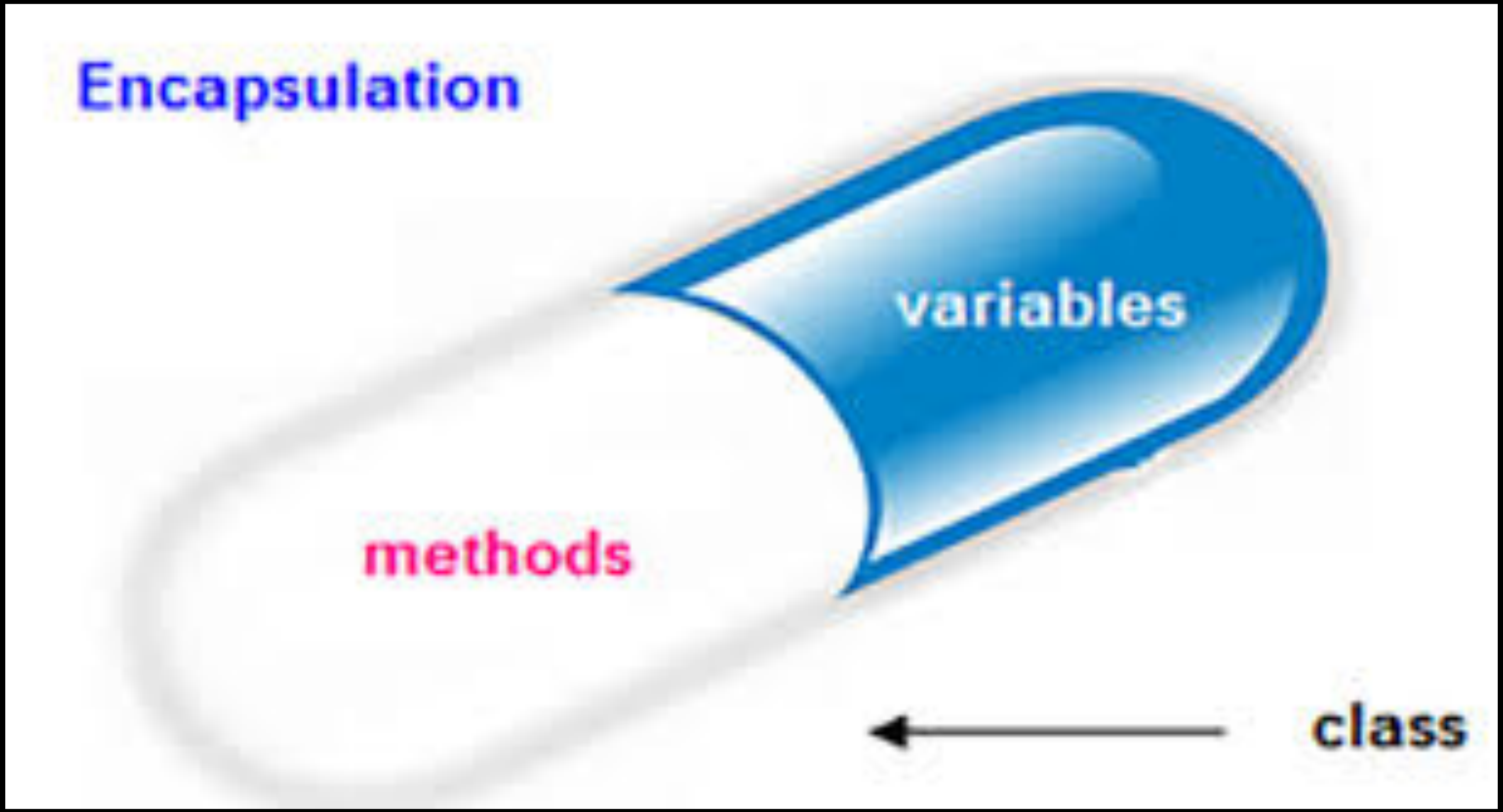
Use classes of objects

- Combine attributes and actions
  - data members + member functions

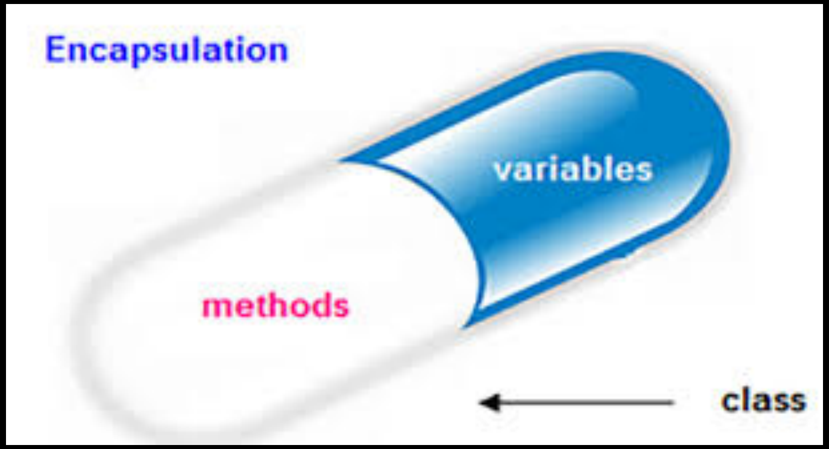
Create a good set of modules

- Self contained unit of code

Encapsulation


Encapsulation
variables
methods
class

Class



```
class SomeClass
{
    access_specifier    // can be private, public or protected

          data_members        // variables used in class

          member_functions    // methods to access data members

 }; // end SomeClass
