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:

  - **Shape**
    - Circle
    - Triangle
    - Rectangle
    - Right-Triangle
    - Equilateral-Triangle
  - **Animal**
    - Insect
    - Mammal
    - Reptile
    - Cat
    - Primate
    - Dog
    - Human
    - Ape

- 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:

![Inheritance Hierarchy Diagram]

- 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
- **Example:** Person.java
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)
  - **Example**: Student.java

- **Faculty**: (derived from Person)
  - **Instance Data**: Year hired
    - int hireYear
  - **Methods**: (same structure as Person)
**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:
  - 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" );
  ```
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() );
  ```

  `bob is a Student, but by inheritance we can invoke Person methods`

- **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

- **Example**: IteratorExample.java