Building Java Programs

Chapter 8

Lecture 8-2: Object Methods and Constructors

reading: 8.2 - 8.4

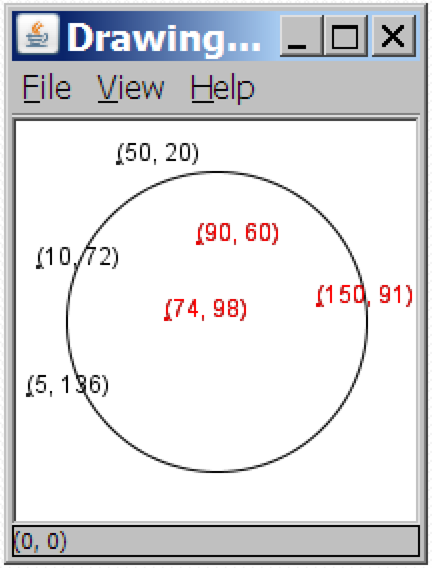
self-checks: #1-12

exercises: #1-4, 9, 11, 14, 16

Recall: earthquake problem

- Given a file of cities' (x, y) coordinates, which begins with the number of cities:

```
6
50 20
90 60
10 72
74 98
5 136
150 91
```



- Write a program to draw the cities on a `DrawingPanel`, then color the cities red that are within the radius of effect of the earthquake:

```
Epicenter x/y? 100 100
Radius of effect? 75
```

Object behavior: methods

reading: 8.3

self-check: #7-9

exercises: #1-4

Client code redundancy

- Our client program wants to draw `Point` objects:

```
// draw each city
g.fillOval(cities[i].x, cities[i].y, 3, 3);
g.drawString("(" + cities[i].x + ", " + cities[i].y + ")",
             cities[i].x, cities[i].y);
```

- To draw them in other places, the code must be repeated.
  - We can remove this redundancy using a method.

Eliminating redundancy, v1

- We can eliminate the redundancy with a static method:

```
// Draws the given point on the DrawingPanel.
public static void draw(Point p, Graphics g) {
    g.fillOval(p.x, p.y, 3, 3);
    g.drawString("(" + p.x + ", " + p.y + ")", p.x, p.y);
}
```

- `main` would call the method as follows:

```
// draw each city
draw(cities[i], g);
```

Problems with static solution

- We are missing a major benefit of objects: code reuse.
  - Every program that draws `Point`s would need a `draw` method.

- The syntax doesn't match how we're used to using objects.

```
draw(cities[i], g);      // static (bad)
```

- The point of classes is to combine state and behavior.
  - The `draw` behavior is closely related to a `Point`'s data.
  - The method belongs *inside* each `Point` object.

```
cities[i].draw(g);       // inside object (better)
```

Instance methods

- **instance method**: One that exists inside each object of a class and defines behavior of that object.

```
public type name(parameters) {
     statements;
}
```

  - same syntax as static methods, but without `static` keyword

Example:

```
public void shout() {
    System.out.println("HELLO THERE!");
}
```

