C/C++ Programming Language

CS205 Spring

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Lecture 10

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Content

- Operator Overloading
  - Operator function
  - Friends
  - Overloading the << operator

- Automatic Conversions and Type Casts for Classes
  - Type cast from single augment to an object
    - ✓Implicit constructor
    - ✓Explicit constructor
  - Conversion function

Brief Review

Review

- Objects and classes
  - Two programming styles
  - Classes in C++
  - Access control
  - Function implementations
  - Constructors and destructors
  - This pointer
  - Class scope

Operator Overloading

Overloading

- Function overloading
  - Let you use **multiple** functions sharing the **same** name
  - Relationship to others:
    - ✓ Default arguments
    - ✓ Function templates

- * operator (An operator overloading example)
  - Applied to an address, yield the value stored at that address
  - Applied two numbers, yield the product of the values

Operator Function

- Operator function
  - Keyword: operator for C++
  - To overload an operator, you use a special function
  - Function header has the form:

```
operatorop(argument-list)
```

    - ✓ operator+() overloads the + operator
    - ✓ operator*() overloads the * operator
    - ✓ operator[]() overloads the [] operator
  - The compiler, recognizing the operands as belonging to the class, replaces the operator with the corresponding operator function

Example: Time on Our Hands

- Developing an operator overloading
  - The compiler uses the operand types to figure out what to do

```
int a, b, c;
Time A, B, C;
c = a + b;        // use int addition
C = A + B;        // use addition as defined for Time objects
```

- Run mytime1.h mytime1.cpp usetime1.cpp
  - The name of the operator+() function allows it to be invoked by using either function notation or operator notation
  - Add more than two objects
  - Left-to-right operator

```
t4 = t1 + t2 + t3;                      // valid?

t4 = t1.operator+(t2 + t3);             // valid?

t4 = t1.operator+(t2.operator+(t3));    // valid? YES
```

Overloading Restrictions

- Must have at least one operand that is a user-defined type
- Can't violate the syntax rules for the original operator
- Can't alter operator precedence
- Can't create new operator symbols
- Use only member functions to overload these operators

Operator	Description
=	Assignment operator
()	Function call operator
[]	Subscripting operator
->	Class member access by pointer operator

Overloading Restrictions

- Cannot overload the following operators

Operator	Description
`sizeof`	The `sizeof` operator
`.`	The membership operator
`.*`	The pointer-to-member operator
`::`	The scope-resolution operator
`?:`	The conditional operator
`typeid`	An RTTI operator
`const_cast`	A type cast operator
`dynamic_cast`	A type cast operator
`reinterpret_cast`	A type cast operator
`static_cast`	A type cast operator

Operators That Can Be Overloaded

- Operators that can be overloaded

+	-	*	/	%	^
&	|	~	!	=	<
>	+=	-=	*=	/=	%=
^=	&=	|=	<<	>>	>>=
<<=	==	!=	<=	>=	&&
||	++	--	,	->*	->
()	[]	new	delete	new []	delete []

- Run mytime2.h mytime2.cpp usetime2.cpp
  - More overloaded operators
    - ✓ Subtract one time from another
    - ✓ Multiply a time by a factor

Introducing Friends

- Access control
  - Can access the public portions directly
  - Can access the private members of an object only by using the public member functions
  - Problems:
    - ✓Public class methods serve as the only access
    - ✓This restriction is too rigid to fit particular problems
- C++ provides another form of access: the friend
  - **Friend functions**
  - Friend classes – will be introduced later
  - Friend member functions – will be introduced later

Motivation for Friend Functions

- Problem: overloading a binary operator
  - Left operand is the invoking object
    - ✓ Time Time::operator*(double mult) const
    - ✓ A = B * 2.75; A = B.operator*(2.75);
    - ✓ A = 2.75 * B; // cannot correspond to a member function
- Solution: using a nonmember function
  - A nonmember function is NOT invoked by an object
  - Any values it uses, including objects, are **explicit** arguments
- Problem: ordinary nonmember functions can't directly access private data in a class

Creating Friends

- Making a function a friend to a class
  - Allow the function the same access privileges that a member function of the class has
- First step: place a prototype in the class declaration and prefix the declaration with the keyword: friend

```
friend Time operator*(double m, const Time & t);  // goes in class declaration
```

