C++ Classes and Objects

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Object-Oriented Programming Concepts

- When you are given a problem description:
  - Instead of asking: "how the problem will be divided into functions" , ask "how it will be divided into objects"
- Real-world object
  - Attributes
  - abilities (responsibilities)
- Programming object
  - Data
  - Functions

Classes and Objects

- Class is a new data type used to define objects
  - serve as a plan or a template
  - specifies data and functions included in objects
  - only a description of similar objects
  - a class declaration does not create objects
- Objects are instances of classes

Class and Object Example

- A model (class) to define points in a graphics program
  - Points on a plane must have two properties (states)
    - x and y coordinates (int variables)
- Points should have the following abilities
  - Points can move on the plane:
    - move function
  - Points can show their coordinates on the screen
    - print function
  - Points can state whether they are on the zero point (0,0)
    - is_zero functiom

Class Declaration: Example

```
class Point {          // Declaration of Point Class
   int x,y;            // Attribute: x and y coordinates    Attributes
   public:             // We will discuss it later
   void move(int, int);// A function to move the points     Behavior
   void print();       // to print the coordinates on the screen
   bool is_zero();     // is the point on the zero point(0,0)
};
```

- In the class declaration, first data and function prototypes are written, the reverse order is also possible.
- Data and functions altogether form the members of the class.
- The bodies of the functions may take place in other parts of the program
- If the functions are defined in the class declaration, they are defined as inline functions

Member Function Definitions: Example

```
// ***** Bodies of Member Functions *****
// A function to move the points
void Point::move(int new_x, int new_y){
  x = new_x;          // assigns new value to x coordinate
  y = new_y;          // assigns new value to y coordinate
}

// To print the coordinates on the screen
void Point::print(){
  cout << "X= " << x << ", Y= " << y << endl;
}

// is the point on the zero point(0,0)
bool Point::is_zero(){
  return (x == 0) && (y == 0);  // if x=0 AND y=0 returns true
}
```

Creating Objects: Example

- Now we have a model (template) to define point objects. We can create necessary points (objects) using the model.

```
int main(){
  Point point1, point2; //2 object are defined: point1 and point2
  point1.move(100,50);  // point1 moves to (100,50)
  point1.print();       // point1's coordinates to the screen
  point1.move(20,65);   // point1 moves to (20,65)
  point1.print();       // point1's coordinates to the screen
  if( point1.is_zero() )      // is point1 on (0,0)?
     cout << "point1 is now on zero point(0,0)" << endl;
  else cout << "point1 is NOT on zero point(0,0)" << endl;
  point2.move(0,0);           // point2 moves to (0,0)
  if( point2.is_zero() )      // is point2 on (0,0)?
     cout << "point2 is now on zero point(0,0)" << endl;
  else cout << "point2 is NOT on zero point(0,0)" << endl;
  return 0;
}
```

See Example e31.cpp

C++ Terminology

- A **class** is a grouping of data and functions. A class is very much like a structure type as used in ANSI-C, it is only a pattern (a template) to be used to create a variable which can be manipulated in a program. Classes are designed to give certain **services**.
- An **object** is an instance of a class, which is similar to a variable defined as an instance of a type. An object is what you actually use in a program.

C++ Terminology, con't

- An **attribute** is a data member of a class that can take different values for different instances (objects) of this class. Example; Name of a student, coordinates of a point.
- A **method (member function)** is a function contained within the class. You will find the functions used within a class often referred to as methods in programming literature.

Classes fulfill their services (responsibilities) by the help of their methods.

C++ Terminology, con't

- A **message** is the same thing as a function call. In object-oriented programming, we send messages instead of calling functions. For the time being, you can think of them as identical. Later we will see that they are in fact slightly different.
- Messages are sent to objects to get some services from them.

Advantages of OOP (revisited)

- Until this slide we have discovered some features of the object-oriented programming and the C++.
- Our programs consist of objects as the real world do.
- Classes are living (active) data types which are used to define objects. We can send messages (orders) to objects to enable them to do something.
- Classes include both data and the functions involved with these data (*encapsulation*). As a result:
  - Software objects are similar to the real world objects,
  - Programs are easy to read and understand,
  - It is easy to find errors,
  - It supports modularity and teamwork.

