Building Java Programs

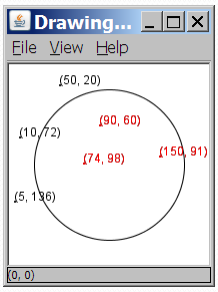
Chapter 8
Lecture 8-1: Classes and Objects

reading: 8.1 – 8.2

A programming 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 mark a quarantine area that turns all cities red that are within a given radius:

```
Quarantine site x? 100
Quarantine site y? 100
Quarantine radius? 75
Stay inside!
```

A bad solution

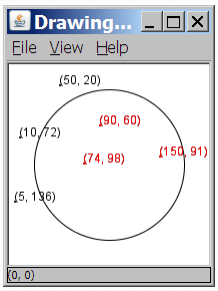
```
Scanner input = new Scanner(new File("cities.txt"));
int cityCount = input.nextInt();
int[] xCoords = new int[cityCount];
int[] yCoords = new int[cityCount];

for (int i = 0; i < cityCount; i++) {
    xCoords[i] = input.nextInt();   // read each city
    yCoords[i] = input.nextInt();
}
...
```

- **parallel arrays**: 2+ arrays with related data at same indexes.
  - Considered poor style.

Observations

- The data in this problem is a set of points.
- It would be better stored as `Point` objects.
  - A `Point` would store a city's x/y data.
  - We could compare distances between `Point`s to see whether to quarantine a given city.
  - Each `Point` would know how to draw itself.
  - The overall program would be shorter and cleaner.



Clients of objects

- **client program**: A program that uses objects.
  - Example: `Art` is a client of `DrawingPanel` and `Graphics`.

```
Art.java (client program)
public class Art {
    main(String[] args) {
        new DrawingPanel(...)
        new DrawingPanel(...)
        ...
    }
}
```

```
DrawingPanel.java (class)
public class DrawingPanel {
    ...
}
```

Classes and objects

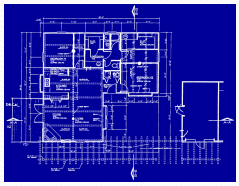
- **class**: A program entity that represents either:
  1. A program / module, or
  2. **A template for a new type of objects.**
  - The `DrawingPanel` class is a template for creating `DrawingPanel` objects.
- **object**: An entity that combines state and behavior.
  - **object-oriented programming (OOP)**: Programs that perform their behavior as interactions between objects.

Blueprint analogy

iPod blueprint

state:
- current song
- volume
- battery life

behavior:
- power on/off
- change station/song
- change volume
- choose random song



creates

iPod #1

state:
- song = "1,000,000 Miles"
- volume = 17
- battery life = 2.5 hrs

behavior:
- power on/off
- change station/song
- change volume
- choose random song

iPod #2

state:
- song = "Letting You"
- volume = 9
- battery life = 3.41 hrs

behavior:
- power on/off
- change station/song
- change volume
- choose random song

iPod #3

state:
- song = "Discipline"
- volume = 24
- battery life = 1.8 hrs

behavior:
- power on/off
- change station/song
- change volume
- choose random song

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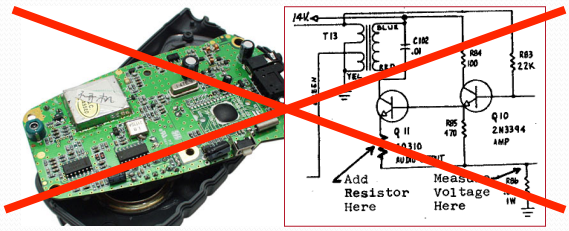
Big Idea: Abstraction

- **abstraction**: A distancing between ideas and details.
  - We can use objects without knowing how they work.
- abstraction in an iPod:
  - You understand its external behavior (buttons, screen).
  - You don't understand its inner details, and **you don't need to**!



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Our task

- We will implement a `Point` class as a way of learning about defining classes.
  - We will define a type named `Point`.
  - Each `Point` object will contain x/y data called **fields**.
  - Each `Point` object will contain behavior called **methods**.
  - **Client programs** will use the `Point` objects.

`Point` objects (desired)

```
Point p1 = new Point(5, -2);
Point p2 = new Point();          // origin, (0, 0)
```

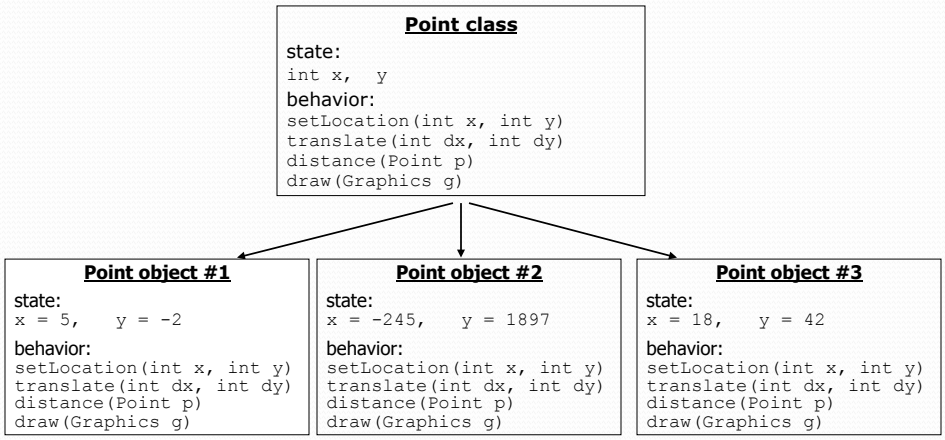
- Data in each `Point` object:

Field name	Description
`x`	the point's x-coordinate
`y`	the point's y-coordinate

- Methods in each `Point` object:

Method name	Description
`setLocation(`**<x>**`, `**<y>**`)`	sets the point's x and y to the given values
`translate(`**<dx>**`, `**<dy>**`)`	adjusts the point's x and y by the given amounts
`distance(`**<p>**`)`	how far away the point is from point *p*
`draw(`**<g>**`)`	displays the point on a drawing panel

`Point` class as blueprint



- The class (blueprint) will describe how to create objects.
- Each object will contain its own data and methods.

