4 - Class Definitions

September 21, 2022

COMP2404

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Class Definitions

1. Class Members
2. Access Specifiers
3. Code Organization
4. Variable Scope
5. Namespaces

Classes in C++

Class Definitions

- `class` keyword followed by class name followed by braces `{}`, followed by semi-colon `;`

In the `class` block are the `class` members

- data members (instance variables)
- member functions (methods)

Each of these should be preceded by an access specifier

- `public`, `private`, `protected`
- default access level for classes is `private`

Access Specifiers

Industrial grade software is typically huge

- Millions of lines of code
- Hundreds of libraries and packages
- Must protect your code from unauthorized changes

Restrict access to unnecessary details, information, access whenever possible

- **Principle of Least Privilege**
- everything should be as close to private as possible
- example – you only want qualified people to access the inner workings of your car

Of course, some (`public`) access is necessary

Access Modifiers

Public access

- class member is visible to all objects and global functions

Protected access

- class member is visible by subclasses only
- different from Java
- make use of this only when using inheritance

Private access

- not visible to other classes or global functions
- visible to other members of the **same class**
  - different from Java

Objects in Memory


```
Student casey("100999999","Casey");
Student joe;
```

Observe there is no "new" here. How did we make new objects?

- C++ gives you the option of putting your objects on the **Stack** or the **Heap**
- It is faster to allocate objects to the **stack**
  - But when the **stackframe** is popped off, the object is gone
  - Convenient for temporary objects
- **Heap** is slower to allocate objects to
  - but the objects last as long as we like
- More on this later

Member Function Implementations

A function implementation is the code for a function

For very small programs, we may include implementation in the class definition

- Getters for example
- This gets messy quickly – discouraged for larger programs

For all other programs, the implementation should be separate

- There are a couple of reasons:
  - Principle of Least Privilege
  - Can help avoid circular `#includes` between your files

Member Function Implementations

Each class should have 2 files:

- A header file (using the `.h` extension) contains the class definition
  - Data member declarations
  - Member function prototypes (not the code!)

- A source file (using the `.cc` extension)
  - This contains the member function implementation (the actual code)
  - Static data member initializations
  - Related global function

Standard Member Functions: Constructors

Job of a constructor to ***initialize all data members***

- There are a few ways to initialize data members
- We will start with the most conventional
  - assignment operators

Constructor with no arguments – **default constructor**

- can be very important for things like arrays
- we decide if there is a default constructor

C++ classes can have multiple constructors

- cannot call "super" as with Java to make use of multiple constructors
- C++ can leverage other constructors, but uses a different syntax

Other Standard Functions

There is no `toString()` function in C++

- initially we will use `print()` functions
- later we will see how to overload the stream insertion operator `<<`
  - C++ equivalent to `toString()`

Example <**p4**> from previous slides is bad – body of functions are within the class definition.

- against C++ conventions (though the compiler is fine with it)
- Keeping headers and source separate has actual advantages:
  - Compiler only needs the function prototype (header) to report usage errors
  - Header can be `#include`-d, and the source still compiled separately and linked.
  - Can help mitigate circular references.

programming example <p1>

Allocating Classes

Like primitive variables, we have choice in how to allocate classes.

- Statically allocated means memory is allocated where it is declared.
- Dynamically allocated means allocated on the Heap.

There is an extra complication using **classes** with **arrays**.

For now we will ***statically allocate*** arrays, but we still have 2 choices in the type of array:

- Array of objects, or
- array of object ***pointers***.
- Arrays of **objects** automatically call the **default constructor** of the **class**.

programming example <p2>

Compiler

The C++ compiler is (deliberately) primitive

- It does not organize the code for you (like Java)

Consider the command: `g++ -c Date.cc`

- The compiler starts reading `Date.cc`.
- When it sees `#include "Date.h"` it jumps to that file and continues reading.
- Think of all `#include`-d files as one large file, in order.
  - If the compiler reads it top to bottom, will it make sense?
  - What information does the compiler need to ensure no errors?
  - What are the potential pitfalls?

Class Interface

A **Class Interface** is *not* the same as a Java interface.

The **Interface** refers to the part of the class that can be accessed and used by other classes. It consists of

- class name and
- public members.