```

Class

Language mechanism for

You have already been working with classes. Which ones?

Encoding abstraction

Enforce encapsulation

Separate interface from implementation

A ***user-defied* data type** that bundles together data and operations on the data

Information Hiding

Class

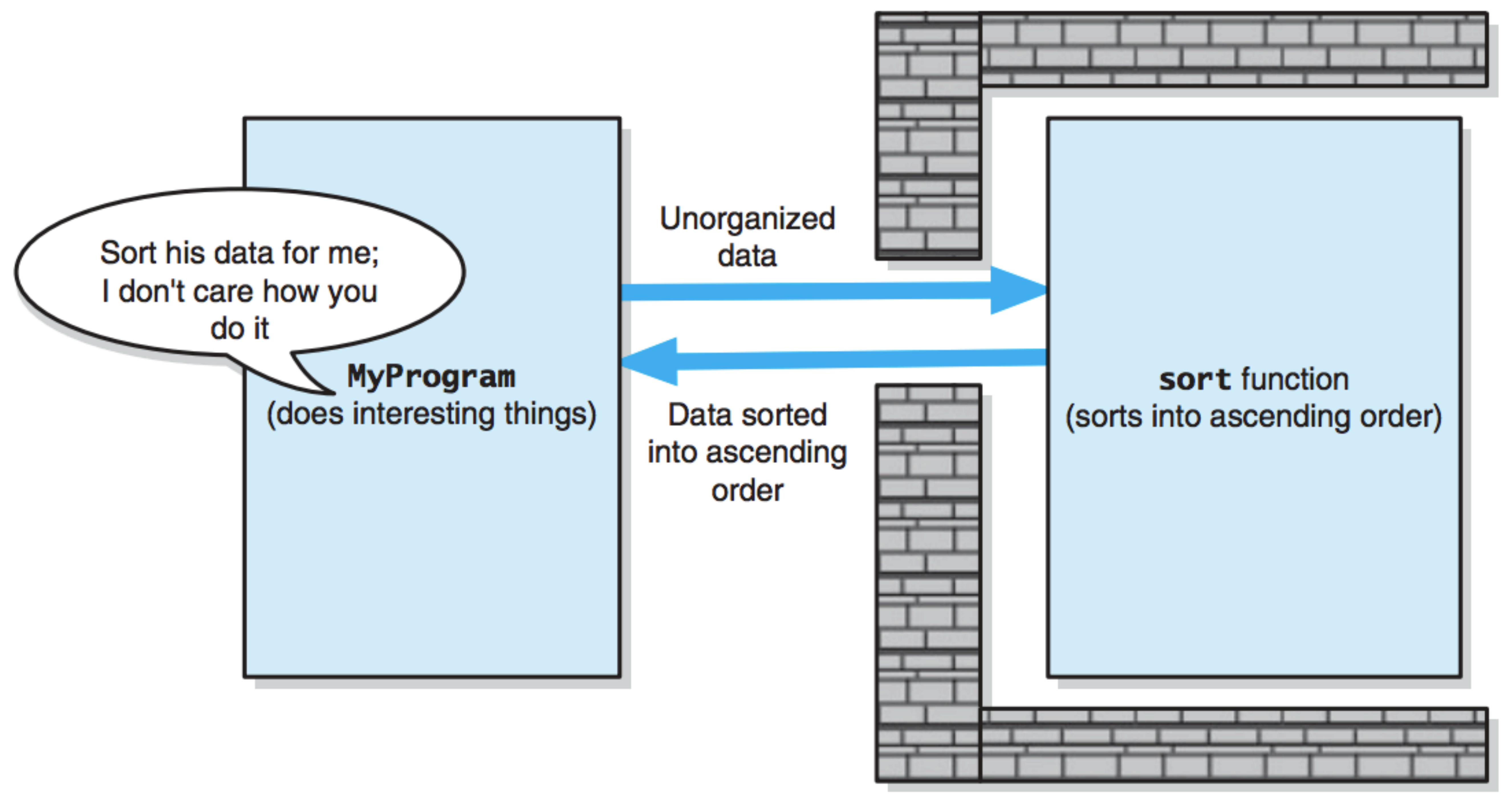
```
class SomeClass
{
    public:
        // public data members and member functions go here

    private:
        // private data members and member functions go here


 }; // end SomeClass
```

