CH-230-A

Programming in C and C++

C/C++

Tutorial 10

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Instances of the Same Class

- Instances of the same class have the same set of data, but they are replicated so that they do not overlap

```
1   Critter a, b;
2   a.setHunger(1);
3   b.setHunger(4);
4   cout << a.getHunger() << " "
5        << b.getHunger();
```

will print
1 4

- `a` and `b` have a different memory space, so their modifications are independent

When Should Data Members be `public`?

- The interface of a class should be *minimal*
  - This gives least commitments in what you should keep untouched in order to avoid modifying client code
- Exceptions: if you need to access a data very frequently, the use of setter and getter methods may result in a bottleneck (after all it is a function call)
- In those cases you could consider to make a data member `public` (but you can also declare the method as `inline`)

Initialization of an Object

- When you declare an instance of a class its data members are **not** initialized
- It is possible to define a piece of code to be executed when the instance is created such that it brings the class into a "consistent" state
  - Remember the problem that in C (older standards) variables are not initialized
- This piece of code is called constructor
- A constructor is a special function, which is automatically called at object creation

Constructors (1)

- A constructor can be declared as "a method" with *no return type information and with the same name as the name of the class*
  - No return type is different from `void`
- The definition of a constructor is like that of a method
- A constructor can take parameters to allow parametric initialization
  - Provides a way to guarantee that the object is initialized with appropriate values
- There can be more constructors, provided that they take a different parameter list (overloading, to be covered later)
- `Complex.h` `Complex.cpp` `testcomplex.cpp`

Constructors (2)

- In the case of constructors with parameters they have to be specified at declaration time
- The choice among overloaded constructors is done on the basis of the effective parameter list given at object creation
- It is possible to specify default values for parameters
  - But they must be at the end of the parameter list

Default Constructors

- If a constructor is not defined, the compiler will create one taking no arguments (default constructor)
- If at least a constructor is defined by the programmer, the compiler will not generate the default constructor
- Default constructors do not initialize properties to 0
- *Good programming practice*: always define your own constructors (also the default one)
- `constructorsexample.cpp`

Constructors of Sub-Objects

- A class can have objects as data members (like name in the student class)
- These objects need to be initialized during constructor execution
- Let us revise the `class Critter` and add a constructor which initializes all data members
- `Critter2.h` `Critter2.cpp` `testcritter2.cpp`

Syntax Details

```
1 A::A(B par1, B par2, int par3) : member1(par1),
2   member2(par2) {
3     // do something with par3
4 }
```

- subobject.cpp
- The order of the constructor calls is determined by how data members are declared in the class declaration and not by the order of calls in the constructor definition
- callsequence.cpp

callsequence.cpp

```
1  #include <string>
2  using namespace std;
3  // simple class just to make an
4  // example of how constructors of internal objects are called
5  class ToTest {
6    private:
7      string First;  // dummy data
8      string Second;
9      string Third;
10     int anint;
11   public:
12     ToTest(string, string, string, int);
13     // constructor: one parameter for each data member
14 };
15 ToTest::ToTest(string a, string b, string c, int d)
16   : Second(b) , Third(c) , First(a) {
17   // no matter the order here indicated, the first object to be initialized
18   // will be First, the second will be Second, the Third will be third,
19   // according to how they were declared in the class definition
20   // (an disregarding the order in the constructor definition
21   anint = d;
22 }
23 int main(int argc, char** argv) {
24   ToTest aninstance("Jacobs", "EECS", "320142", 1);
25 /*    aninstance.First will be the string "Jacobs"
26       aninstance.Second will be the string "EECS"
27       aninstance.Third will be the string "320142" */
28       return 0;
29 }
```

Destructors (1)

