

Unit 2 (Remaining Topics)

Classes, Inheritance, Packages and Interfaces

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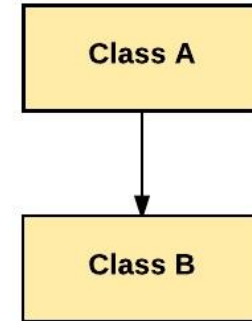
SoCS UPES Dehradun

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UNIT-II

- Class Fundamentals, Objects, Constructors, Garbage Collection, this Keyword, Java's Access Modifiers, Method Overloading, static Keyword
- Inheritance, Types of Inheritance, super to Access Superclass Members, Method Overriding
- Abstract Classes, Using final,
- Packages and Interfaces, Build-in Interface, User defined Interfaces.

Inheritance



- **Inheritance** is a mechanism in which one class acquires the property of another class.
 - E.g. a child inherits the traits of his/her parents.
- Inheritance represents the **IS-A relationship** which is also known as a *parent-child* relationship.

WHY INHERITANCE?

- For Method Overriding (so runtime polymorphism can be achieved).
- For Code Reusability.

Key Terms:

- **Sub Class/Child Class:** Subclass is a class which inherits the other class. It is also called a derived class, extended class, or child class.
- **Super Class/Parent Class:** Superclass is the class from where a subclass inherits the features. It is also called a base class or a parent class.
- **Reusability:** As the name specifies, reusability is a mechanism which facilitates you to reuse the fields and methods of the existing class when you create a new class. You can use the same fields and methods already defined in the previous class.

Extends

- The **extends keyword** indicates that you are making a new class that derives from an existing class.

```
class Subclass-name extends Superclass-name
```

```
{
```

```
    // methods and fields
```

```
}
```

Example

```
class Employee{  
    float salary=40000;  
}  
  
class Programmer extends Employee{  
    int bonus=10000;  
    public static void main(String args[]) {  
        Programmer p=new Programmer();  
        System.out.println("Programmer salary is:"+p.salary);  
        System.out.println("Bonus of Programmer is:"+p.bonus);  
    }  
}
```

O/P:

Programmer salary is:40000.0

Bonus of programmer is:10000

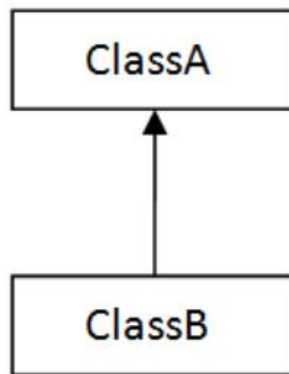
Example:

```
class Vehicle {  
    protected String brand = "TATA";  
    public void honk() {  
        System.out.println("Horn PLz!");  
    }  
}  
  
class Car extends Vehicle {  
    private String modelName = "NEXON";  
    public static void main(String[] args) {  
        Car myFastCar = new Car();  
        myFastCar.honk();  
        System.out.println(myFastCar.brand + " " + myFastCar.modelName);  
    }  
}
```

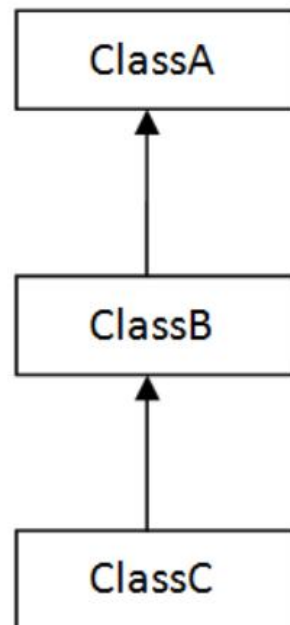
O/P:
Horn PLz!
TATA NEXON

Types of inheritance in java

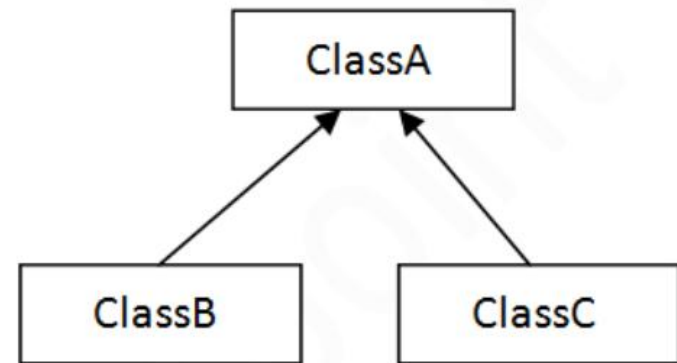
- On the basis of class, there can be three types of inheritance in java:
 - Single
 - multilevel
 - hierarchical



1) Single



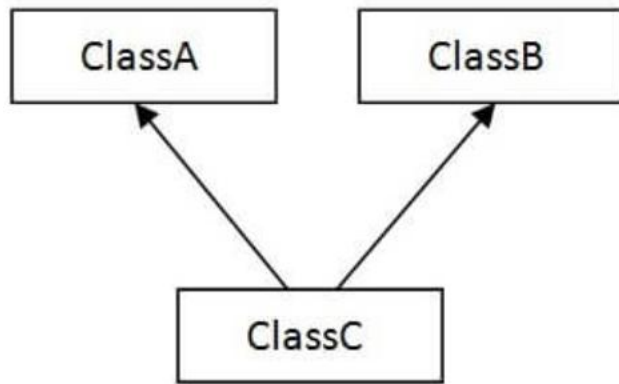
2) Multilevel



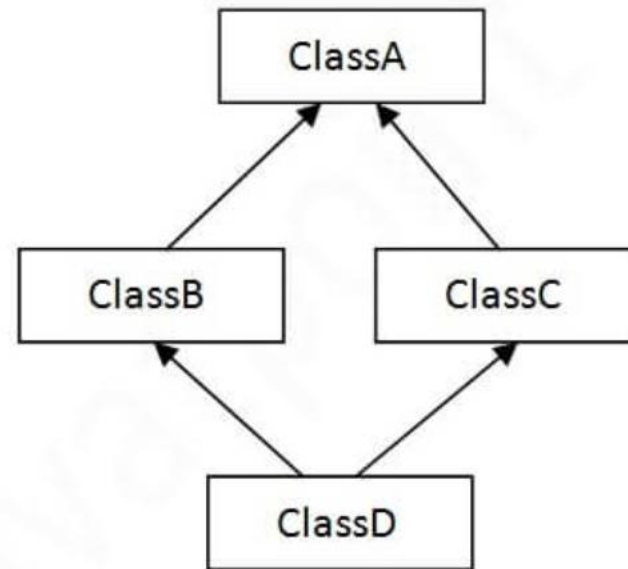
3) Hierarchical

Types of Inheritance

- In java programming, *multiple and hybrid inheritance* is supported through interface only.



