OBJECT-ORIENTED LANGUAGE AND THEORY

7. ABSTRACT CLASS AND INTERFACE

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Outline

1. Redefine/overriding
2. Abstract class
3. Single inheritance and multi-inheritance
4. Interface

2

Outline

1. Redefine/overriding
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1. Re-definition or Overriding

- A child class can define a method with the **same name** of a method in its parent class:
  - If the new method has the same name but different signature (number or data types of method's arguments)
    → Method Overloading
  - If the new method has the same name and signature
    → Re-definition or Overriding
    (Method Redefine/Override)

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- class A {
  a(){ …. }
  }

- class B extends A {
  a(String) {}
  }

… B b = new B();
b.a();
b.a(“test”);

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- ParentClass: aMethod() => overridden method
  - ChildClass1: aMethod(), aMethod(String) => Overloading
  - ChildClass2: aMethod() => Overriding/Redefinition method

- ChildClass1 cc1 = new ChildClass1();
- cc1.aMethod(); cc1.aMethod(“a string”);
- ChildClass2 cc2 = new ChildClass2();
- cc2.aMethod();

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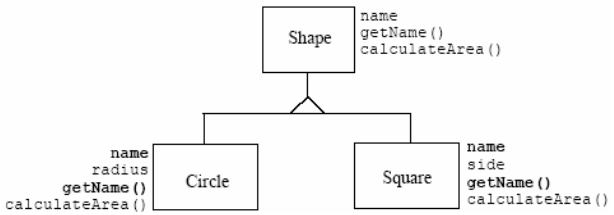
1. Re-definition or Overriding (2)

- Overriding method will replace or add more details to the overriden method in the parent class
- Objects of child class will use the re-defined method



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- this() and this => current object

- super() => Constructor of the parent class
- super: object of the parent class

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```
class Shape {
 protected String name;
 Shape(String n) { name = n; }
 public String getName() { return name; }
 public float calculateArea() { return 0.0f; }
}
class Circle extends Shape {
 private int radius;
 Circle(String n, int r){
   super(n);
   radius = r;
 }

 public float calculateArea() {
   float area = (float) (3.14 * radius * radius);
   return area;
 }
}
```

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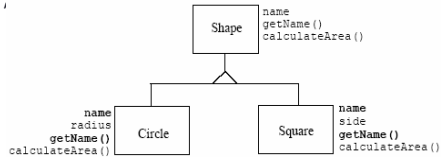
```
class Square extends Shape {
 private int side;
 Square(String n, int s) {
      super(n);
      side = s;
 }
 public float calculateArea() {
      float area = (float) side * side;
      return area;
 }
}
```



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Class `Triangle`

```
class Triangle extends Shape {
 private int base, height;
 Triangle(String n, int b, int h) {
      super(n);
      base = b; height = h;
 }
 public float calculateArea() {
      float area = 0.5f * base * height;
      return area;
 }
}
```

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`this` and `super`

- **this** and **super** can use non-static methods/attributes and constructors
  - **this**: searching for methods/attributes in the current class
  - **super**: searching for methods/attributes in the direct parent class
- Keyword **super** allows re-using the source-code of a parent class in its child classes

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```
package abc;
public class Person {
 private String name;
 private int age;
 public String getDetail() {
      String s = name + "," + age;
      return s;
 }
 private void pM(){}
}

import abc.Person;
public class Employee extends Person {
  double salary;
  public String getDetail() {
   String s = super.getDetail() + "," + salary
   return s;
 }
}
```


The **final** keyword

- Sometimes we want to limit redefinition for the following reasons:
  - Correctness: Redefining a method in a derived class can distort its intended meaning.
  - Efficiency: Dynamic binding is less time-efficient than static binding.
- If it's known in advance that a method of the base class won't be redefined, the **final** keyword should be used with the method
- Example:

```
public final String baseName () {
     return "Person";
}
```


The **final** keyword

- Methods declared as **final** **cannot** be overridden.

```
class A {
    final void method(){ }
}
class B extends A{
    void method(){    // Báo lỗi!!!
    }
}
```


