

# Operator Overloading

- Most programmers **implicitly** use **overload** operators regularly. For example, the addition operator (+) operates quite differently on integers, floats and doubles.
- Can only add user-defined operand types (i.e., the class that you have created) to existing operators, cannot add **new operators** to the existing systems.

# Operator Overloading (2)

- The **number of operands** that an operator takes cannot be altered.
- Cannot redefine the way that basic operations work, should act (and have the **semantics**) as much like the equivalent C operators as possible.
- Cannot change the **precedence** level or **associativity** of an operator.

# Operator Overloading (3)

- Operator functions may not have default parameters.
- Can overload everything but  
.    ::    ?:    sizeof

# Operator Overloaded Definitions

There are two approaches:

- Overloaded by class member functions.
- Using "friend".

# Defined by Member Functions

- When an operator function is implemented as 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.

# Defined by Member Functions (2)

- **Unary** operations:  
the left operand, or the only operand in unary operator overloads, is replaced by "**this**" pointer, so is **not** listed in the operator overload function's argument list.
- E.g., the following overloads **unary minus**,  
***some\_class operator-(void);***  
***some\_class obj;***  
***-obj;***

# Defined by Member Functions (3)

- **Binary** operators:
  1. ***some\_class operator-(some\_class &r);***  
***some\_class x, y;***  
***x - y;***
  2. ***some\_class operator-(int r);***  
***some\_class x;***  
***x - 1; // 1 - x; ??***
- The compiler tells which is which by checking the arguments in the definition.

# Defined by Member Functions (4)

- In a general case, at least one operand of the function must be a user-defined type – needs other approaches.

For example,

***some\_class operator-(some\_class left, int right);***  
***some\_class operator-(int left, some\_class right);***



# Defined using “friend”

- If the **left** operand must be an object of a different class, this operator function must be implemented as a non-member function using “**friend**”.
- A friend function does not have a “this” pointer.

# Defined using “friend” (cont)

- Using friend operator function, you can allow objects to be used in operations involving built-in types where the built-in type is on the left side of the operator.

For example,

***friend some\_class operator-(int left, some\_class right);***

***some\_class obj;***

***1 - obj;***

# Operator++()

- There is no way to determine whether an overloaded ++ or -- preceded or followed its operand as in operator++().

```
some_class operator++();  
++obj;
```

```
some_class operator++(int x)  
obj++;
```

in this case, x will be passed the value 0.

- ***some\_class& operator++()*** {  
    ***\*this += 1;***           // increment  
    ***return \*this;***        // fetch  
}
- ***const some\_class operator++(int)*** { // silently pass 0  
    ***some\_class oldValue = \*this;***    // fetch  
    ***++(\*this);***                    // increment  
    ***return oldValue;***  
}

# A Closer Look at Assignment Operator

- **Cannot** use “friend” to overload assignment operator.
- It takes a **reference** parameter to prevent a **copy** of the object on the right side of the assignment.
- It returns a **reference**, not an object.

- Assignment(=) operator is a special operator that will be provided by the constructor to the class when programmer has not provided (overloaded) as member of the class (like copy constructor).
- When programmer is overloading = operator using friend function, two = operations will exist:
  - 1) compiler is providing = operator
  - 2) programmer is providing (overloading) = operator by friend function.
- Then simply ambiguity will be created and compiler will give error. It's a compilation error.

# Type Conversion

- *class some\_class {  
    operator int () {};*      // convert some\_class to int  
    *operator char \*() {};*    // convert some\_class to char \*  
}
- Takes **no** argument.
- Specifies **no** return type.

# Case Study: an Array Class

```
class Array {
```

```
    friend istream & operator>>( istream & , Array & );
```

```
    friend ostream & operator<<( ostream & , const Array & );
```

```
private:
```

```
    int size;    // size of the array
```

```
    int *ptr;    // pointer to the first element of the array
```

```
    static int arrayCount;           // # of Arrays instantiated
```

```
    // int Array::arrayCount = 0;    // initialize static member
```



# Array Class (2)

***Array( int = 10 );***      // default constructor

***Array( const Array & );***      // copy constructor

***// Array( const Array &init ) : size( init.size ) {***

# Array Class (3)

```
const Array & operator=( const Array & right );    // assign array
// if ( &right == this ) return *this;           // check for self-assignment
//
// for array of different sizes, deallocate original
// left side array, then allocate new left side array.
//
// if ( size != right.size ) {
//     delete [size] ptr;
//     size = right.size;
//     ptr = new int [size];
// }
// for (int i = 0; i < size; i++)
//     ptr[i] = right.ptr[i];
//
// return *this;           // enables x = y = z;
```

# Array Class (4)

***bool operator==( **const** Array & ) **const**;*** // compare equal

// Determine if two arrays are not equal and return true,

// otherwise return false (uses operator ==).

