

FAST

National University of Computer and Emerging Sciences Peshawar

OOP Lab # 14

C++ (Inheritance)

Computer Instructor: Engr. Khuram Shahzad

DEPARTMENT OF COMPUTER SCIENCE



Programming



الذى علم بالقلم- علم الانسان ما لم يعلم-



Contents

- 1) C++ Function Overriding
- 2) Access Overridden Function in C++
- 3) Types of Inheritance
- 4) Single Inheritance
- 5) Multilevel Inheritance
- 6) Multiple Inheritance
- 7) Hierarchical Inheritance
- 8) Hybrid Inheritance



Inheritance

- ❖ As we know, inheritance is a feature of OOP that allows us to create derived classes from a base class. The derived classes inherit features of the base class.
- ❖ Suppose, the same function is defined in both the derived class and the based class. Now if we call this function using the object of the derived class, the function of the derived class is executed.
- ❖ This is known as **function overriding** in C++. The function in derived class overrides the function in base class.



Function Overriding Example 1

// C++ program to demonstrate function overriding

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

class Base {
public:
    void print() {
        cout << "Base Function" << endl;
    }
};
```



Function Overriding Example 1...

```
class Derived : public Base {  
    public:  
        void print() {  
            cout << "Derived Function" << endl;  
        }  
};  
  
int main() {  
    Derived derived1;  
    //Base base;  
    //base.print();  
    derived1.print();  
    return 0;  
}
```

Output:
Derived Function

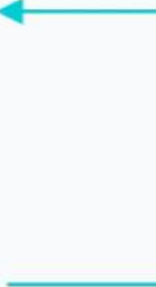


Function Overriding Example 1...

- ❖ Here, the same function `print()` is defined in both Base and Derived classes.
- ❖ So, when we call `print()` from the Derived object `derived1`, the `print()` from Derived is executed by overriding the function in Base.

Working of function overriding in C++

```
class Base {  
    public:  
    void print() {  
        // code  
    }  
};  
  
class Derived : public Base {  
    public:  
    void print() {  
        // code  
    }  
};  
  
int main() {  
    Derived derived1;  
    derived1.print();  
    return 0;  
}
```





Function Overriding Example 1...

- ❖ As we can see, the function was overridden because we called the function from an object of the Derived class.
- ❖ Had we called the print() function from an object of the Base class, the function would not have been overridden.

// Call function of Base class

```
Base base1;  
base1.print();
```

// Output: Base Function



Access Overridden Function in C++

- ❖ To access the overridden function of the base class, we use the scope resolution operator `::` .
- ❖ We can also access the overridden function by using a pointer of the base class to point to an object of the derived class and then calling the function from that pointer.



Example 2: C++ Access Overridden Function to the Base Class

```
// C++ program to access overridden function  
// in main() using the scope resolution operator  
::
```

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

```
class Base {  
    public:  
    void print() {  
        cout << "Base Function" << endl;  
    }  
};
```



Example 2: C++ Access Overridden Function to the Base Class...

```
class Derived : public Base {  
    public:  
        void print() {  
            cout << "Derived Function" << endl;  
        }  
};  
  
int main() {  
    Derived derived1, derived2;  
    derived1.print();  
  
    // access print() function of the Base class  
    derived2.Base::print();  
  
    return 0;  
}
```

Output:
Derived Function
Base Function



Example 2: C++ Access Overridden Function to the Base Class...

Here, this statement

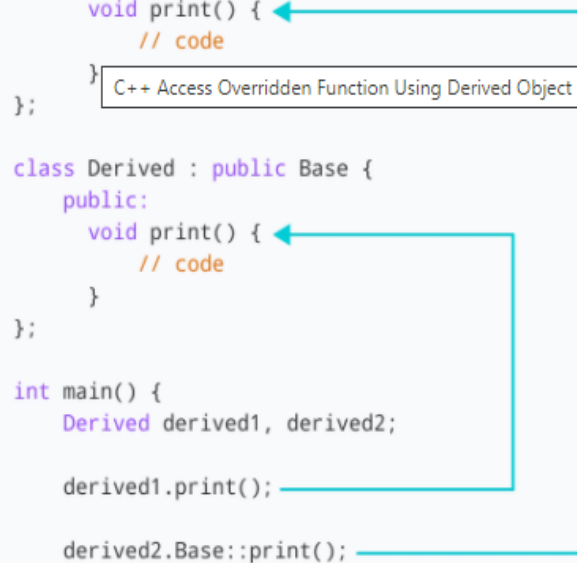
```
derived2.Base::print();
```

accesses the print() function of the Base class.

Access overridden function using object of derived class in C++

