NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES
CL 103 - COMPUTER PROGRAMMING LAB
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Lab # 09

Outline

- Friend Function
- Casting
- Runtime Polymorphism
- Pure Virtual Functions
- Abstract Class
- Examples
- Exercise

Friend Function

Friend Functions:

The functions which are not member functions of the class yet they can access all private members of the class are called friend functions.

Why they are needed?

They are needed in situations where we have written code for some function in one class and it need to be used by other classes as well for example, suppose we wrote the code to compute a complex mathematical formula in one class but later it was required by other classes as well, in that case we will make that function friend of all other classes.

Are friend functions against the concept of Object Oriented Programming?

It can be said that friend functions are against the principle of object oriented programming because they violate the principle of encapsulation which clearly says that each object methods and functions should be encapsulated in it. But there we are making our private member accessible to other outside functions.

Consider the following

class: class X

```
{
    private:
    int a, b;
     public:
    void MemberFunction ();
        …
          }
```

Suppose we have a global function DoSomething that need to access the private members of class X, when we will try to access them compiler will generate error as outside world cannot access private members of a class except its member functions.

```
void DoSomething(X obj)
{
obj.a = 3; //Error
obj.b = 4; //Error
}
```

In order to access the member variables of the class, we must make function friend of that class, **class X**

```
{
private:
        int a, b; public:
 …
friend void DoSomething(X obj);
}
```

Now the function DoSomething can access data members of **class X**

```
void DoSomething(X obj)
{
obj.a = 3;
 obj.b = 4;
}
```

Prototypes of friend functions appear in the class definition. But friend functions are NOT member functions.

Friend functions can be placed anywhere in the class without any effect Access specifiers don't affect friend functions or Classes.

```
class X{
 ...
private:
friend void DoSomething(X); public:
friend void DoAnything(X);
...
} ;
```

While the definition of the friend function is:

```
void DoSomething(X obj)
{       obj.a = 3; // No Error
        obj.b = 4; // No Error
         …
}
```

friend keyword is not given in definition.

Friend Classes:

Similarly, one class can also be made friend of another class: class X

{

friend class Y;

…

} ;

Member functions of class Y can access private data members of class X **class X**

```
 {
        friend class Y; private: int x_var1, x_var2;
...
};
class Y
{
private:
 int y_var1, y_var2;
 X objX;
public:
 void setX()
{ objX.x_var1 = 1;
} };
 int main()
{
        Y objY;
        objY.setX();
        return 0;
}
```

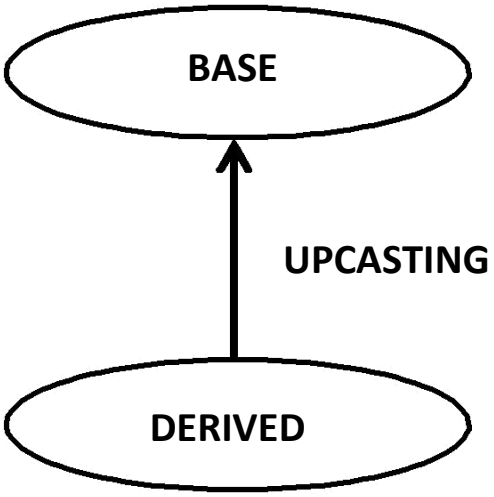
CASTING

A cast is a special operator that forces one type to be converted into another.

UPCASTING

Upcasting is a process of treating a pointer or a reference of derived class object as a base class pointer.

