CSC 211: Computer Programming

Classes, Header Files, Constructors

Michael Conti

Department of Computer Science and Statistics
University of Rhode Island

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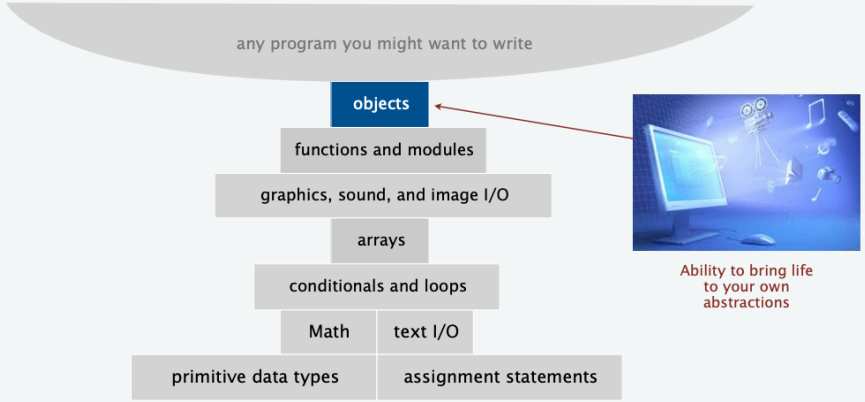
Original design and development by Dr. Marco Alvarez

Basic building blocks

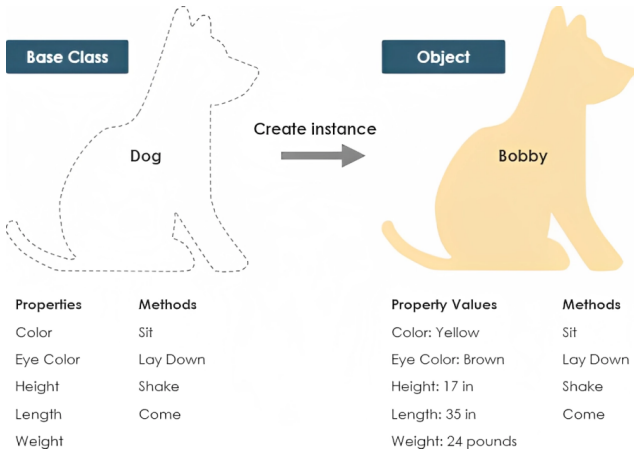


https://introcs.cs.princeton.edu/java/lectures/keynote/CS.9.CreatingDTs.pdf

Classes

- In object-oriented programming (OOP), a **class** is an extensible "datatype" for creating **objects** ("variables")
- Examples of classes you have already used
  - `std::string, std::istream, std::ostream`
- A class can define **member variables** and behavior (called **member functions** or **methods**)
- When an object is created, the resulting object is also called an **instance of the class**

Classes



C++ Classes

- A class in C++ is a user-defined type declared with the keyword **`class`**
- A class can define data members and member functions
  - three levels of access: **private** (default), **protected**, or **public**
- **Private members** are not accessible outside the class
  - only through methods of the class
- **Public members** form an interface to the class and are accessible outside the class

Class declaration

- Similar to structs, however level of access must be specified

```
class MyClass {

  public:

      int myNum;
      string myString;

};
```


Declaration and dot operator

```
#include <iostream>
#include <string>

class MyClass {

    // access specifier
    public:

        // data members
        int myNum;
        std::string myString;
};

int main() {
    // creating an object
    MyClass object;

    // using the dot operator
    object.myNum = 10;
    object.myString  = "My Message";
    std::cout << object.myNum << std::endl;
    std::cout << object.myString << std::endl;

    return 0;
}
```


Methods (member functions)

- Methods must be declared inside the class
  - definition of methods must identify the class they belong to
  - `::` is the **scope resolution operator**

```
class Date {
  public:
    int month;
    int year;
    int day;

    void print();
};
```

declaration

```
void Date::print() {
  std::cout << month << '-'
     << day << '-'
     << year << std::endl;
}
```

definition

Example

```
#include <iostream>

class Date {
    public:
        int month;
        int year;
        int day;

        void print();
};

void Date::print() {
    std::cout << month << '-'
       << day << '-'
       << year << std::endl;
}
```

