Review: Objects and classes

(Chapter 2)

CS 3358
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Jill Seaman

Object Oriented Programming

- An object contains
  - data (or “state”)
  - functions that operate over its data
- Usually set up so code outside the object can access the data only via the member functions.
- If the representation of the data in the object needs to change:
  - The object’s functions must be redefined to handle the changes.
  - The code outside the object does not need to change, it accesses the object in the same way.

Object Oriented Programming
Concepts

- **Encapsulation**: combining data and code into a single object.
- **Information hiding** is the ability to hide the details of data representation from the code outside of the object.
- **Interface**: the mechanism that code outside the object uses to interact with the object.
  - The prototypes/signatures of the object’s functions.

The Class

- A class in C++ is similar to a structure.
- A class contains:
  - variables (members) AND
  - functions (member functions or methods)
- Members can be:
  - private: inaccessible outside the class (this is the default)
  - public: accessible outside the class.

Example class: IntCell

```
class IntCell
{
   public:
      // Construct an IntCell. Initial value is 0
      IntCell ()
      { storedValue = 0; }

      // Construct an IntCell. Initial value is initialValue
      IntCell (int initialValue)
      { storedValue = initialValue; }

      // Return the stored value.
      int read ()
      { return storedValue; }

      // Change the stored value to x.
      void write (int x)
      { storedValue = x; }

   private:
      int storedValue;

};
```

How is this definition different from the way you defined classes in your previous course?

IntCell class

- one data member, four member functions
- private members:
  - storedValue: not visible outside the class
- public members:
  - the four member functions
  - visible and accessible to any function
- constructors
  - describes how instances are created
  - if none, a default constructor is supplied

Using IntCell

```
int main()
{
   IntCell m;  // calls IntCell() constructor

   m.write(5);
   cout << "Cell contents: " << m.read() << endl;

   return 0;

};
```

Output:

```
Cell contents: 5
```

IntCell, version 2

```
class IntCell
{
   public:

      explicit IntCell (int initialValue = 0)
        : storedValue (initialValue)
      {  }


      int read () const
      { return storedValue; }


      void write (int x)
      { storedValue = x; }

   private:
      int storedValue;

};
```

What is different from version 1 (other than not having comments)?

Four changes to IntCell

1. Default parameter

- `IntCell (int initialValue = 0)`
- This constructor has an optional parameter. If not specified, initialValue will be 0.

```
IntCell x;
IntCell y(5);
```

2. Initializer list

- `: storedValue (initialValue)`
- before the constructor body, assigns initialValue to storedValue.
- sometimes initializer list is required

Four changes to IntCell

3. explicit constructor

- IntCell constructor is labelled “explicit”
- applies to one-argument constructors only
- Prevents compiler from doing this conversion:

```
IntCell obj;
obj = 37;  //should be an error
```

→

```
IntCell obj;
IntCell temp(37);
obj = temp;
```

4. Constant member function

- const after param-list declares function will not change any member values: `int read () const`
- signifies function is an accessor (not a mutator)

Separation of Interface from Implementation

- Interface: “What”
  - Class declarations with data members and function prototypes only
  - stored in their own header files (*.h)
- Implementation: “How”
  - Member function definitions are stored in a separate file (*.cpp) Requires use of the scope resolution operator ::
  - must #include the corresponding header file
- Any file using the class should #include *.h
- *.cpp can change without recompiling its users

IntCell, version 3

IntCell.h:

```
#ifndef _IntCell_H_
#define _IntCell_H_

class IntCell
{
   public:
      explicit IntCell (int initialValue = 0);
      int read () const;
      void write (int x);

   private:
      int storedValue;
};

#endif
```

Note the “include guards” which prevent the file from being included more than once

IntCell, version 3

IntCell.cpp:

```
#include “IntCell.h”

IntCell::IntCell (int initialValue)
: storedValue (initialValue)
{   }

int IntCell::read () const
{
   return storedValue;
}

void IntCell::write (int x)
{
   storedValue = x;
}
```

Function signatures must match exactly with class declaration, but default params are not required

Note the scope resolution operations: **IntCell::** Indicates which class the function is a member of

The Big Three

destructor, copy constructor, operator=

- these functions are provided by default, but the default behavior may or may not be appropriate.
- **Destructor**
  - called when object is destroyed (goes out of scope or deleted)
  - responsible for freeing resources used by object
    - ➡ calling delete on dynamically allocated objects
    - ➡ closing files
  - default destructor applies destructor to each member

The Big Three

destructor, copy constructor, operator=

- **Copy Constructor**
  - special constructor, constructs new object from an existing one
  - called:
    - ➡ for a declaration with initialization:

```
IntCell obj = otherObj;
IntCell obj(otherObj);
```

