4.1 Classes, Super classes, and Subclasses

- Using inheritance, we can create a general class that defines common functionality to a set of related items.
- This class can then be inherited by other, more specific classes, each adding those things that are unique to it.
- The keyword **extends** indicates that we are making a new class that derives from an existing class.
- The existing class or inherited class is called the **superclass, base class, or parent class.**
- The new class or inheriting class is called the **subclass, derived class, or child class.**
- Therefore, a subclass is a **specialized version of a superclass**. It inherits all of the members defined by the superclass and adds its own, unique elements.
- Although a subclass includes all of the members of its superclass, it cannot access those members of the superclass that have been declared as private.
- **A reference variable of a superclass can be assigned a reference to any subclass** derived from that superclass. It is important to understand that it is the type of the reference variable—not the type of the object that it refers to—that determines what members can be accessed.
- That is, when a reference to a subclass object is assigned to a superclass reference variable, we will have access **only to those parts of the object defined by the superclass.**

Example -

```
class A{
     int fieldA;
}
class B extends class A{
     int fieldB;
}
class BInheritA{
     public static void main(String[] args){
          A a = new A();
          B b = new B();
          //aMemSum = a.fieldA + a.fieldB; B’s member not accessible
          aMem = a.fieldA;
          bMemSum = b.fieldA + b.fieldB; // A’s member accessible from B
          a = b; // assign subclass ref. variable to superclass;
          aAccb = a.fieldB;
          /*not accessible as a refers to ref.
          variable of b not the object of B.*/
     }
}
```

super –

- Whenever a subclass needs to **refer to its immediate superclass,** it can do so by use of the keyword super.
    - super has two general forms –
    - The first calls the superclass' constructor – super();
    - The second is used to access a member of the superclass that has been hidden by a member a subclass (similar to **this** referring object of current class) – super.member;
- A subclass can call a constructor defined by its superclass by use of the following form of super:

  super(arg-list);

  Here, arg-list specifies any arguments needed by the constructor in the superclass.
- **super**( ) must **always be the first statement executed inside a subclass' constructor.**
- When a subclass calls super( ), it is **calling the constructor of its immediate superclass.**
- Thus, super( ) always refers to the **superclass immediately above the calling class.**
- This is true even in **a multileveled hierarchy**.
- The second form of super acts somewhat like this, except that it always refers to the superclass of the subclass in which it is used.
- This usage has the following general form:

  super.member;
- Here, member can be either a method or an instance variable.
- This second form of super is most applicable to situations in which member names of a subclass hide members by the same name in the superclass.

Usage of Java super Keyword

1) super is used to refer immediate parent class instance variable.

We can use super keyword to access the data member or field of parent class. It is used if parent class and child class have same fields.

```
class Animal{
     String color="white";
}
class Dog extends Animal{
     String color="black";
void printColor(){
     System.out.println(color);//prints color of Dog class
     System.out.println(super.color);//prints color of Animal class

     }
}
```

```
class TestSuper1{
public static void main(String args[]){
Dog d=new Dog();
d.printColor();
}}
```

Output:

```
black
white
```

In the above example, Animal and Dog both classes have a common property color. If we print color property, it will print the color of current class by default. To access the parent property, we need to use super keyword.

2) super can be used to invoke parent class method

The super keyword can also be used to invoke parent class method. It should be used if subclass contains the same method as parent class. In other words, it is used if method is overridden.

```
class Animal{
void eat(){System.out.println("eating...");}
}
class Dog extends Animal{
     void eat(){System.out.println("eating bread...");}
     void bark(){System.out.println("barking...");}
     void work(){
          super.eat();
          bark();
     }
}
class TestSuper2{
public static void main(String args[]){
Dog d=new Dog();
d.work();
}}
```

Output:

```
eating...
barking...
```

In the above example Animal and Dog both classes have eat() method if we call eat() method from Dog class, it will call the eat() method of Dog class by default because priority is given to local.

To call the parent class method, we need to use super keyword.

3) super is used to invoke parent class constructor.