```
class Base {  
    public:  
    void print() {  
        // code  
    }  
};  
  
class Derived : public Base {  
    public:  
    void print() {  
        // code  
    }  
};  
  
int main() {  
    Derived derived1, derived2;  
  
    derived1.print();  
  
    derived2.Base::print();  
  
    return 0;  
}
```

C++ Access Overridden Function Using Derived Object





Example 3: C++ Call Overridden Function From Derived Class

```
// C++ program to call the overridden function  
// from a member function of the derived class
```

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

```
class Base {  
    public:  
        void print() {  
            cout << "Base Function" << endl;  
        }  
};
```



Example 3: C++ Call Overridden Function From Derived Class...

```
class Derived : public Base {  
    public:  
        void print() {  
            cout << "Derived Function" << endl;  
  
            // call overridden function  
            Base::print();  
        }  
};  
  
int main() {  
    Derived derived1;  
    derived1.print();  
    return 0;  
}
```

Output:
Derived Function
Base Function



Example 3: C++ Call Overridden Function From Derived Class...

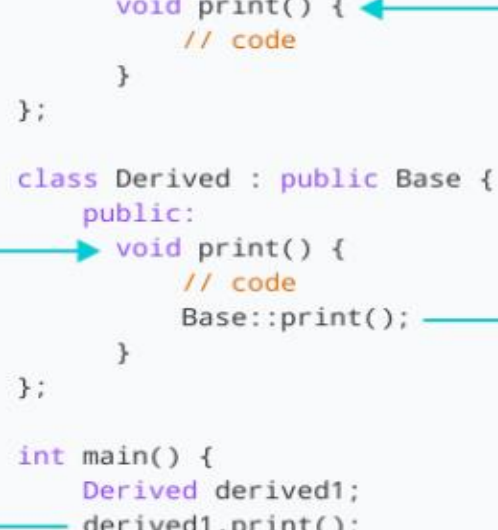
In this program, we have called the overridden function inside the **Derived** class itself.

```
class Derived : public Base {  
    public:  
    void print() {  
        cout << "Derived Function" << endl;  
  
        // call overridden function  
        Base::print();  
    }  
};
```

Notice the code **Base::print();**, which calls the overridden function inside the Derived class,

Access overridden function inside derived class in C++

```
class Base {  
public:  
    void print() {  
        // code  
    }  
};  
  
class Derived : public Base {  
public:  
    void print() {  
        // code  
        Base::print();  
    }  
};  
  
int main() {  
    Derived derived1;  
    derived1.print();  
    return 0;  
}
```





Example 4: C++ Call Overridden Function Using Pointer

```
// C++ program to access overridden function using pointer  
// of Base type that points to an object of Derived class
```

```
#include <iostream>  
using namespace std;  
  
class Base {  
public:  
    void print() {  
        cout << "Base Function" << endl;  
    }  
};
```



Example 4: C++ Call Overridden Function Using Pointer...

```
class Derived : public Base {
public:
    void print() {
        cout << "Derived Function" << endl;
    }
};

int main() {
    Derived derived1;

    // pointer of Base type that points to derived1
    Base* ptr = &derived1;

    // call function of Base class using ptr
    ptr->print();
    return 0;
}
```

Output:
Base Function



Example 4: C++ Call Overridden Function Using Pointer...

- ❖ In this program, we have created a pointer of **Base** type named **ptr**. This pointer points to the **Derived** object **derived1**.

```
// pointer of Base type that points to derived1
```

```
Base* ptr = &derived1;
```

- ❖ When we call the **print()** function using **ptr**, it calls the overridden function from Base.