***bool operator!=( **const** Array &*right* ) **const*****  
***{ return ! ( \**this* == *right* ); }***

// reference return creates an lvalue

***int & operator[] ( int subscript );*** // subscript operator

***// assert ( 0 <= subscript && subscript < size );***

***// return ptr[subscript];***

// const reference return creates an rvalue

***const int & operator[] ( int ) **const**;***

- **int & operator[]( int subscript );**  
// The non-const version allows for l-value assignment with  
// non-const objects.
- **const int & operator[]( int ) const;**  
// The const version allows for r-value usage with const objects.

```
const Array ca;           // ca is a const Array
```

```
Array nca;                // nca is a non-const Array
```

```
ca[0];                    // uses the 'const' version
```

```
nca[0];                   // uses the 'non-const' version
```

```
ca[0] = 5;                // ERROR - const version returns a const reference...  
                           // cannot assign to a const reference
```

```
foo = ca[0];              // OK
```

```
nca[0] = 5;               // OK - non-const version allows assignment
```

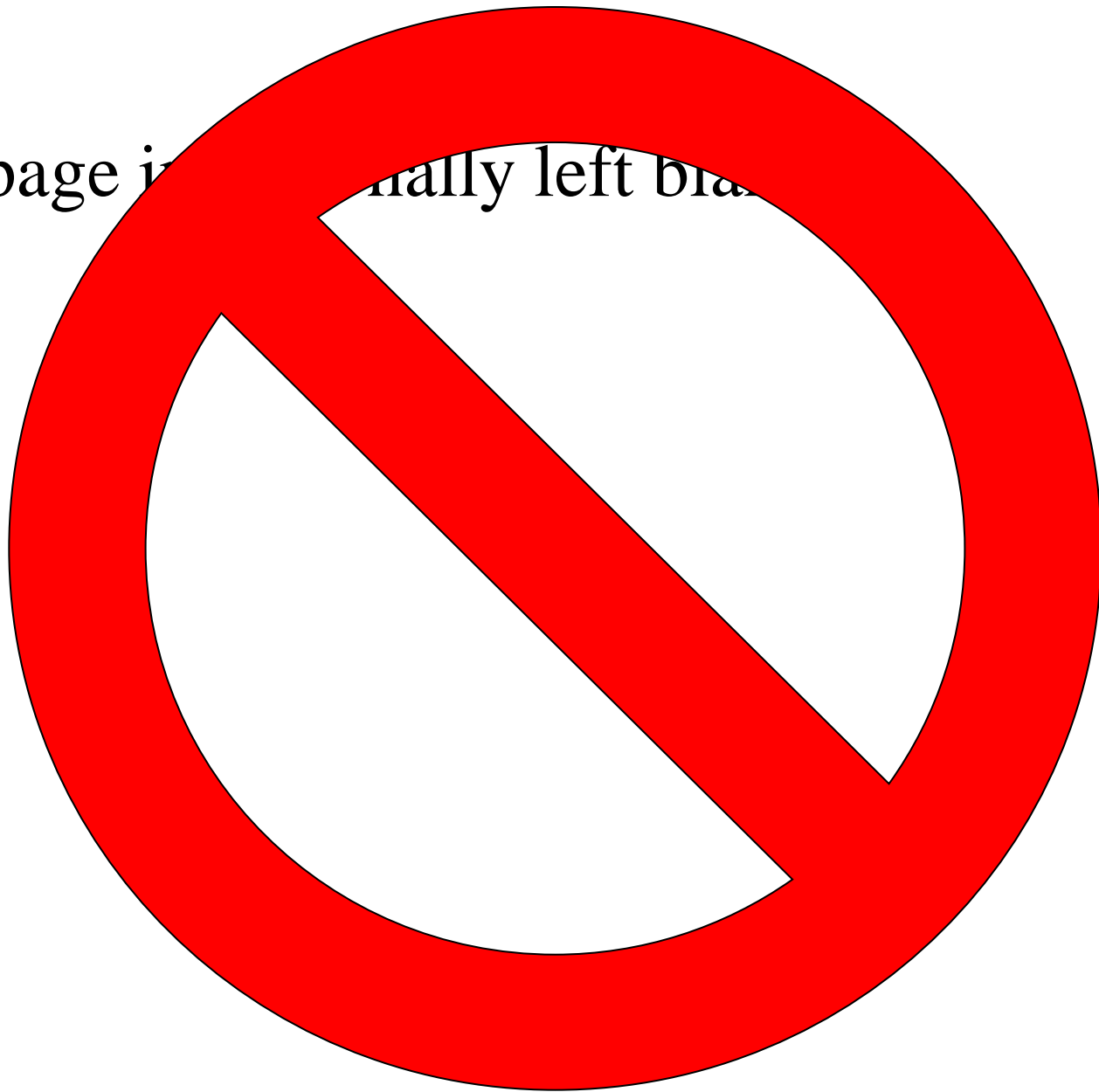
```
foo = nca[0];             // also OK
```

