Software Engineering 2 (C++)

CSY2006

Important Points (C++ vs Java)

Passing objects to functions:

In C++, functions create a copy of the object passed (unlike Java).

See: PassObjectDemo.cpp

Assigning one object to another:

In C++, when you assign one object to another, it again creates a copy (unlike Java).

See: AssignObjectDemo.cpp

Passing objects to functions:

```
class Rect{     // Member variables
    public:
    int length;
    int width;

        Rect ()
       {
        length = 0;
        width = 0;
       }
};
  void changelength(Rect r){
   r.length = 20;
}
int main(){
    Rect r1;
    r1.length = 5;
    r1.width = 3;
    changelength(r1);
    cout << "RECT Length " << r1.length << endl;
    cout << "RECT Width " << r1.width << endl;
    system("PAUSE");
    return 0;
}
```

Assigning one object to another:

```
class Rect
{
    // Member variables
    public:
        int length;
     int width;
        Rect ()
          {
          length = 0;
          width = 0;
          }
};
int main()
{
    Rect r1;
    r1.length = 5;
    r1.width = 3;
    Rect r2;
    r2 = r1;
    r2.width = 4;
        cout << "RECT Length " << r2.length << endl;
        cout << "RECT Width "  << r2.width << endl;
        system("PAUSE");
        return 0;
}
```

Friends of Classes

Friends of Classes

- Friend: a function or class that is not a member of a class, but has access to private members of the class
- A friend function can be a stand-alone function or a member function of another class
- It is declared a friend of a class with `friend` keyword in the function prototype

`friend` Function Declarations

- Stand-alone function:

```
friend void setAVal(intVal&, int);
// declares setAVal function to be
// a friend of this class
```

- Member function of another class:

```
friend void SomeClass::setNum(int num)
// setNum function from SomeClass
// class is a friend of this class
```

See:Budget Version 3

`friend` Class Declarations

- Class as a friend of a class:

```
class FriendClass
{
  ...
};
class NewClass
{
  public:
    friend class FriendClass; // declares
  // entire class FriendClass as a friend
  // of this class
  …
};
```

friend Function Example

```
2   using namespace std;
3   class Box {
4      double width;
5      public:
6         friend void printWidth( Box box );
7         void setWidth( double wid );
8   };
9   // Member function definition
10  void Box::setWidth( double wid ) {
11     width = wid;
12  }
13  // Note: printWidth() is not a member function of any class.
14  void printWidth( Box box ) {
15     /* Because printWidth() is a friend of Box, it can
16     directly access any member of this class */
17     cout << "Width of box : " << box.width <<endl;
18  }
19  int main() {
20     Box box;
21     box.setWidth(10.0);
22     printWidth( box );
23     return 0;
24  }
```

friend Class Example

```
3   using namespace std;
4   class Area{
5       int length,breadth,area;
6       public:
7       Area(int length,int breadth):length(length),breadth(breadth){}
8       void calcArea(){
9           area = length * breadth;
10      }
11      friend class printClass;
12  };
13  class printClass{
14      public:
15      void printArea(Area a){
16          cout<<"Area = "<<a.area;
17      }
18   };
19  int main(){
20      Area a(10,15);
21      a.calcArea();
22      printClass p;
23      p.printArea(a);
24      return 0;
```

Copy Constructors

Copy Constructors

- Special constructor used when a newly created object is initialized to the data of another object of same class
- Default copy constructor copies field-to-field
- Default copy constructor works fine in many cases
- e.g. Rectangle r2 = r1;

