Accelerating Information Technology Innovation

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Lesson 09 – Inheritance
What is Inheritance?

• **In the real world:**
  • We have general terms for objects in the real world, example “Vehicle”
  • Vehicles have wheels, they move, you can ride them, etc.
  • There are many specific types of “Vehicles”
    • Cars, bicycle, trucks, busses etc.
    • They all share (inherit) attributes of a vehicle
    • But each is more specific:
      • Cars have 4 wheels, carry 5 people
      • Bicycles have 2 wheels, carry 1 person
What is Inheritance?

In software:

- Objects that are derived from other object "resemble" their parents by *inheriting* both state (fields) and behaviour (methods).

- Parents are more general than children

- Children refine parents class specification for different uses
public class Dog {
    private int numOfLegs;

    public Dog(int legs){
        numOfLegs = 4;
    }

    public int getNumLegs(){
        return numOfLegs;
    }

    public String bark(){
        return "Woof";
    }
}
Duck Class

```java
public class Duck {
    private int numOfLegs;

    public Cat(int legs) {
        numOfLegs = 2;
    }

    public int getNumLegs() {
        return numOfLegs;
    }

    public String quack() {
        return "quack";
    }
}
```
Problem: Code Duplication

- Duck and Dog have the `numOfLegs` field and the `getNumLegs` method in common.
- Classes often have a lot of state and behavior in common.
- Result: lots of duplicate code!
Solution: Inheritance

• Inheritance allows you to write new classes that inherit from existing classes

• The existing class whose properties are inherited is called the "parent" or superclass

• The new class that inherits from the super class is called the "child" or subclass

• Result: Lots of code reuse!
Dog
  int numOfLegs
  int getNumLegs()
  void bark()

Duck
  int numOfLegs
  int getNumLegs()
  void quack()

Animal
  int numOfLegs
  int getNumLegs()

using inheritance

superclass

Dog
  void bark()

Duck
  void quack()
public class Animal {
    public int numOfLegs;

    public Animal(int numOfLegs) {
        this.numOfLegs = numOfLegs;
    }

    public int getNumLegs() {
        return this.numOfLegs;
    }
}
Inheritance Rules

• Use the **extends** keyword to indicate that one class inherits from another

• The subclass inherits public (and *protected*) fields and methods of the superclass

• Use the **super** keyword in the subclass constructor to call the superclass constructor
public class Dog extends Animal {

    public Dog() {
        super(4);
    }

    public String bark() {
        return "Woof";
    }
}

Dog Class
public class Duck extends Animal {
    public Duck() {
        super(2);
    }

    public String quack(){
        return "Quack";
    }
}

Is-A Relationship

- Inheritance defines an “is-a” relationship
  - Dog is an Animal
  - Duck is an Animal

- One way relationship
  - Animal is not a Dog! (Remember this when coding!)

- The derived class inherits access to methods and fields from the parent class
  - Use inheritance when you want to reuse code
Aside: Has-A Relationship

• When one class has a field of another class (or primitive type)
  – Animal has an `int`

• Do not confuse with inheritance!
What is the output of the following?

Dog d = new Dog();
Duck u = new Duck();

System.out.println("A dog has " +
    d.getNumLegs() + d.bark());

System.out.println("A duck has " +
    u.getNumLegs() + u.quack());

(Dog and Duck inherit the getNumLegs() method from the Animal super class, but get bark and quack from their own class)
public static void main(String[] args) {
    Animal a1 = new Animal(4);
    a1.getNumLegs();
    a1.bark();    // Animal does not have bark
    a1.quack();   // Animal does not have quack

    Dog a2 = new Dog();
    a2.getNumLegs();
    a2.bark();
    a2.quack();   // Dog does not have a quack

    Duck du = new Duck();
    du.getNumLegs();
    du.bark();    // Duck does not have bark
    du.quack();
}
Subclass Constructor

- The first thing a subclass constructor must do is call a constructor in the superclass.

- If the subclass constructor does not do this, then the default superclass constructor (with no arguments) will be called implicitly.
Implicit Super Constructor Call

If I have this `Food` class:

```java
public class Food {
    private boolean raw;
    public Food() {
        raw = true;
    }
}
```

then this `Beef` subclass:

```java
public class Beef extends Food {
    private double weight;
    public Beef(double w) {
        super();
        weight = w
    }
}
```

is equivalent to:

```java
public class Beef extends Food {
    private double weight;
    public Beef(double w) {
        super();
        weight = w
    }
}
```
public class A {
    public A() { System.out.println("I'm A"); }
}

public class B extends A {
    public B() { System.out.println("I'm B"); }
}

public class C extends B {
    public C() { System.out.println("I'm C"); }
}

What does this print out?

C x = new C();
Overriding Methods

- Subclasses can *override* methods in their superclass

```java
class Therm {
    protected double celsius;

    public Therm(double c) {
        celsius = c;
    }

    public double getTemp() {
        return celsius;
    }
}

class ThermUS extends Therm {
    public ThermUS(double c) {
        super(c);
    }

    // degrees in Fahrenheit
    public double getTemp() {
        return celsius * 1.8 + 32;
    }
}
```

- What is the output of the following?

```java
ThermUS thermometer = new ThermUS(100);
System.out.println(thermometer.getTemp());
```

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Calling Superclass Methods

When you override a method, you can call the superclass's copy of the method by using the syntax `super.method()`

class Therm {
    private double celsius;
    
    public Therm(double c) {
        celsius = c;
    }
    
    public double getTemp() {
        return celsius;
    }
}

class ThermUS extends Therm {
    
    public ThermUS(double c) {
        super(c);
    }
    
    public double getTemp() {
        return super.getTemp() * 1.8 + 32;
    }
}
Remember Casting?

