

# ECE2800J

## Programming and Elementary Data Structures

### **Operator Overloading**

#### **Learning Objectives:**

Review and master operator overloading.

Understand what is friendship.

Study some examples of operator overloading, e.g.,  
+, +=, [], <<, >>.

# Operator Overloading

## Introduction

- C++ lets us **redefine** the meaning of the operators when applied to objects of **class type**.
- This is known as **operator overloading**.
- We have already seen the overloading of the assignment operator.
- Operator overloading makes programs much easier to write and read:

```
IntSet is;  
int x = is[5]; // overload [] operator  
                // access the IntSet element by index  
cout << is << endl; // overload << operator  
                      // print all the IntSet elements
```

# Operator Overloading

## Basics

- Overloaded operators are functions with special names: the keyword **operator** followed by the symbol (e.g., +, -, etc.) of the operator being redefined.
- Like any other function, an overloaded operator has a return type and a parameter list.

```
A operator+(const A &l, const A &r);
```

# Operator Overloading

## Basics

- Most overloaded operators may be defined as ordinary **nonmember** functions or as class **member** functions.

```
A operator+(const A &l, const A &r);  
// returns l "+" r
```

```
A A::operator+(const A &r);  
// returns *this "+" r
```

- Overloaded operators that are members of a class may appear to have **one fewer** parameter than the number of operands.
  - Operators that are member functions have an implicit **this** parameter that is bound to the **first operand**.

# Operator Overloading

## Basics

- An overloaded **unary** operator has **no** (explicit) parameter if it is a member function and **one** parameter if it is a nonmember function.
- An overloaded **binary** operator would have **one** parameter when defined as a member and **two** parameters when defined as a nonmember function.

# Example

- Overload **operator+=** for a class of complex number.

```
class Complex {  
    // OVERVIEW: a complex number class  
    double real;  
    double imag;  
  
public:  
    Complex(double r=0, double i=0); // Constructor  
    Complex &operator += (const Complex &o);  
    // MODIFIES: this  
    // EFFECTS: adds this complex number with the  
    // complex number o and return a reference  
    // to the current object.  
};
```

# Example

```
Complex &Complex::operator += (const Complex &o) {  
    real += o.real;  
    imag += o.imag;  
    return *this;  
}
```

# Example

- **operator+=** is a member function.
- We can also define a nonmember function that adds two numbers.

```
Complex operator + (const Complex &o1,  
                     const Complex &o2) {  
  
    Complex rst;  
  
    rst.real = o1.real + o2.real;  
    rst.imag = o1.imag + o2.imag;  
  
    return rst;  
}
```



# What are the issues with the non-member version, if any?

```
Complex operator + (const Complex &o1,  
                     const Complex &o2) {  
    Complex rst;  
    rst.real = o1.real + o2.real;  
    rst.imag = o1.imag + o2.imag;  
    return rst;  
}
```

Select all the correct answers.

- A. Since there's an extra space between operator and +, the code wouldn't compile as is.
- B. The const keyword shouldn't be used here.
- C. The code wouldn't compile as is.
- D. There's no issue.



# Friend

- So, we'll need some other mechanism to make the function as a "**friend**".
- The "friend" declaration allows you to expose the **private** state of one class to another function (and only that function) explicitly.

```
class foo {  
    friend void baz();  
    int f;  
};  
void baz() { ... }
```

The function **baz** has access to **f**, which would otherwise be private to class **foo**.

# Friend

- So, we'll need some other mechanism to make the function as a "**friend**".
- The "friend" declaration allows you to expose the **private** state of one class to another function (and only that function) explicitly.

```
class foo {  
    friend void baz();  
    int f;  
};  
void baz() { ... }
```

**Note:** a friend function is  
**NOT** a member function; it  
is an ordinary function.

**Note:** NOT **void foo::baz() { ... }**

# Friend

- So, we'll need some other mechanism to make the function as a "**friend**".
- The "friend" declaration allows you to expose the **private** state of one class to another function (and only that function) explicitly.

```
class foo {  
    friend void baz();  
    int f;  
};  
void baz() { ... }
```

Note: "friend void  
baz();" goes inside foo. It  
means foo gives friendship to  
function baz().

# Friend

- Besides function, we can also declare a class to be friend.

```
class foo {  
    friend class bar;  
    int f;  
};  
  
class bar {  
    ...  
};
```

Then, objects of class bar  
can access private member f  
of foo.