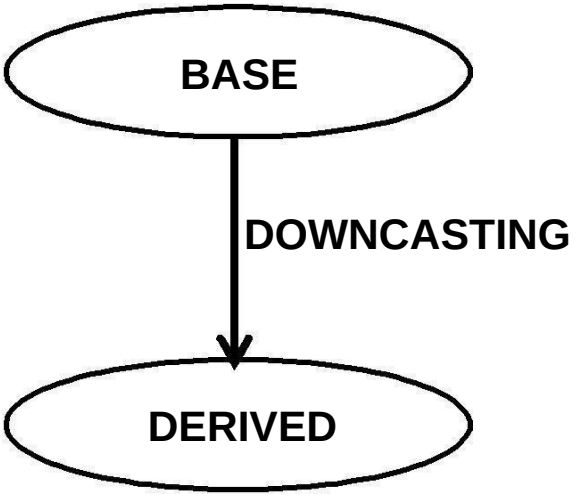
- A base class pointer can only access the public interface of the base class.
- The additional members defined in the derived class are therefore inaccessible.
- Upcasting is not needed manually. We just need to assign derived class pointer (or reference) to base class pointer.



DOWNCASTING

The opposite of Upcasting is Downcasting, It converts base class pointer to derived class pointer.

- Type conversions that involve walking down the tree, or *downcasts*, can only be performed explicitly by means of a cast construction. The cast operator **(type)** or the **static_cast<>**operator are available for this task, and are equivalent in thiscase.
- After downcasting a pointer or a reference, the entire public interface of the derived class isaccessible.



STATIC_CAST

Syntax: static_cast<type>(expression)

The operator static_cast<> converts the expression to the target type type.

```
#include     <iostream>
using namespace std;
class Employee
{
public:
        Employee(string fName, string lName, double sal)
        {
                FirstName = fName;
                LastName  =  lName;
                salary = sal;
        }
        string FirstName;
        string LastName;
        double salary; void
        show()
        {
                cout<< "First Name: " <<FirstName<< " Last Name: " <<LastName<< " Salary: " << salary<<endl;
        }
        void addBonus(double bonus)
        {
                salary += bonus;
        } };

class Manager :public Employee
{
public:
        Manager(string fName, string lName, double sal, double comm) :Employee(fName, lName, sal)
        {
                Commision = comm;
        }
        double Commision; double
        getComm()
        {
                return Commision; }
};
```

FOR UPCASTING

```
int main()
{
        Employee* emp;          //pointer to base class object
        Manager m1("Ali", "Khan", 5000, 0.2); //object of derived class
         emp = &m1; //implicit upcasting
        emp->show(); //okay because show() is a base class function
         return 0;
 }
```

FOR DOWNCASTING USING (type)

```
int main()
{
Employee e1("Ali", "Khan", 5000); //object of base class

//try to cast an employee to Manager
Manager* m3 = (Manager*)(&e1); //explicit downcasting

cout<< m3->getComm() <<endl;
return 0;
}
```

FOR DOWNCASTING USING (static_cast)

```
int main()
{
Employee e1("Ali", "Khan", 5000); //object of base class

//try to cast an employee to Manager
Manager* m3 = static_cast<Manager*>(&e1); //explicit downcasting

cout<< m3->getComm() <<endl;
return 0;
}
```

DOWNCASTING IS UNSAFE

-Since, e1 object is not an object of Manager class so, it does not contain any information about commission.

-That's why such an operation can produce unexpected results.

-Downcasting is only safe when the object referenced by the base class pointer really is a derived class type.

-To allow safe downcasting C++ introduces the concept of *dynamic casting.*

VIRTUAL FUNCTION

Virtual Function is a function in base class, which is overrided in the derived class, and which tells the compiler to perform Late Binding on this function.

```
#include
<iostream> using namespace
std;

class Shape
{
        public:
         virtual void Draw()
                { cout<<"Shape
                drawn!"<<endl;
        }
};

class Square : public Shape
{
        public: void
        Draw()
                { cout<<"Square
                drawn!"<<endl;
        }
};

int main()
{
        Squareobj;    //Derived ClassObject

        Shape* shape = &obj; /* derived class object being referenced by a pointer
                                to the base class */


        shape->Draw(); /* outputs "Square drawn!" if Draw() is virtual in base class
                          else outputs "Shape drawn!"*/
        return 0;
}
```