4) Multiple



5) Hybrid

Note: Multiple inheritance is not supported in Java through class.

Single Inheritance Example

//Parent Class

```
class Animal{  
void eat(){System.out.println("eating...");}  
}
```

//Child Class

```
class Dog extends Animal{  
void bark(){System.out.println("barking...");}  
}
```

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

O/P:
barking...
eating...

Multilevel Inheritance Example

- When there is a chain of inheritance, it is known as *multilevel inheritance*.

```
class Animal{  
void eat(){System.out.println("eating...");}  
}
```

```
class Dog extends Animal{  
void bark(){System.out.println("barking...");}  
}
```

```
class BabyDog extends Dog{  
void weep(){System.out.println("weeping...");}  
}
```

```
class TestInheritance{  
public static void main(String args[]){  
BabyDog d=new BabyDog();  
d.weep();  
d.bark();  
d.eat();  
}}
```

O/P:
weeping...
barking...
eating...

Hierarchical Inheritance Example

- When two or more classes inherit a single class.

```
class Animal{  
    void eat(){System.out.println("eating...");}  
}
```

```
class Dog extends Animal{  
    void bark(){System.out.println("barking...");}  
}
```

```
class Cat extends Animal{  
    void meow(){System.out.println("meowing...");}  
}
```

```
class TestInheritance{  
    public static void main(String args[]){  
        Cat c=new Cat();  
        c.meow();  
        c.eat();  
        //c.bark();//Compile time Error  
    }  
}
```

Output:
meowing...
eating...

Why multiple inheritance is not supported in java?

- To reduce the complexity and simplify the language, multiple inheritance is not supported in java.
- To avoid ambiguity while calling same method present in both parent classes.

```
class A{
void msg(){System.out.println("Hello");}
}
class B{
void msg(){System.out.println("Welcome");}
}
class C extends A,B{//suppose if it were

public static void main(String args[]){
    C obj=new C();
    obj.msg();//Now which msg() method would be invoked?
}
}
```

Output: Compile time Error

Aggregation in Java

- If a class have an entity reference, it is known as Aggregation.
Aggregation represents HAS-A relationship (part of relationship).

```
class Employee {  
    int id;  
    String name;  
    Address address; // Address is a class  
    ...  
}
```

- Employee has an entity reference address, so relationship is Employee HAS-A address.

Example of Aggregation

// Address class

class Address {

String city, state, country;

public Address(String city, String state, String country) {

 this.city = city;

 this.state = state;

 this.country = country;

}

void displayAddress() {

 System.out.println("City: " + city + ", State: " + state + ", Country: " + country);

}

}

// Student class with Aggregation

class Student {

int id;

String name;

Address address; // Aggregation: Student "has-a" Address

public Student(int id, String name, Address address) {

 this.id = id;

 this.name = name;

 this.address = address;

}

void displayStudent() {

 System.out.println("Student ID: " + id + ", Name: " + name);

 address.displayAddress();

}

}

// Main class

public class AggregationExample {

public static void main(String[] args) {

Address addr1 = new Address("Mumbai", "Maharashtra", "India");

 Student student1 = new Student(101, "Rahul", addr1);

 student1.displayStudent();

}

}

When to use Aggregation?

- Code reuse is also best achieved by aggregation when there is no is-a relationship.
- Inheritance should be used only if the relationship is-a is maintained throughout the lifetime of the objects involved; otherwise, aggregation is the best choice.

Method Overloading and Overriding

Method Overloading

- If a class has multiple methods having same name but different in parameters, it is known as **Method Overloading**.
- Method overloading *increases the readability of the program*.
- There are two ways to overload the method in java
 - By changing number of arguments
 - By changing the data type
- In Java, Method Overloading is not possible by changing the return type of the method only.

//method overloading

```
class OverloadDemo {
```

```
    void test() {
```

```
        System.out.println("No parameters");
```

```
    }
```

```
    void test(int a) {
```

```
        System.out.println("a: " + a);
```

```
    }
```

```
    void test(int a, int b) {
```

```
        System.out.println("a and b: " + a + " " + b);
```

```
    }
```

```
    double test(double a) {
```

```
        System.out.println("double a: " + a);
```

```
    return a*a;
```

```
    }
```

```
}
```

```
class Overload {
```

```
    public static void main(String args[]) {
```

```
        OverloadDemo ob = new OverloadDemo();
```

```
        double result;
```

```
        ob.test();
```

```
        ob.test(10);
```

```
        ob.test(10, 20);
```

```
        result = ob.test(123.25);
```

```
        System.out.println("Result of ob.test(123.25): " + result);
```

```
    }
```

```
}
```

Can we overload java main() method?

- Yes, by method overloading. You can have any number of main methods in a class by method overloading.
- But JVM calls main() method which receives string array as arguments only.

```
class TestOverloading{  
public static void main(String[] args){System.out.println("main with String[]");}  
public static void main(String args){System.out.println("main with String");}  
public static void main(){System.out.println("main without args");}  
}
```

Output: main with String[]

Method Overriding in Java

- If subclass (child class) has the same method as declared in the parent class, it is known as **method overriding in Java**.
- Method overriding is used to provide the specific implementation of a method which is already provided by its superclass.
- Method overriding is used for runtime polymorphism.
- Method overriding applies only to methods, not variables.
- If a subclass declares an instance variable with the same name as the parent class, the subclass variable hides the parent's variable.

Rules for Java Method Overriding

- 1.The method must have the same name as in the parent class
- 2.The method must have the same parameter as in the parent class.
- 3.There must be an IS-A relationship (inheritance).