Access specifier

Access specifier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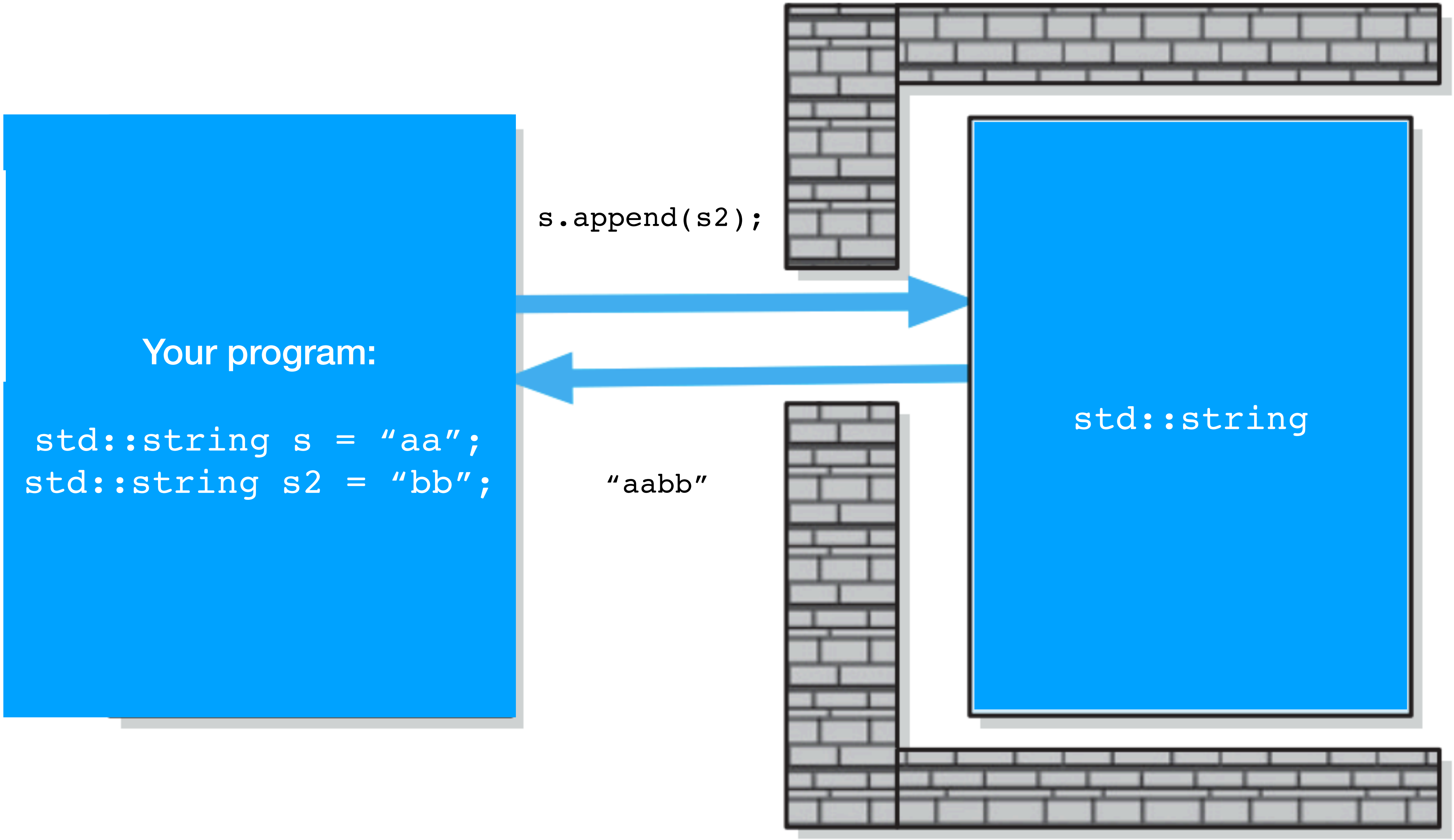