```
// call function of Base class using ptr
```

```
ptr->print();
```



Example 4: C++ Call Overridden Function Using Pointer...

- ❖ This is because even though ptr points to a Derived object, it is actually of Base type. So, it calls the member function of Base.
- ❖ In order to override the Base function instead of accessing it, we need to use [virtual functions](#) in the Base class.



Types of Inheritance

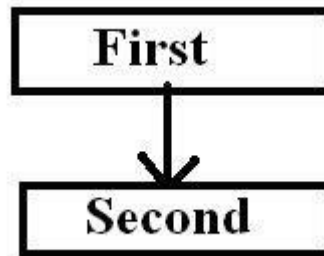
Inheritance is one of the core feature of an object-oriented programming language. It allows software developers to derive a new class from the existing class. The derived class inherits the features of the base class (existing class).

There are various models of inheritance in C++ programming.

- 1) Single Inheritance
- 2) Multilevel Inheritance
- 3) Multiple Inheritance
- 4) Hierarchical Inheritance
- 5) Hybrid Inheritance

1) Single Inheritance

- ❖ It is the inheritance hierarchy wherein one derived class inherits from one base class.
- ❖ There is only one Super Class and Only one Sub Class Means they have one to one Communication between them



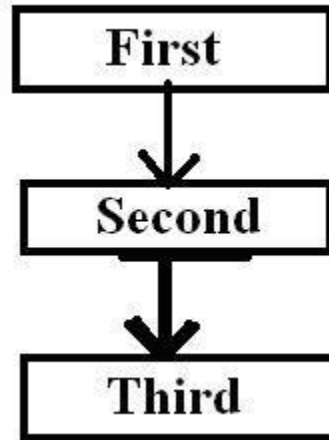


2) Multilevel Inheritance

- ❖ A Derived class can also be inherited by another class. This means that when a Derived Class is again inherited by another Class, it creates multiple levels.
- ❖ It is the inheritance hierarchy wherein a subclass acts as a base class for other classes.
- ❖ In C++ programming, not only can you derive a class from the base class, but you can also derive a class from the derived class. This form of inheritance is known as multilevel inheritance.

2) Multilevel Inheritance...

- ❖ It is implemented by defining atleast three classes. Each derived class must have a kind of relationship with its immediate base class.





2) Multilevel Inheritance...

```
class A {  
    ... ..  
};  
  
class B: public A {  
    ... ..  
};  
  
class C: public B {  
    ... ..  
};
```

Here, class B is derived from the base class A and the class C is derived from the derived class B.



Example 1: C++ Multilevel Inheritance

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

class A {
    public:
        void display() {
            cout<<"Base class content.";
        }
};
```



Example 1: C++ Multilevel Inheritance...

```
class B : public A {};
```

```
class C : public B {};
```

```
int main() {  
    C obj;  
    obj.display();  
    return 0;  
}
```

Output:

Base class content."



Example 1: C++ Multilevel Inheritance...

- ❖ In this program, class C is derived from class B (which is derived from base class A).
- ❖ The obj object of class C is defined in the main() function.
- ❖ When the display() function is called, display() in class A is executed. It's because there is no display() function in class C and class B.
- ❖ The compiler first looks for the display() function in class C. Since the function doesn't exist there, it looks for the function in class B (as C is derived from B).



Example 1: C++ Multilevel Inheritance...

- ❖ The function also doesn't exist in class B, so the compiler looks for it in class A (as B is derived from A).
- ❖ If display() function exists in C, the compiler overrides display() of class A (because of member function overriding).



Example 2: C++ Multilevel Inheritance

```
#include<iostream>
using namespace std;
class person {
    private:
        char name[20];
        long int phno;
    public:
        void read() {
            cout<<"Enter name and phno = ";
            cin>>name>>phno;
        }
        void show() {
            cout<<"\nName = "<<name;
            cout<<"\nPhone number = "<<phno;
        }
}; // end of person class
```



Example 2: C++ Multilevel Inheritance...

```
class student : public person {
private:
    int rollno;
    char course[20];
public:
    void read() {
        person::read();//Access person's read()
        cout<<"Enter rollno and course=";
        cin>>rollno>>course;
    }
    void show() {
        person::show(); //Access person's show()
        cout<<"\nRollno = "<<rollno;
        cout<<"\nCourse = "<<course;
    }
}; // end of student class
```