- A destructor is the companion concept of the constructor
  - It provides operations to be done when an object instance is removed from memory
    - Typical use: releasing resources acquired during object lifecycle
- Destructors do not take parameters, do not return any type and their name is that of the class preceded by a $\sim$ character
- `destructors.cpp`

destructors.cpp

```
1  #include <iostream>
2  #include <string>
3  using namespace std;
4  /* This example illustrates that destructor call are handled by the
5      compiler. Please compile this code and observe the output  */
6  class ToTest {
7    private:
8      string name;
9    public:
10     ToTest(char*);
11     ~ToTest();
12     void doSomething();
13 };
14 ToTest::ToTest(char* n) : name(n) {
15   cout <<  "Executing " << name << "'s constructor" << endl;
16 }
17 ToTest::~ToTest() {
18   cout << "Executing " << name << "'s destructor" << endl;
19 }
20 void ToTest::doSomething() {
21   cout << "Doing something with " << name << endl;
22 }
23 int main(int argc, char** argv)  {
24   ToTest a("FIRST");  {
25     ToTest b("SECOND");
26     a.doSomething();
27     b.doSomething();
28     // b's destructor will be called here, as it is going out of scope
29   } // a's destructor will be called here
30   return 0;
31 }
```

Destructors (2)

- Destructor calls are managed by the compiler
  - The destructor is called when the object goes out of scope or when it is removed from the heap (more on this later)
- *Good programming practice*: if your class allocates memory on the heap, it should de-allocate it while executing the destructor
  - Your programs must avoid *memory leaks* (i.e., incorrect management of memory allocations)

Overloading (1)

While programming it is often useful to indicate with the same name more entities with related functionality

- Example: to print on the screen it would be nice to have a family of functions, say called `screen_print`, which are used to print data of different types

```
1  screen_print("prints a string");
2  int a;
3  screen_print(a);
4  float b;
5  screen_print(b);
```

- Their implementation is however different, thus requiring different calls

Overloading (2)

- From the argument list the compiler can infer which version of the function needs to be called
- Every function or method is associated with a signature:
  - The signature is the concatenation of the *name* and of the *parameters type* (the order is relevant)
    - The name of the parameters and the return type do not appear in the signature. Why?
- Overloading is possible if this yields different signatures
- `overloading.cpp`

overloading1.cpp

```
1  #include <iostream>
2  #include <string>
3  using namespace std;
4
5  class Student {
6    private:
7      string name;
8      float grade;
9    public:
10     Student(const string& n, int grade) {
11     name = n ;
12     cout << n << " initialized with an integer grade." << endl;
13   }
14   Student(const string& n, double grade) {
15     name = n ;
16     cout << n << " initialized with a float grade." << endl;
17   }
18 };
19 int main() {
20   Student first("Anni Friesinger", 2);
21   // parameters determine which constructor will be called
22   Student second("Claudia Pechstein", 2.3);
23   return 0;
24 }
```

Overloading: When?

- If a class offers the same service (i.e., method) for different data types and just the implementation changes, this is a good candidate for overloading
- Class users need to remember just one usage policy
- Overloading increases the capacity to abstract during coding

Pointers to Classes

- Being types, it is possible to declare pointers to a class as for basic data types. The syntax is the usual

```
1  string a("this is one string");
2  string *ptr;
3  ptr = &a;
```

- The special operator -> allows to access data members and call methods through pointers

```
1  cout << ptr->substr(1, 3) << endl;
2  cout << (*ptr).substr(1, 3) << endl;
```

- Access to data members and methods through pointers is subject to the data hiding restrictions

The Copy Constructor

To correctly manage by value argument passing for objects it is necessary to define a copy constructor:

- For class X a copy constructor has the form:

```
1    X::X(const X&);
```

- If defined, this will replace bit-copy (exact, bit by bit copy of an object) when passing by value object parameters
- Its goal is to correctly create a copy of an object starting from an existing one
- `copyconstructor.cpp`

Compiler Generated Constructors

To summarize, the compiler can generate two types of constructors:

- The default constructor, taking no arguments
  - This is generated only if you do not provide any constructor
- The copy constructor, which performs bit-copy initialization from an existing object
  - This is not generated if you either provide an `X::X(const X&)` implementation or you declare a `private X::X(const X&)` constructor
  - The `private X::X(const X&)` constructor does not need to be implemented