Instance method example

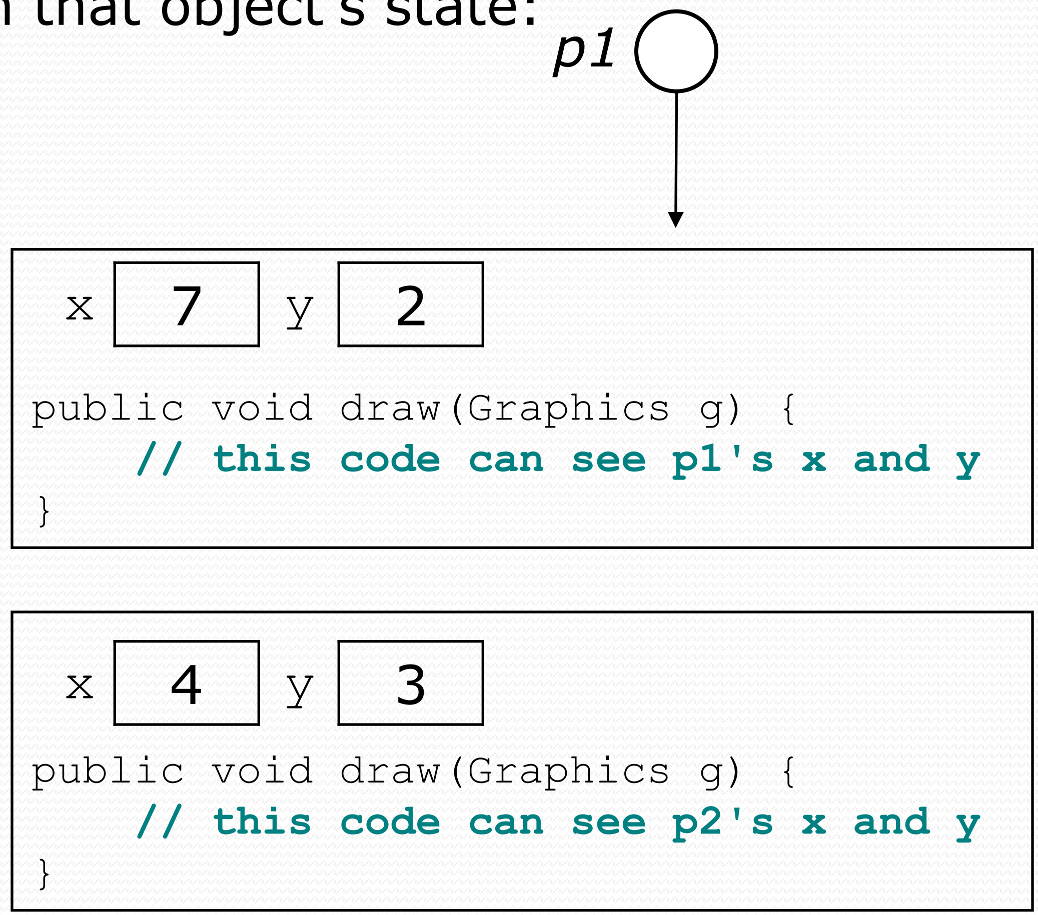
```
public class Point {
    int x;
    int y;

    // Draws this Point object with the given pen.
    public void draw(Graphics g) {
        ...
    }
}
```

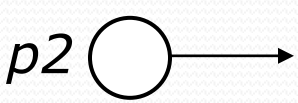
- The `draw` method no longer has a `Point p` parameter.
- How will the method know which point to draw?
  - How will the method access that point's x/y data?

Point objects w/ method

- In effect, each `Point` object has its own copy of the `draw` method, which operates on that object's state:

```
Point p1 = new Point();
p1.x = 7;
p1.y = 2;

Point p2 = new Point();
p2.x = 4;
p2.y = 3;

p1.draw(g);
p2.draw(g);
```





The implicit parameter

- **implicit parameter**:
  The object on which an instance method is called.
  - During the call `p1.draw(g);`
    the object referred to by `p1` is the implicit parameter.
  - During the call `p2.draw(g);`
    the object referred to by `p2` is the implicit parameter.

  - The instance method can refer to that object's fields.
    - We say that it executes in the *context* of a particular object.
    - `draw` can refer to the `x` and `y` of the object it was called on.

Point class, version 2

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

    // Changes the location of this Point object.
    public void draw(Graphics g) {
        g.fillOval(x, y, 3, 3);
        g.drawString("(" + x + ", " + y + ")", x, y);
    }
}
```

- Now each `Point` object contains a method named `draw` that draws that point at its current `x`/`y` position.

Kinds of methods

- Instance methods take advantage of an object's state.
  - Some methods allow clients to access/modify its state.

- **accessor**: A method that lets clients examine object state.
  - Example: A `distanceFromOrigin` method that tells how far a `Point` is away from (0, 0).
  - Accessors often have a non-`void` return type.

- **mutator**: A method that modifies an object's state.
  - Example: A `translate` method that shifts the position of a `Point` by a given amount.

Mutator method questions

- Write a method `setLocation` that changes a `Point`'s location to the (*x*, *y*) values passed.
  - You may want to refactor the `Point` class to use this method.

- Write a method `translate` that changes a `Point`'s location by a given *dx*, *dy* amount.

- Modify the client code to use these methods as appropriate.

Mutator method answers

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


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

// alternative solution
public void translate(int dx, int dy) {
    setLocation(x + dx, y + dy);
}
```

Mini-exercise

Define a “reset” method that resets the point’s location to 0,0

Cheat sheet example:

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

Mini-exercise -solution

Define a “reset” method that resets the point’s location to 0,0

Cheat sheet example:

```
public void reset() {
    x = 0;
    y = 0;
}

// alternate solution:
public void reset() {
    setLocation(0,0);
}
```

Accessor method questions

- Write a method `distance` that computes the distance between a `Point` and another `Point` parameter.