Example 2: C++ Multilevel Inheritance...

```
class exam : public student {  
    private:  
        int m[4];  
        double per;  
    public:  
        void read() ;  
        void cal();  
        void show() ;  
}; // end of exam class
```



Example 2: C++ Multilevel Inheritance...

```
// Function definitions
void exam::read() {
    student::read();//Access student's read()
    cout<<"Enter marks :";
    for(int i=0;i<4;i++)
        cin>>m[i];
}
void exam::cal() {
    int tot_marks=0;
    for(int i=0;i<4;i++)
        tot_marks+=m[i];
    per=double(tot_marks)/4;
}
```



Example 2: C++ Multilevel Inheritance...

```
void exam::show() {
    student::show();//Access student's show()
    cout<<"\nMarks :";
    for(int i=0;i<4;i++)
        cout<<m[i]<<"\t";
    cout<<"\nPercentage = "<<per;
}
//main function
int main() {
    exam e1;
    e1.read();
    e1.cal();
    e1.show();
    return 0;
}
```

Output:

Name = Aisha
Phone number = 57868882
Rollno = 1222
Course =Computer
Marks :88 77 66 98
Percentage = 82.25



Example 2: C++ Multilevel Inheritance...

Explanation: The above program implements multilevel inheritance. The program inputs the students basic and academic information calculates the result and displays all the students' information. The program consists of three classes, namely person, student and exam. The class person is the base class. The class student is derived from person base class, which acts as a base class for the derived class exam. The exam class inherits the features of student class directly and features of person class indirectly. In main(),the statement

```
e1.read();  
e1.show();
```

Invokes the respective member functions of exam class as e1 is the object of this class. Look carefully at the definition of read() and show() of the exam class, and you will find that both the member functions access same-named member function of the student class directly and person class indirectly. The statement,

```
e1.cal();
```

Invokes the member function cal() of exam class for calculating the result of a student.

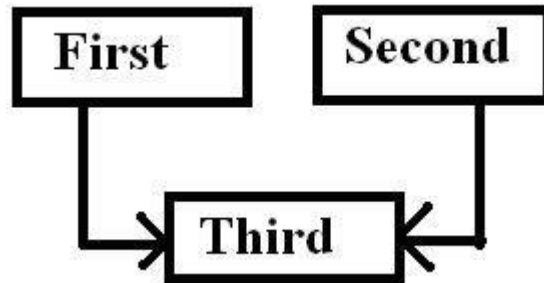


3) Multiple Inheritance

- ❖ It is the inheritance hierarchy wherein one derived class inherits from multiple base class(es).
- ❖ So far, we have been deriving a class from a single base class. However, it is also possible to derive a class from two or more unreleased base classes. When we derive a class from two or more base classes, this form of inheritance is known as Multiple Inheritance. It allows the new class to inherit the functionality of two or more well developed and tested base classes, thus reusing predefined classes' features.
- ❖ Like Single Inheritance, each derived class in multiple inheritances must have a kind of relationship with its base classes.

3) Multiple Inheritance...

- ❖ This form of inheritance is useful in those situations in which derived class represents a combination of features from two or more base classes.
- ❖ **For Example:** In an educational institute, a member can act like a teacher and a student. He may be a student of higher class as well as teaching lower classes.





3) Multiple Inheritance Syntax

The syntax for declaring a derived class which inherited from more than one base classes is:

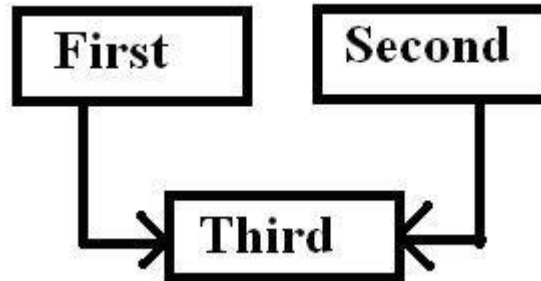
```
class der_class_name : access_specifier base1, access_specifier base2, ... {
```

```
    //Implementation  
};
```

Here access_specifier may be either public, private or protected. Each base class from which class is derived must be specified to the colon's right after the access specifier and must be separated by commas.

