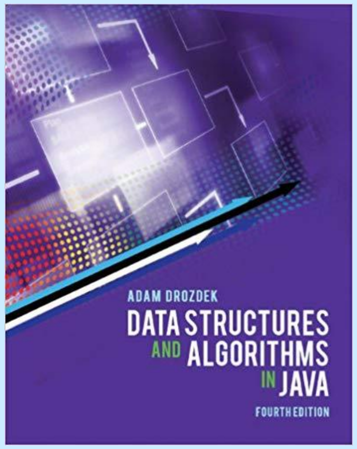
CSE 202 : DATA STRUCTURES



Lecture # 01:

Review of Object-Oriented Concepts in JAVA

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Review of Object-Oriented Concepts in JAVA

- Introduction
- Object-Oriented Concepts supported by JAVA.
- Advantages of Object-Orientation.
- Inheritance.
- Abstract Classes.
- Interfaces.
- Review Questions.

Introduction

- **Data Structures**: A data structure is a collection of data values, the relationships among them, and the functions or operations that can be applied to the data. In simple words, ***it is a particular way of organizing data in a computer so that it can be used effectively***. For example, we can store a list of items having the same data-type using the array data structure.

- **Computer Science** is the study of data structures and algorithms.

- **Object Oriented Programming (OOP)**: Four major principles of an object oriented language are ***Encapsulation, Data Abstraction, Polymorphism and Inheritance.***

Cont…

- **Class**: A class is a blueprint or ***prototype*** from which objects are created. A class models the ***state*** and ***behavior*** of a real-world object.
- **Object**: An object is a software bundle of related state and behavior. It is a specimen / ***instance of class***.
- **Package**: A package is a ***namespace for organizing classes and interfaces in a logical manner***. Packages make large software projects easier to manage.
- **Interface**: An interface is ***a contract between a class and the outside world***. When a class implements an interface, it promises to provide the behavior published by that interface.

Object-Oriented Concepts supported by JAVA

- Java provides explicit support for many of the fundamental Object-Oriented Concepts. Some of these are:
  - **Classification**: Grouping related things together. This is supported through classes, inheritance & packages.
  - **Encapsulation**: Representing data and the set of operations on the data as a single entity - exactly what classes do.
  - **Information Hiding**: An object should be in full control of its data, granting specific access only to whom it wishes. ***Abstraction*** can be used as a technique for identifying which information should be hidden.
  - **Inheritance**: Java allows related classes to be organized in a hierarchical manner using the *extends* keyword.
  - **Polymorphism**: Same code behaves differently at different times during execution. This is due to dynamic binding.

Advantages of Object-Orientation.

- A number of advantages can be derived as a result of these object-oriented features. Some of these are:
  - **Reusability**: Rather than endlessly rewriting the same piece of code, we write it once and use it or inherit it as needed.
  - **Extensibility**: A class can be extended without affecting its users provided that the user-interface remains the same.
  - **Maintainability**: Again, once the user-interface does not change, the implementation can be changed at will.
  - **Security**: Thanks to information hiding, a user can only access the information he has been allowed to access.
  - **Abstraction**: Classification and Encapsulation allow portrayal of real-world problems in a simplified model.

Review of inheritance

- Suppose we have the following **Employee** class:

```
class Employee  {
   protected String name;
   protected double payRate;
   public Employee(String name, double payRate)  {
      this.name = name;
      this.payRate = payRate;
   }
   public String getName()  {return name;}
   public void setPayRate(double newRate)  { payRate = newRate; }

   public double pay()  {return payRate;}

   public void print()  {
      System.out.println("Name: " + name);
      System.out.println("Pay Rate: "+payRate);
   }
}
```

Review of inheritance (contd.)

Now, suppose we wish to define another class to represent a part-time employee whose salary is paid per hour. We inherit from the **Employee** class as follows:

```
class HourlyEmployee extends Employee  {
   private int hours;
   public HourlyEmployee(String hName, double hRate)  {
     super(hName, hRate);
     hours = 0;
   }
   public void addHours(int moreHours)  {hours += moreHours;}

   public double pay()  {return payRate * hours;}

   public void print()  {
     super.print();
     System.out.println("Current hours: " + hours);
   }
}
```

Notes about Inheritance

We observe the following from the examples on inheritance:

- Methods and instance variables of the super class are inherited by subclasses, thus allowing for code reuse.
- A subclass can define additional instance variables (e.g. hours) and additional methods (e.g. addHours).
- A **subclass can override some of the methods of the super class** to make them behave differently (e.g. the pay & print)
- **Constructors are not inherited**, but can be called using the super keyword. Such a call must be the first statement.
  - If the constructor of the super class is not called, then the complier inserts a call to the default constructor -watch out!
- super may also be used to call a method of the super class.