  - This prototype has three implications
    - ✓Not a member function
    - ✓Isn't invoked by using the membership operator
    - ✓Has the same access rights as a member function

Creating Friends

- The second step is to write the function definition
  - Not a member function you don't use the :: qualifier
  - Don't use the friend keyword in the definition

```
Time operator*(double m, const Time & t)  // friend not used in definition
{
    Time result;
    long totalminutes = t.hours * mult * 60 +t. minutes * mult;
    result.hours = totalminutes / 60;

    result.minutes = totalminutes % 60;
    return result;
}
```

- A friend function to a class is a nonmember function that has the same access rights as a member function

More About Friends

- Summary
  - Only a class declaration can decide which functions are friends, so the class declaration still controls which functions access private data
  - Class methods and friends are simply two different mechanisms for expressing a class interface
  - Overload an operator for a class and use the operator with a nonclass term as the **first** operand
- Uncomment: mytime2.h mytime2.cpp usetime2.cpp

```
Time operator*(double m, const Time & t)
{
    return t * m;      // use t.operator*(m)
}
```

A Common Kind of Friend: Overloading the << Operator

- A question?
  - Suppose trip is a Time object
    - ✓ cout << trip; // make cout recognize Time class?
  - Suppose fun is a function name – a question from one student
    - ✓ cout << "(fun)= " << (void*)fun<< endl; // how about no (void*)

- Heavily overloaded
  - << : bit manipulation operators - shifts bits left in a value
  - << : output tool - recognize all the basic C++ types.

The First Version of Overloading <<

- Use a Time member function to overload <<, the Time object would come first
  - Be confusing
  - The problem is the same to the overloaded * operator

```
trip << cout;    // if operator<<() were a Time member function
```

- Use a friend function to overload the operator:

```
void operator<<(ostream & os, const Time & t)
{
    os << t.hours << " hours, " << t.minutes << " minutes";
}
```

  - Enable to have the original syntax of cout

```
cout << trip;
```

The Second Version of Overloading <<

- Consider the example:
  - Read the output statement from left to right
  - Return a reference to the invoking object—cout

```
int x = 5;
int y = 8;
cout << x << y;
```

```
(cout << x) << y;
```

cout

- Problem:

```
cout << "Trip time: " << trip << " (Tuesday)\n"; // can't do
```

- Return a reference to an ostream object
- Run mytime3.h mytime3.cpp usetime3.cpp

```
ostream & operator<<(ostream & os, const Time & t)
{
    os << t.hours << " hours, " << t.minutes << " minutes";
    return os;
}
```

Overloaded Operators: Member Versus Nonmember Functions

- Have a choice between using member functions or nonmember functions to implement operator overloading
  - One: has the prototype in the Time class declaration
    - ✓One operand is passed implicitly via the this pointer

```
Time operator+(const Time & t) const; // member version
```

  - Two: use the prototype with keyword: friend

```
// nonmember version
friend Time operator+(const Time & t1, const Time & t2);
```

  - Compiler can convert the statement

```
T1 = T2 + T3;
```

```
T1 = T2.operator+(T3);     // member function
T1 = operator+(T2, T3);    // nonmember function
```

  - Must choose **one form**

Automatic Conversions and Type Casts for Classes

Conversions for Built-in Types

- Generate numeric type conversions

```
long count = 8;       // int value 8 converted to type long
double time = 11;     // int value 11 converted to type double
int side = 3.33;      // double value 3.33 converted to type int 3
```

  - Recognize that the diverse numeric types all represent the same basic thing—a number
  - Incorporate built-in rules for making the conversions

- Does not automatically convert types that are not compatible

```
int * p = 10;   // type clash

int * p = (int *) 10;   // ok, p and (int *) 10 both pointers
```

Define a class related to a basic type or to another class

- See stonewt.h
  - Have three constructors
  - Write code like the following

```
Stonewt blossem(132.5);    // weight = 132.5 pounds
Stonewt buttercup(10, 2); // weight = 10 stone, 2 pounds
Stonewt bubbles;           // weight = default value
```

```
Stonewt myCat;        // create a Stonewt object
myCat = 19.6;         // use Stonewt(double) to convert 19.6 to Stonewt
```

✓Implicit conversion: happen automatically, no need explicit type cast

✓Provided a default value for the second parameter

```
Stonewt(int stn, double lbs);  // not a conversion function
```

```
Stonewt(int stn, double lbs = 0);  // int-to-Stonewt conversion
```

✓Explicit conversions: turn off the automatic aspect (keyword: explicit)

```
explicit Stonewt(double lbs);    // no implicit conversions allowed
Stonewt myCat;           // create a Stonewt object
myCat = 19.6;            // not valid if Stonewt(double) is declared as explicit
mycat = Stonewt(19.6);   // ok, an explicit conversion
mycat = (Stonewt) 19.6; // ok, old form for explicit typecast
```

When does the compiler use the Stonewt(double) function?

