CMSC 132:
Object-Oriented Programming II

Abstract Classes

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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
```
Abstract – Motivating Example

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

**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.
- Draws all the shapes. Each call invokes drawMe for the specific shape.

Heap:
- shapes
- [0]: (a Circle object)
- [1]: (a Rectangle object)
- [2]: ...
- ...
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?

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

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 Method

- Behaves much like method in interface
- Give a signature, but no body
- Includes modifier `abstract` in method signature
- Class descendents provide the implementation
- Abstract methods cannot be final
  - Since must be overridden by descendent 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( … );
    ```
Example Solution – Shapes

```java
public abstract class Shape {
    private int color;
    Shape ( int c ) { color = c; }
    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.
Abstract – Summary

Abstract methods

- Method that contains no body
- Subclass provides actual implementation

Abstract classes

- Required if any method in class is abstract
- Can contain non-abstract methods
- Can be partial description of class