# String Class

```
class String {  
    operator char *() const; // cast operator  
    const String & operator+=( const String & );  
    // concatenation  
    String operator()( int index, int subLength );  
    // return a substring
```

避免像(s1+=s2)+=s3

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# Chapter 8 - Operator Overloading

## Outline

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- 8.11 Overloading `++` and `--`
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## 8.1 Introduction

- Operator overloading
  - Using traditional operators with user-defined objects
  - Requires great care; when overloading is misused, program difficult to understand
  - Examples of **already overloaded** operators
    - Operator **<<** is both the stream-insertion operator and the bitwise left-shift operator
    - **+** and **-**, perform arithmetic on multiple types





## 8.2 Fundamentals of Operator Overloading

- Overloading an operator
  - Write function definition as normal
  - Function name is keyword **operator** followed by the symbol for the operator being overloaded
  - **operator+** used to overload the addition operator (+)



## 8.3 Restrictions on Operator Overloading

- C++ operators that can be overloaded

Operators that can be overloaded							
+	-	*	/	%	^	&	
~	!	=	<	>	+=	-=	*=
/=	%=	^=	&=	=	<<	>>	>>=
<<=	==	!=	<=	>=	&&		++
--	->*	,	->	[]	()	new	delete
new[]	delete[]						

- C++ Operators that **cannot** be overloaded

Operators that cannot be overloaded				
.	.*	::	?:	sizeof



## 8.3 Restrictions on Operator Overloading

- Overloading restrictions
  - Precedence of an operator cannot be changed
  - Associativity of an operator cannot be changed
  - Arity (number of operands) cannot be changed
    - Unary operators remain unary, and binary operators remain binary
    - Operators `&`, `*`, `+` and `-` each have unary and binary versions
    - Unary and binary versions can be overloaded separately
- No new operators can be created
  - Use only existing operators
- No overloading operators for built-in types
  - Cannot change how two integers are added
  - Produces a syntax error



## 8.4 Operator Functions as Class Members vs. as friend Functions

- Member vs non-member
  - Operator functions can be member or non-member functions
  - When overloading ( ), [ ], -> or any of the assignment operators, must use a member function
- Operator functions as member functions
  - Leftmost operand must be an object (or reference to an object) of the class
    - If left operand of a different type, operator function must be a non-member function
- Operator functions as non-member functions
  - Must be **friends** if needs to access private or protected members
  - Enable the operator to be commutative



## 8.5 Overloading Stream-Insertion and Stream-Extraction Operators

- Overloaded << and >> operators
  - Overloaded to perform input/output for user-defined types
  - Left operand of types **ostream &** and **istream &**
  - Must be a non-member function because left operand is not an object of the class
  - Must be a **friend** function to access private data members



## 8.6 Overloading Unary Operators

- Overloading unary operators
  - Can be overloaded with no arguments or one argument
  - Example declaration as a member function:

```
class String {  
public:  
    bool operator!() const;  
    ...  
};
```



## 8.6 Overloading Unary Operators

- Example declaration as a non-member function

```
class String {  
    friend bool operator!( const String & )  
    ...  
}
```



## 8.7 Overloading Binary Operators

- Overloaded Binary operators
  - Non-static member function, one argument
  - Example:

```
class String {  
public:  
    const String &operator+=(  
        const String & );  
    ...  
};
```

`y += z` is equivalent to `y.operator+=( z )`





## 8.7 Overloading Binary Operators

- Non-member function, two arguments
- Example:

```
class String {  
    friend const String &operator+=(  
        String &, const String & );  
    ...  
};  
  
y += z is equivalent to operator+=( y, z )
```



## 8.8 Case Study: An Array class

- Implement an **Array** class with
  - Range checking
  - Array assignment
  - Arrays that know their size
  - Outputting/inputting entire arrays with << and >>
  - Array comparisons with == and !=

