

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

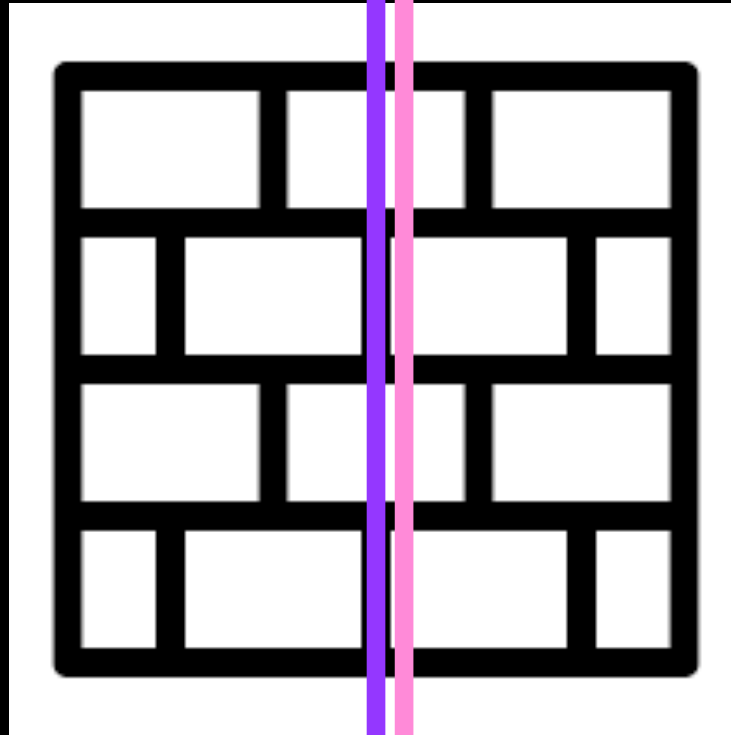
Separate functionality from implementation
(i.e. what can be done from how it's actually done)

Wall of Abstraction

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

Painstaking work to
design technology
and implement
printers

**Design and
implementation**



Press button
Or
Send print job from
application

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

Attributes (data):

A yellow speech bubble with a black border and a tail pointing towards the left. It contains the text "Designing the interface: think about what the user needs to do / know about".

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

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*)

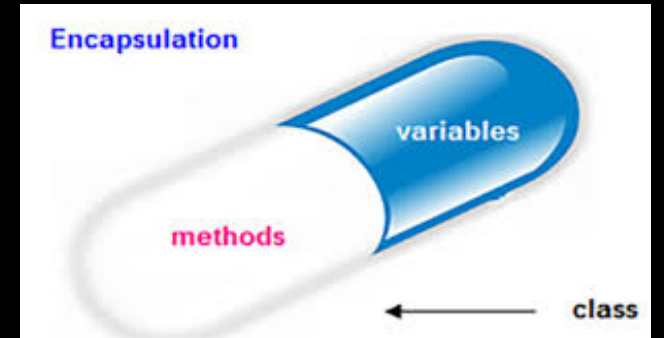
- Voluntarily/involuntarily **break it - misuse it**
- **Reduces flexibility and modifiability** by locking implementation in place
- Increases number of **interactions** between modules

Object Oriented Design

Principles of Object Oriented Programming (OOP)