The **final** keyword

- The "final" keyword can be used when declaring a class.
  - A class declared as final (unchangeable) is a class that cannot have any subclasses inheriting from it.
  - It is used to restrict inheritance and prevent modification of a class.

```
public final class A {
 //...
}
```

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Overriding Rules

- Overriding methods must have:
  - An argument list that is the same as the overriden method in the parent class => signature
  - The same return data types as the overriden method in the parent class
- Can not override:
  - Constant (**final**) methods in the parent class
  - **Static** methods in the parent class
  - **Private** methods in the parent class

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Overriding Rules (2)

- Accessibility can not be more restricted in a child class (compared to in its parent class)
  - For example, if we override a protected method, the new overriding method can only be protected or public, and can not be private.

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Example

```
class Parent {
 public void doSomething() {}
 protected int doSomething2() {
     return 0;
 }
}
class Child extends Parent {
 protected void doSomething() {}
 protected void doSomething2() {}
}
```

cannot override: attempting to use incompatible return type

cannot override: attempting to assign weaker access privileges; was public

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Example: private

```
class Parent {
 public void doSomething() {}
 private int doSomething2() {
     return 0;
 }
}
class Child extends Parent {
 public void doSomething() {}
 private void doSomething2() {}
}
```

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Outline

1. Redefine/overriding
2. Abstract class
3. Single inheritance and multi-inheritance
4. Interface

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Abstract Class

- An abstract class is a class that we can not create its objects. Abstract classes are often used to define "Generic concepts", playing the role of a basic class for others "detailed" classes.
- Using keyword abstract

```
public abstract class Product
{
    // contents
}
```

…Product aProduct = new Product(); //error

concrete class vs. abstract class

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2. Abstract Class

- Can not create objects of an abstract class
- Is not complete, is often used as a parent class. Its children will complement the un-completed parts.

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Abstract Class

- Abstract class can contain abstract methods
- Derived classes that are no abstract must implement these abstract methods
- Using abstract class plays an important role in software design. It defines common objects in inheritance tree, but these objects are too abstract to create their instances.

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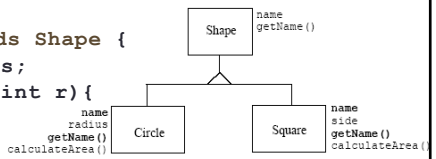
2. Abstract Class (2)

- To be abstract, a class needs:
  - To be declared with **abstract** keyword
  - May contain abstract methods – that have only signatures without implementation
    - public abstract float calculateArea();
  - Child classes must implement the details of abstract methods of their parent class → Abstract classes can not be declared as **final** or static.
- If a class has one or more abstract methods, it must be an abstract class


```
abstract class Shape {
  protected String name;
  Shape(String n) { name = n; }
  public String getName() { return name; }
  public abstract float calculateArea();
}
class Circle extends Shape {
  private int radius;
  Circle(String n, int r){
    super(n);
    radius = r;
  }
  public float calculateArea() {
   float area = (float) (3.14 * radius * radius);
   return area;
  }
}
```



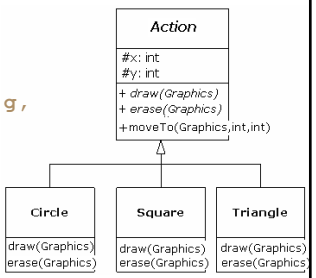
Child class must override all the abstract methods of its parent class

Example of abstract class

```
import java.awt.Graphics;
abstract class Action {
  protected int x, y;
  public void moveTo(Graphics g,
           int x1, int y1) {
    erase(g);
    x = x1; y = y1;
    draw(g);
   }

  public abstract void erase(Graphics g);
  public abstract void draw(Graphics g);
}

..Circle c = new Circle();
c.moveTo(...);
```



Example of abstract class (2)

```
class Circle extends Action {
  int radius;
  public Circle(int x, int y, int r) {
   super(x, y); radius = r;
  }
  public void draw(Graphics g) {
   System out println("Draw circle at ("
                          + x + "," + y + ")");
   g.drawOval(x-radius, y-radius,
                2*radius, 2*radius);
  }
  public void erase(Graphics g) {
    System.out.println("Erase circle at ("
                          + x + "," + y + ")");
    // paint the circle with background color...
  }
}
```