Must include the object

```
int main() {
    Date today;

    today.day = 12;
    today.month = 07;
    today.year = 2023;

    today.print();

    return 0;
}
```


Improving the class declaration

- Making changes to the internal representation of `Date` requires changes to the entire program
- A better declaration of the class `Date` would allow for changes to the class without requiring changes to the program(s) that use `Date`

don't allow the program to directly reference or access member variables

Example

```
#include <iostream>

class Date {
    public:
        int mymonth;
        int year;
        int day;

        void print();
};

void Date::print() {
    std::cout << month << '-'
       << day << '-'
       << year << std::endl;
}
```

Internal change to date broke this line

```
int main() {
    Date today;

    today.day = 12;
    today.month = 07;
    today.year = 2023;

    today.print();

    return 0;
}
```



```
#include <iostream>

class Date {
    public:
        int month;
        int year;
        int day;

        void set(int m, int d, int y);
        void print();
};
```

```cpp
void Date::print() {
    std::cout << month << '-'
              << day << '-'
              << year << std::endl;
}


void Date::set(int m, int d, int y) {
    month = m;
    day = d;
    year = y;
}
```

When accessing data members or methods inside the class, the object name is not required


```cpp
int main() {
    Date today;

    today.set(07, 12, 2023);
    today.print();

    return 0;
}
```

Now changes to the date class will not require changes to main (programs that use date)

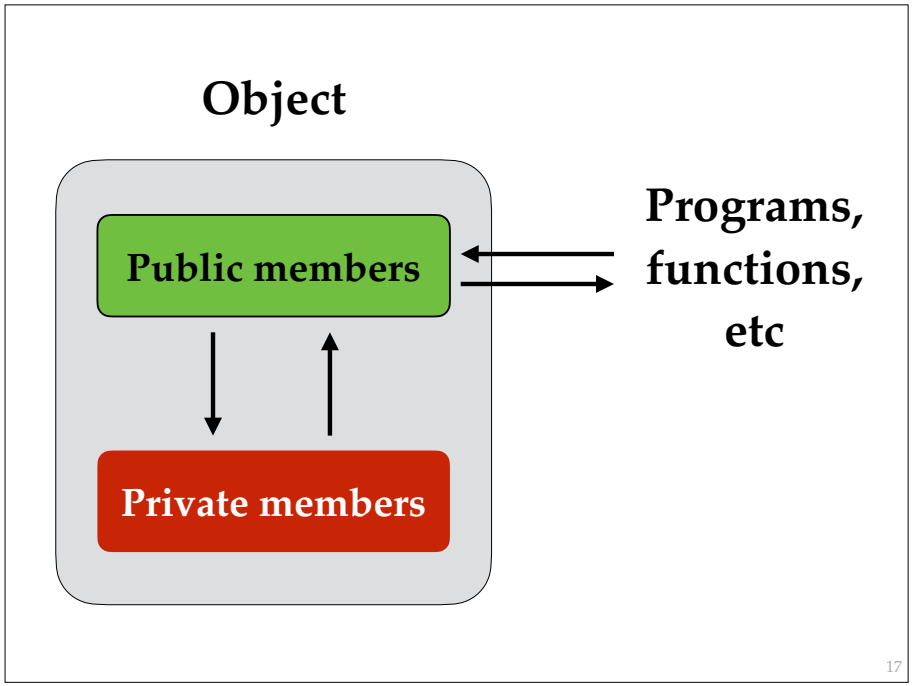
Encapsulation

- **Encapsulation** is one of the most fundamental concepts of OOP
- In OOP, encapsulation is used to hide the values or state of a structured data object inside a class. It is implemented as a:
  - language construct that **facilitates the bundling of data with the methods** (or other functions) operating on that data
  - language mechanism for **restricting direct access** to some of the object's components

https://en.wikipedia.org/wiki/Encapsulation_(computer_programming)

Public vs Private

- C++ helps us restrict the program from directly referencing member variables
- Private members of a class can **only be referenced** within member functions
  - otherwise, the compiler gives an error message
- The keyword **`private`** identifies the members of a class that can be accessed only by member functions
- The keyword **`public`** identifies the members of a class that can be accessed from outside the class




```
class Date {
    private:
        int month;
        int year;
        int day;

    public:
        void set(int m, int d, int y);
        void print();
};
```