Problem without method overriding

```
class Vehicle{  
    void run(){System.out.println("Vehicle is running");}  
}
```

//Creating a child class

```
class Bike extends Vehicle{  
    public static void main(String args[]){  
        //creating an instance of child class  
        Bike obj = new Bike();  
        //calling the method with child class instance  
        obj.run();  
    }  
}
```

Output: Vehicle is running

Problem: Need to provide a specific implementation of run() method in subclass

Example: method overriding

```
class Vehicle{  
    //defining a method  
    void run(){System.out.println("Vehicle is running");}  
}  
//Creating a child class  
class Bike extends Vehicle{  
    //defining the same method as in the parent class  
    void run(){System.out.println("Bike is running safely");}  
  
    public static void main(String args[]){  
        Bike obj = new Bike();//creating object  
        obj.run();//calling method  
    }  
}
```

Output: Bike is running safely

Example: Method Overriding

```
class Bank{  
int getRateOfInterest(){return 0;}  
}
```

//Creating child classes.

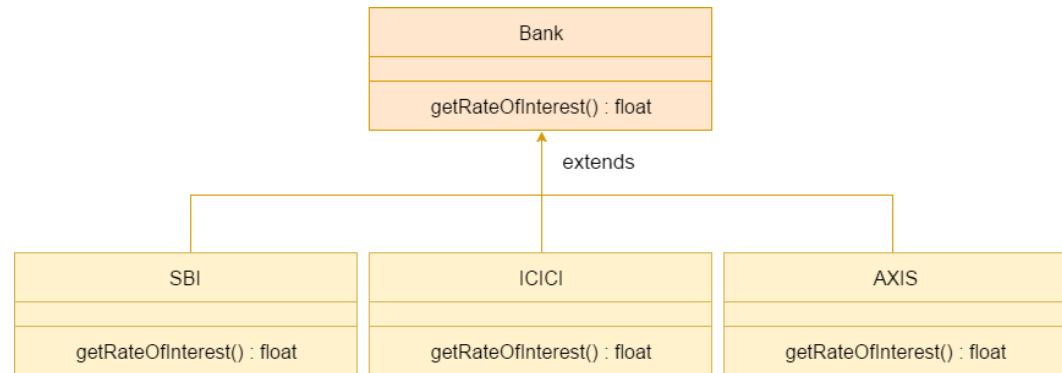
```
class SBI extends Bank{  
int getRateOfInterest(){return 4;}  
}
```

```
class ICICI extends Bank{  
int getRateOfInterest(){return 3;}  
}
```

```
class AXIS extends Bank{  
int getRateOfInterest(){return 5;}  
}
```

//Test class to create objects and call the methods

```
class Test{  
public static void main(String args[]){  
SBI s=new SBI();  
ICICI i=new ICICI();  
AXIS a=new AXIS();  
System.out.println("SBI Rate of Interest: "+s.getRateOfInterest());  
System.out.println("ICICI Rate of Interest: "+i.getRateOfInterest());  
System.out.println("AXIS Rate of Interest: "+a.getRateOfInterest());  
}  
}
```



Output:

SBI Rate of Interest: 4

ICICI Rate of Interest: 3

AXIS Rate of Interest: 5

Can we override static method?

- No, a static method cannot be overridden.
- the static method is bound with class whereas instance method is bound with an object.

Can we override java main method?

- No, because the main is a static method.

Super Keyword

- The **super** keyword in Java is a reference variable which is used to refer immediate parent class object.
- Whenever you create the instance of subclass, an instance of parent class is created implicitly which is referred by super reference variable.

Usage of Java super Keyword

1. super can be used to refer immediate **parent class instance variable**.
2. super can be used to invoke immediate **parent class method**.
3. super() can be used to invoke immediate **parent class constructor**.

Super- to refer immediate parent class instance variable

- to access the data member or field of parent class.
- 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 TestSuper{
public static void main(String args[]){
Dog d=new Dog();
d.printColor();
}}
```

Output:
Black
white

Super- to invoke parent class method

- It should be used if subclass contains the same method as parent class (Methods are 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 TestSuper{
public static void main(String args[]){
Dog d=new Dog();
d.work();
}}
```

Output:
eating...
barking...

Super() - to invoke parent class constructor

- To invoke parent class constructor.

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

Output:
animal is created
dog is created

Super() - to invoke parent class constructor

- Note: `super()` is added in each class constructor automatically as the first statement by compiler if there is no `super()` or `this()`.

```
class Animal{  
    Animal(){System.out.println("animal is created");}  
}
```

```
class Dog extends Animal{  
    Dog(){  
        System.out.println("dog is created");  
    }  
}
```

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

Output:
animal is created
dog is created

Example- Super()

```
class Person{
    int id;
    String name;
    Person(int id,String name){
        this.id=id;
        this.name=name;
    }
}
```

```
class Emp extends Person{
    float salary;
    Emp(int id,String name,float salary){
        super(id,name);//reusing parent constructor
        this.salary=salary;
    }
    void display(){System.out.println(id+" "+name+" "+salary);}
}
```

```
class TestSuper{
    public static void main(String[] args){
        Emp e1=new Emp(4,"aman",95000f);
        e1.display();
    }
}
```

Output:
4 aman 95000

Instance initializer block- Example

- **Instance Initializer block** is used to initialize the instance data member.
- It runs each time when an object of the class is created.

```
class Bike{  
    int speed;  
  
    Bike(){System.out.println("speed is "+speed);}  
  
    {speed=100;}  
  
    public static void main(String args[]){  
        Bike b1=new Bike();  
        Bike b2=new Bike();  
    }  
}
```

Output:
speed is 100
speed is 100

Instance initializer block

- It runs each time when an object of the class is created.

We can directly
assign a value in
instance data
member

```
class Bike{  
    int speed=100;  
}
```

Why initializer block?

- To perform some operations while assigning value to instance data member
 - e.g. a for loop to fill a complex array or error handling etc.

There are three places in Java where you can perform operations:

- method
- constructor
- block

Instance initializer block

What is invoked first, instance initializer block or constructor?

```
class Bike{  
    int speed;  
  
    Bike(){System.out.println("constructor is invoked");}  
  
    {System.out.println("instance initializer block invoked");}
```

```
public static void main(String args[]){  
    Bike b1=new Bike();  
    Bike b2=new Bike();  
}  
}
```

Output:

```
instance initializer block invoked  
constructor is invoked  
instance initializer block invoked  
constructor is invoked
```

- Instance initializer block is invoked at the time of object creation.