# Friend

```
class foo {  
    friend class bar;  
    friend void baz();  
    int f;  
};  
class bar { ... };  
void baz() { ... }
```

Friendship of both  
class and function.

- Note: Although “**friendship**” is declared inside **foo, bar** and **baz ()** are not the members of **foo**!
- “**friend**” declaration may appear anywhere in the class.
  - It is a good idea to **group** friend declarations **together** either at the beginning or end of the class definition.

# Example

- In our example of complex number class, we will declare **operator+** as a friend:

```
class Complex {  
    // OVERVIEW: a complex number class  
    double real;  
    double imag;  
  
public:  
    Complex(double r=0, double i=0);  
    Complex &operator += (const Complex &o);  
    friend Complex operator+(const Complex &o1,  
                            const Complex &o2);  
};
```

Its implementation is the same as before.

# Overloading Operator []

- We want to access each individual element in the IntSet through **subscript operator []**, just like how we access an ordinary array.
  - For example, **is [5]** accesses the sixth element in the IntSet **is**.
- We need to overload the **operator []**.
  - It is a binary operator: The first operand is the IntSet object and the second one is the index.

# Overloading Operator []

- We write two versions with bound checking

```
const int &IntSet::operator[](int i) const {  
    if(i >= 0 && i < numElts) return elts[i];  
    else throw -1;  
}
```

const version returning a const reference to int

```
int &IntSet::operator[](int i) {  
    if(i >= 0 && i < numElts) return elts[i];  
    else throw -1;  
}
```

nonconst version returning a reference to int

# Overloading Operator []

- Why we need a nonconst version that returns a reference to int?
  - We need to assign to an element through subscript operation  
**is[5] = 2;**
- Why we need a const version that returns a const reference to int?
  - We may call the subscript operator with some const IntSet objects or within some const member function. Const objects/const member function can only call their const member functions.
  - Furthermore, the return type should be const reference because we cannot use a const object (elts[i] in this case is a const int) to initialize a non-const reference.

# Overloading Output Operator <<

- We want to redefine the **operator<<** for the IntSet class, so that it prints all the elements in the set in sequence.
- Convention of the IO library
  - The **operator<<** should take an **ostream&** as its first parameter and a **const** reference to an object of the class type as its second.

```
os << obj;
```

- The **operator<<** should return a reference to its **ostream parameter**.

```
ostream &operator<<(ostream &os, const IntSet &is) {  
    ...  
    return os;  
}
```

# Overloading Output Operator <<

```
ostream &operator<<(ostream &os, const IntSet &is) {  
    ...  
    return os;  
}
```

- Why should **operator<<** return a reference to its **ostream parameter**?
  - Because **operator<<** can be **chained together**:  
**cout << "hello " << "world!" << endl;**
  - It is equivalent to  
**cout << "hello ";**  
**cout << "world!" ;**  
**cout << endl;**

# Overloading Output Operator <<

- **operator<<** must be a nonmember function!
  - The first operand is not of the class type.
- We can implement **operator<<** as follows

```
ostream &operator<<(ostream &os, const IntSet &is) {  
    for(int i = 0; i < is.size(); i++)  
        os << is[i] << " ";  
    return os;  
}
```

- Now we can write **cout << is << endl;**



# Select all the correct statements

```
ostream &operator<<(ostream &os,
    const IntSet &is) {
    for(int i = 0; i < is.size(); i++)
        os << is[i] << " ";
    return os;
}
```

Select all the correct answers.

- A. In `is[i]`, the `const` version of operator `[ ]` is called.
- B. In `is[i]`, the non-`const` version of operator `[ ]` is called.
- C. Operator `<<` needs to be friend with `IntSet`.
- D. Operator `<<` need not be friend with `IntSet`.



# Overloading Input Operator >>

- Convention of the IO library
  - The **operator>>** should take an **istream&** as its first parameter and a **nonconst** reference to a object of the class type as its second.  
`is >> obj;`  
Question: why nonconst?
  - The **operator>>** should return a reference to its **istream parameter**.  
Question: why returning reference?

```
istream &operator>>(istream &is, foo &obj) {  
    ...  
    return is;  
}
```

# Reference

- **C++ Primer (4<sup>th</sup> Edision)**, by *Stanley Lippman, Josee Lajoie, and Barbara Moo*, Addison Wesley Publishing (2005)
  - Chapter 12.5 Friends
  - Chapter 14 Overloaded Operations and Conversions