Object-Oriented Programming I

Inheritance Intro, Iterators

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Overview

- Introduction Inheritance
- Iterators
Inheritance

- **Inheritance**: is the process by which one new class, called the **derived class**, is created from another class, called the **base class**
  - The **derived class** is also called: **subclass** or **child class**
  - The **base class** is also called: **superclass** or **parent class**

- **Motivation**: In real life objects have a hierarchical structure:

![Class Hierarchy Diagram]

- We want to do the same with our program objects.
Inheritance

- **Object Inheritance**: What does inheritance mean within the context of object-oriented programming?

- Suppose a **derived class**, Circle, comes from a **base class**, Shape:
  - Circle should have **all the instance variables** that Shape has. (E.g., Shape stores a color, and thus, Circle stores a color.)
  - Circle should have **all the methods** that Shape has (E.g., Shape has an accessor, getColor(), and thus, Circle has getColor()).
  - Circle is allowed to define **new instance variables** and **new methods** that are particular to it:
    - **(New) Circle Instance variables**: Center, radius.
    - **(New) Methods**: draw(), getArea(), getPerimeter().

- **Code reuse**: Code/Data that is common to all the derived classes can be stored in the base class. This allows us to **avoid code duplication**, and so makes development and maintenance easier.
Example: University People

- Consider the following **Inheritance Hierarchy** (University Database)
- Stores information on various people at the university. The various objects form a hierarchy:

  - We will consider the design of the **Person**, **Student**, and **Faculty** classes
  - These classes will be very simple (almost trivial). Watch for the relationships between these classes
package university;

public class Person {
    private String name; // person's name
    private String idNum; // ID number

    public Person() {
        name = "No Name";
        idNum = "000-00-0000";
    }

    public Person(String n, String id) {
        name = n;
        idNum = id;
    }

    public Person(Person p) {
        name = p.name;
        idNum = p.idNum;
    }

    // ...other methods in part 2
}
**Base Class: Person (Part 2)**

```java
public class Person {
    private String name;       // person's name
    private String idNum;      // ID number

    // ... constructors in part 1

    public String getName() { return name; }
    public String getIdNum() { return idNum; }
    public void setName(String n) { name = n; }
    public void setIdNum(String id) { idNum = id; }
    public String toString() {
        return "[" + name + "] " + idNum;
    }
    public boolean equals(Person p) {
        return name.equals(p.name) && idNum.equals(p.idNum);
    }
}
```

**Base class: Person (part 2)**

**Instance variables (part 1)**

**Accessors and setters**

**This is all standard stuff. Eclipse will set much of this up for you with:**

**Source → Generate Getters and Setters**

**toString and equals**
Derived Classes: Student and Faculty

- We derive two classes Student and Faculty. Each class inherits all the data and methods from Person, and adds data and methods that are particular to its particular function.

  - **Student**: In addition to name and ID, has **admission year** and **GPA**.
  - **Faculty**: In addition to name and ID, has the **year they were hired**.
Derived Class Structure

- **Person**: (base class)
  - **Instance Data**: Name and ID-number
    - String name
    - String idNum
  - **Methods**:
    - **Constructors**: default, standard, copy constructors.
    - **Accessors/Setters**: getName(), setName(), getIdNum(), setIdNum().
    - **Standard methods**: toString(), equals().

- **Student**: (derived from Person)
  - **Instance Data**: Admission year and GPA
    - int admitYear
    - double gpa
  - **Methods**: (same structure as Person)

- **Faculty**: (derived from Person)
  - **Instance Data**: Year hired
    - int hireYear
  - **Methods**: (same structure as Person)
package university;
public class Student extends Person {
    private int admitYear;
    private double gpa;

    public Student() {
        super();
        admitYear = -1;
        gpa = 0.0;
    }

    public Student(String n, String id, int yr, double g) {
        super(n, id);
        admitYear = yr;
        gpa = g;
    }

    public Student(Student s) {
        super(s);
        admitYear = s.admitYear;
        gpa = s.gpa;
    }

    // ...other methods in part 2
}
Dissecting the Student Class

- **Extends**: To specify that Student is a *derived class* (subclass) of Person we add the descriptor “extends” to the class definition:

  ```java
  public class Student extends Person { ... }
  ```

- Notice that a Student class
  - Inherits everything from the Person class
  - A Student IS-A Person (wherever a Person is needed, we can use a Student).

- **super()**: When initializing a new Student object, we need to initialize its *base class* (or *superclass*). This is done by calling `super( … )`. For example, `super(name, id)` invokes the constructor `Person(name, id)`
  - `super( ... )` must be the *first statement* of your constructor
  - If you *do not* call `super( )`, Java will automatically invoke the base class’s *default constructor*
  - What if the base class’s default constructor is *undefined? Error*
  - You must use “`super( ... )`”, not “`Person( ... )`”.
Memory Layout and Initialization Order

- When you create a new derived class object:
  - Java allocates space for both the base class instance variables and the derived class variables
  - Java initializes the base class variables first, and then initializes the derived class variables
- Example:

  ```java
  Student bob = new Student("Bob Goodstudent", "123-45-6789", 2004, 4.0);
  Person ted = new Person("Ted Goodman", "111-22-3333");
  ```
public class Student extends Person {
    private int admitYear;
    private double gpa;

    // ... constructors in part 1

    public int getAdmitYear() { return admitYear; }
    public double getGpa() { return gpa; }

    public void setAdmitYear(int yr) { admitYear = yr; }
    public void setGpa(double g) { gpa = g; }

    public String toString() {
        return super.toString() + " " + admitYear + " " + gpa;
    }

    public boolean equals(Student s) {
        return super.equals(s) && admitYear == s.admitYear && gpa == s.gpa;
    }
}
Inheritance

- **Inheritance**: Since Student is derived from Person, a Student object can invoke any of the Person methods, it **inherits** them.

```java
Student bob = new Student( "Bob Goodstudent", "123-45-6789", 2004, 4.0 );
String bobsName = bob.getName( );
bob.setName( "Robert Goodstudent" );
System.out.println( "Bob's new info: " + bob.toString( ) );
```

- **A Student “is a” Person**:
  - By inheritance a Student object is also a Person object. We can use a Student reference anywhere that a Person reference is needed.

```java
Person robert = bob; // Okay: A Student is a Person
```

  - We cannot reverse this. (A Person need not be a Student.)

```java
Student bob2 = robert; // Error! Cannot convert Person to Student
```
Iterators

- **ArrayList** is inherited from an class called **AbstractList**.
  - Java provides **many different data structures** that are inherited from AbstractList, e.g. linked lists, binary trees, hash tables.
  - They all provide a device for enumerating all the elements of the data structure: **Iterator**. An **iterator** is an **object** that allows you to **enumerate** the elements of a collection, one by one.

- **How Iterators work**: Let **list** be an ArrayList (or any class inherited from AbstractList).
  - **Iterator x = list.Iterator( )**: Creates a **new iterator** object for list. It is positioned at the **start** of the list.
  - **x.next( )**: Returns the **next element** of the list, and advances the iterator. (Throws an exception if none left.)
  - **x.hasNext( )**: Returns **true** if more elements remain in the list
Iterator Example

ArrayList<String> names = new ArrayList<String>();
names.add("Mary");
names.add("Kelly");
names.add("John");

Iterator<String> iter = names.iterator();
while (iter.hasNext()) {
    String value = iter.next();
    System.out.println(value);
}