Rules for instance initializer block :

Three rules:

- The instance initializer block is created when instance of the class is created.
- The instance initializer block is invoked after the parent class constructor is invoked (i.e. after `super()` constructor call).
- The instance initializer block comes in the order in which they appear.

Program of instance initializer block that is invoked after super()

```
class A{
A(){
System.out.println("parent class constructor invoked");
}
}

class B2 extends A{
B2(){
super();
System.out.println("child class constructor invoked");
}

{System.out.println("instance initializer block is invoked");}

public static void main(String args[]){
B2 b=new B2();
}
}
```

Note: Sequence of execution when an object is instantiated:

- Memory for the object is allocated.
- Any default values for the instance variables are set.
- The superclass's constructor is invoked.
- The instance initializer block(s) are executed in the order in which they appear in the class.
- The constructor is executed.

Output:

parent class constructor invoked
instance initializer block is invoked
child class constructor invoked

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:

- variable
- method
- 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.
- The blank final variable can be static which will be initialized in the static block only.

Java final variable

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

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

Output: Compile Time Error

Java final variable

```
class Bike{  
    final int speedlimit; // final variable  
  
    Bike() {  
        speedlimit = 400; // Initializing the final variable in the constructor  
    }  
  
    void run() {  
        System.out.println("Speed Limit: " + speedlimit);  
    }  
  
    public static void main(String args[]) {  
        Bike obj = new Bike();  
        obj.run();  
    }  
} // end of class
```

Output: Speed Limit: 400

Rules (final variables)

- **Local final variables:** Must be initialized before use.
- **Instance final variables:** Must be initialized in the constructor, an instance block, or directly.
- **Static final variables:** Must be initialized at declaration or in a static block.
- Once assigned, final variables cannot be changed.

Java final method

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

```
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

Java final class

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

```
final class Bike{}
```

```
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

Is final method inherited?

- Yes, final method is inherited but you cannot override it.

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

Can we declare a constructor final?

- No, because constructor is never inherited.

Blank or uninitialized final variable

- A final variable that is not initialized at the time of declaration.
- If you want to create a variable that is initialized at the time of creating object and once initialized may not be changed. (e.g. PAN Card Number)
- It can be initialized only in constructor.

```
class Student {  
    private String name;  
    private final String panCardNumber;  
  
    public Student(String name, String panCardNumber) {  
        this.name = name;  
        this.panCardNumber = panCardNumber;  
    }  
  
    public void displayDetails() {  
        System.out.println(name + " has PAN: " + panCardNumber);  
    }  
  
    public static void main(String[] args) {  
        Student deepak = new Student("Deepak", "XYZDE5678G");  
        deepak.displayDetails();  
    }  
}
```

Output:
Deepak has PAN: XYZDE5678G

static blank final variable

- A static final variable that is not initialized at the time of declaration is known as static blank final variable. It can be initialized only in static block.

```
class A{  
    static final int data;//static blank final variable  
    static{ data=50;}  
    public static void main(String args[]){  
        System.out.println(A.data);  
    }  
}
```

final parameter

- If you declare any parameter as final, you cannot change the value of it.

```
class Bike{  
    int cube(final int n){  
        n=n+2;//can't be changed as n is final  
        n*n*n;  
    }  
    public static void main(String args[]){  
        Bike b=new Bike();  
        b.cube(5);  
    }  
}
```

Polymorphism in Java

- **Polymorphism in Java** is a concept by which we can perform a *single action in different ways*.
- Types:
 - compile-time polymorphism
 - runtime polymorphism
- polymorphism in java is done by
 - method overloading
 - method overriding
- Compile time polymorphism
 - Example- Overload a static method

Runtime Polymorphism in Java

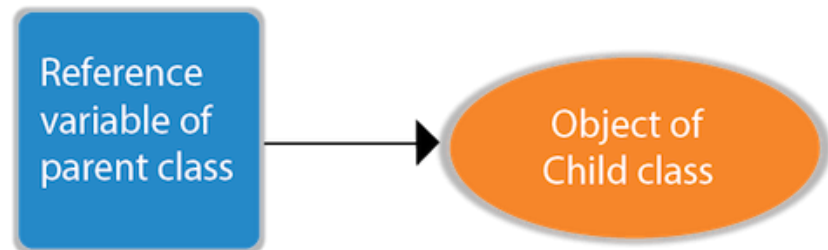
- **Runtime polymorphism** or **Dynamic Method Dispatch** is a process in which a call to an overridden method is resolved at runtime rather than compile-time.
- An overridden method is called through the reference variable of a superclass.
- The determination of the method to be called is based on the object being referred to by the reference variable.
- Since method invocation is determined by the JVM not compiler, it is known as runtime polymorphism.

Runtime Polymorphism

Upcasting

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

```
class A{  
class B extends A{  
public static void main(String args[]){  
A a=new B(); //upcasting  
}  
}
```



Example of Java 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.

Example

```
class Bank{
float getRateOfInterest(){return 0;}
}
class SBI extends Bank{
float getRateOfInterest(){return 8.4f;}
}
class ICICI extends Bank{
float getRateOfInterest(){return 7.3f;}
}
class AXIS extends Bank{
float getRateOfInterest(){return 9.7f;}
}
class TestPolymorphism{
public static void main(String args[]){
Bank b;
b=new SBI();
System.out.println("SBI Rate of Interest: "+b.getRateOfInterest());
b=new ICICI();
System.out.println("ICICI Rate of Interest: "+b.getRateOfInterest());
b=new AXIS();
System.out.println("AXIS Rate of Interest: "+b.getRateOfInterest());
}
}
```

Output:

SBI Rate of Interest: 8.4

ICICI Rate of Interest: 7.3

AXIS Rate of Interest: 9.7

Java Runtime Polymorphism with Data Member

- A method is overridden, not the data members, so runtime polymorphism can't be achieved by other data members .

```
class Bike{  
    int speedlimit=90;  
}  
class Honda extends Bike{  
    int speedlimit=150;  
  
    public static void main(String args[]){  
        Bike obj=new Honda();  
        System.out.println(obj.speedlimit);  
    }  
}
```

Output:

90

Java Runtime Polymorphism with Multilevel Inheritance

```
class Animal{
void eat(){System.out.println("eating");}
}
class Dog extends Animal{
void eat(){System.out.println("eating fruits");}
}
class BabyDog extends Dog{
void eat(){System.out.println("drinking milk");}
public static void main(String args[]){
Animal a1,a2,a3;
a1=new Animal();
a2=new Dog();
a3=new BabyDog();
a1.eat();
a2.eat();
a3.eat();
}
}
```