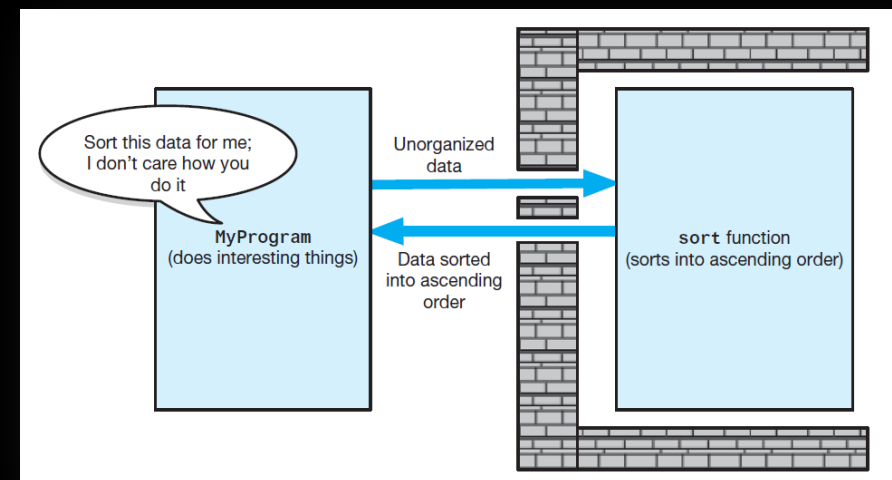
Encapsulation

Objects combine data and operations



Information Hiding

Objects hide inner details



Inheritance

Objects inherit properties from other objects

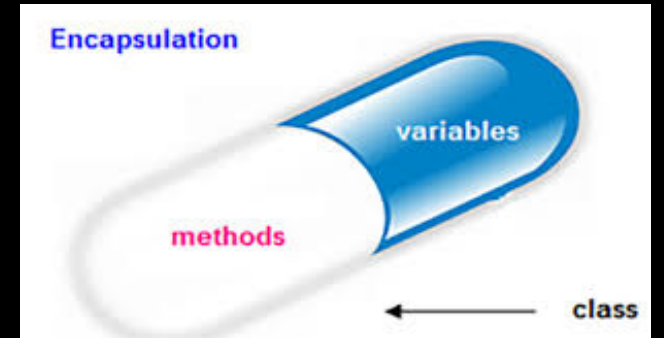
Polymorphism

Objects determine appropriate operations at execution

Principles of Object Oriented Programming (OOP)

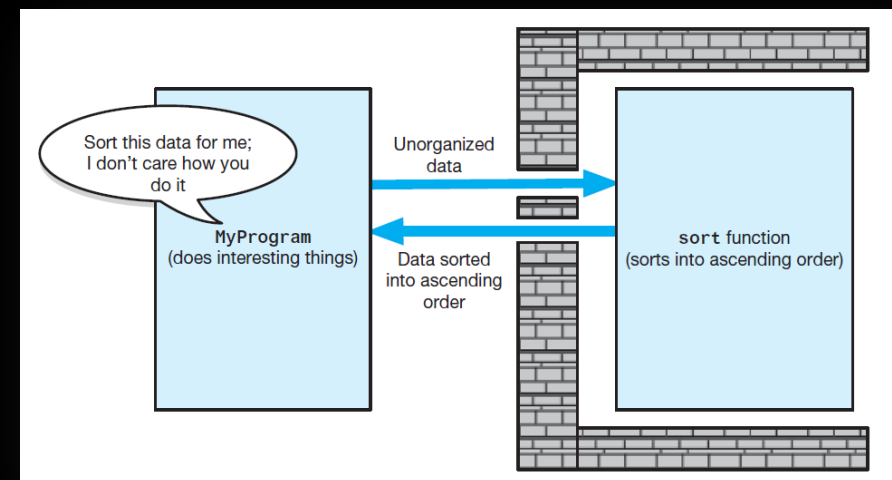
Encapsulation

Objects combine data and operations



Information Hiding

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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**