Object state: Fields

reading: 8.2

Point class, version 1

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

- Save this code into a file named `Point.java`.

- The above code creates a new type named `Point`.
  - Each `Point` object contains two pieces of data:
    - an `int` named `x`, and
    - an `int` named `y`.
  - `Point` objects do not contain any behavior (yet).

Fields

- **field**: A variable inside an object that is part of its state.
  - Each object has *its own copy* of each field.

- Declaration syntax:

  <type> <name>;

  - Example:

```
public class Student {
    String name;     // each Student object has a
    double gpa;      // name and gpa field
}
```

Accessing fields

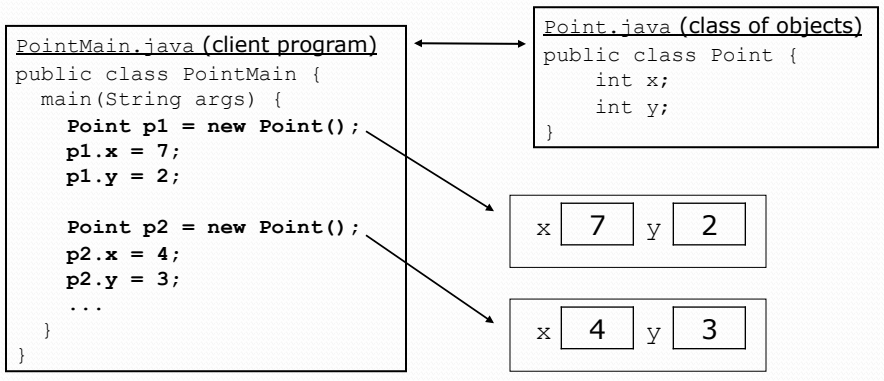
- Other classes can access/modify an object's fields.
  - access: ***<variable>.<field>***
  - modify: ***<variable>.<field>*** = **<expression>**;

- Example:

```
Point p1 = new Point();
Point p2 = new Point();
System.out.println("the x-coord is " + p1.x);    // access
p2.y = 13;                                       // modify
```


A class and its client

- `Point.java` is not, by itself, a runnable program. Why not?
  - It does not contain a `main` method.
  - A class can be used by **client** programs.



PointMain client example

```
public class PointMain {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point();
        p1.y = 2;
        Point p2 = new Point();
        p2.x = 4;

        System.out.println(p1.x + ", " + p1.y);    // 0, 2

        // move p2 and then print it
        p2.x += 2;
        p2.y++;
        System.out.println(p2.x + ", " + p2.y);    // 6, 1
    }
}
```


Object behavior: Methods

reading: 8.2

Client code redundancy

- Suppose our client program wants to draw `Point` objects:

```
// draw each city
Point p1 = new Point();
p1.x = 15;
p1.y = 37;
g.fillOval(p1.x, p1.y, 3, 3);
g.drawString("(" + p1.x + ", " + p1.y + ")", p1.x, p1.y);
```

- To draw other points, the same 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(p1, g);
```

- What is wrong with this solution?

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(p1, g);    // static (bad)
```

- The whole 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.

```
p1.draw(g);     // inside the object (better)
```


Instance methods

- **instance method** (or **object method**): Exists inside each object of a class and gives behavior to each object.

```
public <type> <name>(<parameters>) {
    <statement(s)>;
}
```

  - 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?

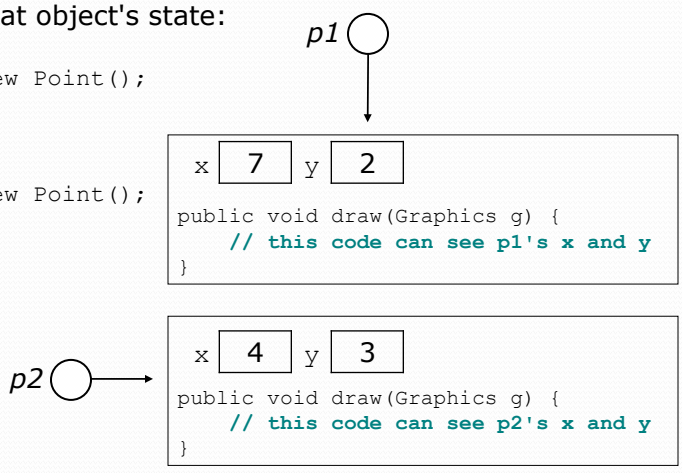
`Point` objects w/ method

- 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.
    - `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);
    }
}
```

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

Class method questions

- Write a method `translate` that changes a `Point`'s location by a given *dx*, *dy* amount.
- Write a method `distanceFromOrigin` that returns the distance between a `Point` and the origin, (0, 0).

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

  - Modify the `Point` and client code to use these methods.

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Class method answers

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

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

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

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Test your understanding

- What is the significance of the `static` keyword?
  - instance method == NOT declared `static`
- Is `sqrt` in the Math class static? Why or why not?
  - Yes, because no object is needed to use `sqrt`.
- Is `nextInt` in the Scanner class static? Why or why not?
  - No, because you need a Scanner object to use `nextInt`.

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