Copy Constructors

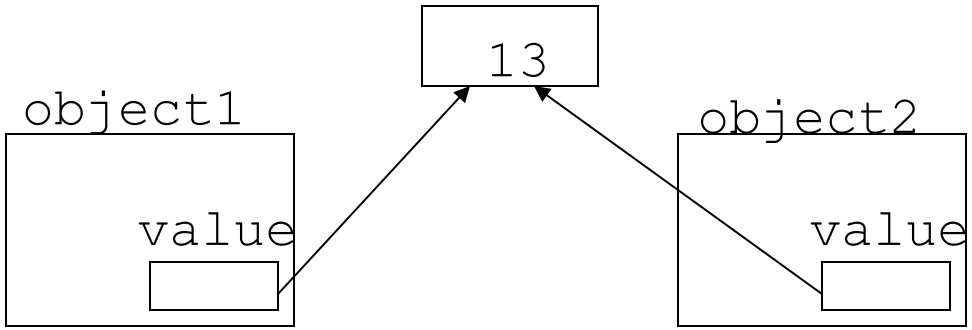
Problem: what if object contains a pointer?

```
class SomeClass
{ public:
      SomeClass(int val = 0)
          {value=new int; *value = val;}
      int getVal();
      void setVal(int);
     private:
      int *value;
}
```

Copy Constructors

What we get using memberwise copy with objects containing dynamic memory:

```
SomeClass object1(5);
SomeClass object2 = object1;
object2.setVal(13);
cout << object1.getVal(); // also 13
```



Programmer-Defined Copy Constructor

- Allows us to solve problem with objects containing pointers:

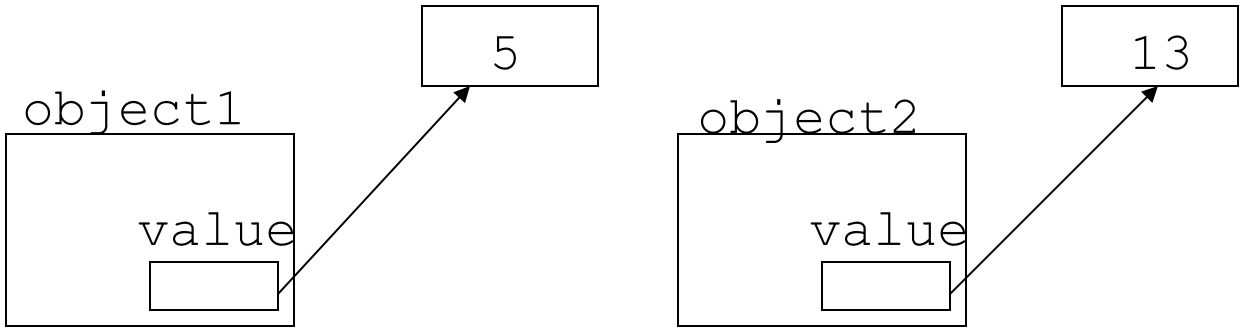
```
SomeClass::SomeClass(const SomeClass &obj)
{
   value = new int;
   *value = obj.value;
}
```

- Copy constructor takes a reference parameter to an object of the class

Programmer-Defined Copy Constructor

- Each object now points to separate dynamic memory:

```
SomeClass object1(5);
SomeClass object2 = object1;
object2.setVal(13);
cout << object1.getVal(); // still 5
```



Programmer-Defined Copy Constructor

- Since copy constructor has a reference to the object it is copying from,

```
SomeClass::SomeClass(SomeClass &obj)
```

  it can modify that object.
- To prevent this from happening, make the object parameter `const`:

```
SomeClass::SomeClass
                    (const SomeClass &obj)
```

```
 3  class Line {
 4     public:
 5        int getLength( void );
 6        Line( int len );                  // simple constructor
 7        Line( const Line &obj);  // copy constructor
 8        ~Line();                          // destructor
 9     private:
10         int *ptr;};
11  Line::Line(int len) {
12     cout << "Normal constructor allocating ptr" << endl;
13     ptr = new int;
14     *ptr = len;       }
15  Line::Line(const Line &obj) {
16     cout << "Copy constructor allocating ptr." << endl;
17     ptr = new int;
18     *ptr = *obj.ptr;          }// copy the value
19  Line::~Line(void) {
20     cout << "Freeing memory!" << endl;
21     delete ptr;     }
22  int Line::getLength( void ) {
23     return *ptr;    }
24  void display(Line obj) {
25     cout << "Length of line : " << obj.getLength() <<endl; }
26  // Main function for the program
27  int main() {
28     Line line(10);
29     display(line);
30     return 0;
31  }
```