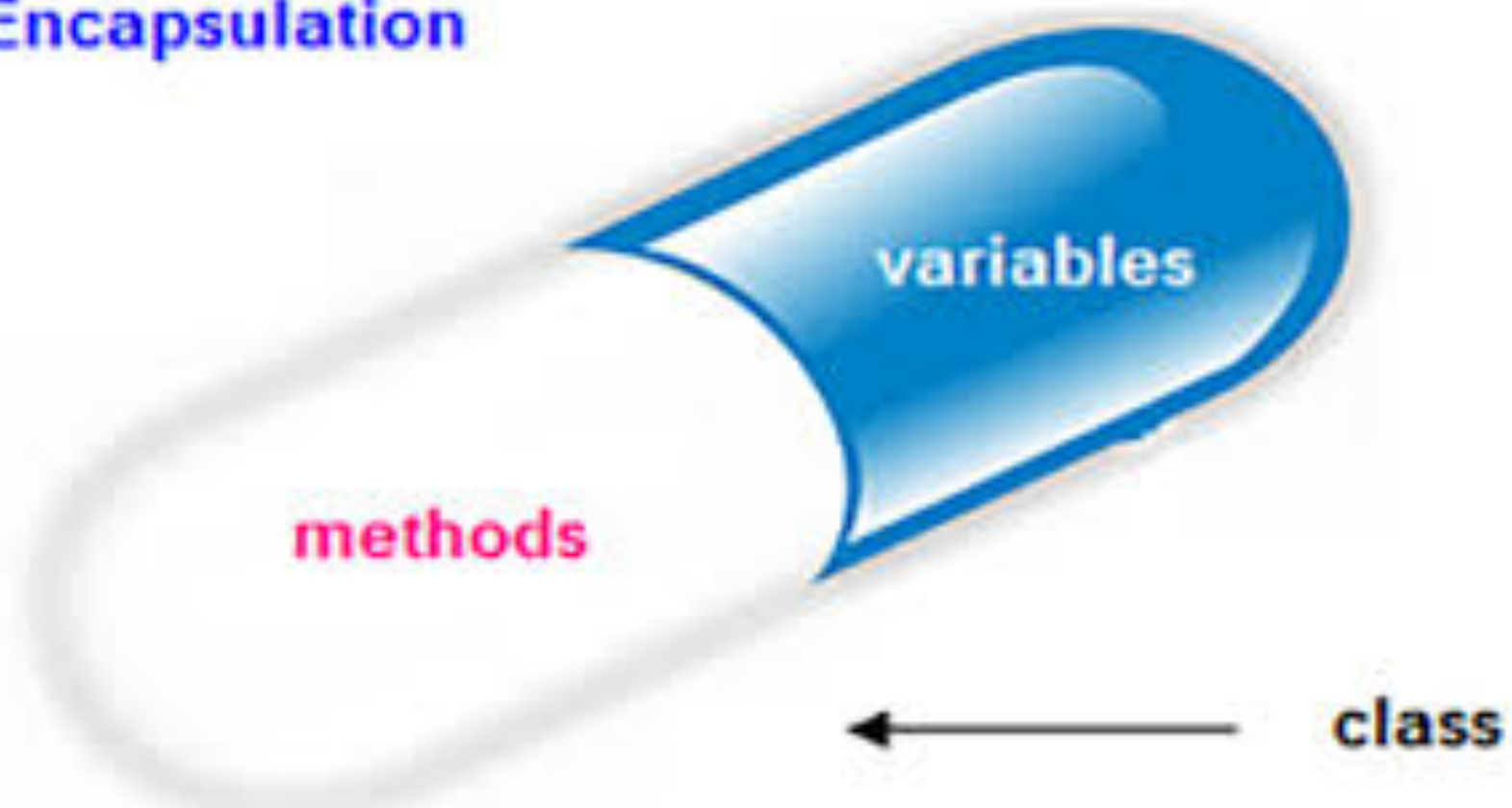
data members + **member functions**

Create a good set of **modules**

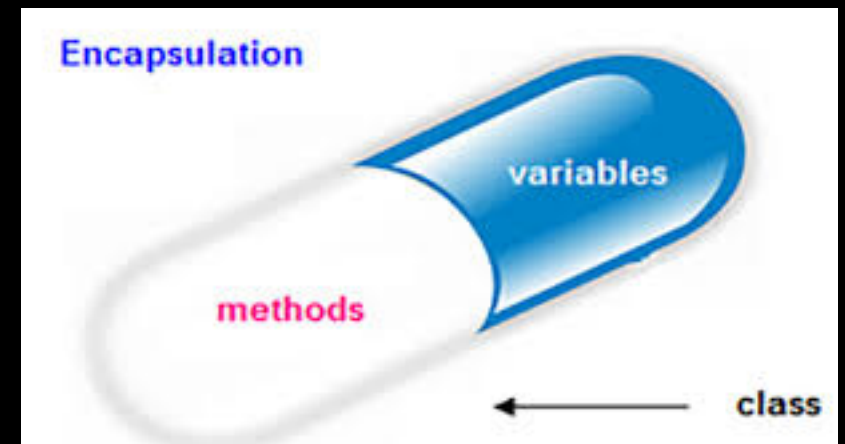
Self contained unit of code

Encapsulation

Encapsulation



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

Encoding **abstraction**

Enforce **encapsulation**

Separate **interface** from **implementation**

You have already been
working with classes.
Which ones?

