FUNDAMENTALS

CS062

DATA STRUCTURES AND ADVANCED PROGRAMMING

3: Inheritance, Interfaces, and Generics

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Lecture 3: Inheritance, Interfaces, and Generics

- Inheritance
- Interfaces
- Generics

Some slides adopted from Algorithms, 4th Edition and Oracle tutorials

Inheritance

- When you want to create a new class and there is already a class that includes some of the code that you want, you can derive your new class from the existing class. → reuse code!
- Central concept in OOP.

- A class that is derived from another is called a subclass or child class.
- The class from which the subclass is derived is called a superclass or parent class.
- Single inheritance: A class can only extend ONE AND ONLY one parent class.
- Multilevel inheritance: A class can extend a class which extends another class etc.

Remember our `Bicycle` class?

```
/**
 * Represents a bicycle
 * @author https://docs.oracle.com/javase/tutorial/java/concepts/class.html
 *
 */
public class Bicycle {

    //instance variables
    private int cadence = 0;
    private int speed = 0;
    private int gear = 1;

    // the Bicycle class has one constructor
    public Bicycle(int startCadence, int startSpeed, int startGear) {
        gear = startGear;
        cadence = startCadence;
        speed = startSpeed;
    }


    public void changeCadence(int newValue) {
         cadence = newValue;
    }

    public void changeGear(int newValue) {
         gear = newValue;
    }

    public void changeSpeed(int change) {
         speed = speed + change;
    }

    public int getCadence() {
         return cadence;
    }

    public void printGear() {
       System.out.println("Gear:" + gear);
    }

    public String toString() {
         return "cadence:" + cadence + " speed:" + speed + " gear:" + gear;
    }
}
```

A `MountainBike` is a specialized type of `Bicycle`

```
/**
 * Demonstrates concept of inheritance
 * @author https://docs.oracle.com/javase/tutorial/java/IandI/subclasses.html
 *
 */
public class MountainBike extends Bicycle {

    // the MountainBike subclass adds one field
    private int seatHeight;

    // the MountainBike subclass has one constructor
    public MountainBike(int startHeight,
                        int startCadence,
                        int startSpeed,
                        int startGear) {
        super(startCadence, startSpeed, startGear);
        seatHeight = startHeight;
    }

    // the MountainBike subclass adds one method
    public void setHeight(int newValue) {
        seatHeight = newValue;
    }
}
```

Inheritance

- The subclass inherits all the `public` and `protected` members.
  - Not the `private` ones, although it can access them with appropriate getters and setters.
- The inherited fields can be used directly, just like any other fields.
- You can declare a field in the subclass with the same name as one in the superclass, thus hiding it.
  - AVOID
- You can write a new instance method in the subclass that has the same signature as the one in the superclass, thus overriding it.
- You can write a new static method in the subclass that has the same signature as the one in the superclass, thus hiding it.
- You can write a subclass constructor that invokes either implicitly the default constructor of the superclass or by directly invoking it using the keyword `super()`.

`super` keyword

- Refers to the direct parent of the subclass.
- `super.variable`: for hidden fields, avoid altogether.
- `super.instanceMethod()`: for overridden methods.
- `super(args)`: to call the constructor of the super class. First line in constructor of subclass.

Polymorphism

- The ability of an object to take many forms.
- Static Polymorphism: Happens during method overloading, that is more than one method have the same name but different sets of parameters (signature).
  - Also known as Compile-Time Polymorphism, Static binding, Compile-Time binding, Early binding
- Dynamic Polymorphism: Happens during method overriding, that is a method with the same signature exists both in parent and child class. When a parent reference is used to refer to a child object, the method that will be executed with be defined at run-time, therefore will be the child's overridden method.
  - ```
    Student student = new Student();
    Person person = new Student();
    ```
  - Also known as Run-Time Polymorphism, Dynamic binding, Run-Time binding, Late binding

https://medium.com/@shanikae/polymorphism-explained-simply-7294c8deeef7
    ```

Example: Animal