Contents of `StudentTestScores.h` (Version 2)

```
1  #ifndef STUDENTTESTSCORES_H
2  #define STUDENTTESTSCORES_H
3  #include <string>
4  using namespace std;
5
6  const double DEFAULT_SCORE = 0.0;
7
8  class StudentTestScores
9  {
10 private:
11    string studentName;  // The student's name
12    double *testScores;  // Points to array of test scores
13    int numTestScores;   // Number of test scores
14
15     // Private member function to create an
16     // array of test scores.
17    void createTestScoresArray(int size)
18    { numTestScores = size;
19      testScores = new double[size];
20      for (int i = 0; i < size; i++)
21         testScores[i] = DEFAULT_SCORE; }
22
23 public:
24     // Constructor
25    StudentTestScores(string name, int numScores)
26    { studentName = name;
```

```
27      createTestScoresArray(numScores); }
28
29    // Copy constructor
30    StudentTestScores(const StudentTestScores &obj)
31    { studentName = obj.studentName;
32      numTestScores = obj.numTestScores;
33      testScores = new double[numTestScores];
34      for (int i = 0; i < numTestScores; i++)
35         testScores[i] = obj.testScores[i]; }
36
37     // Destructor
38    ~StudentTestScores()
39    { delete [] testScores; }
40
41     // The setTestScore function sets a specific
42     // test score's value.
43    void setTestScore(double score, int index)
44    { testScores[index] = score; }
45
46     // Set the student's name.
47    void setStudentName(string name)
48    { studentName = name; }
49
50     // Get the student's name.
51    string getStudentName() const
52    { return studentName; }
```

```
53
54      // Get the number of test scores.
55      int getNumTestScores() const
56      { return numTestScores; }
57
58       // Get a specific test score.
59      double getTestScore(int index) const
60      { return testScores[index]; }
61  };
62  #endif
```

14.5

Operator Overloading

Operator Overloading

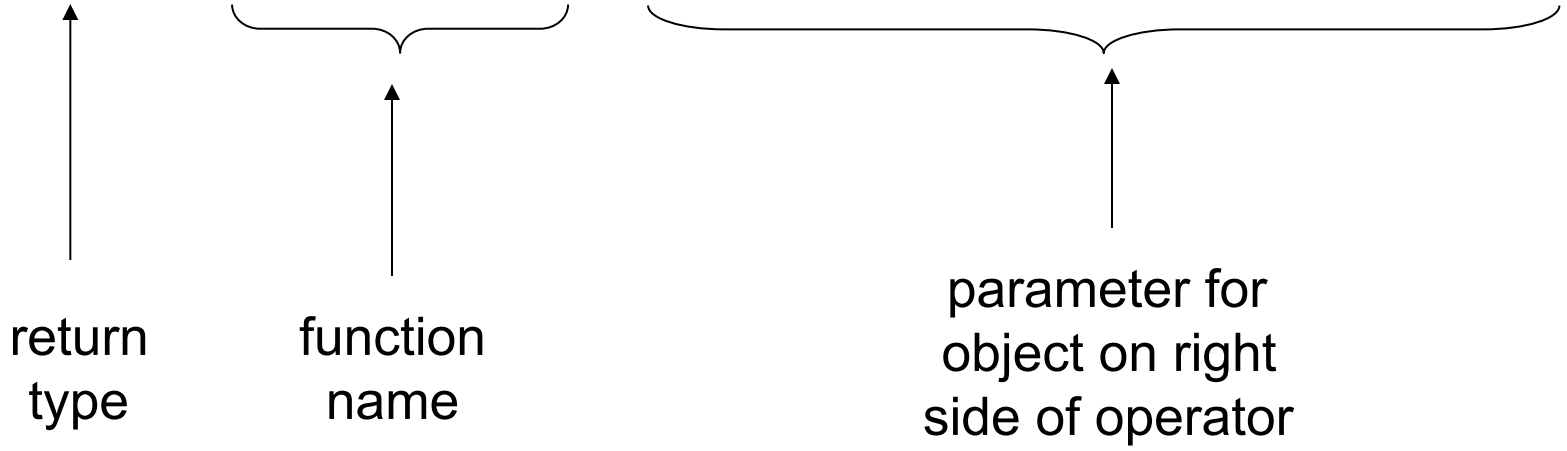
- Operators such as =, +, and others can be redefined when used with objects of a class
- The name of the function for the overloaded operator is `operator` followed by the operator symbol, *e.g.*,
  - `operator+` to overload the + operator, and
  - `operator=` to overload the = operator
- Prototype for the overloaded operator goes in the declaration of the class that is overloading it
- Overloaded operator function definition goes with other member functions

