CSE 230
Intermediate Programming in C and C++
Operator Overloading

Fall 2017

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http://www3.cs.stonybrook.edu/~cse230/

Ref. Book: C How to Program, 8th edition by Deitel and Deitel

Introduction

- How to enable C++'s operators to work with class objects—a process called operator overloading.
- The jobs performed by overloaded operators also can be performed by explicit function calls, but operator notation is often more natural.

General View

- Consider the following examples:

```
Date d;
d.increment();

Bag b;
cout << b.getData(i);
b.setData(i, value);

Matrix x, y, z;
x.add( y );
multiply(x, y, z);
```

General View (cont.)

- How do you prefer the replacements below?

```
Date d;
d.increment();                  d++;

Bag b;
cout << b.getData(i);           cout << b[i];
b.setData(i,value);             b[i] = value;

Matrix x, y, z;
x.add( y );                     x += y;
multiply(x, y, z);              x = y * z;
```

General View (cont.)

- Manipulation on class objects are accomplished by sending messages (by function calls) to the objects.
- Function-call notation is cumbersome for certain kinds of classes, especially mathematical classes.
- It would be nice to use C++'s rich set of built-in operators to specify object manipulation.
- For example, operator << (or >>, +, -, etc.) has several purposes as the stream-insertion and bitwise left-shift.
- Overloaded operators perform operation depending on their context and set of operands.

Fundamentals of Operator Overloading

- Programmers can define user-defined types and use operators with user-defined types.
- New operators can not be created but existing operators may be overloaded, so when they are used with class objects, they have meaning appropriate to the new types.
- This is one of C++'s most powerful features.
- The assignment (=) and address (&) operators may be used with objects of any class without overloading. But they can be overloaded also.
- Programmer must explicitly write operator overloading function to perform a desired operation. These functions may be defined as a member function, **friend**, etc.
- Extreme Misuse is not recommended! (* for addition, + for division, etc.)

Implementation Issues

- When overloading (), [], -> or any other assignment operators, the operator overloading function must be declared as a class member.
- For other operators, the operator overloaded function can be non-member functions.
- When an operator function is a member function, the leftmost (or only) operand must be a class object (or a reference to a class object) of the operator's class.
- If the left operand is an object of a different class or a built-in type, this function must be a non-member.
- The keyword **operator** followed by the operator replaces the name of a function, for example `className::operator =(…)`

Implementation Issues (cont.)

- A unary operator for a class can be overloaded as a class member function with no arguments or as a non-member function with one argument; that argument must be either an object of the class or a reference to an object of the class.
- A binary operator can be overloaded as a class member function with one argument or as a non-member function with two arguments (one of those argument must be either an object of the class or a reference to an object of the class).

Restrictions on Operator Overloading

- Most of the C++ operators can be overloaded
- Following operators are non-overloadable:

  . .* :: ?:

- The precedence of operators cannot be changed by overloading, unless parenthesis is used to force the order.
- The associativity of an operator or the number of operands cannot be changed by overloading.
- It is not possible to create new operators
- The meaning of how an operator works on built-in objects cannot be changed.

Overloading Stream-Insertion & Stream-Extraction

- The stream-insertion and stream-extraction operators can also be overloaded to perform input and output for user-defined types.
- When overloading << and >>, the operator function needs to be as a **friend** (i.e. a non-member function).
- The overloaded << must have a left operand of type **ostream&**(such as **cout**) in the expression **cout << classObject**.
- The overloaded >> must have a left operand of type **istream&**(such as **cin**) in the expression **cin >> classObject**.

Overloading ++ and - -

- Let d be of type Date. The pre-increment expression:

```
++d;
```

- generates the member function call:

```
d.operator++();
```

- whose prototype is:

```
Date& Date::operator++();
```

Overloading ++ and - -

- Let d be of type Date. The post-increment expression:

```
d++;
```

- generates the member function call:

```
d.opeartor++(0);
```

- whose prototype is:

```
Date& Date::operator++(int);
```

- Note that the 0 is strictly a “dummy value” to make the argument list of operator++, used for post-incrementing.

Example of Overloading ++

```
Complex & Complex::operator++( )    // preincrement
{
   real += 1;
   return *this;                    // enables cascading
} // end operator++ function

Complex Complex::operator++(int)  // postincrement
{
   Complex temp = *this;
   real += 1;
   return temp;                     // enables cascading
} // end operator++ function
```

Example of Overloading - -

```
Complex & Complex::operator--( )// predecrement
{
   real -= 1;
   return *this;
} // end operator- function

Complex Complex::operator--(int)//postdecrement
{
   int temp = *this;
   real -= 1;
   return temp;

} // end operator-- function
```

Example of Overloading =

```
Employee & Employee::operator=( const Employee
                                        &right )
{
   if ( right != this ) //check for self-assignment
   {
       strcpy(firstname, right.firstname);
       strcpy(lastname, right.lastname);
   }
   return *this;   // enables cascading
} // end operator= function
```

Converting Between Types

- It is often necessary to convert data of one type to data of another type.
- Certain conversions among built-in types are performed by the compiler. Programmers can force conversions by casting.
- The programmer may specify how to convert among user-defined types and built-in types.
- Such conversions can be performed with *conversion constructors* (or *conversion/cast operator*)- single argument constructors that turn objects of other types (including built-in types) into objects of a particular class.
- A conversion operator must be a non-static class member function (it can't be a **friend** function).

Converting Between Types(cont.)