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

Information Hiding

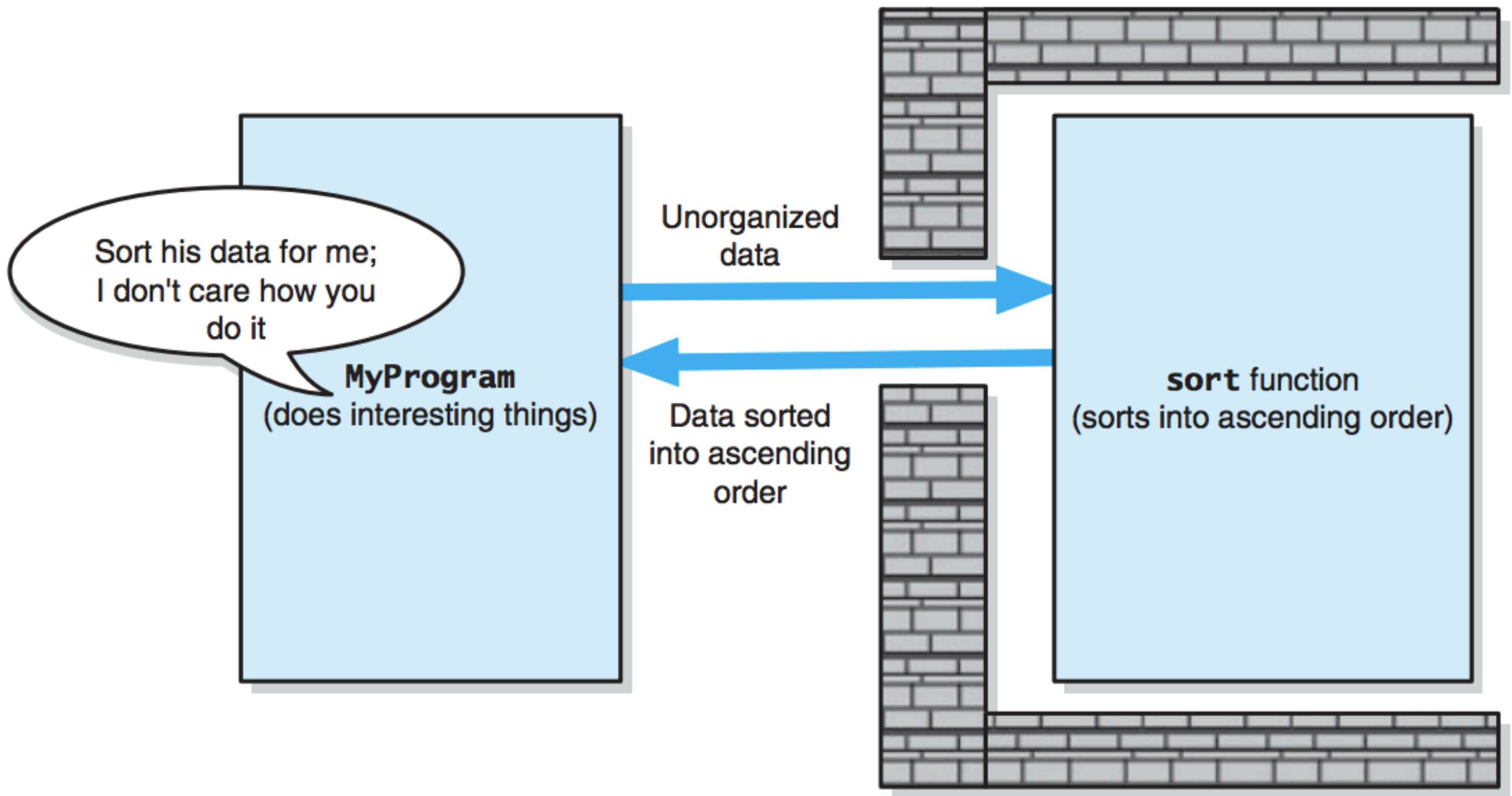
Class

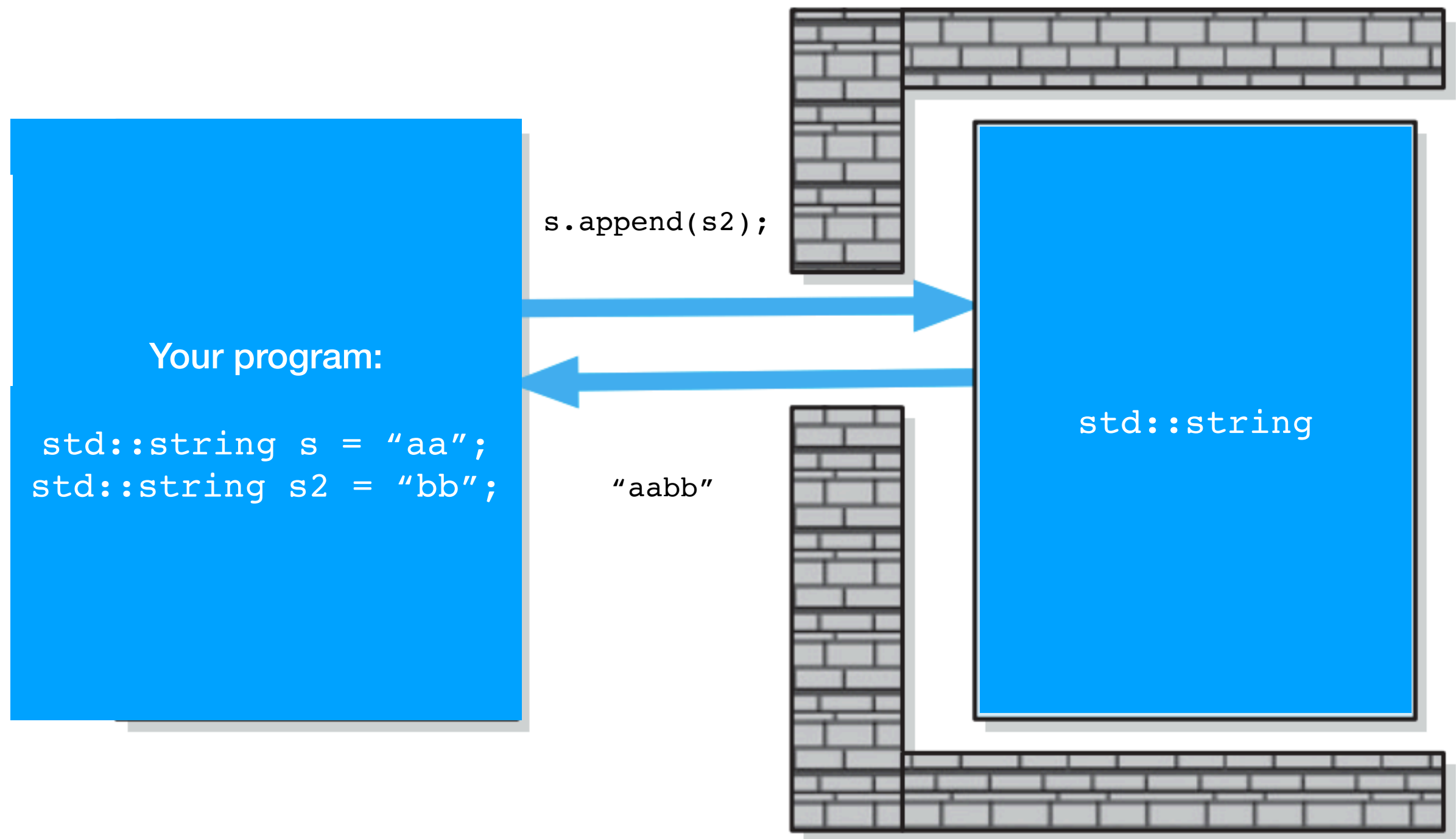
Information
Hiding

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

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

}; // end SomeClass
```





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
(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
```

Include Guards:

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

Implementation

SomeClass.cpp

```
#include "SomeClass.hpp"

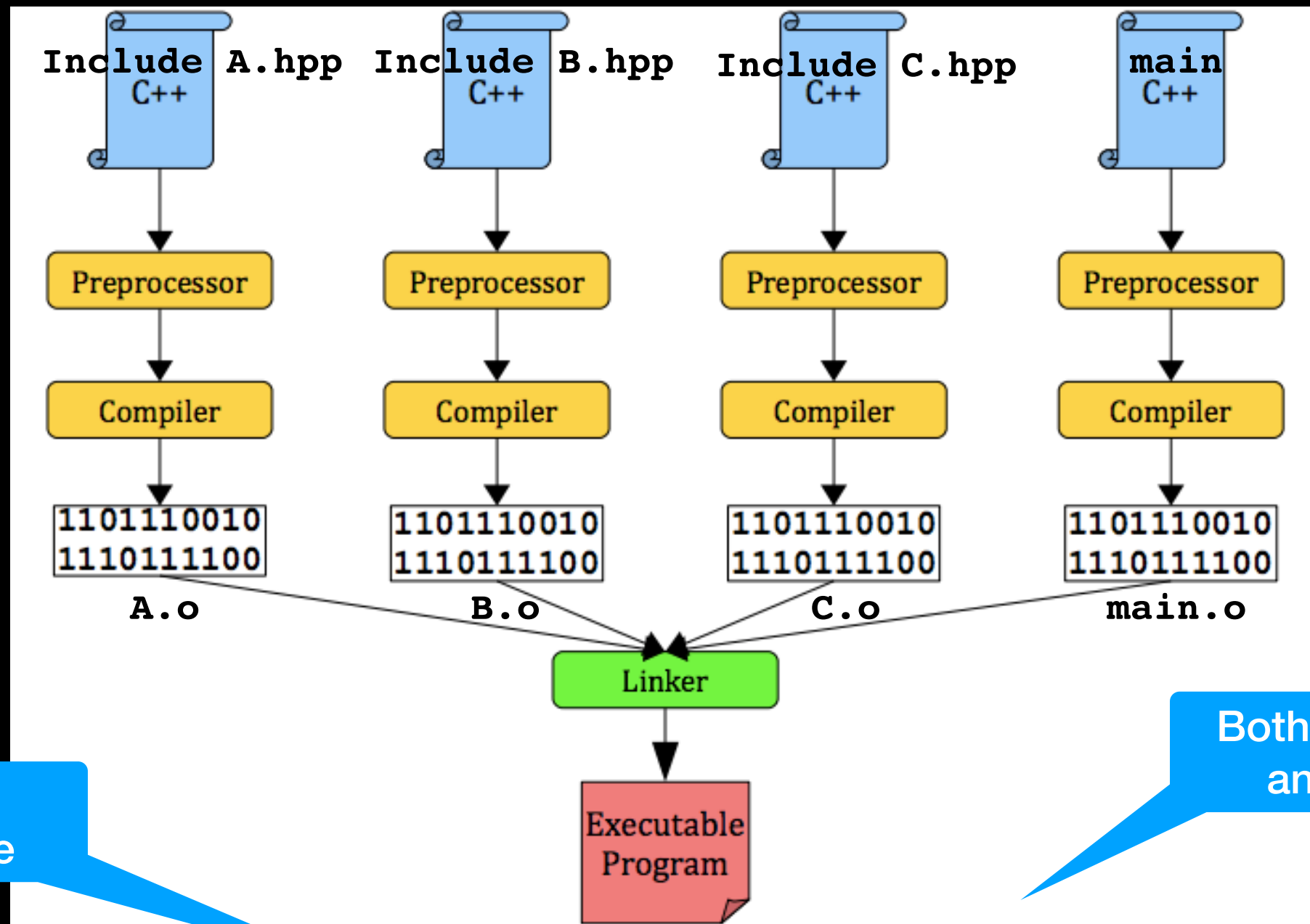
SomeClass::SomeClass()
{
    //implementation here
}

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

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

bool SomeClass::methodThree(int
someParameter)
{
    //implementation here
}
```

Separate Compilation



```
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

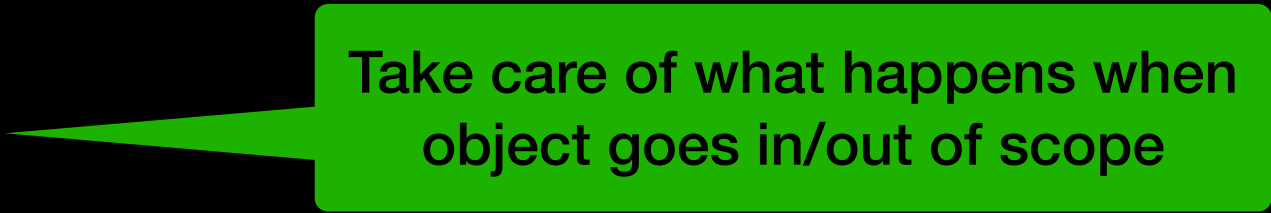
Access specifiers: determines what data or methods are **public**, **private** or **protected** (more on protected later)

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)**



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

- **Destructor**

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()  
{
```

