Northeastern University

Lecture 12: Inheritance and Polymorphism - 2

Prof. Chen-Hsiang (Jones) Yu, Ph.D.

College of Engineering

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Liang, Y. Daniel. Introduction to Java Programming, Comprehensive Version, 12th edition, Pearson, 2019.

Outline

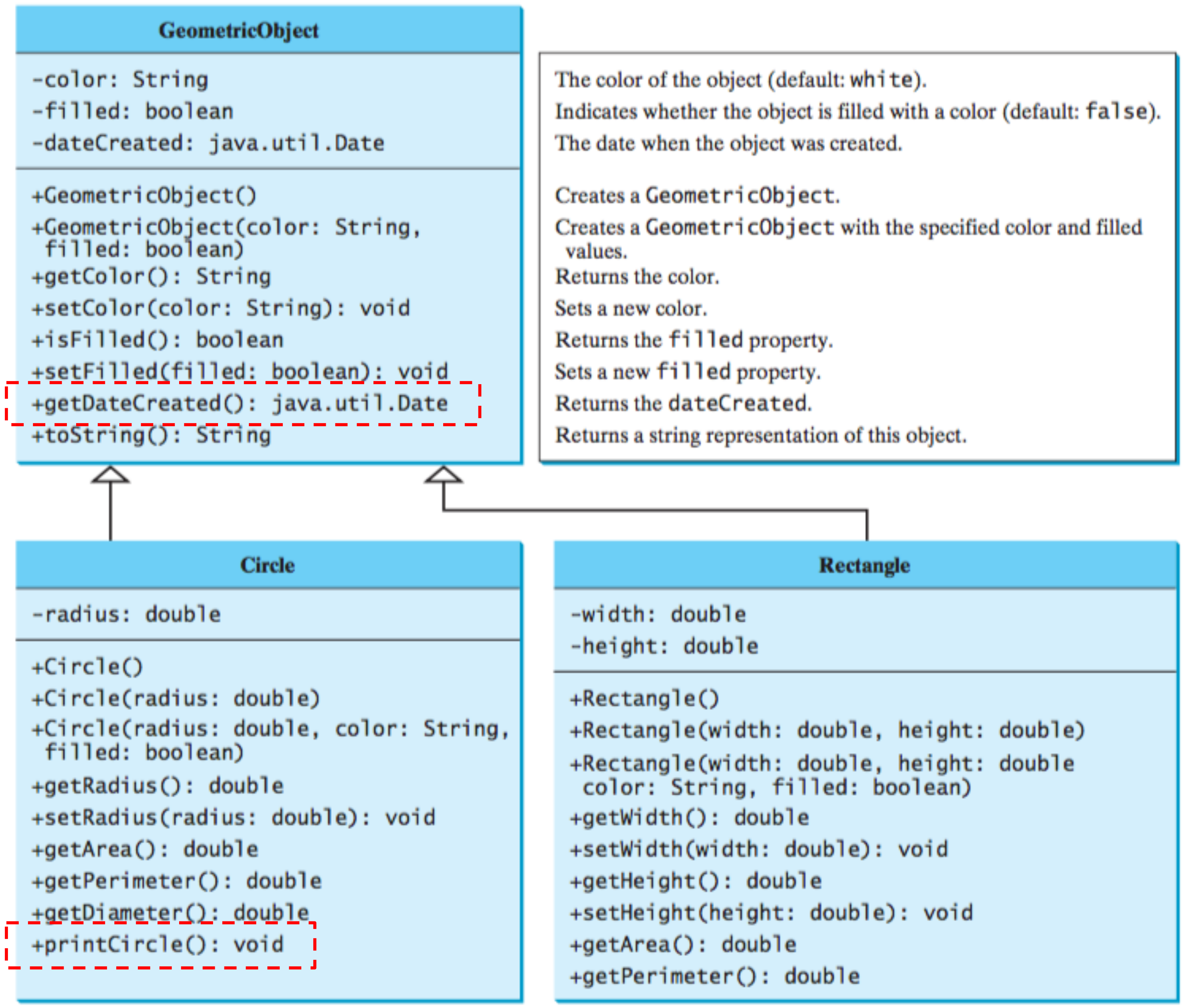
- Inheritance
- Polymorphism

Inheritance (cont.)

Defining a Subclass

- A subclass inherits from a superclass. (Use "extends" keyword)
- You can also:
  - » Add new properties (data fields)
  - » Add new methods
  - » Override the methods of the superclass

Superclasses and Subclasses



GeometricObject
-color: String
-filled: boolean
-dateCreated: java.util.Date
+GeometricObject()
+GeometricObject(color: String, filled: boolean)
+getColor(): String
+setColor(color: String): void
+isFilled(): boolean
+setFilled(filled: boolean): void
+getDateCreated(): java.util.Date
+toString(): String
The color of the object (default: white).
Indicates whether the object is filled with a color (default: false).
The date when the object was created.
Creates a GeometricObject.
Creates a GeometricObject with the specified color and filled values.
Returns the color.
Sets a new color.
Returns the filled property.
Sets a new filled property.
Returns the dateCreated.
Returns a string representation of this object.
Circle
-radius: double
+Circle()
+Circle(radius: double)
+Circle(radius: double, color: String, filled: boolean)
+getRadius(): double
+setRadius(radius: double): void
+getArea(): double
+getPerimeter(): double
+getDiameter(): double
+printCircle(): void
Rectangle
-width: double
-height: double
+Rectangle()
+Rectangle(width: double, height: double)
+Rectangle(width: double, height: double color: String, filled: boolean)
+getWidth(): double
+setWidth(width: double): void
+getHeight(): double
+setHeight(height: double): void
+getArea(): double
+getPerimeter(): double