3) Multiple Inheritance Syntax...

- ❖ The Fig. shows multiple inheritances in which class Third is derived from class First and class Second, which are independent of each other.
- ❖ Here, class Third inherits all the members of its base classes First and Second. The following program segment shows how a class Third is derived from two base classes First and Second publicly.





3) Multiple Inheritance Syntax...

```
class Third: public First, public Second
{
//Implementation
};
```

- ❖ The inheritance rules and the usages of access specifier for each base class member remain the same as in single inheritance. The access to each base class member is independent of the access to the members of other base classes using which you derive your class.



Example 1: Multiple Inheritance

```
#include<iostream>
using namespace std;
class base1 {
    protected:
        int x;
    public:
        void readx() {
            cout<<"Enter value of x : ";
            cin>>x;
        }
        void showx()
        {
            cout<<"x= "<<x;
        }
}; // end of class base1
```



Example 1: Multiple Inheritance...

```
class base2 {  
    protected:  
        int y;  
    public:  
        void ready() {  
            cout<<"Enter value of y: ";  
            cin>>y;  
        }  
        void showy()  
        {  
            cout<<"\ny= "<<y;  
        }  
}; // end of class base2
```



Example 1: Multiple Inheritance...

```
class der : public base1,public base2 {  
    private:  
        int z;  
    public:  
        void add() {  
            z=x+y; //Accessing protected members of base classes  
        }  
        void showz ()  
        {  
            cout<<"\nz = "<<z;  
        }  
}; // end of class der1
```



Example 1: Multiple Inheritance...

```
int main() {  
    der d1;  
    d1.readx();//calling readx() of base1  
    d1.ready();//calling ready() of base2  
    d1.add();//calling add() of der  
  
    d1.showx();//calling showx() of base1  
    d1.showy();//calling showy() of base2  
    d1.showz();//calling showz() of der  
    return 0;  
}
```

Output:

```
Enter value of x : 22  
Enter value of y: 11  
x= 22  
y= 11  
z = 33
```



Example 1: Multiple Inheritance...

Explanation: In this program, we define a class `base1` containing a protected data member `x` and public member functions `readx()` and `showx()` for inputting and displaying the value of `x`. Similarly, another class `base2` is defined that contains a data member `y` and two public member function `ready()` and `showy()`. The class `der` is inherited from both the base classes `base1` and `base2` publicly through multiple inheritances. As the class `der` is derived publicly from both the base class `base1` and `base2`, the derived class object can access public base `el` and `base2` in the `main()`. In the `main()`, the statement `d1.readx()`; invokes the member function `readx()` of the `base1` class for inputting value of `x`. Similarly the statement, `d1.ready()`; invokes the `ready()` of `base2` for inputting value of `y`. The statement `d1.add()`; invokes the member function `add()` of the `der` class to perform addition of values of protected data members `x` and `y` as they can be accessed directly in the `der` class. The remaining statement displays the values of `x`, `y` and `z`.



Ambiguity in Multiple Inheritance

- ❖ The most obvious problem with multiple inheritance occurs during function overriding.
- ❖ Suppose, two base classes have a same function which is not overridden in derived class.
- ❖ If you try to call the function using the object of the derived class, compiler shows error. It's because compiler doesn't know which function to call.
- ❖ For example,



Ambiguity in Multiple Inheritance...

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

class base1 {
public:
    void someFunction( )
    {
        cout<<"Function of base1";
    }
}; // end of base1 class

class base2 {
public:
    void someFunction( )
    {
        cout<<"Function of base1";
    }
}; // end of base2 class
```




Ambiguity in Multiple Inheritance...

