Building Java Programs

Chapter 8

Lecture 8-3: Encapsulation, `toString`

reading: 8.5 - 8.6

self-checks: #13-18, 20-21

exercises: #5, 9, 14

The `toString` method

reading: 8.6

self-check: #18, 20-21
exercises: #9, 14

Printing objects

- By default, Java doesn't know how to print objects:

```
Point p = new Point(10, 7);
System.out.println("p: " + p);  // p: Point@9e8c34
```

- We can print a better string (but this is cumbersome):

```
System.out.println("p: (" + p.x + ", " + p.y + ")");
```

- We'd like to be able to print the object itself:

```
// desired behavior
System.out.println("p: " + p);  // p: (10, 7)
```

The `toString` method

- tells Java how to convert an object into a `String`
- called when an object is printed/concatenated to a `String`:

```
Point p1 = new Point(7, 2);
System.out.println("p1: " + p1);
```

  - If you prefer, you can write `.toString()` explicitly.

```
System.out.println("p1: " + p1.toString());
```

- Every class has a `toString`, even if it isn't in your code.
  - The default is the class's name and a hex (base-16) number:

```
Point@9e8c34
```

`toString` syntax

```
public String toString() {
    code that returns a suitable String;
}
```

- The method name, return, parameters must match exactly.
- Example:

```
// Returns a String representing this Point.
public String toString() {
    return "(" + x + ", " + y + ")";
}
```

Client code

```
// This client program uses the Point class.
public class PointMain {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point(7, 2);
        Point p2 = new Point(4, 3);

        // print each point
        System.out.println("p1: " + p1);
        System.out.println("p2: " + p2);

        // compute/print each point's distance from the origin
        System.out.println("p1's distance from origin: " + p1.distanceFromOrigin());
        System.out.println("p2's distance from origin: " + p1.distanceFromOrigin());

        // move p1 and p2 and print them again
        p1.translate(11, 6);
        p2.translate(1, 7);
        System.out.println("p1: " + p1);
        System.out.println("p2: " + p2);

        // compute/print distance from p1 to p2
        System.out.println("distance from p1 to p2: " + p1.distance(p2));
    }
}
```

Encapsulation

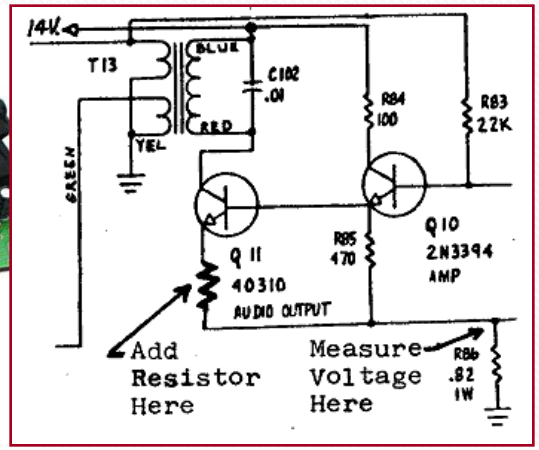
reading: 8.5 - 8.6

self-check: #13-17

exercises: #5

Encapsulation

- **encapsulation**: Hiding implementation details of an object from its clients.
  - Encapsulation provides *abstraction*.
    - separates external view (behavior) from internal view (state)
  - Encapsulation protects the integrity of an object's data.



Private fields

- A field can be declared *private*.
  - No code outside the class can access or change it.

```
private type name;
```

  - Examples:

```
private int id;
private String name;
```

- Client code sees an error when accessing private fields:

```
PointMain.java:11: x has private access in Point
System.out.println("p1 is (" + p1.x + ", " + p1.y + ")");
                                   ^
```

Accessing private state

- We can provide methods to get and/or set a field's value:

```
// A "read-only" access to the x field ("accessor")
public int getX() {
    return x;
}

// Allows clients to change the x field ("mutator")
public void setX(int newX) {
    x = newX;
}
```

  - Client code will look more like this:

```
System.out.println("p1: (" + p1.getX() + ", " + p1.getY() + ")");
p1.setX(14);
```

Point class, version 4

```
// A Point object represents an (x, y) location.
public class Point {
    private int x;
    private int y;

    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }

    public double distanceFromOrigin() {
        return Math.sqrt(x * x + y * y);
    }

    public int getX() {
        return x;
    }

    public int getY() {
        return y;
    }

    public void setLocation(int newX, int newY) {
        x = newX;
        y = newY;
    }

    public void translate(int dx, int dy) {
        x = x + dx;
        y = y + dy;
    }
}
```

Client code, version 4

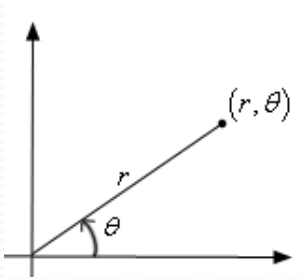
```
public class PointMain4 {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point(5, 2);
        Point p2 = new Point(4, 3);

        // print each point
        System.out.println("p1: (" + p1.getX() + ", " + p1.getY() + ")");
        System.out.println("p2: (" + p2.getX() + ", " + p2.getY() + ")");

        // move p2 and then print it again
        p2.translate(2, 4);
        System.out.println("p2: (" + p2.getX() + ", " + p2.getY() + ")");
  }
}
```

OUTPUT:

```
p1 is (5, 2)
p2 is (4, 3)
p2 is (6, 7)
```

Benefits of encapsulation

- Provides abstraction between an object and its clients.
- Protects an object from unwanted access by clients.
  - A bank app forbids a client to change an `Account`'s balance.
- Allows you to change the class implementation.
  - `Point` could be rewritten to use polar coordinates (radius *r*, angle *θ*), but with the same methods.



- Allows you to constrain objects' state (**invariants**).
  - Example: Only allow `Point`s with non-negative coordinates.

The keyword `this`

reading: 8.7

this

- **`this`** : A reference to the implicit parameter.
  - *implicit parameter:* object on which a method is called
- Syntax for using `this`:
  - To refer to a field:
    `this.`**field**
  - To call a method:
    `this.`**method**`(`**parameters**`);`
  - To call a constructor from another constructor:
    `this(`**parameters**`);`

Variable names and scope

- Usually it is illegal to have two variables in the same scope with the same name.

```
public class Point {
    private int x;
    private int y;
    ...

    public void setLocation(int newX, int newY) {
        x = newX;
        y = newY;
    }
}
```

  - The parameters to `setLocation` are named `newX` and `newY` to be distinct from the object's fields `x` and `y`.

Variable shadowing

- An instance method parameter can have the same name as one of the object's fields:

```
// this is legal
public void setLocation(int x, int y) {
    ...
}
```

  - Fields `x` and `y` are *shadowed* by parameters with same names.
  - Any `setLocation` code that refers to `x` or `y` will use the parameter, not the field.

Avoiding shadowing w/ `this`

```
public class Point {
    private int x;
    private int y;

    ...

    public void setLocation(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

- Inside the `setLocation` method,
  - When `this.x` is seen, the *field* `x` is used.
  - When `x` is seen, the *parameter* `x` is used.

Multiple constructors

- It is legal to have more than one constructor in a class.
  - The constructors must accept different parameters.

```
public class Point {
    private int x;
    private int y;

    public Point() {
        x = 0;
        y = 0;
    }

    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }

    ...
}
```

Constructors and `this`

- One constructor can call another using `this`:

```
public class Point {
    private int x;
    private int y;

    public Point() {
        this(0, 0);  // calls the (x, y) constructor
    }

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    ...
}
```