Review of Abstract Classes

- **Inheritance enforces hierarchical organization**, the benefits of which are: reusability, type sharing and polymorphism.
- Java uses Abstract classes & Interfaces to further strengthen the idea of inheritance.
- To see the role of abstract classes, suppose that the **pay** method is not implemented in the **HourlyEmployee** subclass.
  - Obviously, the **pay** method in the **Employee** class will be assumed, which will lead to wrong result.
  - One solution is to remove the **pay** method out and put it in another extension of the Employee class, **MonthlyEmployee.**
  - The problem with this solution is that it does not force subclasses of **Employee** class to implement the **pay** method.

Review of Abstract Classes (Cont'd)

The solution is to declare the pay method of the Employee class as abstract, thus, making the class abstract.

```
abstract class Employee  {
   protected String name;
   protected double payRate;
   public Employee(String empName, double empRate)  {
     name = empName;
     payRate = empRate;
   }
   public String getName()  {return name;}
   public void setPayRate(double newRate)  {payRate = newRate;}

   abstract public double pay();

   public void print()  {
     System.out.println("Name: " + name);
     System.out.println("Pay Rate: "+payRate);
   }
 }
```

Review of Abstract Classes (Cont'd)

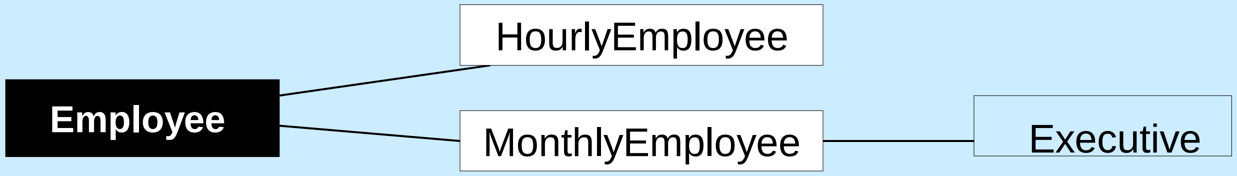
- The following extends the Employee abstract class to get MonthlyEmployee class.

```
class MonthlyEmployee extends Employee  {
   public MonthlyEmployee(String empName, double empRate) {
       super(empName, empRate);
   }
   public double pay()  {
       return payRate;
   }
}
```

- The next example extends the MonthlyEmployee class to get the Executive class.

Review of Abstract Classes (Cont'd)

```
class Executive extends MonthlyEmployee  {
    private double bonus;
    public Executive(String exName, double exRate)  {
        super(exName, exRate);
        bonus = 0;
    }
    public void awardBonus(double amount)  {
        bonus = amount;
    }
    public double pay()  {
        double paycheck = super.pay() + bonus;
        bonus = 0;
        return paycheck;
    }
    public void print()  {
        super.print();
        System.out.println("Current bonus: " + bonus);
    }
}
```

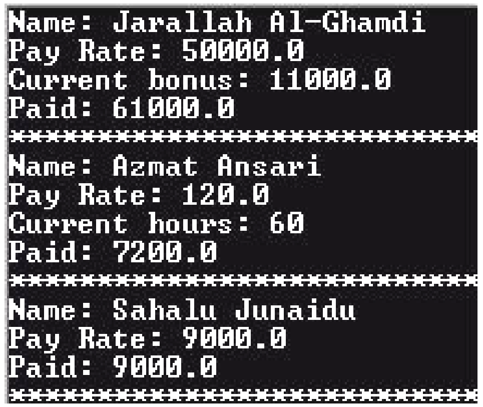


Review of Abstract Classes (Cont'd)

- The following further illustrates the advantages of organizing classes using inheritance - same type, polymorphism, etc.

```
public class TestAbstractClass  {
   public static void main(String[] args)  {
     Employee[] list = new Employee[3];
     list[0] = new Executive("Jarallah Al-Ghamdi", 50000);
     list[1] = new HourlyEmployee("Azmat Ansari", 120);
     list[2] = new MonthlyEmployee("Sahalu Junaidu", 9000);
      ((Executive)list[0]).awardBonus(11000);
     for(int i = 0; i < list.length; i++)
        if(list[i] instanceof HourlyEmployee)
           ((HourlyEmployee)list[i]).addHours(60);
     for(int i = 0; i < list.length; i++)  {
         list[i].print();
          System.out.println("Paid: " + list[i].pay());
          System.out.println("***************************");
     }
   }
}
```

The Program Output



```
Name: Jarallah Al-Ghamdi
Pay Rate: 50000.0
Current bonus: 11000.0
Paid: 61000.0
***************************
Name: Azmat Ansari
Pay Rate: 120.0
Current hours: 60
Paid: 7200.0
***************************
Name: Sahalu Junaidu
Pay Rate: 9000.0
Paid: 9000.0
***************************
```

Review of Interfaces

- **Interfaces are not classes**, they are entirely a separate entity.
- They provide a list of abstract methods which MUST be implemented by a class that implements the interface.
- Unlike abstract classes which may contain implementation of some of the methods, **interfaces provide NO implementation**.
- Like abstract classes, the purpose of interfaces is to provide organizational structure.
- More importantly, **interfaces are here to provide a kind of "multiple inheritance"** which is not supported in Java.
  - Interfaces allow a child to be both of type A and B.