```
class derived : public base1, public base2 {  
    // code of derived class  
};
```

```
int main() {  
    derived obj;  
    obj.someFunction() // Error!  
} // end of main function
```



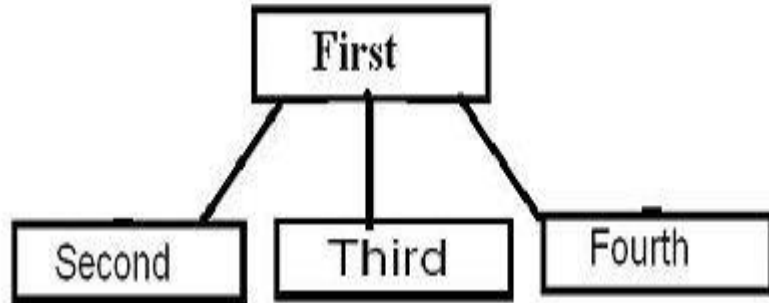
Ambiguity in Multiple Inheritance...

- ❖ This problem can be solved using the scope resolution function to specify which function to class either **base1** or **base2**

```
int main() {  
    derived obj;  
  
    obj.base1::someFunction( ); // Function of base1 class is called  
  
    obj.base2::someFunction();  // Function of base2 class is called.  
}
```

4) Hierarchical Inheritance

- ❖ If more than one class is inherited from the base class, it's known as hierarchical inheritance. In hierarchical inheritance, all features that are common in child classes are included in the base class.
- ❖ For example, Physics, Chemistry, Biology are derived from Science class. Similarly, Dog, Cat, Horse are derived from Animal class.





Syntax of Hierarchical Inheritance

```
class base_class {  
    ... ..  
}  
  
class first_derived_class: public base_class {  
    ... ..  
}  
  
class second_derived_class: public base_class {  
    ... ..  
}  
  
class third_derived_class: public base_class {  
    ... ..  
}
```



Example 1: Hierarchical Inheritance in C++ Programming

```
// C++ program to demonstrate hierarchical inheritance
#include <iostream>
using namespace std;

// base class
class Animal {
public:
    void info() {
        cout << "I am an animal." << endl;
    }
};
```



Example 1: Hierarchical Inheritance in C++ Programming...

```
int main() {  
    // Create object of Dog class  
    Dog dog1;  
    cout << "Dog Class:" << endl;  
    dog1.info(); // Parent Class function  
    dog1.bark();  
  
    // Create object of Cat class  
    Cat cat1;  
    cout << "\nCat Class:" << endl;  
    cat1.info(); // Parent Class function  
    cat1.meow();  
  
    return 0;  
}
```



Example 1: Hierarchical Inheritance in C++ Programming...

```
// derived class 1
class Dog : public Animal {
public:
    void bark() {
        cout << "I am a Dog. Woof woof." << endl;
    }
};

// derived class 2
class Cat : public Animal {
public:
    void meow() {
        cout << "I am a Cat. Meow." << endl;
    }
};
```

Here, both the **Dog** and **Cat** classes are derived from the **Animal** class. As such, both the derived classes can access the **info()** function belonging to the **Animal** class.

Output:

Dog Class:
I am an animal.
I am a Dog. Woof woof.

Cat Class:
I am an animal.
I am a Cat. Meow.



Example 2: Hierarchical Inheritance in C++ Programming

- ❖ The following program implements hierarchical Inheritance. Here, we define a base class person. Then we derive two classes teacher and student. The derived classes inherit the common member's name, phno, read(), show() from the base class person, and have its members.
- ❖ The public read() and show() of the base class redefined in each derived class to input and display teacher and student information.



Example 2: Hierarchical Inheritance in C++ Programming...

```
#include<iostream>
using namespace std;
class person {
    private:
        char name[20];
        long int phno;
    public:
        void read() {
            cout<<"Enter name and phno = ";
            cin>>name>>phno;
        }
        void show() {
            cout<<"\nName = "<<name;
            cout<<"\nPhone number = "<<phno;
        }
}; //Base class specification ends
```



Example 2: Hierarchical Inheritance in C++ Programming...

```
class student : public person {
private:
    int rollno;
    char course[20];
public:
    void read() {
        person::read();
        cout<<"Enter rollno and course=";
        cin>>rollno>>course;
    }
    void show() {
        person::show();
        cout<<"\nRollno = "<<rollno;
        cout<<"\nCourse = "<<course;
    }
}; //Derived class specification ends
```



Example 2: Hierarchical Inheritance in C++ Programming...