Constructor is
called here

```
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
```

object (dot) method
calls the member function for this object

DECLARATION / INTERFACE:

```
class SomeClass
{
```

```
public:
```

```
    SomeClass();
```

```
    SomeClass( parameter_list );
```

```
    // public data members and member functions go here
```

```
private:
```

```
    // private members go here
```

```
}; // end SomeClass
```

Constructors



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

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
```

Constructors



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



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 and member functions go 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!!!



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);
```



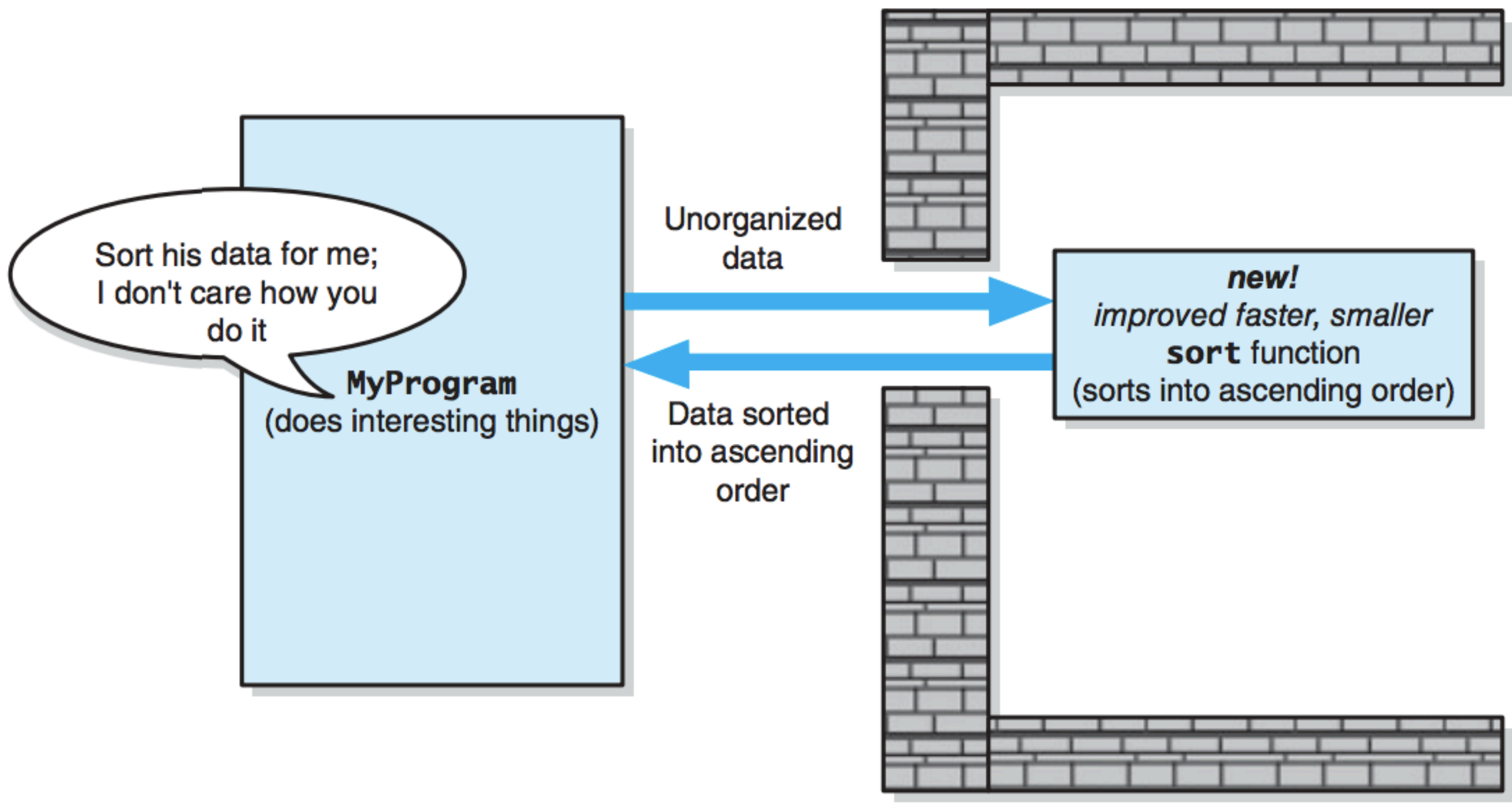
Modifiability

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#R1-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!!!