Your program:

```
std::string s = “aa”;
std::string s2 = “bb”;
```

```
s.append(s2);
```

“aabb”

std::string

Interface

SomeClass.hpp
(same as SomeClass.h)

```
#ifndef SOME_CLASS_HPP_
#define SOME_CLASS_HPP_

#include <somelibrary>
#include “AnotherClass.hpp”


class SomeClass
{

public:
    SomeClass(); //Constructor
    int methodOne();
    bool methodTwo();
    bool methodThree(int
                    someParameter);


private:
    int data_member_one_;
    bool data_member_two_;


};    //end SomeClass

#endif
```

Implementation

SomeClass.cpp

```
#include “SomeClass.hpp”

SomeClass::SomeClass()
{
    //implementation here
}


int SomeClass::methodOne()
{
    //implementation here
}


bool SomeClass::methodTwo()
{
    //implementation here
}


bool SomeClass::methodThree(int

someParameter)
{
    //implementation here
}
```

Interface

SomeClass.hpp
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```
#ifndef SOME_CLASS_HPP_
#define SOME_CLASS_HPP_

#include <somelibrary>
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class SomeClass
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public:
    SomeClass(); //Constructor
    int methodOne();
    bool methodTwo();
    bool methodThree(int
                    someParameter);


private:
    int data_member_one_;
    bool data_member_two_;