```
class teacher : public person {  
    private:  
        char dept_name[10];  
        char qual[10];  
    public:  
        void read() {  
            person::read();  
            cout<<"Enter dept_name and qualification = ";  
            cin>>dept_name>>qual;  
        }  
        void show() {  
            person::show();  
            cout<<"\nDepartment name = "<<dept_name;  
            cout<<"\nQualification = "<<qual;  
        }  
}; //Derived class specification ends
```



Example 2: Hierarchical Inheritance in C++ Programming...

```
int main() {  
    student s1;  
    cout<<"Enter student Information\n";  
    s1.read();  
    cout<<"Displaying Student Information ";  
    s1.show();  
    teacher t1;  
    cout<<"\nEnter teacher Information\n";  
    t1.read();  
    cout<<"Displaying teacher Information ";  
    t1.show();  
    return 0;  
}
```

Output:

Enter student Information
Enter name and phno = Ausaf 0344
Enter rollno and course=44 OOP

Displaying Student Information
Name = Ausaf
Phone number = 344
Rollno = 44
Course = OOP

Enter teacher Information
Enter name and phno = Abdullah
0332
Enter dept_name and qualification = Computer MS

Displaying teacher Information
Name = Abdullah
Phone number = 332
Department name = Computer
Qualification = MS



Example 2: Hierarchical Inheritance in C++ Programming...

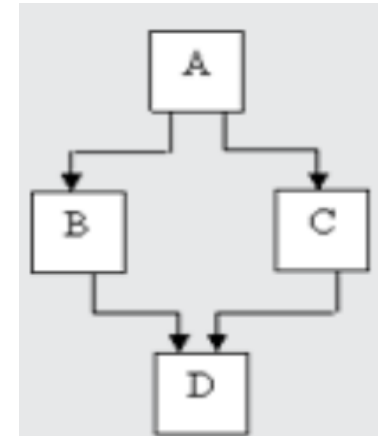
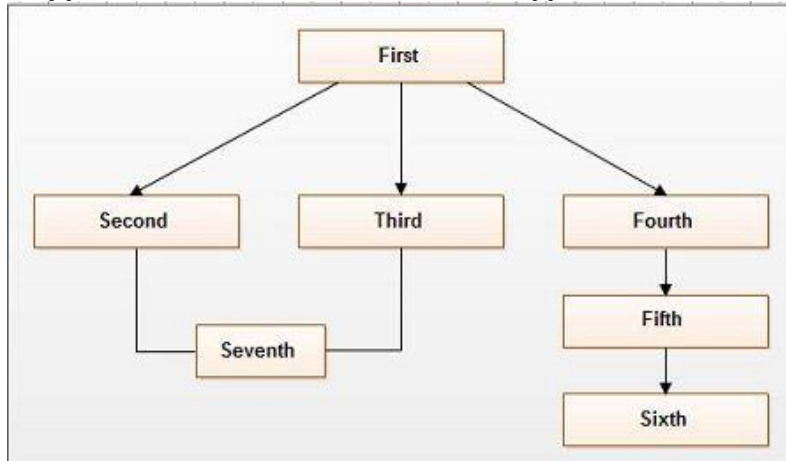
Explanation: In main (), we first create an object s1 of class student through which we call the read() and show() member functions of student's class for inputting and displaying student information .

Then similarly, we create an object t1 of teacher class for inputting and displaying teacher information.

5) Hybrid Inheritance

The inheritance hierarchy that reflects any legal combination of other four types of inheritance.

This is a Mixture of two or More Inheritance and in this Inheritance a Code May Contains two or Three types of inheritance in Single Code.



5) Hybrid Inheritance...



Example 2: Hierarchical Inheritance in C++ Programming...



Example 2: C++ Multilevel Inheritance...



2) Multilevel Inheritance...



2) Multilevel Inheritance...



Inheritance



Inheritance





References

- <https://beginnersbook.com/2017/08/cpp-data-types/>
- http://www.cplusplus.com/doc/tutorial/basic_io/
- <https://www.w3schools.com/cpp/default.asp>
- <https://www.javatpoint.com/cpp-tutorial>
- <https://www.geeksforgeeks.org/object-oriented-programming-in-cpp/?ref=lbp>
- <https://www.programiz.com/>
- <https://ecomputernotes.com/cpp/>

THANK YOU