See: Weird, StudentTestScores Version 3, Feet Inches Versions 1 - 5

Operator Overloading

- Prototype:

```
void operator=(const SomeClass &rval)
```



- Operator is called via object on left side

Invoking an Overloaded Operator

- Operator can be invoked as a member function:

```
object1.operator=(object2);
```

- It can also be used in more conventional manner:

```
object1 = object2;
```

Returning a Value

- Overloaded operator can return a value

```
class Point2d
{
  public:
    double operator-(const point2d &right)
    { return sqrt(pow((x-right.x),2)
                + pow((y-right.y),2)); }
...
  private:
    int x, y;
};
Point2d point1(2,2), point2(4,4);
// Compute and display distance between 2 points.
cout << point2 – point1 << endl; // displays 2.82843
```

Returning a Value

- Return type the same as the left operand supports notation like:

```
object1 = object2 = object3;
```

- Function declared as follows:

```
const SomeClass operator=(const someClass &rval)
```

- In function, include as last statement:

```
return *this;
```

Overloading Binary Operator

```
3  class A{
4      int x;
5        public:
6        A(){}
7      A(int i){
8         x=i;
9      }
10     int operator+(A);
11     void display();
12 };
13 int A :: operator+(A a){
14     return (x+a.x);
15 }
16 int main()
17 {
18     A a1(5);
19     A a2(4);
20     cout<<"The result of the addition of two objects is : "<<a1+a2;
21     return 0;
22 }
```

The `this` Pointer

- `this`: predefined pointer available to a class's member functions
- Always points to the instance (object) of the class whose function is being called
- Is passed as a hidden argument to all non-static member functions
- Can be used to access members that may be hidden by parameters with same name

`this` Pointer Example

```
class SomeClass
{
   private:
        int num;
   public:
        void setNum(int num)
        { this->num = num; }
        ...
};
```

Notes on Overloaded Operators

- Can change meaning of an operator
- Cannot change the number of operands of the operator
- Only certain operators can be overloaded. Cannot overload the following operators:

```
?:   .   .*   :: sizeof
```

Overloading Types of Operators

- `++`, `--` operators overloaded differently for prefix vs. postfix notation
- Overloaded relational operators should return a `bool` value
- Overloaded stream operators `>>`, `<<` must return reference to `istream`, `ostream` objects and take `istream`, `ostream` objects as parameters

Overloaded `[]` Operator

- Can create classes that behave like arrays, provide bounds-checking on subscripts
- Must consider constructor, destructor
- Overloaded `[]` returns a reference to object, not an object itself

See: Pr 14-12 and Pr 14-13

14.6

Object Conversion

Object Conversion

- Type of an object can be converted to another type
- Automatically done for built-in data types
- Must write an operator function to perform conversion
- To convert an `FeetInches` object to an `int`:

```
FeetInches::operator int()
{return feet;}
```

