Constructors and Destructors

C++ Object Oriented Programming

Pei-yih Ting

NTOU CS

Contents

- House Keeping Problem
- Constructors
- Destructors
- Invoking Mechanisms
- Advantage of OOP
- Multiple Constructors
- Array of Objects
- Default Arguments
- Initialization Lists
- Constant Data Members Initialization

House Keeping Problems

- What is wrong with the following code?

```
class Array {
public:
    void initArray(int arraySize);
    void insertElement(int element, int slot);
    int getElement(int slot) const;
    void  cleanUp();
private:
    int m_arraySize;
    int *m_arrayData;
};
void Array::initArray(int arraySize) {
    m_arrayData = new int[arraySize];
    m_arraySize = arraySize;
}
void main() {
    Array array;
    array.insertElement(10, 0);
}
```

Assume insertElement(), getElement(), and cleanUp() are defined elsewhere.

In the client code: main

1. Forget to initialize the object array (there is no call to initArray())
2. Forget to call cleanUp() code segment

Invalid Internal State

- Initialization
  - Interface functions are required to maintain the internal state of an object such that they are valid and consistent all the time.
  - Without suitable initialization, the object's initial state would be invalid.
  - We need a method to guarantee that each new object is well initialized. No additional care should be taken by a user.
- Clean up
  - Clean up is important if a program is supposed to run for a long time. If resources (memory, file, …) are occupied one by one and forget to released afterwards, sooner or later no program would have enough resources to get executed.
  - We need a method to guarantee that each object is well cleaned up. No additional care should be taken by a user.

Constructors

- **ctor**: A **constructor** is a function executed automatically when an object comes into existence.
- Syntax
  - The name of the constructor is the same as the class name
  - Must **not** have a return type
  - Parameters must be supplied when the object is defined.
  - Do **not** call it (explicitly) inside the program except the following 3 situations:
    1. new statements, 2. initialization lists, 3. temporary objects

```
class Array
{
public:
    Array(int arraySize);
    void insertElement(int element, int slot);
    int getElement(int slot) const;
private:
    int m_arraySize;
    int *m_array;
};
```

```
void main()
{
    Array array(20);
    array.insertElement(10, 0);
}

Array::Array(int arraySize)
{
    m_array = new int[arraySize];
    m_arraySize = arraySize;
}
```

Destructors

- **dtor**: A **destructor** is a function executed automatically when an object's life comes to an end. (goes out of scope, program ends, or is deleted dynamically)
- Syntax
  - The name of the destructor must be the same as the name of the class preceded by **~** (tilde).

    ~Array();
  - Destructors take **no** arguments and return **no** values
- Purpose: to free any resource (memory, file, network) allocated by the object.

class Array
{
public:
    …
    ~Array();
    …
};
	Array::~Array()
	{
	    delete [] m_array;
	}

When are ctors and dtors invoked?

- Static variables (local, global)

codes inserted by the C++ compiler

```
void Foo() {
    Array array(20);  // ctor invoked
    array.insertElement(10, 0);
    cout << array.getElement(0);
}  // dtor invoked
```

What would happen if there were no destructor?

  - dtor of a global variable will be invoked when the program exits

- Dynamic variables

```
Array *Foo(int numElements) {
    Array *array;
    array = new Array(numElements); // ctor invoked
    return array;
}
void Bar() {
    Array *mainData = Foo(20);
    delete mainData;  // dtor invoked
}
```

What would happen if we did not call delete?

Advantages Achieved by OOP

Automatic initialization

```
Array::Array(int arraySize) {
    m_array = new int[arraySize];
    m_arraySize = arraySize;
}
```

Reduced memory-leakage risks

```
Array::~Array(){
    delete [] m_array;
}
```

Safe client/server programming

```
void Array::insertElement(int element, int slot) {
    if ((slot < m_arraySize) && (slot >=0))
        m_array[slot] = element;
    else
        cout << "Warning, out of range!!";
}
int Array::getElement(int slot) const {
    if ((slot < m_arraySize) && (slot >= 0))
        return m_array[slot];
    else {
        cout << "Warning, out of range!!";
        return 0;
    }
}
```

Better abstraction

```
cout << array.getElement(0);
```

Conceptually, an array is no longer just a chunk of data storages.

Multiple Constructors

- A class can have more than one constructor (function overloading)

```
class Name
{
public:
   Name();
   Name(char *firstName, char *lastName);
   ~Name();
   void setName(char *firstName, char *lastName);
   void printName() const;
private:
   char *m_firstName;
   char *m_lastName;
};
Name::Name()
{
   m_firstName = 0;
   m_lastName = 0;
}
Name::Name(char *firstName, char *lastName)
{
   setName(firstName, lastName);
}
```

This ctor has special name: "**default constructor**".