Defining Methods as Inline Functions

- When the bodies of methods are written in the class declaration, they are defined as inline functions.

```
class Point{        // Declaration of Point Class
  int x,y;          // Properties: x and y coordinates
 public:
  void move(int, int);     // A function to move the points
  void print(); // to print the coordinates on the screen
  bool is_zero() {  // inline function
   return (x == 0) && (y == 0);     // the body of is_zero
  }
};
```

Do not write long methods in the class declaration. It decreases the readibility and the performance

Defining Dynamic Objects

- Classes can be used to define variables like built-in data types (`int`, `float`, `char` etc.) of the compiler.
  - For example it is possible to define pointers to objects. In the example below two pointers (`ptr1` and `ptr2`) to objects of type `Point` are defined.

```
int main(){
   Point *ptr1 = new Point; //allocating memory for the object
   Point *ptr2 = new Point; //allocating memory for the object
   ptr1->move(50, 50);    //'move' message to the object
   ptr1->print();  //'print' message to the object pointed by ptr1
   ptr2->move(100, 150);  // 'move' message to the object

   if( ptr2->is_zero() )  // is the object pointed by ptr2 on zero
      cout << " Object pointed by ptr2 is on zero." << endl;
   else cout << " Object pointed by ptr2 is NOT on zero." << endl;
   delete ptr1;              // Releasing the memory
   delete ptr2;
   return 0;
}
```


Defining Arrays of Objects

- One can define static and dynamic arrays of objects. In the example below a static array with ten elements of type **`Point`** are created.

```
int main(){
   Point   array[10];     // defining an array with ten objects
   array[0].move(15, 40); // 'move' message to the first element
   array[1].move(75, 35); // 'move' message to the second element
       :                          //message to other elements
   for (int i = 0; i < 10; i++)  // 'print' message to all objects
                                    in the array
        array[i].print();

   return 0;
}
```


Controlling Access to Members

- Class creators vs. Client Programmers
- Class creator builds the class with all members of it.
  - The class should expose only what's necessary to the client programmer and keeps everything else **hidden**.
- The goal of the client programmer is to collect a toolbox full of classes to use for rapid application development.

Controlling Access to Members, con't

- Access control is needed to keep client programmers' hands off portions they shouldn't touch. The hidden parts are only necessary for the internal machinations of the data type. This protection also prevents accidentally changes of states of objects.
- Access control is needed to ensure that the client programmer can't use it, which means that the class creator can change the hidden portion at will without worrying about the impact to anyone else.

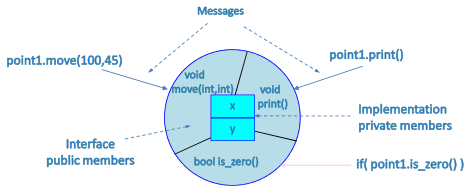
Controlling Access to Members, con't

- The labels **`public:`**, **`private:`** (and **`protected:`** as we will see later) are used to control access to a class' data members and functions.
- Private class members can be accessed only by members of that class.
- Public members may be accessed by any function in the program.

Controlling Access to Members, con't

- The default access mode for classes is **`private:`** After each label, the mode that was invoked by that label applies until the next label or until the end of class declaration.
- The primary purpose of public members is to present to the class's clients a view of the *services* the class provides. This set of services forms the *public interface* of the class.
- The private members are not accessible to the clients of a class. They form the *implementation* of the class.