This defines how the user interacts with your class.

In C++, this is contained in the header file.

- Though there are also private and protected members in the header.

Class Interface

To use a class, you `#include` the header file.

- This contains the public interface.
- This is enough information for the compiler to ensure that you use the class correctly.
- It is exactly like forward referencing your functions.

To make an executable using this class, you then must link your code to the object code.

- I.e., the implementation.

Users of your class do not need to see the source code.

- The interface and documentation give enough information for other developers to use your class.

Code Organization

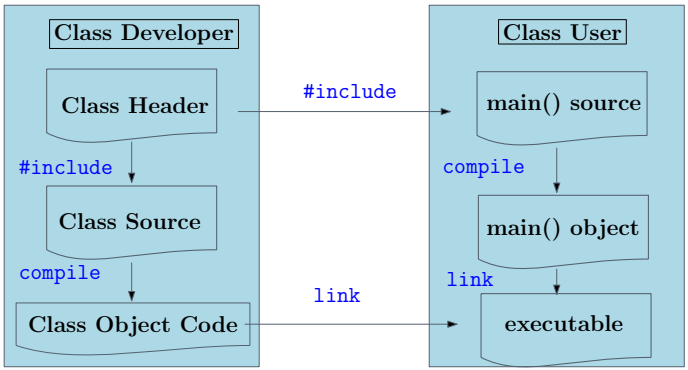
Who will be using your class?

- Mostly other developers
- Even when writing end user code, you may want API's or other developers to contribute.

Other developers need to know:

- Class name,
- public members,
- descriptions of functions where appropriate, and
- (sometimes) protected members.

Class Interface



- If we change our source code, we can recompile this separately from applications that use it.
- User only needs to re-link this source, not re-compile.

Class Header File

Make sure to include the ***header guards***.

- These guard against multiple `#include`-s.

`#include`-ing source code is inefficient.

- Unnecessarily forces recompilation of all code.
- This is frowned upon...mostly.
- **Source** file should `#include` the **header**, not vice-versa.

Understand what belongs in the header file (essentially your class API) vs the source file

- All source files should be compiled separately.
- Class users will only have to **relink** your code (for bug fixes, etc), which is fast.

Source Files

Source files contain:

- All class related source code
  - (i.e., member function implementations).

- By default, all functions are global!
- Use the **scope resolution operator** of the ***class*** to inform the compiler of what is a class member.
  - This lets the compiler resolve the visibility of variables and other functions from the class definition (`public, protected, private`).
  - Or to identify static data member initializations...
    - ...more on this later.

Variable Scope

Variable scope refers to where in the program a variable is visible.

- Block scope
  - including Class blocks.
- File scope
  - is outside of any block.
- Function scope for labels (we don't cover labels).
- Function prototype scope for parameters (we won't cover this either).
  - `int foo(int n, int x[n])`

Block Scope

A variable declared within a block has **block scope**.

- Visible within that block and all inner blocks (unless shadowed).
- Once we exit the block, the variable disappears and its value is discarded.
- Variables in inner blocks can hide variables in outer blocks.
  - Shadowing.
- If variables in nested blocks have the same name, the innermost block variable is the one used.
  - Try to avoid this - use unique identifiers when possible.
- Can always use the unary resolution operator to access a global value.
  - Other shadowed variables remain invisible, unless blocks are ***namespaces***.
  - Coming soon.

File Scope

A variable in File scope:

- Is declared outside of all blocks
- Visible everywhere in that file.
  - Global variables, or
  - global functions.

Such a variable can be accessed from another file using the `extern` keyword.

- Without `extern` the compiler will think it is a new variable declaration.

Coding example <p3>

Namespaces

What is a **Namespace**?

- Not a class! Not a package! Has properties of both.
- Closest equivalent is Java ***package***, but more flexible.
- It is the definition of a (named) scope.

To use an element from a **namespace** you must scope it in by either

- using the `using` keyword
- use the ***scope resolution operator*** `::`

A **namespace** may be unnamed, then it is automatically scoped in.

- Has only ***internal*** linkage.
- Visible only to the current ***translation unit***
  - Current source and #include-d headers.
  - I.e., everything that makes this object file.