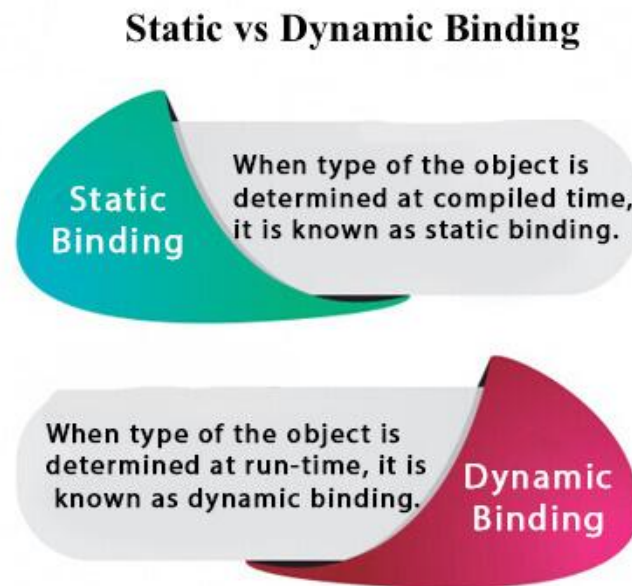
Output:

eating
eating fruits
drinking Milk

Static Binding and Dynamic Binding

Connecting a method call to the method body is known as binding.

- There are two types of binding
 - Static Binding (also known as Early Binding).
 - Dynamic Binding (also known as Late Binding).



Understanding Type

1) variables have a type

- Each variable has a type, it may be primitive and non-primitive.

```
int data=30;
```

- Here data variable is a type of int.

2) References have a type

```
class Dog{  
    public static void main(String args[]) {  
        Dog d1; // Here d1 is a type of Dog  
    }  
}
```

Understanding Type

3) **Objects have a type**

An object is an instance of particular java class, but it is also an instance of its superclass.

```
class Animal {}  
class Dog extends Animal {  
    public static void main(String args[]) {  
        Dog d1=new Dog();  
    } }  
}
```

- Here d1 is an instance of Dog class and is also an instance of Animal.

static binding

- When type of the object is determined at compiled time (by the compiler), it is known as static binding.
- **If there is any private, final or static method in a class, there is static binding.**

Example of static binding

```
class Dog{  
    private void eat(){System.out.println("dog is eating...");}  
  
    public static void main(String args[]){  
        Dog d1=new Dog();  
        d1.eat();  
    }  
}
```

- Static methods use method hiding, not overriding.
- Final methods cannot be overridden, so they are statically bound.
- Private methods are not inherited, so they are always resolved within their own class.

Static Binding

When Does Static Binding Occur?

Methods

- private, final, and static methods
- Method overloading (compile-time polymorphism)
- Method calls via super and this

```
class Parent {  
    void show() {  
        System.out.println("Parent method");  
    }  
}
```

```
class Child extends Parent {  
    void show() {  
        System.out.println("Child method");  
    }  
  
    void display() {  
        super.show(); // Statically bound to Parent's show() at compile-time  
    }  
}
```

```
public class StaticBindingSuper {  
    public static void main(String[] args) {  
        Child obj = new Child();  
        obj.display(); // Calls super.show(), bound at  
        compile-time  
    }  
}
```

Dynamic binding

- When type of the object is determined at run-time, it is known as dynamic binding.

Example of dynamic binding

```
class Animal{  
    void eat(){System.out.println("animal is eating...");}  
}
```

Output:dog is eating...

```
class Dog extends Animal{  
    void eat(){System.out.println("dog is eating...");}
```

```
public static void main(String args[]){  
    Animal a=new Dog();  
    a.eat();  
}
```

- Object type cannot be determined by the compiler, because the instance of Dog is also an instance of Animal.
- So, compiler doesn't know its type, only its base type.

instanceof operator

- The **java instanceof operator** is used to test whether the object is an instance of the specified type (class or subclass or interface).
- The instanceof in java is also known as *type comparison operator* because it compares the instance with type.
- It returns either true or false.
- If we apply the instanceof operator with any variable that has null value, it returns false.

```
class Simple{  
    public static void main(String args[]){  
        Simple s=new Simple();  
        System.out.println(s instanceof Simple);//true  
    }  
}
```

Output: true

instanceof operator

- An object of subclass type is also a type of parent class.

```
class Animal{}  
class Dog extends Animal{//Dog inherits Animal
```

Output:true

```
public static void main(String args[]){  
    Dog d=new Dog();  
    System.out.println(d instanceof Animal);//true  
}  
}
```

Note:

Dog extends Animal therefore object of Dog can be referred by either Dog or Animal class.

- If we apply instanceof operator with a variable that have null value, it returns false

```
class Dog{  
    public static void main(String args[]){  
        Dog d=null;  
        System.out.println(d instanceof Dog);//false  
    }  
}
```

Output: false

Downcasting with java instanceof operator

- When Subclass type refers to the object of Parent class, it is known as downcasting.
- If we perform it directly, compiler gives Compilation error.

```
Dog d=new Animal();//Compilation error
```

- If you perform it by typecasting, ClassCastException is thrown at runtime. But if we use instanceof operator, downcasting is possible.

```
Dog d=(Dog)new Animal();  
//Compiles successfully but ClassCastException is thrown at runtime
```

Abstraction in Java

- **Abstraction** is a process of hiding the implementation details and showing only functionality to the user.
- Abstraction lets you focus on what the object does instead of how it does it.

Ways to achieve Abstraction

- Abstract class
- Interface

Abstract class

- A class which is declared with the abstract keyword is known as an abstract class in Java.
- 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.

```
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.

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

Abstract class that
has an abstract
method.