Controlling Access to Members, con't



Controlling Access to Members: Example

- We modify the move function of the class Point. Clients of this class can not move a point outside a window with a size of 500x300.

```
class Point{              // Point Class
   int x,y;               // private members: x and y coordinates
  public:                 // public members
   bool move(int, int);   // A function to move the points
   void print();          // to print the coordinates on the screen
   bool is_zero();        // is the point on the zero point(0,0)
};

 // A function to move the points (0,500 x 0,300)
bool Point::move(int new_x, int new_y){
  if( new_x > 0 &&  new_x < 500 &&         // if new_x is in 0-500
      new_y > 0 &&  new_y < 300) {         // if new_y is in 0-300
       x = new_x;                        // assigns new value to x coordinate
       y = new_y;                        // assigns new value to y coordinate
      return true;                       // input values are accepted
  }
  return false;                         // input values are not accepted
}
```


Controlling Access to Members: Example

- The new move function returns a boolean value to inform the client programmer whether the input values are accepted or not.

```
int main(){
   Point p1;  // p1 object is defined
   int x,y;   // Two variables to read some values from the keyboard
   cout << " Give x and y coordinates ";
   cin >> x >> y;         // Read two values from the keyboard
   if( p1.move(x,y) )     // send move message and check the result
        p1.print();       // If result is OK print coordinates on the screen
    else
       cout << "\nInput values are not accepted";
}
```

It is not possible to assign a value to x or y directly outside the class.

```
p1.x = -10;                    //ERROR! x is private
```


Friend Functions and Friend Classes

- A function or an entire class may be declared to be a friend of another class.
- A *friend* of a class has the right to access all members (`private, protected or public`) of the class.

Friend: Example

```
class A{
  friend class B; // Class B is a friend of class A
  private:        // private members of A
     int i;
     float f;
  public:   // public members of A
     void func1(char *c);
};
class B{          // Class B
    int j;
  public:
    void func2(A &s) { cout << s.i; } // B can
   access private members of A
};
```

```
int main(){
  A objA;
  B objB;
  objB.func2(objA);
  return 0;
}
```

In this example, A is not a friend of B. A can not access private members of B.

Friend: Example, con't

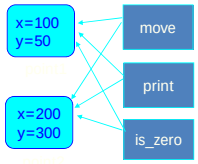
- A *friend* function has the right to access all members (`private, protected or public`) of the class.

```
class Point{          // Point Class
  friend void zero(Point &);  // A friend function of Point
   int x,y;           // private members: x and y coordinates
  public:                     // public members
   bool move(int, int);       // A function to move the points
   void print();      // to print the coordinates on the screen
   bool is_zero();    // is the point on the zero point(0,0)
};

// Assigns zero to all coordinates
void zero(Point &p) {         // Not a member of any class
  p.x = 0;                    // assign zero to x of p
  p.y = 0;                    // assign zero to y of p
}
```

‘this’ Pointer

- Each object has its own data space in the memory of the computer. When an object is defined, memory is allocated only for its data members.
- The code of member functions are created only once. Each object of the same class uses the same function code.



C++ compiler maintains a pointer, called this pointer to refer the object itself

‘this’ Pointer: Example

- C++ compiler defines an object pointer **this**. When a member function is called, this pointer contains the address of the object, for which the function is invoked. So member functions can access the data members using the pointer **this**.
- We add a new function to `Point` class: `far_away`. This function will return the address of the object that has the largest distance from (0,0).

```
Point *Point::far_away(Point &p){
   unsigned long x1 = x*x;              // x1 = x²
   unsigned long y1 = y*y;              // y1 = y²
   unsigned long x2 = p.x * p.x;
   unsigned long y2 = p.y * p.y;
   if ( (x1+y1) > (x2+y2) ) return this;     // Object
   returns its address
      else return &p;// The address of the incoming object
}
```

See Example e32.cpp

‘this’ Pointer: Example

- **this** pointer can also be used in the methods if a parameter of the method has the same name as one of the members of the class.

```
class Point{              // Point Class
    int x,y;      // private members: x and y coordinates
  public:                       // public members
    bool move(int, int); // A function to move the points
   :               // other methods are omitted
};
bool Point::move(int x, int y) {
  if( x > 0 &&  x < 500 &&       // if given x is in 0-500
      y > 0 &&  y < 300) {       // if given y is in 0-300
        this->x = x; //assigns given x value to member x
        this->y = y; //assigns given y value to member y
      return true;  // input values are accepted
  }
  return false;     // input values are not accepted
}
```