

C++ Function and Operator Overloading

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C++ Function Overloading

C++ allows defining same-named functions with different parameters.

- You've already seen some examples.
 - Class constructors.
 - Some STL container's member functions.
- Both regular functions and class member functions can be overloaded.
- Exactly same functions except return types are not allowed.
 - At least one parameter is different, or
 - the const-ness of the class should be different.
- Beware of default parameters, and implicit type casting of parameter values.

C++ Function Overloading Example

```
class MyClass {
public:
    MyClass() : x_(0) {}
    MyClass(const MyClass& c) : x_(c.x_) {}
    explicit MyClass(int x) : x_(x) {} // Prevent implicit type conversion.

    int& x() { return x_; } // Differ in constness.
    const int& x() const { return x_; }

    int DoSomething() { return x_ * x_; }
    double DoSomething(double c) { return c * x_; }
    void DoSomething(double a, double b) { x_ = a * x_ + b; }

    void DoSomething(double a, double b, double c = 0.0); // Error!

private:
    int x_;
};
```

C++ Operator Overloading

C++ even allows redefining built-in operators.

- Operators are just functions in specific forms.

http://en.wikipedia.org/wiki/Operators_in_C_and_C++

```
class A {                                // A a0, a1;
    A& operator =(const A& a);           // a0 = a1;
    A operator +(const A& a) const;     // a0 + a1
    A operator +() const;               // +a0
    A& operator +=(const A& a);          // a0 += a1;
    A& operator ++();                   // ++a0
    A& operator ++(int);                 // a0++
};

A operator +(const A& a0, const A& a1); // a0 + a1
A operator +(const A& a0);              // +a0
A& operator +=(A& a0, const A& a1);     // a0 += a1;
A& operator ++(A& a0);                  // ++a0
A& operator ++(A& a0, int);              // a0++

std::ostream& operator <<(std::ostream& out, const A& a); // cout << a0;
```

C++ Operator Overloading

C++ even allows redefining built-in operators.

- Most commonly overloaded operators are
 - Arithmetic operators : +, -, *, / ...
 - Assignment operators : =, +=, -=, *= ...
 - Comparison operators : <, >, <=, >=, ==, != ...
 - For array or containers : [], () ...
 - Rarely : ->, new, delete, , ...
- Operator overloading must be used very carefully, since it can hamper the readability seriously.

C++ Operator Overloading Example

```
class Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& Copy(const Complex& c) {
        real = c.real, imag = c.imag;
        return *this;
    }
    Complex Add(const Complex& c) const {
        return Complex(real + c.real, imag + c.imag);
    }

private:
    double real, imag;
};

void Test() {
    Complex a(1.0, 2.0), b(2.0, 5.0);
    Complex c(a.Add(b));
    c.Copy(c.Add(a));
}
```

C++ Operator Overloading Example

```
class Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& operator=(const Complex& c) {
        real = c.real, imag = c.imag;
        return *this; // This enables c = a = b;
    }
    Complex operator+(const Complex& c) const {
        return Complex(real + c.real, imag + c.imag);
    }

private:
    double real, imag;
};

void Test() {
    Complex a(1.0, 2.0), b(2.0, 5.0);
    Complex c(a + b);
    c = c + a;
}
```

C++ Operator Overloading

- How can we make the following code to work?

```
class Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& operator=(const Complex& c);
    Complex operator+(const Complex& c) const;

private:
    double real, imag;
};

void Test() {
    Complex a(1.0, 2.0), b(2.0, 5.0), c;
    c = a + b;      // OK.
    c = a + 3.0;    // Error.
    c = 2.0 + b;    // Error.
}
```

- Define operators for all possible parameters?

C++ Operator Overloading

- We can use implicit type conversion.

```
class Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double v) : real(v), imag(0.0) {} // Constructor for a single v.
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& operator=(const Complex& c);
    Complex operator+(const Complex& c) const;

private:
    double real, imag;
};

void Test() {
    Complex a(1.0, 2.0), b(2.0, 5.0), c;
    c = a + b; // OK.
    c = a + 3.0; // OK.
    c = 2.0 + b; // Error.
}
```

- Why the last line of the code still does not work?