But **not** for: `obj = otherObj`

    - ➡ when object is passed by value
    - ➡ when object is returned by value
  - default copy constructor:
    - ➡ uses assignment for primitive-type data members
    - ➡ uses copy constructor for object-type data members

The Big Three

destructor, copy constructor, operator=

- **operator=** (aka copy assignment operator)
  - called when = operator is used on existing objects:

```
obj = otherObj;
```

  - default operator= applies = to each member (aka member-wise assignment)

The Big Three

destructor, copy constructor, operator=

- When do the defaults not work?
- Generally, when one of the members is dynamically allocated by the class (via a pointer).
- As an example, let's rewrite IntCell and store the value in a dynamically allocated memory location.

IntCell, version 4

```
class IntCell
{
   public:
      explicit IntCell (int initialValue = 0);
      int read () const;
      void write (int x);

   private:
      int *storedValue;
};
```

```
IntCell::IntCell (int initialValue)
{ storedValue = new int;
  *storedValue = initialValue; }

int IntCell::read () const
{ return *storedValue; }

void IntCell::write (int x)
{ *storedValue = x; }
```

What is different from version 3?

IntCell, v. 4, problem with defaults

```
int main()
{
   IntCell a(2);
   IntCell b = a;       //copy constructor
   IntCell c;

   c = b;               //operator=

   a.write(4);
   cout << a.read() << endl
        << b.read() << endl
        << c.read() << endl;

};
```

What is output?

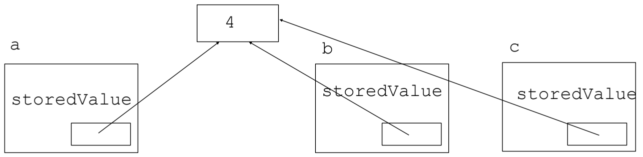
```
4
2
2
```

or

```
4
4
4
```

IntCell, v. 4, problem with defaults

- Why are they all changed to 4?
- Default copy constructor and operator= all do a shallow copy. They copy the pointer instead of making a new copy.
- As an result, all 3 objects point to the same location in memory



IntCell, version 5

```
class IntCell
{
   public:
      explicit IntCell (int initialValue = 0);

      IntCell(const IntCell &rhs);
      ~IntCell();
      void operator= (const IntCell & rhs);

      int read () const;
      void write (int x);

   private:
      int *storedValue;
};
```

Note the prototypes for the big 3

IntCell, version 5

```
IntCell::IntCell (int initialValue)
{ storedValue = new int;
  *storedValue = initialValue; }

IntCell::IntCell (const IntCell & rhs)
{ storedValue = new int;
  *storedValue = *(rhs.storedValue); }

IntCell::~IntCell()
{ delete storedValue; }

void IntCell::operator= (const IntCell & rhs)
{ *storedValue = *(rhs.storedValue); }

int IntCell::read () const
{ return *storedValue; }

void IntCell::write (int x)
{ *storedValue = x; }
```

() not needed

() not needed

Note: `*storedValue = *(rhs.storedValue);`
alternatively: `write(rhs.read());`

Default constructor

- A default constructor is automatically provided if no constructors are provided by the programmer
- It takes no parameters
- For each data member, it
  - ➡ uses defaults for primitive-type data members
  - ➡ uses no-parameter constructor for object-type data members

Operator Overloading

- Operators such as =, +, ==, and others can be redefined to work over objects of a class
- The name of the function defining the over-loaded operator is `operator` followed by the operator symbol:

  `operator+` to overload the + operator, and

  `operator=` to overload the = operator
- Just like a regular member function:
  - Prototype goes in the class declaration
  - Function definition goes in implementation file

Overload == for IntCel

- Add the prototype to the class decl:

```
bool operator== (const IntCell &rhs);
```

- Add the function definition to the impl file:

```
bool IntCell::operator== (const IntCell &rhs) {
   return *storedValue == *(rhs.storedValue);
}
```

- Use operator== in another file/function:

```
IntCell object1(5), object2(0), object3;
if (object2==object3)
   cout << “object 2 and object3 are equal” << endl;
```

Exceptions

- An exception is an object that stores information transmitted outside the normal return sequence.
- It is propagated back through calling stack until some function catches it.
- If no calling function catches the exception, the program terminates.

```
int findMax (vector<int> a) {
   int max;
   if (a.size()==0)
      throw "Unable to findMax of empty vector";
   else {
      max = a[0];
      //code to find maximum goes here
   }
   return max;
};
```