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## 1. Class definition

### 1.1 Function prototypes

```

1 // Fig. 8.4: array1.h
2 // Simple class Array (for integers)
3 #ifndef ARRAY1_H
4 #define ARRAY1_H
5
6 #include <iostream>
7
8 using std::ostream;
9 using std::istream;
10
11 class Array {
12     friend ostream &operator<<( ostream &, const Array & );
13     friend istream &operator>>( istream &, Array & );
14 public:
15     Array( int = 10 );           // default constructor
16     Array( const Array & );     // copy constructor
17     ~Array();                   // destructor
18     int getSize() const;        // return size
19     const Array &operator=( const Array & ); // assign arrays
20     bool operator==( const Array & ) const; // compare equal
21
22     // Determine if two arrays are not equal and
23     // return true, otherwise return false (uses operator==).
24     bool operator!=( const Array &right ) const
25     { return ! ( *this == right ); }
26
27     int &operator[]( int );      // subscript operator
28     const int &operator[]( int ) const; // subscript operator
29     static int getArrayCount(); // Return count of
30                                // arrays instantiated.
31 private:
32     int size; // size of the array
33     int *ptr; // pointer to first element of array
34     static int arrayCount; // # of Arrays instantiated

```

Notice all the overloaded operators used to implement the class.

## 8.9 Converting between Types

- Cast operator
  - Conversion operator must be a **non-static** member function
  - Cannot be a **friend** function
  - Do **not** specify return type
    - Return type is the type to which the object is being converted
  - For user-defined class **A**
    - A::operator char \*() const;**
      - Declares an overloaded cast operator function for creating a **char \*** out of an **A** object



## 8.9 Converting between Types

**A::operator int() const;**

- Declares an overloaded cast operator function for converting an object of **A** into an integer

**A::operator otherClass() const;**

- Declares an overloaded cast operator function for converting an object of **A** into an object of **otherClass**



## 8.10 Case Study: A `string` Class

- Build a class to handle strings
  - Class **`string`** in standard library
- Conversion constructor
  - Single-argument constructors that turn objects of other types into class objects





## 1. Class definition

### 1.1 Member functions, some definitions

```
1 // Fig. 8.5: String1.h
2 // Definition of a String class
3 #ifndef STRING1_H
4 #define STRING1_H
5
6 #include <iostream>
7
8 using std::ostream;
9 using std::istream;
10
11 class String {
12     friend ostream &operator<<( ostream &, const String & );
13     friend istream &operator>>( istream &, String & );
14
15 public:
16     String( const char * = "" ); // conversion/default ctor
17     String( const String & );    // copy constructor
18     ~String();                  // destructor
19     const String &operator=( const String & ); // assignment
20     const String &operator+=( const String & ); // concatenation
21     bool operator!() const;      // is String empty?
22     bool operator==( const String & ) const; // test s1 == s2
23     bool operator<( const String & ) const;  // test s1 < s2
24
25     // test s1 != s2
26     bool operator!=( const String & right ) const
27     { return !( *this == right ); }
28
29     // test s1 > s2
30     bool operator>( const String &right ) const
31     { return right < *this; }
32
33     // test s1 <= s2
```



## 1.2 Member variables

```
34  bool operator<=( const String &right ) const
35      { return !( right < *this ); }
36
37  // test s1 >= s2
38  bool operator>=( const String &right ) const
39      { return !( *this < right ); }
40
41  char &operator[]( int );           // subscript operator
42  const char &operator[]( int ) const; // subscript operator
43  String operator()( int, int );     // return a substring
44  int getLength() const;             // return string length
45
46 private:
47     int length;                     // string length
48     char *sPtr;                     // pointer to start of string
49
50     void setString( const char * ); // utility function
51 };
52
53 #endif
54 // Fig. 8.5: string1.cpp
55 // Member function definitions for class String
56 #include <iostream>
57
58 using std::cout;
59 using std::endl;
60
61 #include <iomanip>
62
63 using std::setw;
64
```



## 8.11 Overloading ++ and --

- Pre/post incrementing/decrementing operators
  - Allowed to be overloaded
  - Distinguishing between pre and post operators
    - prefix versions are overloaded the same as other prefix unary operators

```
d1.operator++( );           // for ++d1
```

- convention adopted that when compiler sees postincrementing expression, it will generate the member-function call

```
d1.operator++( 0 );        // for d1++
```

- 0 is a dummy value to make the argument list of **operator++** distinguishable from the argument list for **++operator**