- Assuming distance is a `FeetInches` object, allows statements like:

```
int d = distance;
```

See Program FeetInches Version 5

14.7

Aggregation

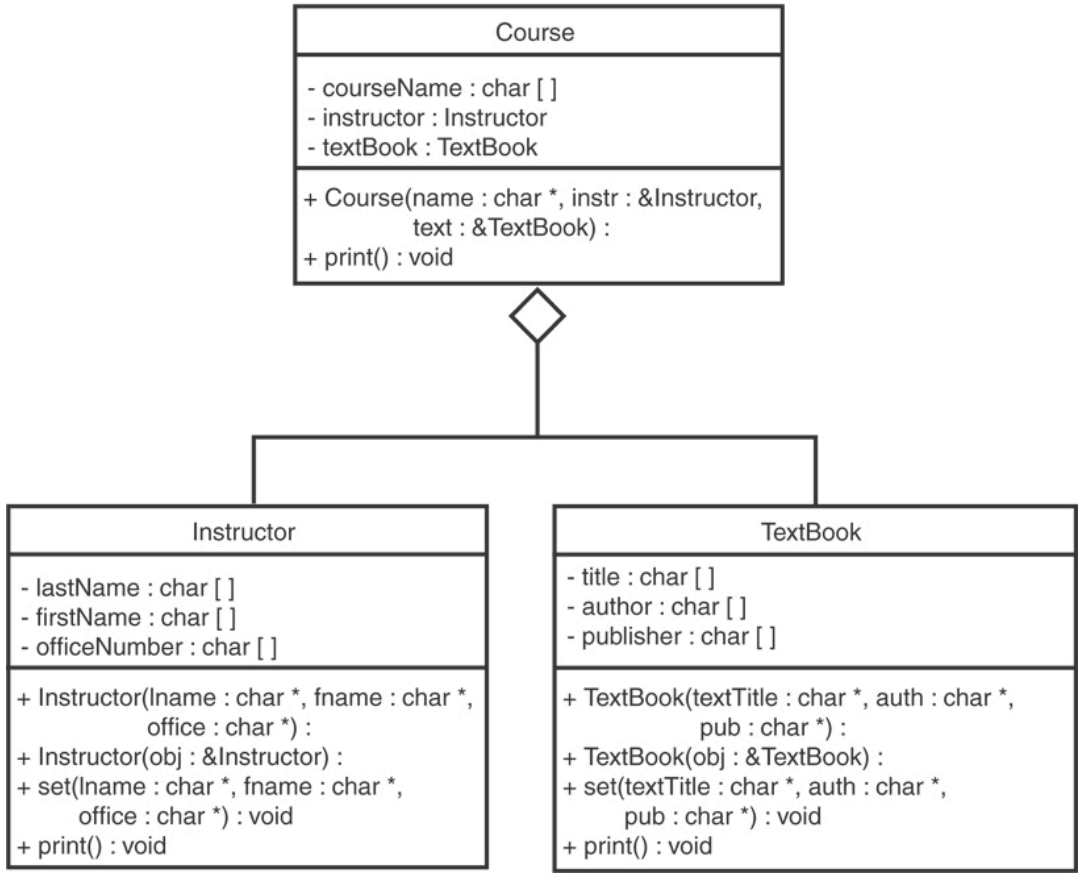
Aggregation

- Aggregation: a class is a member of a class
- Supports the modeling of ‘has a’ relationship between classes – enclosing class ‘has a’ enclosed class
- Same notation as for structures within structures

Aggregation

```
class StudentInfo
{
   private:
          string firstName, LastName;
          string address, city, state, zip;
  ...
};
class Student
{
   private:
          StudentInfo personalData;
  ...
};
```

See the `Instructor`, `TextBook`, and `Course` classes.



See Program Pr14-15