Abstract Classes/Modifiers

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Modifier – Abstract

• Description
  • Represents generic concept
  • Just a placeholder
  • Leave lower-level details to subclass

• Applied to
  • Methods
  • Classes

• Example

```java
abstract class Foo {
  // abstract class
  abstract void bar() { … }  // abstract method
}
```
Motivating Example – Shapes

- Implementation
  - Picture consists of array `shapes` of type `Shape[]`
  - To draw the picture, invoke `drawMe()` for all shapes

```java
Shape[] shapes = new Shape[...];
shapes[0] = new Circle( ... );
shapes[1] = new Rectangle( ... );
...
for ( int i = 0; i < shapes.length; i++ )
  shapes[i].drawMe( );
```

Store the shapes to be drawn in an array.

Heap:

- `shapes[0]` (a Circle object)
- `shapes[1]` (a Rectangle object)
- ...
Motivating Example – Shapes

• Graphics drawing program
  • Define a base class Shape
  • Derive various subclasses for specific shapes
  • Each subclass defines its own method drawMe( )

```java
public class Shape {
    public void drawMe() { ... } // generic drawing method
}
public class Circle extends Shape {
    public void drawMe() { ... } // draws a Circle
}
public class Rectangle extends Shape {
    public void drawMe() { ... } // draws a Rectangle
}
```
Motivating Example – Shapes

• Problem
  • Shape object does not represent a specific shape
    • Since Shape is just a superclass

  • How to implement Shape’s drawMe( ) method?
    public class Shape {
        void drawMe( ) { … }  // generic drawing method
    }

• Possible solutions
  • Draw some special “undefined shape”
  • Ignore the operation
  • Issue an error message
  • Throw an exception

• Better solution
  • Abstract drawMe( ) method, abstract Shape class
  • Tells compiler Shape is incomplete class
Abstract Class

- **Abstract Methods**
  - Behaves much like method in interface
  - Give a signature, but no body
  - Includes modifier `abstract` in method signature
  - Class descendants provide the implementation
  - Abstract methods cannot be final
    - Since must be overridden by descendant class (final would prevent this)

- **Abstract Class**
  - Required if class contains any abstract method
  - Includes modifier `abstract` in the class heading
    
    ```java
    public abstract class Shape { … }
    ```
  - An abstract class is incomplete
    - Cannot be created using “new”
      ```java
      Shape s = new Shape( … );  // Illegal!
      ```
    - But can create concrete shapes (Circle, Rectangle) and assign them to variables of type Shape
      ```java
      Shape s = new Circle( … );
      ```
public abstract class Shape {
   private int color;
   Shape ( int c ) { color = c; }
   int getColor() { return color; }
   public abstract void drawMe( );
}

public class Circle extends Shape {
   private double radius;
   public Circle( int c, double r ) { ... details omitted ... }
   public void drawMe( ) { ... Circle drawing code goes here ... }
}

public class Rectangle extends Shape {
   private double height;
   private double width;
   public Rectangle( int c, double h, double w ) { ... details omitted ... }
   public void drawMe( ) { ... Rectangle drawing code goes here ... }
}

Base class Shape is abstract because it contains the abstract (undefined) method drawMe( ).

Derived class Circle is concrete because it defines drawMe( ).

Derived class Rectangle is concrete because it defines drawMe( ).

The code for drawing the shapes given earlier can now be applied.
Modifers

- Description
  - Java keyword (added to definition)
  - Specifies characteristics of a language construct
- (Partial) list of modifiers
  - Visibility modifiers (public / private / protected)
  - static
  - final
  - abstract
- Examples
  ```java
  public class Foo {
    private static int count;
    private final int increment = 5;
    protected void finalize { … }
  }
  public abstract class Bar {
    abstract int go( ) { … }
  }
  ```
Visibility Modifiers

- **None specified** (package)
  - Referenced only within package
- **public**
  - Referenced anywhere (i.e., outside package)
- **protected**
  - Referenced within package, or by subclasses outside package
- **private**
  - Referenced only within class definition
  - Applicable to class fields & methods
Visibility Modifier

package fooBar;
public class A {
    public int vPub;
    protected int vProt;
    int vPack;
    private int vPriv;
}

package fooBar;
public class B {
    can access vPub;
    can access vProt;
    can access vPack;
    cannot access vPriv;
}

package fooBar;
public class C extends A {
    can access vPub;
    can access vProt;
    can access vPack;
    cannot access vPriv;
}

package fooBar;
public class D extends A {
    can access vPub;
    can access vProt;
    cannot access vPack;
    cannot access vPriv;
}

package fooBar;
public class E {
    can access vPub;
    cannot access vProt;
    cannot access vPack;
    cannot access vPriv;
}

“Access” means access by name, e.g.:
a = new A();
a.vProt = 2;
Static Modifier

• Static variable
  • Single copy for class
  • Shared among all objects of class

• Static method
  • Can be invoked through class name
  • Does not need to be invoked through object
  • Can be used even if no objects of class exist
  • Can not reference instance variables
Final Modifier

- **Final variable**
  - Value can not be changed
  - Must be initialized in every constructor
  - Attempts to modify final are caught at compile time

- **Final static variable**
  - Used for constants
  - Example
    ```java
    final static int Increment = 5;
    ```

- **Final method**
  - Method *can not be overridden* by subclass
  - Private methods are implicitly final

- **Final class**
  - Class can not be a superclass (extended)
  - Methods in final class are implicitly final
  - Prevents inheritance / polymorphism
  - May be useful for
    - Security
    - Object oriented design
  
- **Example: String class**