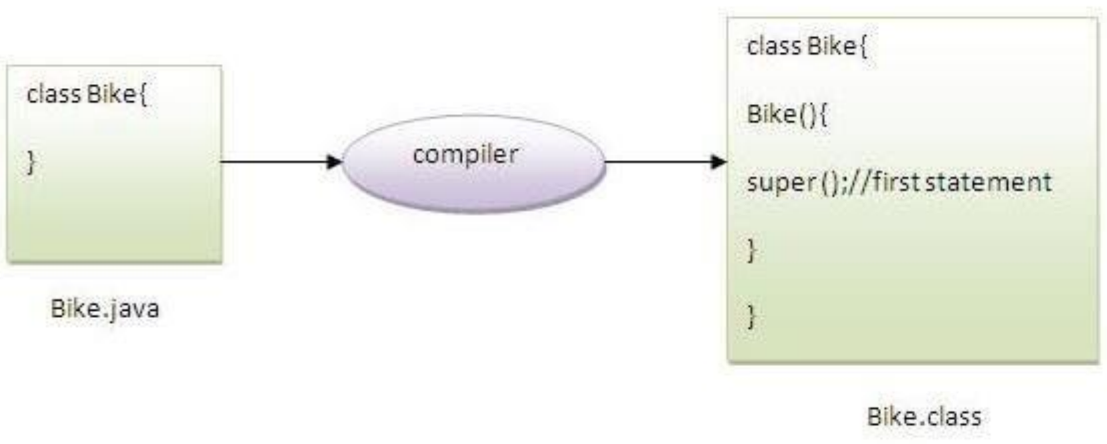
The super keyword can also be used to invoke the parent class constructor. Let's see a simple example:

```
class Animal{
     Animal(){System.out.println("animal is created");}
}
class Dog extends Animal{
     Dog(){
          super();
          System.out.println("dog is created");
     }
}
class TestSuper3{
     public static void main(String args[]){
     Dog d=new Dog();
}}
```

Output:

```
animal is created
dog is created
```

Note: super() is added in each class constructor automatically by compiler if there is no super() or this().



As we know well that default constructor is provided by compiler automatically if there is no constructor. But, it also adds super() as the first statement.

Another example of super keyword where super() is provided by the compiler implicitly.

```
class Animal{
     Animal(){System.out.println("animal is created");}
}
class Dog extends Animal{
     Dog(){
          System.out.println("dog is created");
     }
}
class TestSuper4{
     public static void main(String args[]){
          Dog d=new Dog();
}}
```

Output:

```
animal is created
dog is created
```

4.2 Polymorphism

Polymorphism in Java is a concept by which we can perform a *single action in different ways*. Polymorphism is derived from 2 Greek words: poly and morphs. The word "poly" means many and "morphs" means forms. So polymorphism means many forms.

There are two types of polymorphism in Java: compile-time polymorphism and runtime polymorphism. We can perform polymorphism in java by method overloading and method overriding.

If you overload a static method in Java, it is the example of compile time polymorphism. Here, we will focus on runtime polymorphism in java.

Runtime Polymorphism in Java

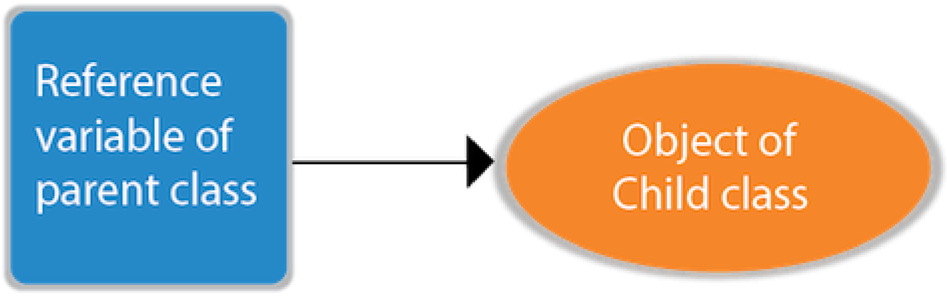
Runtime polymorphism or **Dynamic Method Dispatch** is a process in which a call to an overridden method is resolved at runtime rather than compile-time.

In this process, an overridden method is called through the reference variable of a superclass. The determination of the method to be called is based on the object being referred to by the reference variable.

Let's first understand the upcasting before Runtime Polymorphism.

Upcasting

If the reference variable of Parent class refers to the object of Child class, it is known as upcasting. For example:



```
class A{}
class B extends A{}
A a=new B();//upcasting
```

Example of Java Runtime Polymorphism

In this example, we are creating two classes Bike and Splendor. Splendor class extends Bike class and overrides its run() method. We are calling the run method by the reference variable of Parent class. Since it refers to the subclass object and subclass method overrides the Parent class method, the subclass method is invoked at runtime.

