OPERATOR OVERLOADING

CS A250 – C++ Programming II

FUNCTION VS. OPERATOR OVERLOADING

- Do not confuse
  - **Function overloading**
    - **Functions** that have same name
  - **Operator overloading**
    - Customizing an **operator** to make it work with a class you implemented.

OVERLOADING FUNCTIONS

- ***Same*** function name

- ***Different*** parameter lists

- Two ***separate*** function definitions

- Function "**signature**"
  - Function **name** & **parameter list**
  - Must be "unique" for each function definition

- Allows same task performed on different data

OVERLOADING EXAMPLE: AVERAGE

- Function computes average of 2 numbers:

```
double average(double n1, double n2)
{
        return ((n1 + n2) / 2.0);
}
```

- Now compute average of 3 numbers:

```
double average(double n1, double n2, double n3)
{
        return ((n1 + n2 + n3) / 3.0);
}
```

- Same name, two functions

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OVERLOADING EXAMPLE (CONT.)

- Which function gets called?

- Depends on function call itself:

    - **avg = average(5.2, 6.7);**
        - Calls **two-parameter** **average()**

    - **avg = average(6.5, 8.5, 4.2);**
        - Calls **three-parameter** **average()**

- Compiler resolves invocation based on **signature** of function call
    - "Matches" call with appropriate function
    - Each considered separate function

MEMBER VS. NON-MEMBER FUNCTIONS

- A **member** function
  - Belongs to a **class**
  - Can access **private member variables** *directly*
  - **NO** need to use accessor functions to access its own private member variables.

- A **non-member** function
  - Does **NOT** belong to a **class**
  - **Cannot** access private member variables directly
  - **Must** use **accessor functions** to access **private member variables** of a class.

FRIEND FUNCTIONS

- A **friend** function
  - Is a <u>**non-member**</u> function
    - **BUT** has access to *all* the members (**public** and **private**) of the class where the function is declared.

- The word *friend*
  - Is added <u>*only*</u> in the **function declaration**
  - Is written <u>*inside*</u> the **class definition**, typically <u>*before*</u> the **public declaration**

- Important for **overloading operators**

TYPES OF FUNCTIONS (SUMMARY)

- **Member functions**
  - Member of a **class**
  - Can access *private member variables* **directly**

- **Friend function**
  - **Not** a member of a class
  - Can access *private member variables* **directly**

- **Non-member function**
  - **Cannot** access private member variables
  - Need to use *accessor* *functions*

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REVIEW: CONST FUNCTIONS

- When to make function **const**?
  - Constant functions ***not*** allowed to alter class member variables
  - Constant objects can **ONLY** call constant member functions

- **Good style** dictates:
  - Any **member function** that will NOT modify data should be made **const**

- Use keyword **const** *after* function declaration and heading

OPERATOR OVERLOADING

- We use **operators** such as +, -, %, ==, etc.
  - These are just *functions*:

```
int n = x + 7;      // all the same
int n = add(x,7);
int n = +(x,7);
```

  - where "**+**" is the ***binary operator*** with
    x and **7** as ***operands***
      OR
  - "**+**" is the ***function name***
  - **x** and **7** are the ***arguments***
  - Function "**+**" ***returns*** "sum" of its arguments

OPERATOR OVERLOADING (CONT.)

- We can **overload operators** to work with **OUR** types
  - The class **Pair** creates objects that contain two integers
  - We create two objects of the class **Pair**

```
Pair p1(1,20), p2(3,40);
```

  - We would like to check if they are **equal**

```
if (p1.getFirst() == p2.getFirst() &&
      p1.getSecond() == p2.getSecond())
{
    // do something…
}
```

OPERATOR OVERLOADING (CONT.)

- If we **overload** the **comparison operator** **==** then our statement can be simplified to:

```
if ( p1 == p2 )
{
    // do something…
}
```

- Obviously, without overloading the comparison operator, the statement above will produce an error.

