

Programming Concepts Using Java

Week 3 Revision

W03:L01: The philosophy of OO programming

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- **Structured programming**
 - The algorithms come first
 - Design a set of procedures for specific tasks
 - Combine them to build complex systems
 - Data representation comes later
 - Design data structures to suit procedural manipulations
- **Object Oriented design**
 - First identify the data we want to maintain and manipulate
 - Then identify algorithms to operate on the data
- **Designing objects**
 - **Behaviour** – what methods do we need to operate on objects?
 - **State** – how does the object react when methods are invoked?
 - **State** is the information in the instance variables
 - **Encapsulation** – should not change unless a method operates on it

W03:L01: The philosophy of OO programming (Cont.)

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- Relationship between classes
 - Dependence
 - Order needs Account to check credit status
 - Item does not depend on Account
 - Robust design minimizes dependencies, or coupling between classes
 - Aggregation
 - Order contains Item objects
 - Inheritance
 - One object is a specialized versions of another
 - ExpressOrder inherits from Order
 - Extra methods to compute shipping charges, priority handling

W03:L02: Subclasses and inheritance

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- A subclass extends a parent class
- Subclass inherits instance variables and methods from the parent class
- Subclass can add more instance variables and methods
 - Can also **override** methods
- Subclasses cannot see private components of parent class
- Use **super** to access constructor of parent class
- **Manager** objects inherit other fields and methods from **Employee**
- Every **Manager** has a **name**, **salary** and methods to access and manipulate these.

```
public class Employee{
    private String name;
    private double salary;

    // Some Constructors ...

    // "mutator" methods
    public boolean setName(String s){ ... }
    public boolean setSalary(double x){ ... }

    // "accessor" methods
    public String getName(){ ... }
    public double getSalary(){ ... }

    // other methods
    public double bonus(float percent){
        return (percent/100.0)*salary;
    }
}

public class Manager extends Employee{
    private String secretary;
    public boolean setSecretary(name s){ ... }
    public String getSecretary(){ ... }
}
```

W03:L03: Dynamic dispatch and polymorphism

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- **Manager** can redefine **bonus()**

```
double bonus(float percent){  
    return 1.5*super.bonus(percent);  
}
```

 - Uses parent class **bonus()** via **super**
 - **Overrides** definition in parent class
- Consider the following assignment

```
Employee e = new Manager(...)
```
- Can we invoke **e.setSecretary()**?
 - **e** is declared to be an **Employee**
 - Static typechecking – **e** can only refer to methods in **Employee**

```
public class Employee{  
    private String name;  
    private double salary;  
  
    // Some Constructors ...  
  
    // "mutator" methods  
    public boolean setName(String s){ ... }  
    public boolean setSalary(double x){ ... }  
  
    // "accessor" methods  
    public String getName(){ ... }  
    public double getSalary(){ ... }  
  
    // other methods  
    public double bonus(float percent){  
        return (percent/100.0)*salary;  
    }  
}  
  
public class Manager extends Employee{  
    private String secretary;  
    public boolean setSecretary(name s){ ... }  
    public String getSecretary(){ ... }  
}
```

W03:L03: Dynamic dispatch and polymorphism (Cont.)

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- What about `e.bonus(p)`? Which `bonus()` do we use?
 - **Static:** Use `Employee.bonus()`
 - **Dynamic:** Use `Manager.bonus()`
- **Dynamic dispatch** (dynamic binding, late method binding, . . .) turns out to be more useful
- **Polymorphism**
 - Every Employee in `emparray` "knows" how to calculate its bonus correctly!

```
Employee[] emparray = new Employee[2];
Employee e = new Employee(...);
Manager e = new Manager(...);
emparray[0] = e;
emparray[1] = m;
for (i = 0; i < emparray.length; i++){
    System.out.println(emparray[i].bonus(5.0));
}
```

```
public class Employee{
    private String name;
    private double salary;

    // Some Constructors ...

    // "mutator" methods
    public boolean setName(String s){ ... }
    public boolean setSalary(double x){ ... }

    // "accessor" methods
    public String getName(){ ... }
    public double getSalary(){ ... }

    // other methods
    public double bonus(float percent){
        return (percent/100.0)*salary;
    }
}

public class Manager extends Employee{
    private String secretary;
    public boolean setSecretary(name s){ ... }
    public String getSecretary(){ ... }
}
```

W03:L03: Dynamic dispatch and polymorphism (Cont.)