Since method invocation is determined by the JVM not compiler, it is known as runtime polymorphism.

```
class Bike{
  void run(){System.out.println("running");}
}
class Splendor extends Bike{
  void run(){System.out.println("running safely with 60km");}

  public static void main(String args[]){
    Bike b = new Splendor();//upcasting
    b.run();
  }
}
```

Output

```
Running safely with 60km
```

Java Runtime Polymorphism Example: Shape

```
class Shape{
void draw(){System.out.println("drawing...");}
}
class Rectangle extends Shape{
void draw(){System.out.println("drawing rectangle...");}
}
class Circle extends Shape{
void draw(){System.out.println("drawing circle...");}
}
class Triangle extends Shape{
void draw(){System.out.println("drawing triangle...");}
}
class TestPolymorphism2{
public static void main(String args[]){
Shape s;
s=new Rectangle();
s.draw();
s=new Circle();
s.draw();
s=new Triangle();
s.draw();
}
}
```

Output:

```
drawing rectangle...
drawing circle...
drawing triangle...
```

4.3 Dynamic Binding

- Dynamic method dispatch is the mechanism by which a call to an overridden method is resolved at run time, rather than compile time.

- Dynamic method dispatch is important because this is how Java implements run-time polymorphism.
- As already mentioned a superclass reference variable can refer to a subclass object.
- Java uses this fact to resolve calls to overridden methods at run time.
- When an overridden method is called through a superclass reference, Java determines which version of that method to execute based upon the type of the object being referred to at the time the call occurs.
- It is the type of the object being referred to (not the type of the reference variable) that determines which version of an overridden method will be executed.
- Therefore, if a superclass contains a method that is overridden by a subclass, then when different types of objects are referred to through a superclass reference variable, different versions of the method are executed.
- Example -

```
class A{
     int fieldA=10;
     void show(){
          System.out.println(fieldA);
     }
}
class B extends A{
     int fieldB=20;
     // override show() in class A
     @Override
     void show(){
          super.show();
          System.out.println(fieldB);
     }
}
class C extends B{
     int fieldC=30;
     // override show() in class B
     @Override
     void show(){
          super.show();
          System.out.println(fieldC);
     }
}
class overriding{
     public static void main(String[] args){
          A a;
          B b = new B();
          a = b;
          a.show();
          C c = new C();
          a = c;
          a.show();
     }
}
```

Output
```
10
20
10
20
30
```

4.4 Final Classes and Methods

Final Keyword In Java

The **final keyword** in java is used to restrict the user. The java final keyword can be used in many context. Final can be:

1. variable
2. method
3. class

The final keyword can be applied with the variables, a final variable that have no value it is called blank final variable or uninitialized final variable. It can be initialized in the constructor only. The blank final variable can be static also which will be initialized in the static block only. We will have detailed learning of these. Let's first learn the basics of final keyword.

1) Java final variable

If you make any variable as final, you cannot change the value of final variable(It will be constant).

Example of final variable

There is a final variable speedlimit, we are going to change the value of this variable, but It can't be changed because final variable once assigned a value can never be changed.

```
class Bike9{
 final int speedlimit=90;//final variable
 void run(){
  speedlimit=400;
 }
 public static void main(String args[]){
 Bike9 obj=new  Bike9();
 obj.run();
 }
}//end of class
```

Output: Compile Time Error

2) Java final method

If you make any method as final, you cannot override it.

Example of final method

```
class Bike{
  final void run(){System.out.println("running");}
}

class Honda extends Bike{
   void run(){System.out.println("running safely with 100kmph");}

   public static void main(String args[]){
   Honda honda= new Honda();
   honda.run();
   }
}
```

Output:Compile Time Error

3) Java final class

If you make any class as final, you cannot extend it.

Example of final class

```
final class Bike{}
```

```
class Honda1 extends Bike{
  void run(){System.out.println("running safely with 100kmph");}
  public static void main(String args[]){
  Honda1 honda= new Honda1();
  honda.run();
  }
}
```

Output:Compile Time Error

Q) Is final method inherited?

Ans) Yes, final method is inherited but you cannot override it. For Example:

```
class Bike{
  final void run(){System.out.println("running...");}
}
class Honda2 extends Bike{
   public static void main(String args[]){
    new Honda2().run();
   }
}
```

Output:running...