C++ Operator Overloading

- Make the operator a non-member function.

```
class Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double v) : real(v), imag(0.0) {} // Constructor for a single v.
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& operator=(const Complex& c);

private:
    double real, imag;
};

Complex operator+(const Complex& lhs, const Complex& rhs) {
    return Complex(lhs.real + rhs.real, lhs.imag + rhs.imag);
}

void Test() {
    Complex a(1.0, 2.0), b(2.0, 5.0), c;
    c = a + b; // OK.
    c = a + 3.0; // Error.
    c = 2.0 + b; // Error, but a different kind.
}
```

C++ Operator Overloading

- Make it to be a ‘friend’ to the class.

```
class Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double v) : real(v), imag(0.0) {} // Constructor for a single v.
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& operator=(const Complex& c);

private:
    double real, imag;
    friend Complex operator+(const Complex& lhs, const Complex& rhs);
};

Complex operator+(const Complex& lhs, const Complex& rhs) {
    return Complex(lhs.real + rhs.real, lhs.imag + rhs.imag);
}

void Test() {
    Complex a(1.0, 2.0), b(2.0, 5.0), c;
    c = a + b;    // OK.
    c = a + 3.0;  // OK.
    c = 2.0 + b;  // OK.
}
```

Friend Class and Function

- Functions or classes can be ‘friends’ of other classes.
 - Declare them as friends in the class definition.
 - Friends can access all members including private members.

```
class ClassA {  
    private:  
        int var_;  
        friend ClassB;  
        friend void DoSomething(const ClassA& a);  
};  
  
class ClassB {  
    // ...  
    void Function(const ClassA& a) { a.var_ = 0; } // OK.  
};  
  
void DoSomething(const ClassA& a) { cout << a.var_; } // OK.
```

```

struct Complex {
public:
    Complex() : real(0.0), imag(0.0) {}
    Complex(double v) : real(v), imag(0.0) {}
    Complex(double r, double i) : real(r), imag(i) {}
    Complex(const Complex& c) : real(c.real), imag(c.imag) {}

    Complex& operator=(const Complex& c) {           // Complex a(1.0, 0.0), c;
        real = c.real, imag = c.imag;              // c = a;
        return *this;
    }

    Complex operator+(const Complex& rhs) const { return *this + rhs; } // c = +a;
    Complex operator-(const Complex& rhs) const { return *this - rhs; } // c = -a;

    double& operator[](int i) { return i == 0 ? real : imag; } // i = c[0];
    const double& operator[](int i) const { return i == 0 ? real : imag; }

private:
    double real, imag;

    friend Complex operator+(const Complex& lhs, const Complex& rhs);
    friend bool operator<(const Complex& lhs, const Complex& rhs);
};

Complex operator+(const Complex& lhs, const Complex& rhs) const { // c + a
    return Complex(lhs.real + rhs.real, lhs.imag + rhs.imag);
}

bool operator<(const Complex& lhs, const Complex& rhs) { // if (c < a)
    return lhs.real < rhs.real && lhs.imag < rhs.imag;
}

```

Other C++ Operators

```
class T {
    // Constructors...

    T operator+() const;           // +t
    T operator-() const;          // -t
    T operator+(const T& a) const; // t + a (t - a, t * a, ...)

    T& operator=(const T& a) { /* ... */ return *this; } // t = a
    T& operator+=(const T& a) { /* ... */ return *this; } // t += a (t -= a ...)

    T& operator++();              // Prefix form: ++a
    T& operator++(int);           // Postfix form: a++

    T& operator[](int i);         // t[i]
    const T& operator[](int i) const; // t[i]
    T& operator()(int i, int j);   // t(i, j)
    const T& operator()(int i, int j) const; // t(i, j)
};

T operator-(const T& a, const T& b); // a - b
bool operator==(const T& a, const T& b); // a == b

ostream& operator<<(ostream& os, const T& a); // cout << a
istream& operator>>(istream& is, T& a) { // cin >> a
    is >> a.member;
    return is;
}
```

Summary

- Operators are just functions.
- Operators and functions can be overloaded.
- Friends can access the private members.