```
abstract class Bike{  
    abstract void run();  
}  
class Honda extends Bike{  
    void run(){System.out.println("running safely");}  
    public static void main(String args[]){  
        Bike obj = new Honda();  
        obj.run();  
    }  
}
```

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

Example

```
abstract class Shape{  
abstract void draw();  
}
```

//In real scenario, implementation is provided by others i.e. unknown by end user

```
class Rectangle extends Shape{  
void draw(){System.out.println("drawing rectangle");}  
}
```

```
class Circle 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 Circle();//In a real scenario, object is provided through method, e.g., getShape() method  
s.draw();  
}  
}
```

Output:
drawing circle

Example

```
abstract class Bank{  
    abstract int getRateOfInterest();  
}  
class SBI extends Bank{  
    int getRateOfInterest(){return 7;}  
}  
class PNB extends Bank{  
    int getRateOfInterest(){return 8;}  
}
```

Output:

Rate of Interest is: 7 %

Rate of Interest is: 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()+" %");  
    }  
}
```

Example

//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");}
```

An abstract class can have :

- **data members**
- **abstract method**
- **non-abstract method**
- **constructor**
- **main() method**

//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 TestAbstraction{  
    public static void main(String args[]){  
        Bike obj = new Honda();  
        obj.run();  
        obj.changeGear();  
    }  
}
```

Output:
bike is created
running safely..
gear changed

Example

Output:
Bark bark
I can eat.

```
abstract class Animal {  
    abstract void makeSound();  
    public void eat() {  
        System.out.println("I can eat.");  
    }  
}
```

```
class Dog extends Animal {  
    // provide implementation of abstract method  
    public void makeSound() {  
        System.out.println("Bark bark");  
    }  
}
```

```
class Main {  
    public static void main(String[] args) {  
        // create an object of Dog class  
        Dog d1 = new Dog();  
        d1.makeSound();  
        d1.eat();  
    }  
}
```

Abstract Class- Key Points

- We use the abstract keyword to create abstract classes and methods.
- An abstract method doesn't have any implementation (method body).
- A class containing abstract methods should also be abstract.
- We cannot create objects of an abstract class.
- To implement features of an abstract class, we inherit subclasses from it and create objects of the subclass.
- A subclass must override all abstract methods of an abstract class. However, if the subclass is declared abstract, it's not mandatory to override abstract methods.
- We can access the static attributes and methods of an abstract class using the reference of the abstract class. For example,

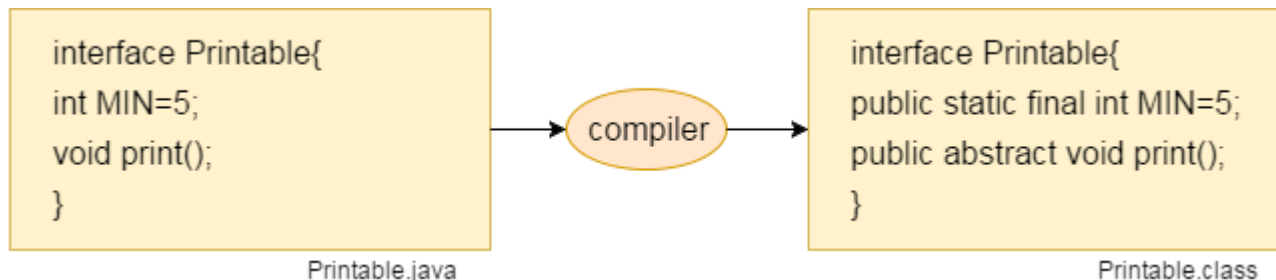
`AbstractClass.staticMethod();`

Java Interface

- An **interface in Java** is a blueprint of a class.
- A Java *interface* is a collection of **constants** and **abstract methods**
- It is used to achieve abstraction.
- By interface, we can support the functionality of multiple inheritance.
- Methods in an interface have public visibility by default

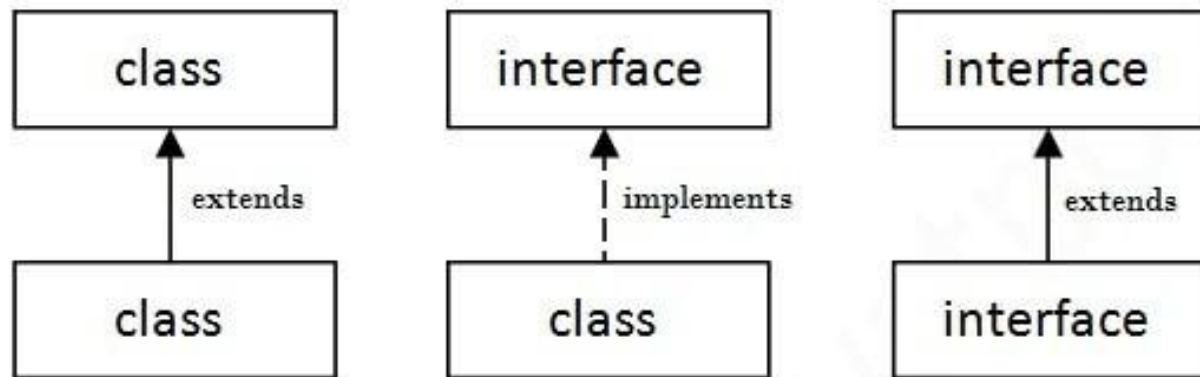
Declaring Interface:

- An interface is declared by using the interface keyword.
- A class that implements an interface must implement all the methods declared in the interface.
- Since Java 8, interface can have default and static methods.
 - (default method will be discussed in upcoming sessions)
- The Java compiler adds **public** and **abstract** keywords before the interface **method**.
- Moreover, it adds **public, static and final keywords before data members**.



The relationship between classes and interfaces

- A class extends another class,
- An interface extends another interface,
- but a **class implements an interface**.



Example: Interface

```
public interface Doable  
{  
    public static final String NAME;  
  
    public void doThis();  
    public int doThat();  
    public void doThis2 (float value, char ch);  
    public boolean doTheOther (int num);  
}
```

Note: Like abstract classes, we cannot create objects of interfaces.