4.5 Abstract Class

A class which is declared with the abstract keyword is known as an abstract class in Java. It can have abstract and non-abstract methods (method with the body).
Before learning the Java abstract class, let's understand the abstraction in Java first.

Abstraction in Java
Abstraction is a process of hiding the implementation details and showing only functionality to the user.

Another way, it shows only essential things to the user and hides the internal details, for example, sending SMS where you type the text and send the message. You don't know the internal processing about the message delivery.
Abstraction lets you focus on what the object does instead of how it does it.
Ways to achieve Abstraction
There are two ways to achieve abstraction in java

1. Abstract class (0 to 100%)
2. Interface (100%)

Abstract class in Java
A class which is declared as abstract is known as an **abstract class**. It can have abstract and non-abstract methods. It needs to be extended and its method implemented. It cannot be instantiated.
Points to Remember

- An abstract class must be declared with an abstract keyword.
- It can have abstract and non-abstract methods.
- It cannot be instantiated.
- It can have constructors and static methods also.
- It can have final methods which will force the subclass not to change the body of the method.

Example of abstract class

```
abstract class A{}
```

Abstract Method in Java
A method which is declared as abstract and does not have implementation is known as an abstract method.
Example of abstract method

```
abstract void printStatus();//no method body and abstract
```

Example of Abstract class that has an abstract method
example of Abstract class in java
File: TestBank.java

```
abstract class Bank{
abstract int getRateOfInterest();
}
class SBI extends Bank{
int getRateOfInterest(){return 7;}
}
class PNB extends Bank{
```

```
int getRateOfInterest(){return 8;}
}

class TestBank{
public static void main(String args[]){
Bank b;
b=new SBI();
System.out.println("Rate of Interest is: "+b.getRateOfInterest()+" %
");
b=new PNB();
System.out.println("Rate of Interest is: "+b.getRateOfInterest()+" %
");
}}
```

```
Rate of Interest is: 7 %
Rate of Interest is: 8 %
```

Understanding the real scenario of Abstract class

In this example, Shape is the abstract class, and its implementation is provided by the Rectangle and Circle classes.

Mostly, we don't know about the implementation class (which is hidden to the end user), and an object of the implementation class is provided by the **factory method**.

A **factory method** is a method that returns the instance of the class. A Factory Pattern or Factory Method Pattern says that just define an interface or abstract class for creating an object but let the subclasses decide which class to instantiate. In other words, subclasses are responsible to create the instance of the class.

In this example, if you create the instance of Rectangle class, draw() method of Rectangle class will be invoked.

File: TestAbstraction1.java

```
abstract class Shape{
abstract void draw();
}
//In real scenario, implementation is provided by others i.e. unknow
n by end user
class Rectangle extends Shape{
void draw(){System.out.println("drawing rectangle");}
}
```

```
class Circle1 extends Shape{
void draw(){System.out.println("drawing circle");}
}
//In real scenario, method is called by programmer or user
class TestAbstraction1{
public static void main(String args[]){
Shape s=new Circle1();//In a real scenario, object is provided throu
gh method, e.g., getShape() method
s.draw();
}
}
```

Output:

```
draw ing circle
```

Abstract class having constructor, data member and methods

An abstract class can have a data member, abstract method, method body (non-abstract method), constructor, and even main() method.

File: TestAbstraction2.java

```
//Example of an abstract class that has abstract and non-abstract methods
 abstract class Bike{
   Bike(){System.out.println("bike is created");}
   abstract void run();
   void changeGear(){System.out.println("gear changed");}
 }
//Creating a Child class which inherits Abstract class
 class Honda extends Bike{
 void run(){System.out.println("running safely..");}
 }
//Creating a Test class which calls abstract and non-abstract methods
 class TestAbstraction2{
 public static void main(String args[]){
  Bike obj = new Honda();
  obj.run();
  obj.changeGear();
 }
}
```

Output:

```
bike is created
running safely..
gear changed
```

Rule: If there is an abstract method in a class, that class must be abstract.

```
class Bike12{
abstract void run();
}
```

Output:

```
compile time error
```

4.6 Access Specifiers

There are four types of Java access modifiers:

1. **Private**: The access level of a private modifier is only within the class. It cannot be accessed from outside the class.
2. **Default**: The access level of a default modifier is only within the package. It cannot be accessed from outside the package. If you do not specify any access level, it will be the default.
3. **Protected**: The access level of a protected modifier is within the package and outside the package through child class. If you do not make the child class, it cannot be accessed from outside the package.
4. **Public**: The access level of a public modifier is everywhere. It can be accessed from within the class, outside the class, within the package and outside the package.