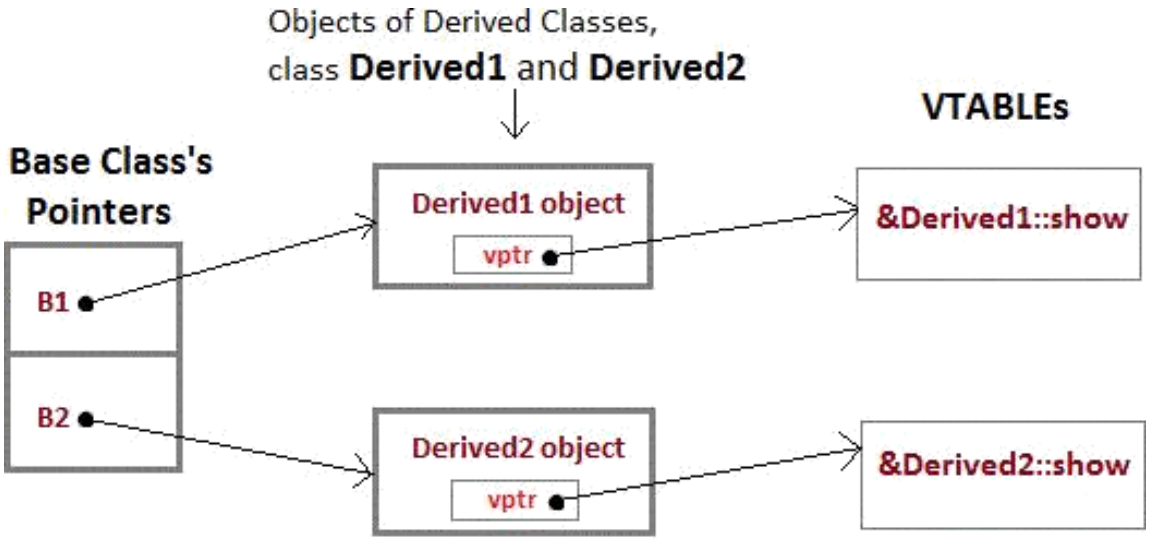
INTERESTING FACTS

We can call private function of derived class from the base class pointer with the help of virtual keyword. Compiler checks for access specifier only at compile time. So at run time when late binding occurs it does not check whether we are calling the private function or public function.

MECHANISM OF LATE BINDING

To accomplish late binding, Compiler creates VTABLEs, for each class with virtual function. The address of virtual functions is inserted into these tables. Whenever an object of such class is created the compiler secretly inserts a pointer called vpointer, pointing to VTABLE for that object. Hence when function is called, compiler is able to resolve the call by binding the correct function using the vpointer.

- Only the Base class Method's declaration needs the Virtual Keyword, not the definition.
- If a function is declared as virtual in the base class, it will be virtual in all its derived classes.
- The address of the virtual Function is placed in the VTABLE and the compiler uses VPTR (vpointer) to point to the Virtual Function.



vptr, is the vpointer, which points to the Virtual Function for that object.

VTABLE, is the table containing address of Virtual Functions of each class.

Overriding Methods – virtual keyword

- Methods in the parent class can be redefined in the child class
- In C++, static binding is the defaults behaviour
- The keyword virtual allows the use of dynamic binding.

```
//Header.h

//Polygon.h
#ifndef___POLYGON_H_INCLUDED___// if polygon.h hasn't been included yet...
#define_POLYGON_H_INCLUDED // #define this so the compiler knows it has been included
class Polygon {
            protected:
              int width, height;
            public:
              void set_values (int a, int b);
              virtual int area ();


          };
#endif

          //Rectangle.h
          #include "Polygon.h"
          class Rectangle: public
            Polygon { public:
              int area();

          };
//Triangle.h
#include "Polygon.h"
class Triangle: public
  Polygon { public:
    int area ();

};
//Impl
//Polygon.cpp
#include "Polygon.h"
```

```
void Polygon::set_values (int a, int b)
  {
             width=a;
              height=b;
            }
int Polygon::area()
            {
                        return 0;
            }

//Rectangle.cpp
#include "Rectangle.h"

int Rectangle::area()
             {
             return width*height;
           }
//Triangle.cpp
#include "Triangle.h"

int Triangle::area()
          {
          return (width * height / 2);
}
//Main.cpp

#include <iostream>
#include "Rectangle.h"
#include "Triangle.h"
using namespace std;

int main () {
  Rectangle rect;
  Triangle trgl;
  Polygon poly;
    Polygon * ppoly1 = &rect;
    Polygon * ppoly2 = &trgl;
    Polygon * ppoly3 = &poly;
    ppoly1->set_values (4,5);
     ppoly2->set_values (4,5);
    ppoly3->set_values (4,5);
 cout<< ppoly1->area() << '\n';
 cout<< ppoly2->area() << '\n';
 cout<< ppoly3->area() << '\n';

  return 0;
}
```