Multiple Constructors (cont'd)

```
void Name::setName(char *firstName, char *lastName)
{
   m_firstName = new char[strlen(firstName)+1];
   m_lastName = new char[strlen(lastName)+1];
   strcpy(m_firstName, firstName);
   strcpy(m_lastName, lastName);
}
```

```
Name::~Name()
{
   delete[] m_firstName;
   delete[] m_lastName;
}
```

```
void Name::printName() const
{
   if (m_firstName) cout << m_firstName << ' ';
   if (m_lastName) cout << m_lastName << ' ';
}
```

- Usage:

```
void main()
{
   Name name1, name2("Mary", "Smith");
   name1.setName("Mark", "Anderson");
   name1.printName(); name2.printName();
}
```

Constructors and Arrays

- If you try to define an array of objects, you can NOT do this

```
class Name
{
public:
   Name(char *firstName, char *lastName);
   ~Name();
   void setName(char *firstName, char *lastName);
   void printName() const;
private:
   char *m_firstName;
   char *m_lastName;
};
void main()
{
   Name names[100];
   names[0].setName("Mark", "Anderson");
   names[0].printName();
}
```

- error C2512: 'Name' : no appropriate default constructor available

Name() is the so-called default constructor

Name names[] = {Name("Mark", "Anderson"), name1};

Solutions to Array of Objects

- Solution 1: provide a ctor without arguments … i.e. the default ctor

```
class Name {
public:
    Name();
    Name(char *firstName, char *lastName);
    ~Name();
    void setName(char *firstName, char *lastName);
    void printName() const;
private:
    char *m_firstName;
    char *m_lastName;
};
```

- Solution 2: have no ctor at all … i.e. use the implicit default ctor

```
class Name {
public:
    ~Name();
    void setName(char *firstName, char *lastName);
    void printName() const;
private:
    char *m_firstName;
    char *m_lastName;
};
```

Constructors with Default Arguments

- Consider this class with two constructors

```
class Account {
public:
    Account();
    Account(double startingBalance);
    void changeBalance(double amount);
    void showBalance() const;
private:
    double m_balance;
};

Account::Account() {
    m_balance = 0.0;
}

Account::Account(double startingBalance) {
    m_balance = startingBalance;
}
```

```
void main() {
    Account client1, client2(100.0);
    client1.showBalance();
    client2.showBalance();
}
```

```
Output:
0.0
100.0
```

Ctor with Default Arguments (cont’d)

- The class is rewritten as follows

```
class Account {
public:
    Account(double startingBalance=0.0);
    void changeBalance(double amount);
    void showBalance() const;
private:
    double m_balance;
};

Account::Account(double startingBalance) {
    m_balance = startingBalance;
}
```

The single ctor is exactly the same as before

- We can now declare an array of Account.

```
void main() {
    Account clients[100];
    clients[0].changeBalance(100.0); clients[0].showBalance();
}
```

This works fine without default ctor.

Initialization Lists

- Consider the following class

```
enum Breed {undefined, collie, poodle, coca, bulldog};
class Dog {
public:
    Dog();
    Dog(char *name, Breed breed, int age);
    ~Dog();
    void list() const;
private:
    char *m_name;
    Breed m_breed;
    int m_age;
};
```

★ This ctor can be rewritten as:

```
Dog::Dog(char *name, Breed breed, int age)
    : m_name(new char[strlen(name)+1]),
     m_breed(breed), m_age(age) {
   strcpy(m_name, name);
}
```

- The constructor might look like this

```
Dog::Dog(char *name, Breed breed, int age) {
    m_name = new char[strlen(name)+1];
    strcpy(m_name, name);
    m_breed = breed;
    m_age = age;
}
```

Constant Data Member Initialization

- The breed of the dog will not change, so let us make this a constant variable in the class declaration.

```
class Dog {
public:
    Dog();
    Dog(char *name, Breed breed, int age);
    ~Dog();
    void list() const;
private:
    char *m_name;
    const Breed m_breed;
    int m_age;
};
```

- Constant variables MUST be initialized in the initialization list

```
Dog::Dog():m_breed(undefined) {}
```

- Other good uses for const

```
Dog::Dog(const char *name, const Breed breed, const int age)
    : m_name(new char[strlen(name)+1]),
      m_breed(breed), m_age(age) {
    strcpy(m_name, name);
}
```

Initialization List (cont'd)

- There are several cases where initialization list **MUST** be used
  - Constant data member
  - Reference data member
  - Non-default parent class constructor
  - Non-default component object constructor
- Coding style: use initialization list as much as possible
  - initialization list is inevitable in many cases
  - initialization will be performed implicitly in the initialization list whether you use it or not. It saves some computation to do it in the initialization list.
- Caution:
  - The order of expressions in the initialization list is NOT the order of execution, the defining order of member variables in the class definition defines the order of execution.

```
Dog::Dog(const char *name, const Breed breed, const int age)
    : m_age(age) , m_name(new char[strlen(name)+1]), m_breed(breed){
    strcpy(m_name, name);
}
```

- **first**: m_age(age)
- **second**: m_breed(breed)
- **third**: m_name(new char[strlen(name)+1])

Ctor of Intrinsic Data Type

- int, long, float, double, char
- Initialize with constructor:

```
int x(10);
```

- Construction of a temporary variable

```
int x;
x = int(10.3); // assignment from a temporary integer
               // which is initialized with 10.3
```

- Some people think that this is a kind of coercion like

```
x =  (int) 10.3;
```

  Actually the above two are not the same mechanism in C++. Each invoke different procedures to achieve their specified functions.