Access Modifier	within class	within package	outside package by subclass only	outside package
Private	Y	N	N	N
Default	Y	Y	N	N
Protected	Y	Y	Y	N
Public	Y	Y	Y	Y

1) Private

The private access modifier is accessible only within the class.

Simple example of private access modifier

In this example, we have created two classes A and Simple. A class contains private data member and private method. We are accessing these private members from outside the class, so there is a compile-time error.

```
class A{
private int data=40;
private void msg(){System.out.println("Hello java");}
}

public class Simple{
 public static void main(String args[]){
   A obj=new A();
   System.out.println(obj.data);//Compile Time Error
   obj.msg();//Compile Time Error
   }
}
```

Role of Private Constructor

If you make any class constructor private, you cannot create the instance of that class from outside the class. For example:

```
class A{
private A(){}//private constructor
void msg(){System.out.println("Hello java");}
}
public class Simple{
public static void main(String args[]){
A obj=new A();//Compile Time Error
}
}
```

Note: A class cannot be private or protected except nested class.

2) Default

If you don't use any modifier, it is treated as **default** by default. The default modifier is accessible only within package. It cannot be accessed from outside the package. It provides more accessibility than private. But, it is more restrictive than protected, and public.

Example of default access modifier

In this example, we have created two packages pack and mypack. We are accessing the A class from outside its package, since A class is not public, so it cannot be accessed from outside the package.

```
//save by A.java
package pack;
class A{
  void msg(){System.out.println("Hello");}
}
//save by B.java
package mypack;
import pack.*;
class B{
  public static void main(String args[]){
   A obj = new A();//Compile Time Error
   obj.msg();//Compile Time Error
  }
}
```

In the above example, the scope of class A and its method msg() is default so it cannot be accessed from outside the package.

3) Protected

The **protected access modifier** is accessible within package and outside the package but through inheritance only.

The protected access modifier can be applied on the data member, method and constructor. It can't be applied on the class.

It provides more accessibility than the default modifer.

Example of protected access modifier

In this example, we have created the two packages pack and mypack. The A class of pack package is public, so can be accessed from outside the package. But msg method of this package is declared as protected, so it can be accessed from outside the class only through inheritance.

```
//save by A.java
package pack;
public class A{
protected void msg(){System.out.println("Hello");}
}
//save by B.java
package mypack;
import pack.*;

class B extends A{
  public static void main(String args[]){
   B obj = new B();
   obj.msg();
  }
}
```

```
Output: Hello
```

4) Public

The **public access modifier** is accessible everywhere. It has the widest scope among all other modifiers.

Example of public access modifier

```
//save by A.java

package pack;
public class A{
public void msg(){System.out.println("Hello");}
}
//save by B.java

package mypack;
import pack.*;
```

```
class B{
  public static void main(String args[]){
   A obj = new A();
   obj.msg();
  }
}
```

Output: Hello

4.7 Interfaces

An **interface in Java** is a blueprint of a class. It has static constants and abstract methods.

The interface in Java is *a mechanism to achieve abstraction*. There can be only abstract methods in the Java interface, not method body. It is used to achieve abstraction and multiple inheritance in Java.

In other words, you can say that interfaces can have abstract methods and variables. It cannot have a method body.

Java Interface also **represents the IS-A relationship**.
It cannot be instantiated just like the abstract class.
Since Java 8, we can have **default and static methods** in an interface.
Since Java 9, we can have **private methods** in an interface.

Why use Java interface?