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OVERLOADING OPERATOR ==

```
if ( p1 == p2 )
```

- We could produce the same results with a function **equal**:

```
if ( p1.equal(p2))
```

OVERLOADING OPERATOR == (CONT.)

```
if ( p1.equal(p2))
```

- You implement the function as follows:

```
bool Pair::equal(const Pair& otherPair) const
{
    return ( first == otherPair.first &&
             second == otherPair.second );
}
```

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OVERLOADING OPERATOR == (CONT.)

- To **overload** the **operator ==**, simply change the **name** of the function:

```cpp
bool Pair::operator==(const Pair& otherPair) const
{
    return ( first == otherPair.first &&
             second == otherPair.second );
}
```

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WHICH OPERATORS CAN BE OVERLOADED?

- **Built-in** operators
  - **+, -, = , %, ==, /, *** (and more)
  - Already work for C++ built-in types

- Both **binary** and **unary** operators can be overloaded
  - Binary has 2 operands   →   3 + 4
  - Unary has 1 operand   →   ++3

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OVERLOADING THE SUBSCRIPT OPERATOR [ ]

- The **subscript operator [ ]** can also be overloaded
  - **Must** be a **member** function

```
List myList;
myList.addElement(10);
myList.addElement(20);
myList.addElement(30);

cout << myList [1];   // would not work
       if //operator [] is not overloaded
```

Note that the class **List** is an **abstract class**—it could be implemented as a linked list, as a vector, as an array, etc.

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OVERLOADING OPERATOR **+**

- The next slides show an example of overloading the **operator +** of the **Pair** class as a **member**, as a **friend**, and as a **non-member** function.

- **NOTE** that the **operator +** for the **Pair** class should be overloaded as a **member function** and **not** as a friend or a non-member function

  - **BUT** the idea is to show the *differences* in implementation.

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OVERLOADING OPERATOR **+** (CONT.)

- We will consider three different functions:
  - **memberPlus**

    - A **member** function of the class **Pair**

  - **friendPlus**

    - A **friend** function of the class **Pair**

  - **nonMemberPlus**

    - A **non-member** function
    - Would be implemented outside the class **Pair**

OVERLOADING OPERATOR + (CONT.)

- Create the objects and call each functions

```
Pair p1(10,11), p2(20,22);
Pair p3, p4, p5;

p3 = p1.memberPlus(p2);
p4 = friendPlus(p1,p2);
p5 = nonMemberPlus(p1,p2);
```

All three functions produce the **same** result.

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OVERLOADING OPERATOR + (CONT.)

Declarations

```
    Pair operator+( const Pair& p2 ) const;
```

Member

```
    friend Pair operator+( const Pair& p1,
                                const Pair& p2 );
```

Friend

```
    Pair operator+( const Pair& p1,
                        const Pair& p2 );
```

Non-member

OVERLOADING OPERATOR + (CONT.)

Definition as a member function

*A **member** function has a **calling object** and passes **only** the second pair as a parameter.*

```
Pair Pair::operator+(const Pair& otherPair) const
{
        //construct the object
    Pair tempPair (first + otherPair.first,
                        second + otherPair.second);


        // return the object
    return tempPair;
}
```

*A **member** function has **direct** access to member variables.*

OVERLOADING OPERATOR **+** (CONT.)

Definition as a friend function

A friend function is NOT a member of the class; therefore, it does not have a calling object and needs to pass both pairs.

```
Pair operator+(const Pair& leftPair,
                  const Pair& rightPair)
{
      //construct the object
    Pair tempPair (leftPair.first + rightPair.first,
            leftPair.second + rightPair.second);

      // return the object
    return tempPair;
}
```

A friend function has direct access to member variables.

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OVERLOADING OPERATOR **+** (CONT.)