Example:

```
interface printable{  
  void print();  
}  
class A implements printable{  
  public void print(){System.out.println("Hello");}  
  
  public static void main(String args[]){  
    A obj = new A();  
    obj.print();  
  }  
}
```

Output:
Hello

Example

//Interface declaration: by first user

```
interface Drawable{  
void draw();  
}
```

Output:

drawing circle

//Implementation: by second user

```
class Rectangle implements Drawable{  
public void draw(){System.out.println("drawing rectangle");}  
}
```

```
class Circle implements Drawable{  
public void draw(){System.out.println("drawing circle");}  
}
```

//Using interface: by third user

```
class TestInterface{  
public static void main(String args[]){  
Drawable d=new Circle();//In real scenario, object is provided by method e.g. getDrawable()  
d.draw();  
}}
```

Example

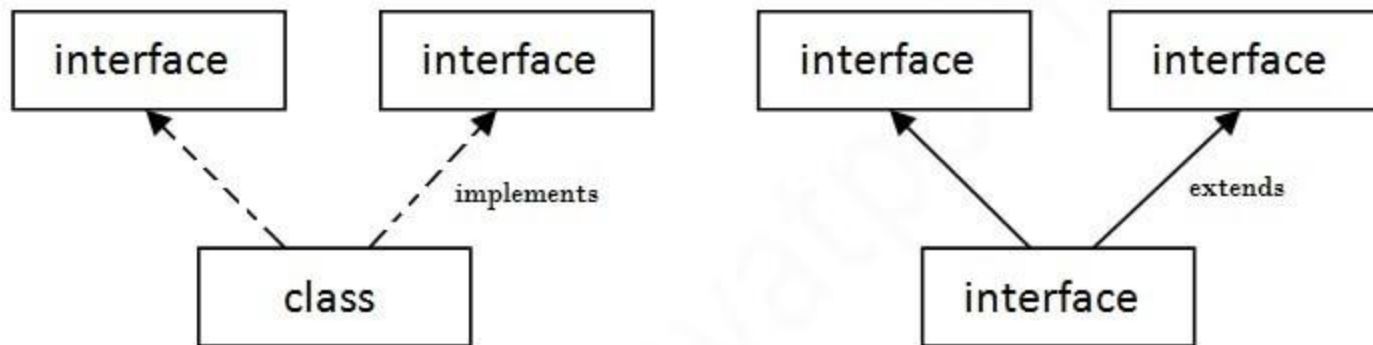
```
interface Bank{
float rateOfInterest();
}
class SBI implements Bank{
public float rateOfInterest(){return 9.15f;}
}
class PNB implements Bank{
public float rateOfInterest(){return 9.7f;}
}
class TestInterface2{
public static void main(String[] args){
Bank b=new SBI();
System.out.println("ROI: "+b.rateOfInterest());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

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

Multiple inheritance using Interfaces

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

```
interface Showable{  
void show();  
}
```

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

```
public static void main(String args[]){  
    A obj = new A();  
    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?

- There is no ambiguity if implementation is provided by the implementation class.

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

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


Interface inheritance

- A class implements an interface, but one interface extends another interface.

```
interface Printable{  
    void print();  
}  
interface Showable extends Printable{  
    void show();  
}  
class TestInterface4 implements Showable{  
    public void print(){System.out.println("Hello");}  
    public void show(){System.out.println("Welcome");}  
  
    public static void main(String args[]){  
        TestInterface4 obj = new TestInterface4();  
        obj.print();  
        obj.show();  
    }  
}
```

Output:
Hello
Welcome

Java 8 Default Method in Interface

- Since Java 8, we can have method body in interface. But we need to make it default method.

```
interface Drawable{  
    void draw();  
    default void msg(){System.out.println("default method");}  
}  
class Rectangle implements Drawable{  
    public void draw(){System.out.println("drawing rectangle");}  
}  
class TestInterfaceDefault{  
    public static void main(String args[]){  
        Drawable d=new Rectangle();  
        d.draw();  
        d.msg();  
    }  
}
```

Output:

drawing rectangle
default method

Overriding Default Methods in Java Interfaces

// interface with a default method

```
interface MyInterface {  
    default void display() {  
        System.out.println("This is the default method in MyInterface.");  
    }  
}
```

// class that overrides the default method

```
class MyClass implements MyInterface {  
    public void display() {  
        System.out.println("This is the overridden method in MyClass.");  
    }  
}
```

Can Class and interface override default method of interface ?

Ans: YES

// Another interface that extends MyInterface and overrides the default method

```
interface ExtendedInterface extends MyInterface {  
  
    default void display() {  
        System.out.println("This is the overridden method in ExtendedInterface.");  
    }  
}
```

// A class that implements ExtendedInterface

```
class ExtendedClass implements ExtendedInterface { }
```

```
public class OverrideDefaultMethodDemo {  
    public static void main(String[] args) {  
        MyClass obj1 = new MyClass();  
        obj1.display(); // Outputs: "This is the overridden method in MyClass."    }  
}
```

```
        ExtendedClass obj2 = new ExtendedClass();  
        obj2.display(); // Outputs: "This is the overridden method in ExtendedInterface."    }  
}
```

O/P:

This is the overridden method in MyClass.

This is the overridden method in ExtendedInterface.

Understanding Diamond Problem in Interfaces

- The Diamond Problem can still manifest with interfaces, especially since Java 8 introduced default methods in interfaces.
- However, Java has clear rules for resolving ambiguities arising from such situations, which ensures that the Diamond Problem does not cause undefined behavior.

```
interface A {  
    default void foo() {  
        System.out.println("Default method in Interface A");  
    }  
}
```

```
interface B extends A { }
```

```
interface C extends A { }
```

```
class D implements B, C { }
```

- In the given scenario, there's no ambiguity because both B and C inherit the default method from A.
- A call to foo() from an object of class D would clearly use the method from interface A.

Diamond Problem with interfaces

```
interface B {  
    default void foo() {  
        System.out.println("Default method in Interface B");  
    }  
}
```

```
interface C {  
    default void foo() {  
        System.out.println("Default method in Interface C");  
    }  
}
```

```
class D implements B, C {  
    public static void main(String[] args) {  
        D obj = new D();  
        obj.foo(); // Compilation error  
    }  
}
```

Output:

Main.java:13: error: types B and C are incompatible;

class D implements B, C {

^

class D inherits unrelated defaults for foo() from types B and C

1 error

The compiler flags this as an error because it cannot unambiguously determine which foo() method D should use: the one from B or from C.