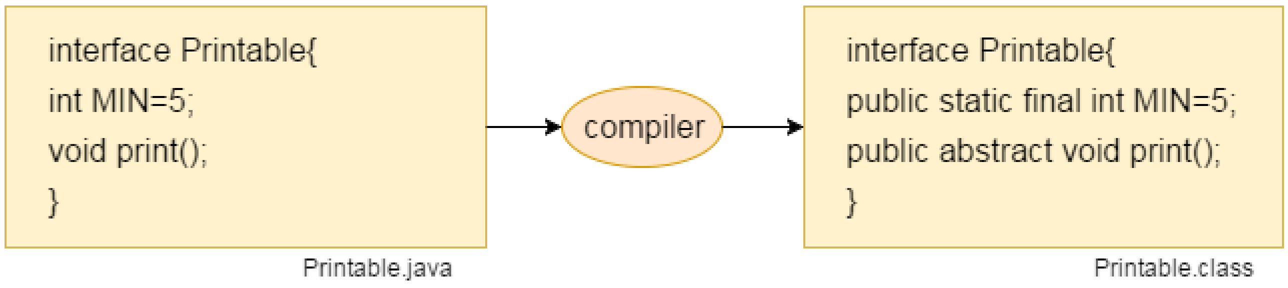
There are mainly three reasons to use interface. They are given below.

- It is used to achieve abstraction.
- By interface, we can support the functionality of multiple inheritance.
- It can be used to achieve loose coupling.

Internal addition by the compiler

The Java compiler adds public and abstract keywords before the interface method. Moreover, it adds public, static and final keywords before data members.

In other words, Interface fields are public, static and final by default, and the methods are public and abstract.



Java Interface Example: Bank

File: TestInterface2.java

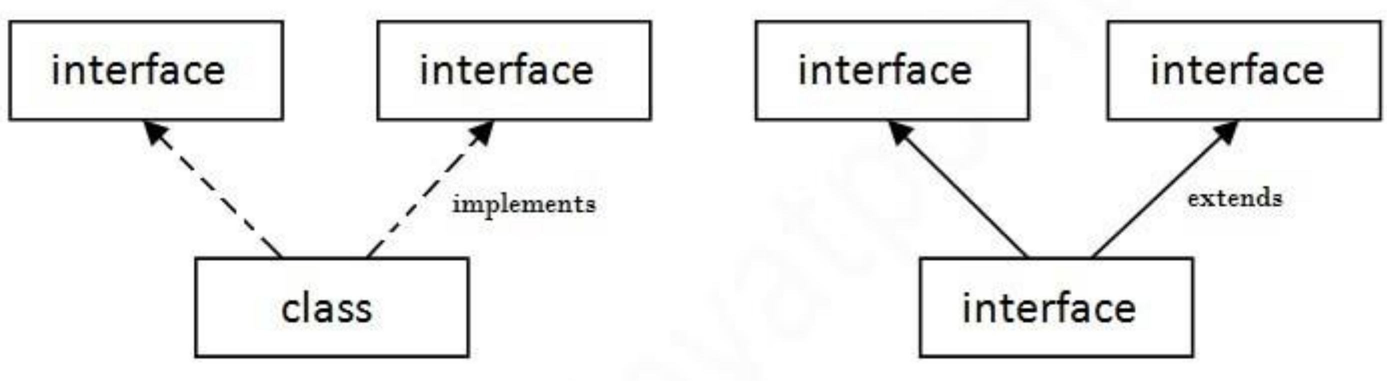
```java
interface Bank{
float rateOfInterest();
}
class SBI implements Bank{
public float rateOfInterest(){return 9.15f;}
}
class PNB implements Bank{
public float rateOfInterest(){return 9.7f;}
}
class TestInterface2{
public static void main(String[] args){
Bank b=new SBI();
System.out.println("ROI: "+b.rateOfInterest());
}}
```

Output:

```
ROI: 9.15
```

Multiple inheritance in Java by interface

If a class implements multiple interfaces, or an interface extends multiple interfaces, it is known as multiple inheritance.



Multiple Inheritance in Java

```
interface Printable{
void print();
}
interface Showable{
void show();
}
class A7 implements Printable,Showable{
public void print(){System.out.println("Hello");}
public void show(){System.out.println("Welcome");}

public static void main(String args[]){
A7 obj = new A7();
obj.print();
obj.show();
 }
}
```

Output:

```
     Hello
   Welcome
```

Q) Multiple inheritance is not supported through class in java, but it is possible by an interface, why?

As we have explained in the inheritance chapter, multiple inheritance is not supported in the case of class because of ambiguity. However, it is supported in case of an interface because there is no ambiguity. It is because its implementation is provided by the implementation class. For example:

```
interface Printable{
void print();
}
interface Showable{
void print();
}

class TestInterface3 implements Printable, Showable{
public void print(){System.out.println("Hello");}
public static void main(String args[]){
TestInterface3 obj = new TestInterface3();
obj.print();
 }
}
```

Output:

```
Hello
```