};    //end SomeClass

#endif
```
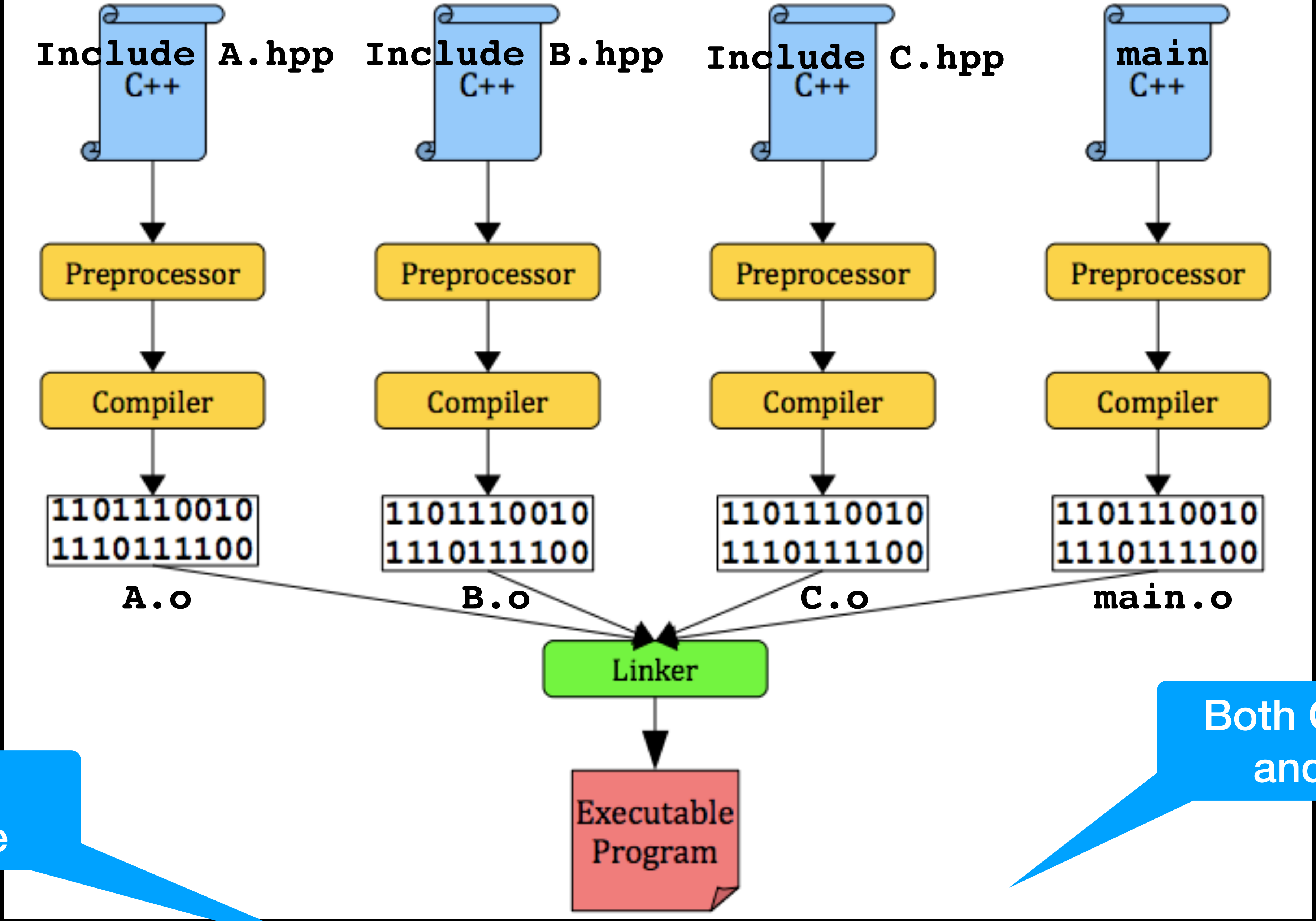

Include Guards:
Tells linker "include only if it has not been included already by some other module"

Implementation

SomeClass.cpp

```
#include "SomeClass.hpp"

SomeClass::SomeClass()
{
    //implementation here
}


int SomeClass::methodOne()
{
    //implementation here
}


bool SomeClass::methodTwo()
{
    //implementation here
}


bool SomeClass::methodThree(int

someParameter)
{
    //implementation here
}
```

Separate Compilation



Name of executable

Both Compile and Link

```
g++ -o my_program A.cpp B.cpp C.cpp main.cpp
```

Compile and Link separately with g++

```
g++ -c A.cpp B.cpp C.cpp main.cpp
```

will generate

```
A.o B.o C.o main.o
```

Then

```
g++ -o my_program A.o B.o C.o main.o
```

Will link the object files into a single executable named `my_program`

Class Recap

Access specifiers: determines what data or methods are public, private or protected (more on protected later)

Data members: the attributes/data

Member functions: the operations/actions available on the data

- **Mutator functions:** modify data members

- **Accessor functions:** retrieve the value of data members

  Use `const` to enforce/indicate it **will not modify the object**

  e.g. `string getName() const;`

- Constructor(s)

- Destructor

Take care of what happens when object goes in/out of scope

Class / Object

A class is a ***user-defined*** **data type** that bundles together data and operations on the data

Class: type (like `int`)

Object: instantiation of the class (like `x` - as in `int x`)

Just like variables, objects have a ***scope***

- they are born (instantiated/constructed)

- they are killed (deallocated/destroyed)

Object instantiation and usage

```
#include “SomeClass.h”


int main()
{


    SomeClass new_object; /instantiation of SomeClass calls constructor


    int my_int_variable = new_object.methodOne();
    bool my_bool_variable = new_object.methodTwo();


    return 0;



}  //end main
```

Constructor is called here

↖ **object (dot) method**

calls the member function for this object

Constructors

DECLARATION / INTERFACE:

```
class SomeClass
{
    public:
        SomeClass();                    //default constructor
        SomeClass( parameter_list );   //parameterized constructor
        // public data members and member functions go here

    private:
        // private members go here

 };// end SomeClass
```

Default Constructor automatically supplied by compiler if no constructors are provided. Primitive types are initialized to 0

If only Parameterized Constructor is provided, compiler WILL NOT supply a Default Constructor and class MUST be initialized with parameters

Executed when object is declared.
Initializes member variables and does whatever else may be required at instantiation

Constructors

DECLARATION / INTERFACE:

```
class SomeClass
{
    public:
        SomeClass();                        //default constructor
        SomeClass( parameter_list );       //parameterized constructor
        // public data members and member functions go here


    private:
        // private members go here


  };// end SomeClass
```

IMPLEMENTATION:

```
SomeClass::SomeClass()
{
}// end default constructor
```

OR:

```
SomeClass::SomeClass():
member_var1_(initial value),
member_var2_(initial value)
{
}// end default constructor
```

```
SomeClass::SomeClass(type parameter_1, type parameter_2):
member_var1(parameter_1), member_var2(parameter_2)
{
}//end parameterized constructor
```

Member Initializer List

Constructors

DECLARATION / INTERFACE:

```
class SomeClass
{
   public:
      SomeClass() = default;                   //default constructor
      SomeClass( parameter_list            parameterized constructor
      // public data members and member functions go here

   private:
      // private members go here

 };// end SomeClass
```

C++ 11

Tells compiler to provide default constructor!

IMPLEMENTATION:

```
SomeClass::SomeClass(type parameter_1, type parameter_2):
member_var1(parameter_1), member_var2(parameter_2)
{
}//end parameterized constructor
```

Destructor

Default Destructors automatically supplied by compiler if not provided.

Must provide Destructor to free-up memory when SomeClass performs dynamic memory allocation

```
class SomeClass
{
   public:
      SomeClass();
      SomeClass( parameter_list );//parameterized constructor
      // public data members and member functions go here
      ~SomeClass(); // destructor

   private:
      // private data members a                         here

 };// end SomeClass
```

Executed when object goes out of scope or explicitly deleted to release memory

Lecture Activity

Write the interface for a printer class:

```
class Printer
{
   access_specifier    // can be private, public or protected

          data_members        // variables used in class

          member_functions    // methods to access data members

 }; // end Printer
```

Interface as Operation Contract

Documents use and limitations of a class and its methods

Function Prototype and Comments **MUST** specify:

- Data flow

    Input => parameters

    Output => return

- Pre and Post Conditions

Operation Contract

In Header file:

```
/** sorts an array into ascending order
// @pre 1 <= number_of_elements <= MAX_ARRAY_SIZE
// @post an_array[0] <= an_array[1] <= ...
//       <= an_array[number_of_elements-1];
//       number_of_elements is unchanged
// @param an_array of values to be sorted
// @param number_of_elements contained in an_array
// @return true if an_array is sorted, false otherwise
*/
bool sort(int an_array[], int number_of_elements);
```

Function prototype

Back to some principles of Software Engineering

Unusual Conditions

Values out of bound, null pointer, inexistent file…

How to address them (strive for fail-safe programming):

- State it as precondition
- Return value that signals a problem
  - Typically a boolean to indicate success or failure
- Throw an exception (later in semester)

Solution guidelines

Many possible designs/solutions

Often no clear best solution

“Better” solution principles:

- *High cohesion*
- *Loose Coupling*

Cohesion

Performs one well-defined task

Well named => self documenting

e.g. `sort()`

SORT ONLY!!!
E.g. If you want to output, do that in another function

Easy to reuse

Easy to maintain

Robust (less likely to be affected by change)

Coupling

Measure of ***dependence (interactions)*** among modules

i.e. share data structures or call each other’s methods

Minimize but cannot eliminate

Objects must collaborate!!!

Minimize complexity

Reduce Coupling

Methods should only call other methods:

- defined within same class
- of argument objects
- of objects created within the method
- of objects that are data members of the class

Control Interaction

Pass-by-value

```
bool my_method(int some_int);
```

Pass-by-reference if need to modify object

```
bool my_method(ObjectType& some_object);
```

Pass-by-constant-reference if function doesn’t modify object