- Argument-matching process provided by function prototyping
  - If the explicit is used in the declaration, Stonewt(double) is used only for an explicit type cast
  - Otherwise, it is used for the following implicit conversions, when
    - ✓ **initialize** a Stonewt object to a type double value
    - ✓ **assign** a type double value to a Stonewt object
    - ✓ **pass** a type double value to a function that expects a Stonewt argument
    - ✓ a function that's declared to return a Stonewt value tries to **return** a double value
    - ✓ any of the preceding situations use a built-in type that can unambiguously be **converted** to type double
- Only a constructor that can be used with just one argument works as a conversion function

Conversion Functions

- Question: Can we do the reverse?

```
Stonewt wolfe(285.7);
double host = wolfe;   // ?? possible ??
```

- Yes, conversion function
  - User-defined type casts

```
Stonewt wolfe(285.7);
double host = double (wolfe);      // syntax #1
double thinker = (double) wolfe;   // syntax #2
```

  - Use a conversion function in this form

```
operator typeName();
```

    - ✓ Must be a class method
    - ✓ Must not specify a return type
    - ✓ Must have no arguments

```
Stonewt::operator double()const
{
    return pounds;
}
```

No return type but has return value

Applying Type Conversions Automatically

- Problem: when omit the explicit type cast

```
Stonewt poppins(9,2.8);
```

```
cout << "Poppins: " << int (poppins) << " pounds.\n";
cout << "Poppins: " << poppins << " pounds.\n";

long gone = poppins;    // ambiguous
```

  - The compiler complains about using an ambiguous conversion
  - The class has defined two (double and int) conversion functions
- Use an explicit type cast, when the class defines two or more conversions

```
long gone = (double) poppins;  // use double conversion
long gone = int (poppins);     // use int conversion
```

Solutions and Summary

- Solutions
  - Declare a conversion operator as explicit

```
class Stonewt
{
...
// conversion functions
    explicit operator int() const;
    explicit operator double() const;
};
```

  - Replace a conversion function with a nonconversion function

```
Stonewt::operator int() { return int (pounds + 0.5); }
```

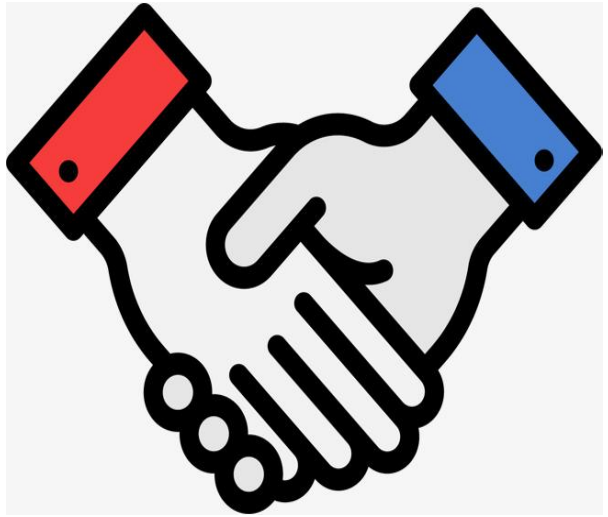
```
int Stonewt::Stone_to_Int() { return int (pounds + 0.5); }
```

- Summary
  - A class constructor that has but a single argument serves as an instruction for converting a value of the argument type to the class type
  - Conversion function serves as an instruction for converting a class object to some other types

Summary

- Operator Overloading
  - Operator function
  - Friends
  - Example: overloading the << operator

- Automatic Conversions and Type Casts for Classes (=)
  - Type cast from single augment to an object
    - ✓Implicit constructor
    - ✓Explicit constructor
  - Conversion function



Thanks

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