Review of Interfaces (contd.)

- Recall that Java has the Comparable interface already defined as:

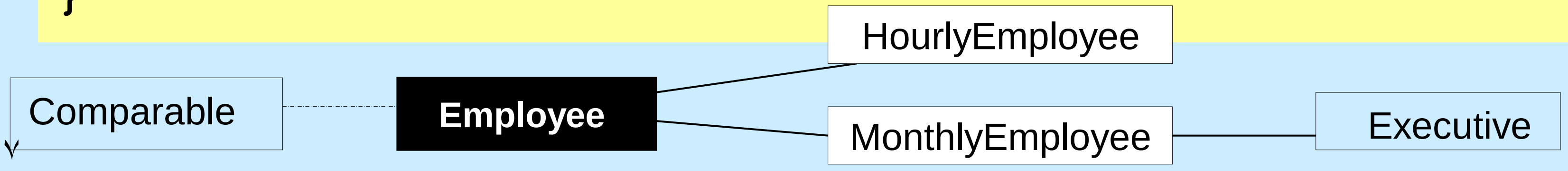
```
interface Comparable {
    int compareTo(Object o);
}
```

- Recall also that java has the java.util.Arrays class, which has a sort method that can sort any array whose contents are either primitive values or Comparable objects.
- Thus, to sort our list of Employee objects, all we need is to modify the Employee class to implement the Comparable interface.
- Notice that this will work even if the Employee class is extending another class or implementing another interface.

- (This modification is shown on the next page.)

Review of Interfaces (contd.)

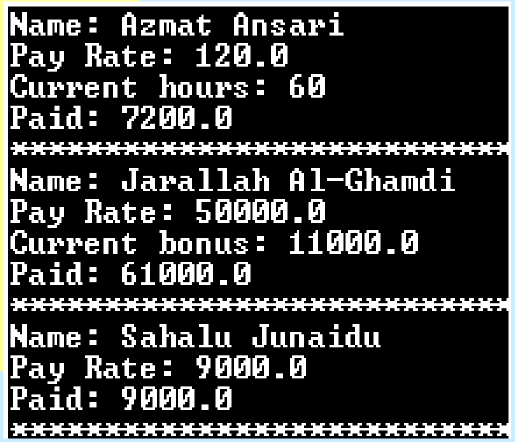
```
abstract class Employee implements Comparable <Employee> {
   protected String name;
   protected double payRate;
   public Employee(String empName, double empRate)  {
        name = empName;
        payRate = empRate;
   }
   public String getName()  {
       return name;
   }
   public void setPayRate(double newRate)  {
      payRate = newRate;
   }
   abstract public double pay();
   public int compareTo(Employee e)  {
       return name.compareTo( e.getName());   // recursive
   }
}
```



Review of Interfaces (contd.)

Since Employee class implements the Comparable interface, the array of employees can now be sorted as shown below:

```
import java.util.Arrays;
public class TestInterface  {
   public static void main(String[] args)  {
      Employee[] list = new Employee[3];
      list[0] = new Executive("Jarallah Al-Ghamdi", 50000);
      list[1] = new HourlyEmployee("Azmat Ansari", 120);
      list[2] = new MonthlyEmployee("Sahalu Junaidu", 9000);
      ((Executive)list[0]).awardBonus(11000);
      for(int i = 0; i < list.length; i++)
         if(list[i] instanceof HourlyEmployee)
            ((HourlyEmployee)list[i]).addHours(60);
      Arrays.sort(list);
      for(int i = 0; i < list.length; i++)  {
         list[i].print();
         System.out.println("Paid: " + list[i].pay());
         System.out.println("**********************");
      }
   }
}
```



```
Name: Azmat Ansari
Pay Rate: 120.0
Current hours: 60
Paid: 7200.0
***************************
Name: Jarallah Al-Ghamdi
Pay Rate: 50000.0
Current bonus: 11000.0
Paid: 61000.0
***************************
Name: Sahalu Junaidu
Pay Rate: 9000.0
Paid: 9000.0
***************************
```

The program output

Review Questions

- How does an interface differ from an abstract class?
- Why does Java not support multiple inheritance? What feature of Java helps realize the benefits of multiple inheritance?
- An Abstract class must contain at least one abstract method, (true or false)?
- A subclass typically represents a larger number of objects than its super class, (true or false)?
- A subclass typically encapsulates less functionality than its super class does, (true or false)?
- An instance of a class can be assigned to a variable of type any of the interfaces the class implements, (true or false)?