```
bool my_method(const ObjectType& some_object);
```

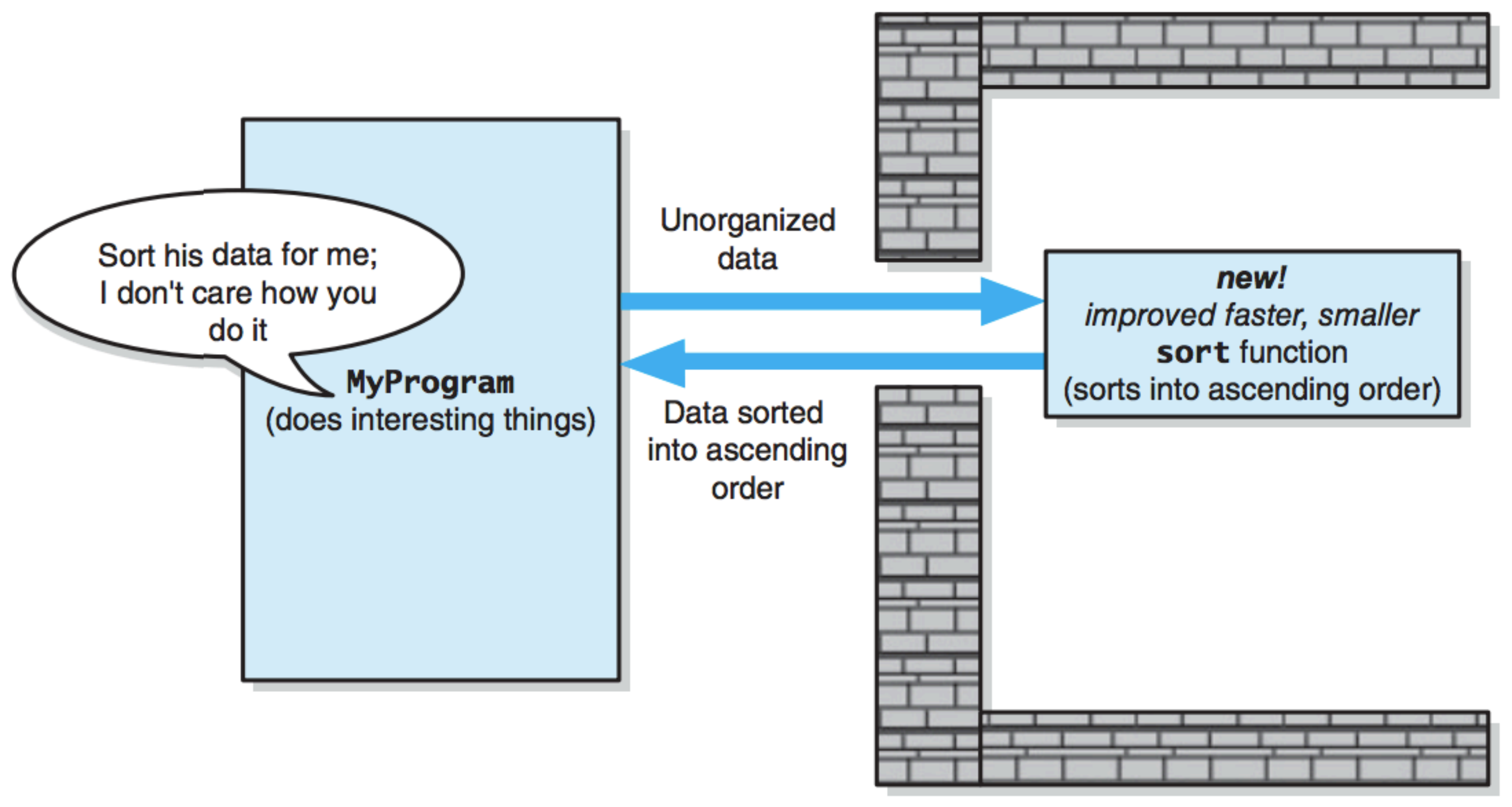
Modifiability

No global variables EVER!!!

Named Constants

```
const int NUMBER_OF_MAJORS = 160;