```
public class Animal {
    public int legs = 2;
    public static String species = "Animal";
    public static void testClassMethod() {
        System.out.println("The static method in Animal");
    }
    public void testInstanceMethod() {
        System.out.println("The instance method in Animal");
    }
}
```

Example: Cat

```
public class Cat extends Animal {
    public int legs = 4;
    public static String species = "Cat";
    public static void testClassMethod() {
        System.out.println("The static method in Cat");
    }
    public void testInstanceMethod() {
        System.out.println("The instance method in Cat");
    }
}
```

Hiding vs overriding

```
public static void main(String[] args) {
    Cat myCat = new Cat();
    myCat.testClassMethod(); //invoking a hidden method
    myCat.testInstanceMethod(); //invoking an overridden method
    System.out.println(myCat.legs); //accessing a hidden field
    System.out.println(myCat.species); //accessing a hidden field
}
```

- Output:

```
The static method in Cat
The instance method in Cat
4
Cat
```

WHAT YOU WERE EXPECTING, RIGHT?

Hiding vs overriding

```
public static void main(String[] args) {
    Animal yourCat = new Cat();
    yourCat.testClassMethod(); //invoking a hidden method
    yourCat.testInstanceMethod(); //invoking an overridden method
    System.out.println(yourCat.legs); //accessing a hidden field
    System.out.println(yourCat.species); //accessing a hidden field
}
```

- Output:

```
The static method in Animal
The instance method in Cat
2
Animal
```

???

Hiding vs overriding

- Hiding: For fields (instance+static) and methods (static) the class is determined at compile-time. Here, the compiler sees that `yourCat` is declared as `Animal`.
- Overriding: For instance methods this is determined at run-time. At this point, we know that `yourCat` is of type `Cat`.
- One form of polymorphism (dynamic).
- You will get a compile-time error if you attempt to change an instance method in the superclass to a static method in the subclass and vice-versa.

All classes inherit class `Object`

- Directly if they do not extend any other class, or indirectly as descendants.
- `Object` class has built-in methods that are inherited.
- `public boolean equals (Object other)`
  - Default behavior returns true only if same object.
- `public String toString()`
  - Returns string representation of object – default is hexadecimal.
  - Does not print the string.
  - Typically needs to be overridden to be useful.
- `public int hashCode()`
  - Unique identifier defined so that if `a.equals(b)` then `a`, `b` have same hashCode.

`final` keyword

- Variable: only assigned once in its declaration or in constructor — its value cannot be changed after initialization.
  - E.g., `static final PI = 3.14;`
- Method: cannot be overridden by subclass.
- Class: cannot be extended.

Practice Time

```
public class ClassA {
    public void methodOne(int i) {
    }
    public void methodTwo(int i) {
    }
    public static void methodThree(int i) {
    }
    public static void methodFour(int i) {
    }
}

public class ClassB extends ClassA {
    public static void methodOne(int i) {
    }
    public void methodTwo(int i) {
    }
    public void methodThree(int i) {
    }
    public static void methodFour(int i) {
    }
}
```

1. Which method *overrides* a method in the superclass?

2. Which method *hides* a method in the superclass?

3. What do the other methods do?

Answers

1. `methodTwo`.

2. `methodFour`.

3. They cause compile-time errors.
   `methodOne`: "`This static method cannot hide the instance method from ClassA`".
   `methodThree`: "`This instance method cannot override the static method from ClassA`".

Lecture 3: Inheritance, Interfaces, and Generics

- Inheritance
- Interfaces
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Interfaces

- Contracts of what a class must do, not how to do it, abstracting from implementation.
- Central concept in OOP.
- In Java, an interface is a reference type (like a class), that contains only constants, method signatures, default methods, and static methods.
- A class that implements an interface is obliged to implement its methods.
- Method bodies exist only for default methods and static methods.
- Interfaces cannot be instantiated (no new keyword). They can only be implemented by classes or extended by other interfaces.

Example