To resolve this, the class D must explicitly override the conflicting method.

```
class D implements B, C {  
    public void foo() {  
        System.out.println("Method in Class D");  
        // If desired, you can also call a specific  
        // default method:  
        // B.super.foo();  
    }  
}
```

Hybrid Inheritance

```
interface A {  
    default void foo() {  
        System.out.println("Default method in Interface A");  
    }  
}
```

```
interface B extends A {  
    default void foo() {  
        System.out.println("Default method in Interface B");  
    }  
}
```

```
interface C extends A {  
    default void foo() {  
        System.out.println("Default method in Interface C");  
    }  
}
```

```
class D implements B, C {  
    public void foo() {  
        System.out.println("Overridden method in Class D");  
        B.super.foo(); // Calling the default method from Interface B  
    }  
}
```

```
public class Main {  
    public static void main(String[] args) {  
        D obj = new D();  
        obj.foo();  
    }  
}
```

Output:
Overridden method in Class D
Default method in Interface B

Java 8 Static Method in Interface

- Since Java 8, we can have static method in interface.

```
interface Drawable{  
    void draw();  
    static int cube(int x){return x*x*x;}  
}  
class Rectangle implements Drawable{  
    public void draw(){System.out.println("drawing rectangle");}  
}
```

```
class TestInterfaceStatic{  
    public static void main(String args[]){  
        Drawable d=new Rectangle();  
        d.draw();  
        System.out.println(Drawable.cube(3));  
    }  
}
```

Output:
drawing rectangle
27

Abstract class and Interface

- Abstract class and interface both are used to achieve abstraction where we can declare the abstract methods. Abstract class and interface both can't be instantiated.

| Abstract class | Interface |
|---|--|
| 1) Abstract class can have abstract and non-abstract methods. | Interface can have only abstract methods. Since Java 8, it can have default and static methods also. |
| 2) Abstract class doesn't support multiple inheritance . | Interface supports multiple inheritance . |
| 3) Abstract class can have final, non-final, static and non-static variables . | Interface has only static and final variables . |
| 4) Abstract class can provide the implementation of interface . | Interface can't provide the implementation of abstract class . |
| 5) The abstract keyword is used to declare abstract class. | The interface keyword is used to declare interface. |
| 6) An abstract class can extend another Java class and implement multiple Java interfaces. | An interface can extend another Java interface only. |
| 7) An abstract class can be extended using keyword "extends". | An interface can be implemented using keyword "implements". |
| 8) A Java abstract class can have class members like private, protected, etc. | Members of a Java interface are public by default. |
| 9) Example: <pre>public abstract class Shape{ public abstract void draw(); }</pre> | Example: <pre>public interface Drawable{ void draw(); }</pre> |

Encapsulation in Java

- **Encapsulation in Java** is a *process of wrapping code and data together into a single unit*, for example, a capsule which is mixed of several medicines.
- We can create a fully encapsulated class in Java by making all the data members of the class private. Now we can use setter and getter methods to set and get the data in it.

Advantage of Encapsulation in Java

- By providing only a setter or getter method, you can make the class **read-only or write-only**. In other words, you can skip the getter or setter methods.
- It provides you the **control over the data**. Suppose you want to set the value of id which should be greater than 100 only, you can write the logic inside the setter method. You can write the logic not to store the negative numbers in the setter methods.
- It is a way to achieve **data hiding** in Java because other class will not be able to access the data through the private data members.
- The encapsulate class is **easy to test**. So, it is better for unit testing.
- The standard IDE's are providing the facility to generate the getters and setters. So, it is **easy and fast to create an encapsulated class** in Java.

Example- 1

//A Java class which is a fully encapsulated class.

//It has a private data member and getter and setter methods.

```
package pack;  
public class Student{  
    //private data member  
    private String name;  
    //getter method for name  
    public String getName(){  
        return name;  
    }  
    //setter method for name  
    public void setName(String name){  
        this.name=name  
    }  
}
```

Go to Next Slide to
test encapsulation

Example-1 Cont..

//A Java class to test the encapsulated class.

```
package pack;
```

```
class Test{
```

```
public static void main(String[] args){
```

//creating instance of the encapsulated class

```
Student s=new Student();
```

//setting value in the name member

```
s.setName("vijay");
```

//getting value of the name member

```
System.out.println(s.getName());
```

```
}
```

```
}
```

Read-Only class

//A Java class which has only getter methods.

```
public class Student{  
    //private data member  
    private String college="UPES";  
    //getter method for college  
    public String getCollege(){  
        return college;  
    }  
}
```

Now, you can't change the value of the college data member which is "UPES".

Write-Only class

//A Java class which has only setter methods.

```
public class Student{  
    //private data member  
    private String college;  
    //getter method for college  
    public void setCollege(String college){  
        this.college=college;  
    }  
}
```

Now, you can't get the value of the college, you can only change the value of college data member.

System.out.println(s.getCollege());
//Compile Time Error, because there is no such method

System.out.println(s.college);
//Compile Time Error, because the college data member is private.

//So, it can't be accessed from outside the class

/A Account class which is a fully encapsulated class.

//It has a private data member and getter and setter methods.

```
class Account {
```

```
//private data members
```

```
private long acc_no;
```

```
private String name,email;
```

```
private float amount;
```

```
//public getter and setter methods
```

```
public long getAcc_no() {
```

```
    return acc_no;
```

```
}
```

```
public void setAcc_no(long acc_no) {
```

```
    this.acc_no = acc_no;
```

```
}
```

```
public String getName() {
```

```
    return name;
```

```
}
```

```
public void setName(String name) {
```

```
    this.name = name;
```

```
}
```

```
public String getEmail() {
```

```
    return email;
```

```
}
```

```
public void setEmail(String email) {
```

```
    this.email = email;
```

```
}
```

```
public float getAmount() {
```

```
    return amount;
```

```
}
```

```
public void setAmount(float amount) {
```

```
    this.amount = amount;
```

```
}
```

```
}
```

Go to Next Slide to test the
Account Class

/A Java class to test the encapsulated class Account.

```
public class TestEncapsulation {  
  public static void main(String[] args) {  
    //creating instance of Account class  
    Account acc=new Account();  
    //setting values through setter methods  
    acc.setAcc_no(7560504000L);  
    acc.setName("gagandeep");  
    acc.setEmail("gagandeep@gmail.com");  
    acc.setAmount(500000f);  
    //getting values through getter methods  
    System.out.println(acc.getAcc_no()+" "+acc.getName()+" "+acc.getEmail()+" "+acc.  
getAmount());  
  }  
}
```

Output:

7560504000 gagandeep gagandeep@gmail.com 500000.0

Unit 2
Completed

Keep
Practicing!!!