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- Signature of a function is its name and the list of argument types
- **Overloading**: multiple methods, different signatures, choice is static
- **Overriding**: multiple methods, same signature, choice is static
 - `Employee.bonus()`
 - `Manager.bonus()`
- **Dynamic dispatch**: multiple methods, same signature, choice made at run-time

```
double[] darr = new double[100];
int[] iarr = new int[500];
...
Arrays.sort(darr);
    // sorts contents of darr
Arrays.sort(iarr);
    // sorts contents of iarr
class Arrays{
    ...
    public static void sort(double[] a){..}
        // sorts arrays of double[]
    public static void sort(int[] a){..}
        // sorts arrays of int[]
    ...
}
```

W03:L03: Dynamic dispatch and polymorphism (Cont.)

Week-3

Type casting

- Consider the following assignment
`Employee e = new Manager(...)`
- `e.setSecretary()` does not work
 - Static type-checking disallows this
- Type casting — convert `e` to `Manager`
`((Manager) e).setSecretary(s)`
- Cast fails (error at run time) if `e` is not a `Manager`
- Can test if `e` is a `Manager`

```
if (e instanceof Manager){  
    ((Manager) e).setSecretary(s);  
}
```

```
public class Employee{  
    private String name;  
    private double salary;  
  
    // Some Constructors ...  
  
    // "mutator" methods  
    public boolean setName(String s){ ... }  
    public boolean setSalary(double x){ ... }  
  
    // "accessor" methods  
    public String getName(){ ... }  
    public double getSalary(){ ... }  
  
    // other methods  
    public double bonus(float percent){  
        return (percent/100.0)*salary;  
    }  
}  
  
public class Manager extends Employee{  
    private String secretary;  
    public boolean setSecretary(name s){ ... }  
    public String getSecretary(){ ... }  
}
```


W03:L04: The Java class hierarchy

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- Java does not allow multiple inheritance
 - A subclass can extend only one parent class
- The Java class hierarchy forms a tree
- The root of the hierarchy is a built-in class called **Object**
 - **Object** defines default functions like `equals()` and `toString()`
 - These are implicitly inherited by any class that we write
- When we override functions, we should be careful to check the signature
- Useful methods defined in **Object**

```
public boolean equals(Object o) // defaults to pointer equality
public String toString()       // converts the values of the
                               // instance variables to String
```

- For Java objects `x` and `y`, `x == y` invokes `x.equals(y)`
- To print `o`, use `System.out.println(o+"");`
 - Implicitly invokes `o.toString()`

W03:L05: Subtyping vs inheritance

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- Class hierarchy provides both **subtyping** and **inheritance**
- **Subtyping**
 - Capabilities of the subtype are a superset of the main type
 - If **B** is a subtype of **A**, wherever we require an object of type **A**, we can use an object of type **B**
 - **Employee e = new Manager(...);** is legal
 - **Compatibility of interfaces**
- **Inheritance**
 - Subtype can reuse code of the main type
 - **B** inherits from **A** if some functions for **B** are written in terms of functions of **A**
 - **Manager.bonus()** uses **Employee.bonus()**
 - **Reuse of implementations**
- Using one idea (hierarchy of classes) to implement both concepts blurs the distinction between the two

W03:L06: Java modifiers

Week-3

Lecture-1

Lecture-2

Lecture-3

Lecture-4

Lecture-5

Lecture-6

- **private** and **public** are natural artefacts of encapsulation
 - Usually, instance variables are **private** and methods are **public**
 - However, **private** methods also make sense
- Modifiers **static** and **final** are orthogonal to **public/private**
- Use **private static** instance variables to maintain bookkeeping information across objects in a class
 - Global serial number, count number of objects created, profile method invocations, . . .
- Usually **final** is used with instance variables to denote constants
- A **final** method cannot be overridden by a subclass
- A **final** class cannot be inherited
- Can also have **private** classes