  Use the formula: $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

- Write a method `distanceFromOrigin` that returns the distance between a `Point` and the origin, (0, 0).

- Modify the client code to use these methods.

Accessor method answers

```
public double distance(Point other) {
    int dx = x - other.x;
    int dy = y - other.y;
    return Math.sqrt(dx * dx + dy * dy);
}


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

// alternative solution
public double distanceFromOrigin() {
    return distance(new Point());
}
```

Mini-exercise

Define an “atOrigin” method that returns true if the point’s location is at 0,0

Mini-exercise -solution

Define an "atOrigin" method that returns true if the point's location is at 0,0

```
public boolean atOrigin() {
    return x==0 && y==0;
}
```

Note: using the distanceFromOrigin method would be a good idea from the point of view of code reuse -- but is probably not ideal in this case because of potential rounding errors using real numbers

Object initialization: constructors

reading: 8.4

self-check: #10-12

exercises: #9, 11, 14, 16

Initializing objects

- Currently it takes 3 lines to create a `Point` and initialize it:

```
Point p = new Point();
p.x = 3;
p.y = 8;                              // tedious
```

- We'd rather pass the fields' initial values as parameters:

```
Point p = new Point(3, 8);    // better!
```

  - We are able to do this with most types of objects in Java.

Constructors

- **constructor**: Initializes the state of new objects.

```
public type(parameters) {
    statements;
}
```

  - runs when the client uses the `new` keyword
  - does not specify a return type;
    it implicitly returns the new object being created

  - If a class has no constructor, Java gives it a *default constructor* with no parameters that sets all fields to 0 (or zero-like values for other types).

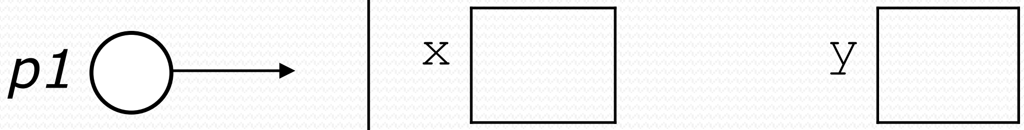
Constructor example

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

    // Constructs a Point at the given x/y location.
    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }

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

Tracing a constructor call

- What happens when the following call is made?

```
Point p1 = new Point(7, 2);
```




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

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

Example Client Code

```
public class PointMain {
    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.x + ", " + p1.y + ")");
        System.out.println("p2: (" + p2.x + ", " + p2.y + ")");

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

OUTPUT:

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

Common constructor bugs

- Accidentally writing a return type such as `void`:

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

  - This is not a constructor at all, but a method!

- Storing into local variables instead of fields ("shadowing"):

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

  - This declares local variables with the same name as the fields, rather than storing values into the fields. The fields remain 0.

Multiple constructors

- A class can have multiple constructors.
  - Each one must accept a unique set of parameters.

- Write a constructor for Point objects that accepts no parameters and initializes the point to the origin, (0, 0).

```
// Constructs a new point at (0, 0).
public Point() {
    x = 0;
    y = 0;
}
```

Mini-exercise

Suppose we have defined a bank account class:

```
public class BankAccount {
  double balance;
}
```

- Define a constructor with one argment, the initial balance
- Define another constructor with zero arguments, which starts the balance off at $10 (PR move by the bank to try and divert attention from its role in the subprime mortgage meltdown …)

Mini-exercise - solution

- Define a constructor with one argment, the initial balance
- Define another constructor with zero arguments, which starts the balance off at $10

```
public class BankAccount {
  double balance;

  public BankAccount() {
       balance = 10.0;
  }

  public BankAccount(double initialBalance) {
       balance = initialBalance;
  }
}
```

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));
    }
}
```