• "Casting" means "promising" the compiler that the object will be of a particular type.
  – So the compiler should go ahead and convert

• You can cast a variable to the type of the object that it references to use that object's methods.

```java
Animal a2 = new Dog();
a2.bark(); //Animal does not have a bark method
-> ((Dog)a2).bark();
```

• The casting will fail if the variable doesn't reference an object of that type.
public static void main(String[] args) {
    Animal a1 = new Dog();
    ((Dog)a1).bark(); // a1 changed to Dog
    ((Duck)a1).quack(); // a1 is not a Duck

    Animal a2 = new Duck();
    ((Duck)a2).quack(); // a2 changed to Duck
    ((Dog)a2).bark(); // a2 is not a Dog
A company has a list of Employees. It asks you to provide a payroll sheet for all employees.

- Different types of employees
  - manager, engineer, software engineer.
  - Manager straight Salary
  - Engineer Hourly

- You have an old Employee class but need to add very different data and methods for managers and engineers.
class Employee {
    // Fields
    private String firstName, lastName;

    // Constructor
    public Employee(String fName, String lName) {
        firstName= fName; lastName= lName;
    }

    // Method
    public void printData() {
        System.out.println(firstName + " " + lastName);
    }
}

This is a simple super or base class.
Inheritance

Employee
String fname
String lname
void printData()

Manager
double salary
void printData()
double getPay()

Engineer
double wage
double hoursWorked
void printData()
double getPay()
class Engineer extends Employee {
    private double wage;
    private double hoursWorked;
    public Engineer(String fName, String lName, 
        double rate, double hours) {
        super(fName, lName);
        wage = rate;
        hoursWorked = hours;
    }
    public double getPay() {
        return wage * hoursWorked;
    }
    public void printData() {
        super.printData(); // PRINT NAME
        System.out.println("Weekly pay: $" + getPay());
    }
}
class Manager extends Employee {
    private double salary;

    public Manager(String fName, String lName, double sal) {
        super(fName, lName);
        salary = sal;
    }

    public double getPay() {
        return salary;
    }

    public void printData() {
        super.printData();
        System.out.println("Monthly salary: $" + salary);
    }
}
More Inheritance

Manager

double salary

void printData()

double getPay()

Sales Manager

double bonus

void printData()

double getBonus()
class SalesManager extends Manager {
    private double bonus;     // Bonus Possible as commission.

    // A SalesManager gets a constant salary of $1250.0
    public SalesManager(String fName, String lName, double b) {
        super(fName, lName, 1250.0);
        bonus = b;
    }

    public double getBonus() {
        return bonus;
    }

    public void printData() {
        super.printData(); //Print from both Super Classes
        System.out.println("Bonus Pay: "$ + getBonus());
    }
}
SalesManager

private double bonus

public SalesManager(String, String, double)
public double getBonus()
public void printData()
public class PayRoll {
    public static void main(String[] args) {
        Engineer fred = new Engineer("Fred", "Smith", 12.0, 8.0);
        Manager ann = new Manager("Ann", "Brown", 1500.0);
        SalesManager mary = new SalesManager("Mary", "Kate", 2000.0);

        Employee[] employees = new Employee[3];
        employees[0] = fred;
        employees[1] = ann;
        employees[2] = mary;
        for (int i = 0; i < 3; i++)
            employees[i].printData();
    }
}

Java knows the object type and chooses the appropriate method at run time
Output from main method

Fred Smith
Weekly pay: $96.0

Ann Brown
Monthly salary: $1500.0

Mary Barrett
Monthly salary: $1250.0
Bonus: $2000.0

Note that we could not write:

```java
employees[i].getPay();
```

because `getPay()` is not a method of the superclass `Employee`.

In contrast, `printData()` is a method of `Employee`, so Java can find the appropriate version, starts from subclass (most inherited) and works the way up for method
How about if you want to test if an object is of a specific class?

Use the `instanceof` operator
- returns true if an object is of the class
- returns true if an object is a subclass of the class

Form:
```
obj instanceof Class
```
instanceof Example

Employee emp = new Employee("first", "last");
Engineer eng = new Engineer("Fred", "Smith", 12.0, 8.0);
Manager mana = new Manager("Ann", "Brown", 1500.0);
SalesManager salesm = new SalesManager("Mary", "Kate", 2000.0);

emp instanceof Employee true
emp instanceof Engineer false
mana instanceof Employee true
eng instanceof Engineer true
salesm instanceof Manager true
public class PayRoll {
    public static void main(String[] args) {
        Engineer fred = new Engineer("Fred", "Smith", 12.0, 8.0);
        Manager ann = new Manager("Ann", "Brown", 1500.0);
        SalesManager mary = new SalesManager("Mary", "Kate", 2000.0);

        Employee[] employees = new Employee[3];
        employees[0]= fred;
        employees[1]= ann;
        employees[2]= mary;
        for (int i=0; i < 3; i++)
            if (employees[i] instanceof SalesManager)
                System.out.println(employees[i].getBonus());
    }
}
Object Class

- All Java classes implicitly inherit from `java.lang.Object`

- So every class you write will automatically have methods in `Object` such as `equals`, `hashCode`, and `toString`.

- We'll learn about the importance of some of these methods in later lectures.