int scores [NUMBER_OF_MAJORS];
for(index = 0 through NUMBER_OF_MAJORS - 1)
      Process
```

Modifiability



Readability

BAD!!!

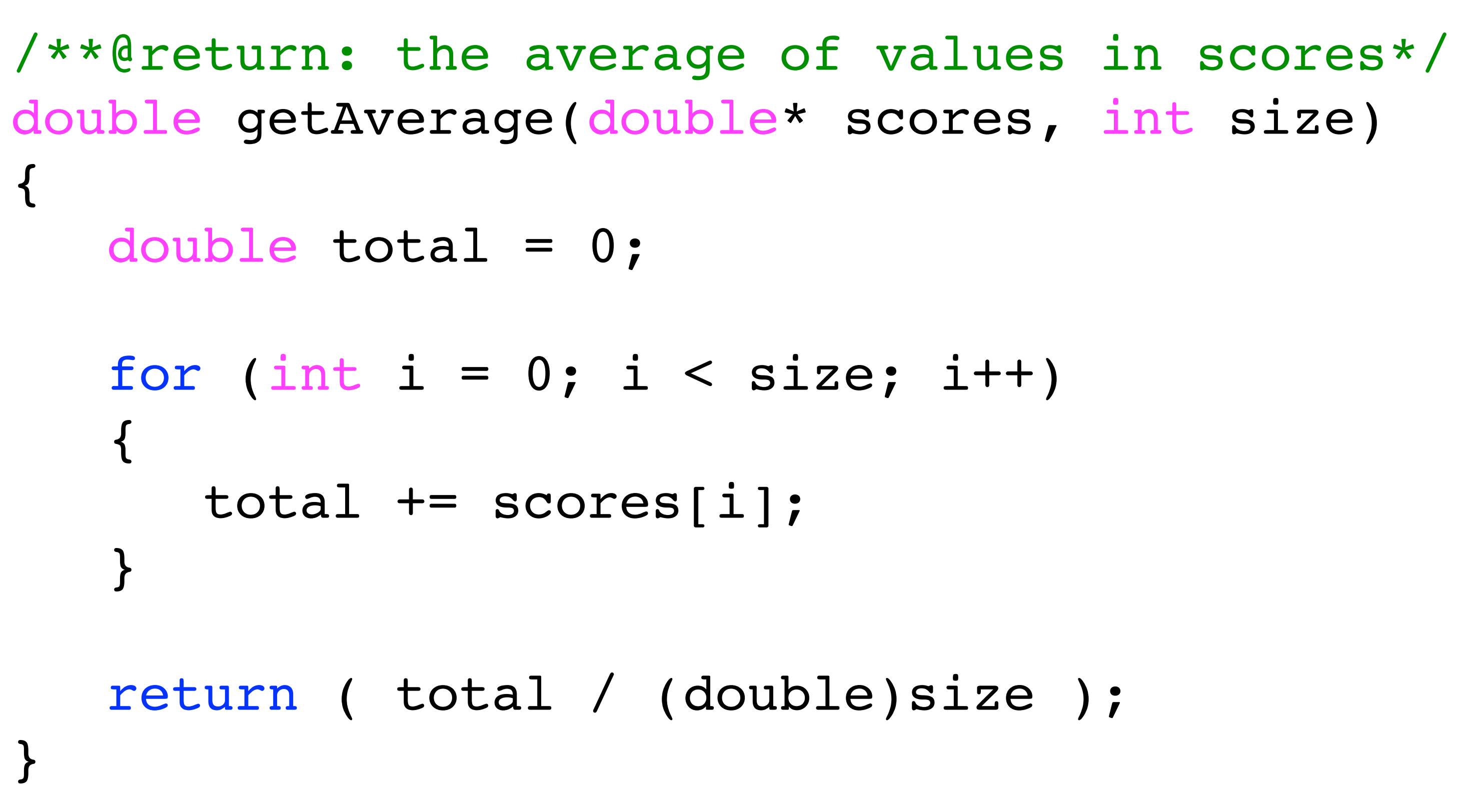
Write self-commenting code

Important to strike balance btw readable code and comments

- don't write the obvious in comments

```
x  += m * v1; //multiply m by v1 and add result to x
```

Use descriptive names for variables and methods



```
/**@return: the average of values in scores*/
double getAverage(double* scores, int size)
{
   double total = 0;

   for (int i = 0; i < size; i++)
   {
      total += scores[i];
   }

   return ( total / (double)size );
}
```

Naming Conventions

https://google.github.io/styleguide/cppguide.html

http://isocpp.github.io/CppCoreGuidelines/CppCoreGuidelines#Rl-comments

```
string my_variable;
```

or

```
string myVariable;
```

Classes ALWAYS

start with capital

```
   MyClass
```

In this course I will strive for:

```
class MyClass
MyClass class_instance;
string my_variable;
string my_member_variable_;
void myMethod();
int MY_CONSTANT;
```

Be consistent!!!