Abstract Class

```
abstract class Point {
  private int x, y;
  public Point(int x, int y) {
    this.x = x;
    this.y = y;
  }
  public void move(int dx, int dy) {
    x += dx; y += dy;
    plot();
  }
  public abstract void plot();
}
```

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Abstract Class

```
abstract class ColoredPoint extends Point {
 int color;
 public ColoredPoint(int x, int y, int color) {
 super(x, y); this.color = color; }
}

class SimpleColoredPoint extends ColoredPoint {
 public SimpleColoredPoint(int x, int y, int color){
       super(x,y,color);
 }
 public void plot() {
       ...
       // code to plot a SimplePoint
 }
}
```

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Abstract Class

- Class ColoredPoint does not implement source code for the method plot(), hence it must be declared as abstract
- Can only create objects of the class SimpleColoredPoint.
- However, we can have:

  Point p = new SimpleColoredPoint(a, b, red); p.plot();

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- abstract class A {
  abstract void a();
- }
- class B extend A {
- }

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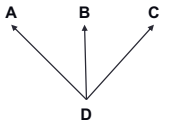
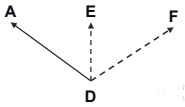
Multiple and Single Inheritances

- Multiple Inheritance
  - A class can inherit several other classes
  - C++ supports multiple inheritance
- Single Inheritance
  - A class can inherit only one other class
  - Java supports only single inheritance
  - → Need to add the notion of Interface





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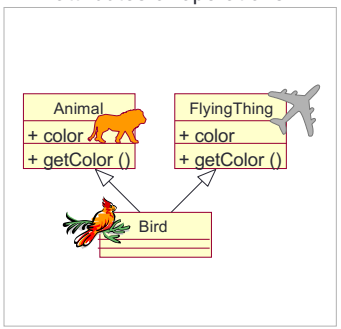
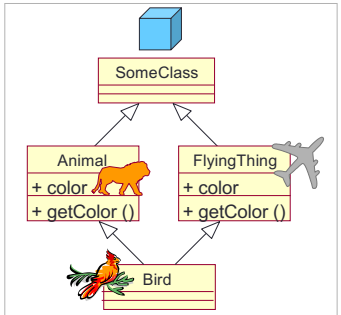
Problems in Multiple Inheritance

Name clashes on attributes or operations



Repeated inheritance



Resolution of these problems is implementation-dependent.

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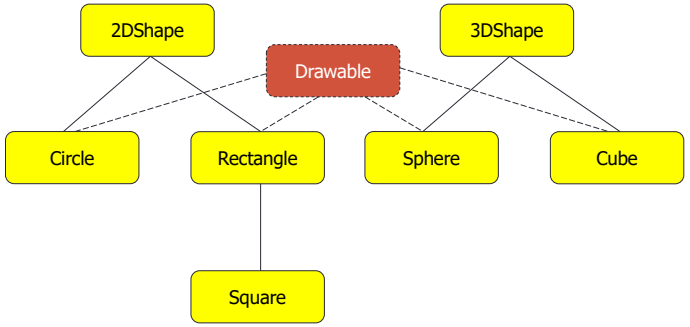
Interface



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Interface

- Interface: Corresponds to different implementations.
- Defines the border:
  - What and How
  - Declaration and Implementation.

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Interface

- Interface does not implement any methods but defines the design structure in any class that uses it.
- An interface: 1 contract – in which software development teams agree on how their products communicate to each other, without knowing the details of product implementation of other teams.

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Example

- Class Bicycle – Class StoreKeeper:
  - StoreKeepers does not care about the characteristics what they keep, they care only the price and the id of products.
- Class AutonomousCar– GPS:
  - Car manufacturers produce cars with features: Start, Speed-up, Stop, Turn left, Turn right,..
  - GPS: Location information, Traffic status – Making decisions for controlling car

  - How does GPS control both car and space craft?