```
public interface Moveable{
  int turn(Direction direction, double radius, double speed);

  default int stop(){
    speed=0;
  }
}
```

```
public class Car implements Moveable{
  int turn(Direction direction, double radius, double speed){
    //code goes here
  }
}

public class Bicycle implements Moveable{
  int turn(Direction direction, double radius, double speed){
    //code goes here
  }
}
```

Interfaces

- A class can implement multiple interfaces.
  - `class A implements Interface1, Interface2{…}`
- An interface can extend multiple interfaces.
  - `public interface GroupedInterface extends Interface1,Interface2{…}`

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Generics

- Compile-time errors can be easier to fix than run-time errors.
- Java introduced generics (similar to templates in C++) to help move more bugs to compile-time (easier to debug!), eliminate casting, and improve abstraction. E.g.,

```
List list = new ArrayList();
list.add("hello");
String s = (String) list.get(0);
```

Is now:

```
List<String> list = new ArrayList<String>();
list.add("hello");
String s = list.get(0);   // no cast
```

- Generics enable types (that is classes and interfaces) to be used as parameters when defining classes, interfaces, and methods.

Formal and actual type parameters

```
public interface List <E> {
    void add(E x);
    Iterator<E> iterator();
}
```

Formal type parameters

```
public interface Iterator<E> {
    E next();
    boolean hasNext();
}
```

- In the invocation (e.g., `List<Integer>`) all occurrences of the formal type parameters are replaced by the actual type argument (e.g., `Integer`).

Generic classes

```
class name <T1, T2, …, Tn> {…}
```

- A type variable can be any non-primitive type (class, interface, array)
- E: element (common in data structures), T: type, K: key, V: value, N: number, etc.

```
/**
* Generic version of the Box class.
* https://docs.oracle.com/javase/tutorial/java/generics/types.html
* @param <T> the type of the value being boxed
*/

public class Box<T> {
    private T t;

    public void set(T t) { this.t = t; }
    public T get() { return t; }
}
```

- Invocation: `Box<Integer> integerBox = new Box<Integer>();`

Multiple Type Parameters Example

```
public interface Pair<K, V> {
    public K getKey();
    public V getValue();
}

public class OrderedPair<K, V> implements Pair<K, V> {
    private K key;
    private V value;

    public OrderedPair(K key, V value) {
        this.key = key;
        this.value = value;
    }
}
Pair<String, Integer> p1 = new OrderedPair<String, Integer>("Even", 8);

OrderedPair<String, Box<Integer>> p = new OrderedPair<String, Box<Integer>>("primes", new
Box<Integer>(...));
```

Generic methods

```
modifier (static) <T1, T2, …, Tn> return-type name(list of type parameters){…}}
```

- The type parameter's scope is limited to the method which is declared.
- Static, non-static generic methods, generic class constructors are allowed.
- Type inference: allows you to invoke a generic method as an ordinary method, without specifying a type between angle brackets.
- E.g., `className/objectName.genericMethod(arguments);`

Example

- Generic method that swaps the elements of an array at two specified indices.

```
public static <T> void swap(T[] a, int i, int j) {
    T temp = a[i];
    a[i] = a[j];
    a[j] = temp;
}
```

Readings:

- Oracle's guides:
  - Interfaces and Inheritance: https://docs.oracle.com/javase/tutorial/java/IandI/index.html
  - Generics: https://docs.oracle.com/javase/tutorial/java/generics/index.html
    https://docs.oracle.com/javase/tutorial/extra/generics/intro.html
- Textbook:
  - Pages 100-104, 122
- Textbook Website:
  - Generics: https://algs4.cs.princeton.edu/13stacks/

Practice Problems:

- If you want more practice with hiding vs overriding:
  http://javabypatel.blogspot.com/2016/04/java-interview-questions.html