Assignment operator

- Objects and structures can be assigned values using the = operator

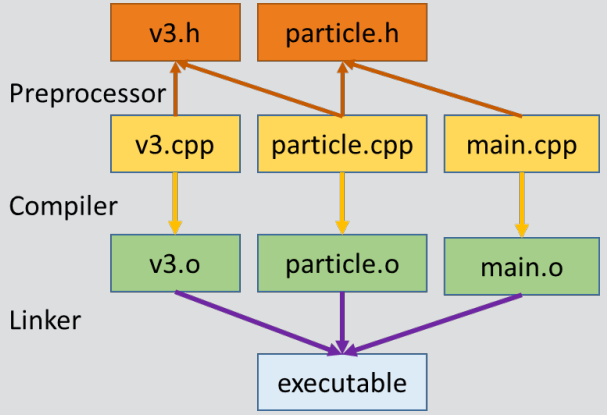
```
int main() {
    Date today;
    Date due;

    today.set(07, 12, 2023);
    due = today;
    today.print();
    due.print();

    return 0;
}
```


Header Files

Separate compilation

- Source code can be divided into multiple files
  - source files can be compiled separately
  - enterprise code files can take hours to compile
    - Source code separation eliminates the need to compile everything, all the time
- Classes can be implemented in their own files
  - allows reusing codes in multiple programs
  - source files including class methods and function definitions
  - header files including declarations and global constants

Compiling multiple files




```
g++ v3.cpp particle.cpp main.cpp –o executable
```

https://devblogs.nvidia.com/separate-compilation-linking-cuda-device-code/

#include

- Used for including header files
  - usually contains class declarations, function prototypes, or global constants
- When used with < >
  - The preprocessor searches in an implementation dependent manner, normally in search directories pre-designated by the compiler/IDE. This method is normally used to include standard library header files
- When used with " "
  - The preprocessor searches first in the same directory as the file containing the directive, and then follows the search path used for the #include <filename> form. This method is normally used to include programmer-defined header files.
- Cannot compile header files directly!

Multiple declarations of classes

- With large projects, multiple declaration of classes must be prevented
- Use `#ifndef`

```
#ifndef DATE_H
#define DATE_H

class Date {
    // ...
};

#endif
```

Multiple declarations of classes

- Do header guards need to be capital or use an underscore instead of a dot?
  - Preprocessor definitions have to use valid identifiers. Dots are not valid in identifiers.
  - Convention that preprocessor definitions (especially preprocessor macros) use all-uppercase names, to distinguish them from non-preprocessor identifiers.
- Not a hard and fast rule, just convention

Constructors

Constructors

- Special `methods` used to initialize data members when objects are created
- A constructor …
  - … is a member function (usually `public`)
  - … must have the same name as its class
  - … is automatically called when an object is created
  - … does not have a return type (not even `void`)

`constructors cannot be called as other methods`

Example

```
class Date {
    private:
        int month;
        int year;
        int day;

    public:
        Date();

        // ...
};
```

No return value

Example: Date

```
#ifndef DATE_H
#def DATE_H
class Date {
    private:
        int month;
        int year;
        int day;

    public:
        Date();
        void print();
};

endif
```

```
#include "date.h"
#include <iostream>

Date::Date() {
    month = 1;
    day = 1;
    year = 1970;
}

void Date::print() {
  std::cout << month << '-' <<
day << '-' << year << '\n';
}
```

```
#include "date.h"

int main() {
    Date mydate;

    mydate.print();
}
```

```
g++ date.cpp main.cpp -o exec
```


Overloading constructors

- A constructor with no parameters is also known as the **default constructor**
- Classes may have multiple constructors
  - constructors are **overloaded** by defining constructors with different parameter lists

```
Date();
Date(int m, int d, int y);
```


Synthesized default constructor

- If you don't define any constructor, C++ will define one default constructor for you
- If you define at least one constructor, C++ will not add any other (not even the default constructor)

Initialization lists

- C++ allows for optional initialization lists as part of the constructor definition

```
Date::Date(int _d, int _m, int _y) {
    day = _d;
    month = _m;
    year = _y;
    // more statements
}
```

Same as…

```
Date::Date(int _d, int _m, int _y) : day(_d), month(_m), year(_y) {
    // more statements
}
```