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Interface OperateCar

```
public interface OperateCar {

  // Constant declaration– if any

  // Method signature
  int turn(Direction direction,   // An enum with values RIGHT, LEFT
           double radius, double startSpeed, double endSpeed);
  int changeLanes(Direction direction, double startSpeed, double
  endSpeed);
  int signalTurn(Direction direction, boolean signalOn);
  int getRadarFront(double distanceToCar, double speedOfCar);
  int getRadarRear(double distanceToCar, double speedOfCar);
      ......
  // Signatures of other methods
}
```

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Class OperateBMW760i
// Car Manufacturer

```
public class OperateBMW760i implements OperateCar {

  // cài đặt hợp đồng định nghĩa trong giao diện
  int signalTurn(Direction direction, boolean signalOn) {
    //code to turn BMW's LEFT turn indicator lights on
    //code to turn BMW's LEFT turn indicator lights off
    //code to turn BMW's RIGHT turn indicator lights on
    //code to turn BMW's RIGHT turn indicator lights off
  }

  // Các phương thức khác, trong suốt với các clients của
  interface
  }
```

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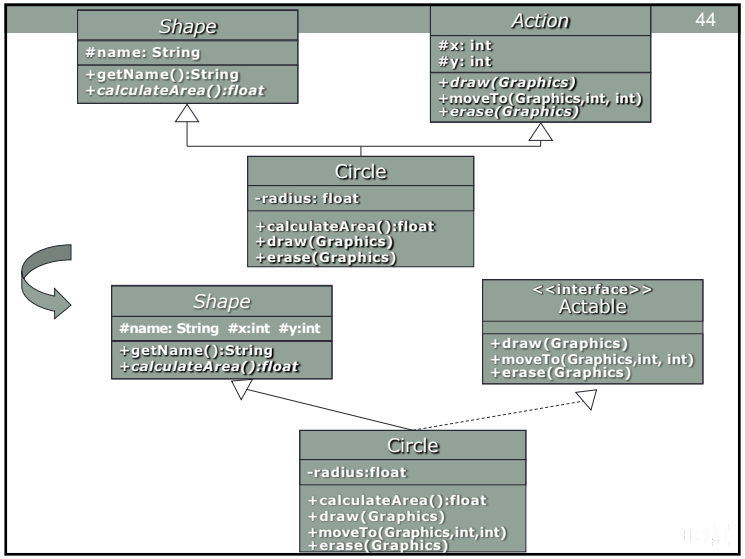

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4. Interface

- Allows a class to inherit (implement) multiple interfaces at the same time.
- Can not directly instantiate
- Inteferface facilitates loose-coupling

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Interface – Technical view (JAVA)

- An interface can be considered as a "class" that
  - Its methods and attributes are implicitly public
  - Its attributes are static and final (implicitly)
  - Its methods are abstract

```
interface TVInterface {
        public void turnOn();
        public void turnOff();
        public void changeChannel(int i);
}
class PanasonicTV implements TVInterface{
        public void turnOn() { …. }
}
```

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4. Interface (2)

- To become an interface, we need
  - To use interface keyword to define
  - To write only:
    - method signature
    - static & final attributes
- Implementation class of interface
  - Abstract class
  - Concrete class: Must implement all the methods of the interface

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4. Interface (3)

- Java syntax:
  - **SubClass *extends* SuperClass *implements* ListOfIntefaces**
  - **SubInterface *extends* SuperInterface**
- Example:

```
public interface Symmetrical {…}
public interface Movable {…}
public class Square extends Shape
            implements Symmetrical, Movable {
  ...
}
```

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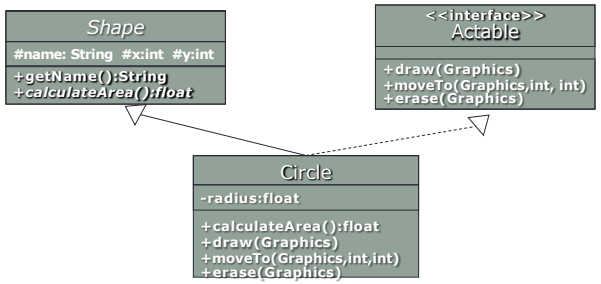
Example