Definition as a non-member function

*A **non-member function** does **not** have a calling object, because it is **not** a member of the class, and needs to pass both pairs.*

```cpp
Pair operator+(const Pair& leftPair,
                   const Pair& rightPair)
{
    //construct the object
    Pair tempPair (leftPair.getFirst() +
                        rightPair.getFirst(),
            leftPair.getSecond() +
                        rightPair.getSecond());
    // return the object
    return tempPair;
}
```

*A **non-member** function needs to use the **accessor functions** to get the values of objects.*

OVERLOADING OPERATOR **+** (CONT.)

Function call

It is the **same** for member, friend, and non-member function:

```
Pair p1(1,2);

Pair p2(3,4);

Pair p3 = p1 + p2;
```

Member

```
Pair p3 = p1 + p2;


    p1 is the calling object

    p2 is the parameter

    p3 is the return value
```

OVERLOADING OPERATOR **+** (CONT.)

Function call

It is the **same** for member, friend, and non-member function:

```
Pair p1(1,2);

Pair p2(3,4);

Pair p3 = p1 + p2;
```

Friend

```
Pair p3 = p1 + p2;


    p1 is the parameter

    p2 is the parameter

    p3 is the return value
```

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OVERLOADING OPERATOR + (CONT.)

Function call

It is the **same** for member, friend, and non-member function:

```
Pair p1(1,2);

Pair p2(3,4);

Pair p3 = p1 + p2;
```

Non-member

```
Pair p3 = p1 + p2;


    p1 is the parameter

    p2 is the parameter

    p3 is the return value
```

OVERLOADING OPERATOR + (CONT.)

- Keep in mind:
  - The **operator +** should be overloaded as a **member function.**
  - The previous examples were created to show you the differences in implementation.

OVERLOADING << AND >>

- Enables **input** and **output** of objects
  - **<<** **insertion** operator
  - **>>** **extraction** operator

- Improves *readability*
  - Like all operator overloads do

```
cout << myObject;
cin >> myObject;
```

  - Instead of:

```
myObject.print();
```

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OVERLOADING << AND >> (CONT.)

- The function that overloads the insertion or the extraction operator **must** be a <u>**non**</u>-**member** function

```
Pair p1(1,20);
cout << p1;
```

- **Why?** Because the **leftmost** operand (that is, **cout**) is an object of the type **ostream** and **not** of the type **Pair**

- To have *direct* **access** to **private** member variables we use a **friend** function

OVERLOADING << AND >> (CONT.)

- Place the declaration **inside** the class definition and *before* the `public:` section

```cpp
friend ostream& operator<<(ostream& out, const Pair& p);
```

- Place the definition in the **cpp** file **without** using the **class name** and **scope resolution**

```cpp
ostream& operator<<(ostream& out, const Pair& p)
{
  out << "(" << p.first << "," << p.second << ")";
  return out;
}
```

A FEW RULES AND EXCEPTIONS

- When overloading an operator:
  - At least **one parameter** must be of **class type**
  - You **cannot** create a new operator
  - You **cannot** change the number of arguments an operator has

- **Cannot** overload
  - The dot operator (.)
  - Scope resolution (::)
  - Conditional operator (**?** :)

A Few Rules and Exceptions (cont.)

- Do *not* overload **&&** and **||**

- Only **member** functions can overload these operators

$$( ) \quad [\quad] \quad -> \quad =$$

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A Few Rules and Exceptions (cont.)

- If the *leftmost* **operand** is

  - An object of a **different type** from the class
    - The function that overloads the operator must be a **non-member**
    - Create a **friend** function instead
    - As seen with **cout**

  - An object of the **same type** of the class
    - The function that overloads the operator **must** be a **member**

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A FEW RULES AND EXCEPTIONS (CONT.)

- Overloading **increment** and **decrement operators**
  - Need 2 versions
    - **Prefix** notation: `++n`
    - **Postfix** notation: `n++`

- Overloading the **assignment operator =**
  - Automatically overloaded
  - **BUT**, need to write your own if using **pointers**

  (These operators will be addressed next time)

OPERATOR OVERLOADING (END)

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