Pure Virtual Functions

virtual Type identifier(parameters) = 0;

// Pure Virtual Functions

virtual void price() = 0;

virtual void type() = 0;

Abstract Base Class

- An abstract base class is a class that includes or inherits at least one pure virtual function that has not been defined.

```
#include <string>
#include<iostream>
using namespace std;
//Header files      //Animal.h
class Animal
{
protected:
string m_strName;
 public:
Animal(string strName);
string GetName();
 virtual string Speak() = 0; // pure virtual function
};
//Cow.h
class Cow: public Animal
{
public:
Cow(string strName);
virtual string Speak();
 };
//Impl
Cow:: Cow(string strName): Animal(strName)
 {
 }
string Cow::Speak() {
return "Meow";
}
Animal::Animal(string strName): m_strName(strName)
 {
}
string Animal::GetName()
 {
return m_strName;
 }

int main()
{
Cow cCow("Betsy");
Cout<<cCow.GetName()<<”says”<<cCow.Speak();
}
```

LAB-09 EXERCISES

QUESTION#1

Design and implement a program that shows the relationship between person, student and professor. Your person class must contain two pure virtual functions named getData() of type void and isOutstanding() of type bool and as well getName() and putName() that will read and print the person name. Class student must consist of function name getData (), which reads the GPA of specific person and isOutstanding() function which returns true if the person GPA is greater than 3.5 else should return false. Class professor should take the respective persons publications in getData() and will return true in Outstanding() if publications are greater than 100 else will return false . Your main function should ask the user either you want to insert the data in professor or student until and unless user so no to add moredata.

QUESTION#2

A company pays its employees weekly. The employees are of four types: **Salariedemployees** are paid a fixed weekly salary regardless of the number of hours worked, **hourlyemployees** are paid by the hour and receive overtime pay for all hours worked in excess of 40 hours, **commissionemployees** are paid a percentage of their sales and **base-salaryplus-commissionemployees** receive a base salary plus a percentage of their sales. For the current pay period, the company has decided to reward base-salaryplus-commission employees by adding 10 percent to their base salaries. The company wants you to draw UML diagram of the given scenario and do implementation on c++ that performs its payroll calculations polymorphically.

Your Employee class must have :

- First name, last name and social security number as private data members. Use accessor and mutators to set and get these values.
- Constructor with first name, last name and ssn number as parameter.
- Pure virtual function named earning with return type double.
- Virtual function named print with return type void, which prints employee first name, last name and ssn number.

Your salaried Employee must have:

- Earning method which return the salary
- Print method that print the employee detail and employee salary.

Your hourly Employee must have:

- You must take the wage and hours as a parameter using base class initializer.
- Earning methods which returns the salary the employed has worked.
- Print method that print the employee detail and employee salary.

Your commission employee must have:

- You must take the commission rate and gross sale rate as a parameter using base class initializer.
- Earning methods which returns the commission of the employee. - Print method that print the employee detail and employee commission.

Your base-salary plus-commission employees must have:

- You must take the base salary as a parameter using base class initializer.
- Earning methods which return the base commission of the employee.
- Print method that print the employee detail and employee base salary.

You have to perform upcasting and downcasting, and print the details of each employee type.