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```
import java.awt.Graphics;
abstract class Shape {
 protected String name;
  protected int x, y;
 Shape(String n, int x, int y) {
      name = n; this.x = x; this.y = y;
  }
 public String getName() {
      return name;
 }
 public abstract float calculateArea();
}
interface Actable {
 public void draw(Graphics g);
  public void moveTo(Graphics g, int x1, int y1);
  public void erase(Graphics g);
}
```

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```
class Circle extends Shape implements Actable {
 private int radius;
  public Circle(String n, int x, int y, int r){
      super(n, x, y); radius = r;
  }
 public float calculateArea() {
      float area = (float) (3.14 * radius * radius);
      return area;
 }
 public void draw(Graphics g) {
    System out println("Draw circle at ("
                          + x + "," + y + ")");
     g.drawOval(x-radius,y-radius,2*radius,2*radius);
 }
 public void moveTo(Graphics g, int x1, int y1){
      erase(g); x = x1; y = y1; draw(g);
 }
 public void erase(Graphics g) {
       System out println("Erase circle at ("
                          + x + "," + y + ")");
     // paint the region with background color...
 }
```

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Abstract class vs. Interface

- May or may not contain abstract methods, can contain instance methods
- Can contain protected and static methods
- Can contain final and non-final attributes
- A class can inherit only one abstract class
- Can contain only method signature
- Can contain only public functions without implementation
- Can contains only constant attributes
- A class can inherite multiple interfaces

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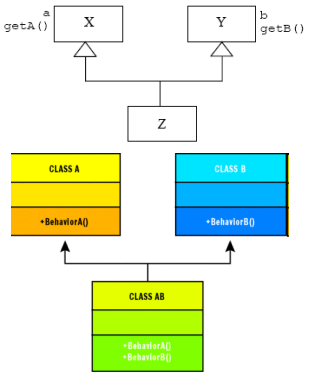
Disadvantages of Interface in solving Multiple Inheritance problems

- Does not provide a nature way for situations without inheritance conflicts
- Inheritance is to re-uses source code but Interface can not do this



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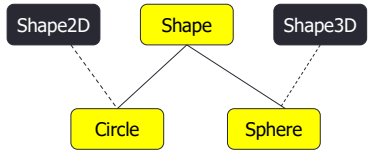
Example

```
interface Shape2D {
  double getArea();
}

interface Shape3D {
  double getVolume();
}

class Point3D {
  double x, y, z;

  Point3D(double x, double y, double z) {
    this.x = x;
    this.y = y;
    this.z = z;
  }
}
```



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

class Circle extends Shape
implements Shape2D {
 Point3D center, p; // p is an point on
circle

  Circle(Point3D center, Point3D p) {
    this.center = center;
    this.p = p;
  }

  public void display() {
    System.out.println("Circle");
  }

  public double getArea() {
    double dx = center.x - p.x;
    double dy = center.y - p.y;
    double d = dx * dx + dy * dy;
    double radius = Math.sqrt(d);
    return Math.PI * radius * radius;
  }
}
```

```
class Sphere extends Shape
implements Shape3D {
  Point3D center;
  double radius;

  Sphere(Point3D center, double radius) {
    this.center = center;
    this.radius = radius;
  }

  public void display() {
    System.out.println("Sphere");
  }

  public double getVolume() {
    return 4 * Math.PI * radius * radius * radius / 3;
  }
}

class Shapes {

  public static void main(String args[]) {

    Circle c = new Circle(new Point3D(0, 0, 0), new
      Point3D(1, 0, 0));
    c.display();
    System.out.println(c.getArea());
    Sphere s = new Sphere(new Point3D(0, 0, 0), 1);
    s.display();
    System.out.println(s.getVolume());
  }
}
```

```
Result :
Circle
3.141592653589793
Sphere
4.1887902047863905
```

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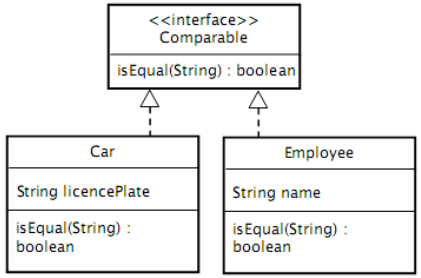
interface Comparable /java.lang



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Application