Calling Superclass Methods

- You could call superclass methods.
- For example, you can implement the `printCircle()` method in the `Circle` class as follows:

```
public void printCircle() {

  System.out.println("The circle is created " +
    super.getDateCreated() + " and the radius is " + radius);

}
```

Overriding Methods in the Superclass

- A subclass inherits methods from a superclass.
- Sometimes it is necessary for the subclass to modify the implementation of a method defined in the superclass. This is referred to as *method overriding*.

```
public class Circle extends GeometricObject {
  // Other methods are omitted
  ...
  /** Override the toString method defined in GeometricObject */
  public String toString() {
    return super.toString() + "\nradius is " + radius;
  }
}
```

Notes

- An instance method can be overridden only if it is accessible.
- Therefore, a private method cannot be overridden, because it is not accessible outside its own class.
- If a method defined in a subclass is private in its superclass, the two methods are completely unrelated.

Notes (cont.)

- Like an instance method, a static method can be inherited.
- However, a static method cannot be overridden.
- If a static method defined in the superclass is redefined in a subclass, the method defined in the superclass is hidden.

Overriding vs. Overloading

```java
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.p(10);
    a.p(10.0);
  }
}

class B {
  public void p(double i) {
    System.out.println(i * 2);
  }
}

class A extends B {
  // This method overrides the method in B
  public void p(double i) {
    System.out.println(i);
  }
}
```

Overriding

```java
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.p(10);
    a.p(10.0);
  }
}

class B {
  public void p(double i) {
    System.out.println(i * 2);
  }
}

class A extends B {
  // This method overloads the method in B
  public void p(int i) {
    System.out.println(i);
  }
}
```

Overloading

The `Object` Class and Its Methods

- Every class in Java is descended from the `java.lang.Object` class.
- If no inheritance is specified when a class is defined, the superclass of the class is Object.

```
public class Circle {
  ...
}
```

Equivalent

```
public class Circle extends Object {
  ...
}
```

The toString() method in Object

- The `toString()` method returns a string representation of the object.
- The default implementation returns a string consisting of a class name of which the object is an instance, the at sign (@), and a number representing this object.

```
Loan loan = new Loan();
System.out.println(loan.toString());
```

The `toString()` method in Object

- The code displays something like Loan@15037e5 . This message is not very helpful or informative.

- Usually you should override the `toString` method so that it returns a digestible string representation of the object.

Exercise

- In terms of inheritance, what is the effect of keeping a constructor private?

Answer

- Declaring a constructor private allows no one outside of the class to instantiate the class.
- It means if the constructor is private, the class can not be inherited.

Private Constructors in Java: https://www.baeldung.com/java-private-constructors#:~:text=Private%20constructors%20allow%20us%20to,is%20known%20as%20constructor%20delegation

Polymorphism

Polymorphism

- A class defines a type.
- A type defined by a subclass is called a *subtype*, and a type defined by its superclass is called a *supertype*.
- Polymorphism means that a variable of a supertype can refer to a subtype object.
- Therefore, you can say that `Circle` is a subtype of `GeometricObject` and `GeometricObject` is a supertype for `Circle`.

Exercise

- Please type following code as "`PloymorphismDemo.java`", run the program and see the results.

```java
public class PolymorphismDemo {
  public static void main(String[] args) {
    m(new GraduateStudent());
    m(new Student());
    m(new Person());
    m(new Object());
  }

  public static void m(Object x) {
    System.out.println(x.toString());
  }
}

class GraduateStudent extends Student {
}

class Student extends Person {
  public String toString() {
    return "Student";
  }
}

class Person extends Object {
  public String toString() {
    return "Person";
  }
}
```

PolymorphismDemo.java

Exercise

```
public class PolymorphismDemo {
  public static void main(String[] args) {
    m(new GraduateStudent());
    m(new Student());
    m(new Person());
    m(new Object());
  }

  public static void m(Object x) {
    System.out.println(x.toString());
  }
}

class GraduateStudent extends Student {
}

class Student extends Person {
  public String toString() {
    return "Student";
  }
}

class Person extends Object {
  public String toString() {
    return "Person";
  }
}
```

Method *m* takes a parameter of the Object type. You can invoke it with any object.

Output:

```
Student
Student
Person
java.lang.Object@6d06d69c
```

```java
public class PolymorphismDemo {
  public static void main(String[] args) {
    m(new GraduateStudent());
    ...
  }

  public static void m(Object x) {
    ...
  }
}
```

```java
Object x = new GraduateStudent();
```

Polymorphism and Dynamic Binding

- When the method `m(Object x)` is executed, the argument *x*'s `toString` method is invoked.
- *x* may be an instance of `GraduateStudent`, `Student`, `Person`, or `Object`.
- Classes `GraduateStudent`, `Student`, `Person`, and `Object` have their own implementation of the `toString` method.
- Which implementation is used will be determined dynamically by the Java Virtual Machine at runtime. This capability is known as *dynamic binding*.