- The function prototype:

```
A::operator char *() const;
```

- declares an *overloaded cast operator* function for creating a temporary **char** * object out of an object of user-defined type A.
- An overloaded cast operator does not specify a return type- the return type is the type to which the object is being converted.
- If **s** is a class object, when the compiler sees the expression **`(char *)s`**, it generates the call

```
s.operator char *()
```

- Cast operator functions can be defined to convert user-defined types into built-in or other user-defined types.

Converting Between Types(cont.)

- The prototypes:

```
A::operator int() const;
A::operator otherClass() const;
```

- declare functions for converting an object of a user-defined type **A** into an integer and an object of a user-defined type **A** into an object of **otherClass.**
- When necessary, the compiler can call these functions to create temporary objects. For example, if an object **s** of a user-defined **String** class appears in a program at a location where an ordinary **(char *)** is expected, such as

  cout << s;

- the compiler calls the cast operator function. With this cast operator, the stream-insertion should not be overloaded.

Type Conversion

- Implicit conversions can be controlled by means of three member functions:
- **Single-argument constructors:** allow implicit conversion from a particular type to initialize an object.
- **Assignment operator:** allow implicit conversion from a particular type on assignments.
- **Type-cast operator:** allow implicit conversion to a particular type.
- To prohibit implicit type conversion use the keyword *explicit* in front of the constructor.

Copy Constructor

- **What is a copy constructor?**
  - A copy constructor is a member function which initializes an object using another object of the same class.
  - A copy constructor has the following general function prototype:

```
ClassName (const ClassName &old_obj);
```

Copy Constructor (cont.)

- **When is copy constructor called?**
  In C++, a Copy Constructor may be called in following cases:

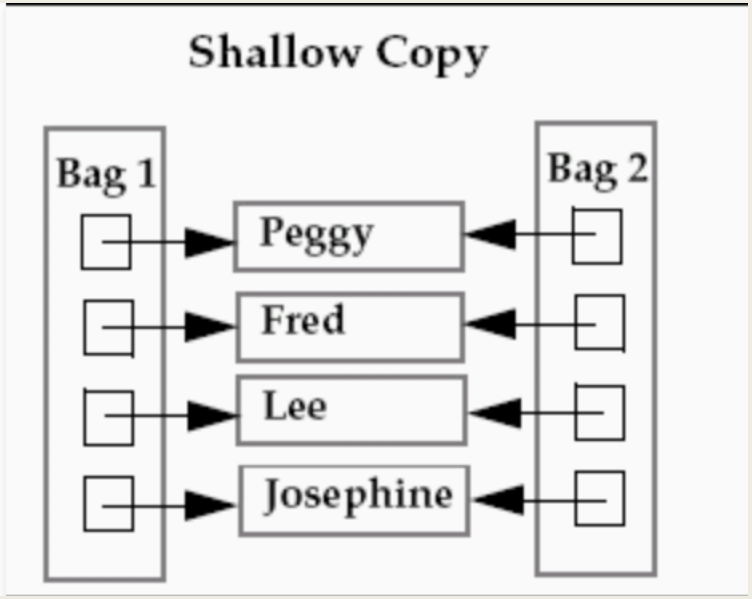
1. When an object of the class is returned by value.
2. When an object of the class is passed (to a function) by value as an argument.
3. When an object is constructed based on another object of the same class.
4. When compiler generates a temporary object.

Copy Constructor (cont.)

- **When is user defined copy constructor needed?**
  - If we don't define our own copy constructor, the C++ compiler creates a default copy constructor for each class which does a member wise copy between objects.
  - We need to define our own copy constructor only if an object has pointers or any run time allocation of resource like file handle, a network connection..etc.

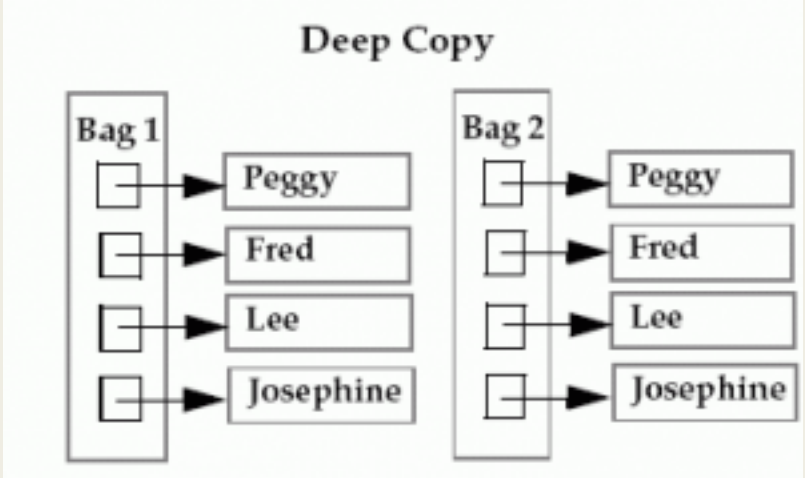
Copy Constructor (cont.)

- *Default constructor does only shallow copy.*



Copy Constructor (cont.)

- ***Deep copy is possible only with user defined copy constructor.***
  - In user defined copy constructor, we make sure that pointers (or references) of copied object point to new memory locations.



Copy constructor vs Assignment Operator

- Which of the following two statements call copy constructor and which one calls assignment operator?

```
MyClass t1, t2;
MyClass t3 = t1; // ----> (1)
t2 = t1; // -----> (2)
```

(1) Copy constructor is called

(2) Assignment