```
public interface Comparable {
    void isEqual(String s);
}

public class Car implements Comparable {
  private String licencePlate;
  public void isEqual(String s){
    return licencePlate.equals(s);
  }
}

public class Employee implements Comparable{
  private String name;
  public void isEqual(String s){
    return name.equals(s);
  }
}
```

Public

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Application

```
public class Foo {
  private Comparable objects[];
  public Foo(){
    objects = new Comparable[3];
    objects[0] = new Employee();
    objects[1] = new Car();
    objects[2] = new Employee();
  }
  public Comparable find(String s){
    for(int i=0; i< objects.length; i++)
      if(objects[i].isEqual(s)
                    return objects[i];
  }
}
```

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Java 8 Interface – default methods

https://gpcoder.com/3854-interface-trong-java-8-default-method-va-static-method/

```
public interface Shape {

   void draw();

   default void setColor(String color) {
      System.out.println("Draw shape with color " + color);
   }
}
```

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Multiple Inheritance

```
interface Interface1 {
   default void doSomething() {
      System.out.println("doSomething1");
   }
}

interface Interface2 {
   default void doSomething() {
      System.out.println("doSomething2");
   }
}

public class MultiInheritance implements Interface1, Interface2 {
   @Override
   public void doSomething() {
      Interface1.super.doSomething();
   }
}
```

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Multiple Inheritance

```
interface Interface3 {
   default void doSomething() {
      System.out.println("Execute in Interface3");
   }
}

class Parent {
   public void doSomething() {
      System.out.println("Execute in Parent");
   }
}

public class MultiInheritance2 extends Parent implements Interface3 {
   public static void main(String[] args) {
      MultiInheritance2 m = new MultiInheritance2();
      m.doSomething(); // Execute in Parent
   }
}
```

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Java 8 interface – Static methods

```
interface Vehicle {
   default void print() {
      if (isValid())
         System.out.println("Vehicle printed");
   }
   static boolean isValid() {
      System.out.println("Vehicle is valid");
      return true;
   }
   void showLog();
}

public class Car implements Vehicle {
   @Override
   public void showLog() {
      print();
      Vehicle.isValid();
   }
}
```

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Static method

```
interface Interface3 {
   default void doSomething() {
      System.out.println("Execute in Interface3");
   }

}

abstract class Parent {
   public void doSomething() {
      System.out.println("Execute in Parent");
   }
   public static void test() {
      System.out.println("test");
   }
}

public class MultiInheritance2 extends Parent implements Interface3 {
   public static void main(String[] args) {
      MultiInheritance2 m = new MultiInheritance2();

      m.test(); // OK
   }
}
```

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Static method

```
interface Interface3 {
   default void doSomething() {
      System.out.println("Execute in Interface3");
   }

}

abstract class Parent {
   public void doSomething() {
      System.out.println("Execute in Parent");
   }
   public static void test() {
      System.out.println("test");
   }
}

public class MultiInheritance2 extends Parent implements Interface3 {
   public static void main(String[] args) {
      MultiInheritance2 m = new MultiInheritance2();

      MultiInheritance2.test(); // OK
   }
}
```

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Static method

```
interface Interface3 {
   default void doSomething() {
      System.out.println("Execute in Interface3");
   }
   public static void test() {
      System.out.println("test");
   }
}

abstract class Parent {
   public void doSomething() {
      System.out.println("Execute in Parent");
   }
}

public class MultiInheritance2 extends Parent implements Interface3 {
   public static void main(String[] args) {
      MultiInheritance2 m = new MultiInheritance2();

      m.test(); // ERROR!!!
   }
}
```

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Static method

```
interface Interface3 {
    default void doSomething() {
        System.out.println("Execute in Interface3");
    }
    public static void test() {
        System.out.println("test");
    }
}

abstract class Parent {
    public void doSomething() {
        System.out.println("Execute in Parent");
    }
}

public class MultiInheritance2 extends Parent implements Interface3 {
    public static void main(String[] args) {
        MultiInheritance2 m = new MultiInheritance2();

        MultiInheritance2.test(); // ERROR!!!
    }
}
```