Topic 27
classes and objects, state and behavior

"A 'class' is where we teach an 'object' to behave."

-Rich Pattis

Based on slides by Marty Stepp and Stuart Reges from http://www.buildingjavaprograms.com/

Object Oriented Programming

- "Object-oriented programming is a method of programming based on a hierarchy of classes, and well-defined and cooperating objects. "
- What is a class?
- "A class is a structure that defines the data and the methods to work on that data. When you write programs in the Java language, all program data is wrapped in a class, whether it is a class you write or a class you use from the Java platform API libraries."
  - a new data type

Object Oriented Programming

- In other words break the problem up based on the things / data types that are part of the problem
- Not the only way
- One of many different kinds of strategies or *paradigms* for software development
  - functional, procedural, event driven, data flow, formal methods, agile or extreme, ...

Clicker 1

- What kind of assignment handout do you prefer?

A. A long assignment handout
B. A short assignment handout

- Why?

Example - Monopoly

If we had to start from scratch what classes would we need to create?

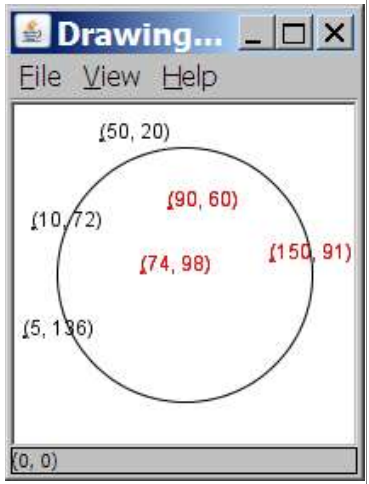
A programming problem

- 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 a terrible event (zombie apocalypse, nuclear meltdown) that turns all cities red that are within a given radius:

```
Ground zero x: 100
Ground zero y: 100
Area of effect: 75
```



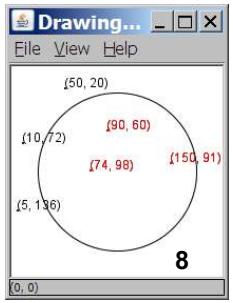
A solution

```
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();
    yCoords[i] = input.nextInt();
}
...
```

– **parallel arrays**: 2+ arrays with related data at same indexes.
  - Considered poor style. (Relationship exists in the programmer's mind, but not explicit in the program.)

Observations

- The data in this problem is a set of points.
- An alternative is to store them as `Point` objects.
  - A `Point` would store a city's x/y data.
  - We could compare distances between `Point`s to see whether the terrible event affects a given city.
  - Each `Point` would know how to draw itself.
  - The driver program would be shorter and cleaner.



Clients of objects

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

`Zombie.java` (client program)

```
public class Zombie {
    main(String[] args) {
        new DrawingPanel(...)
        new DrawingPanel(...)
        ...
    }
}
```

`DrawingPanel.java` (class)

```
public class DrawingPanel {
    ...
}
```

Classes and objects

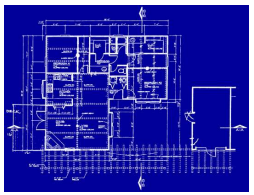
- **class**: A program entity that represents either:
  1. A program / module, or
  2. **A template for a new type of objects.**
  - The `DrawingPanel` class is a template for creating `DrawingPanel` objects.
  - **Other classes: String, Random, Scanner, File, …**
- **object**: An entity that combines 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

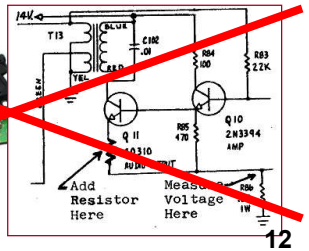
iPod #3

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

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

Abstraction

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



Our task

- In the following slides, we will implement a `Point` class as a way of learning about defining classes.
  - We will define a type of objects 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)
```

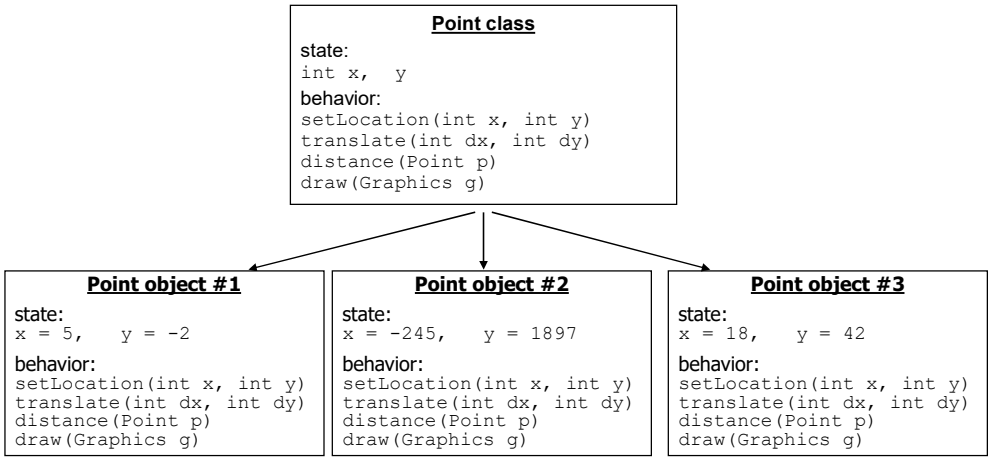
- Data in each `Point` object:

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.

Clicker 2 What is output by the following code?

```
Point p1 = new Point();
Point p2 = new Point();
boolean b1 = (p1 == p2);
System.out.print(b1);
```

A. Syntax error

B. Runtime error

C. false

D. true

E. no output

Object state: Fields

Point class, version 1

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

```
access_modifier type name;
```

  - Example:

```
public class Student {
    // each Student object has a name and
    // gpa field (instance variable)
    private String name;
    private double gpa;
}
```


Accessing fields

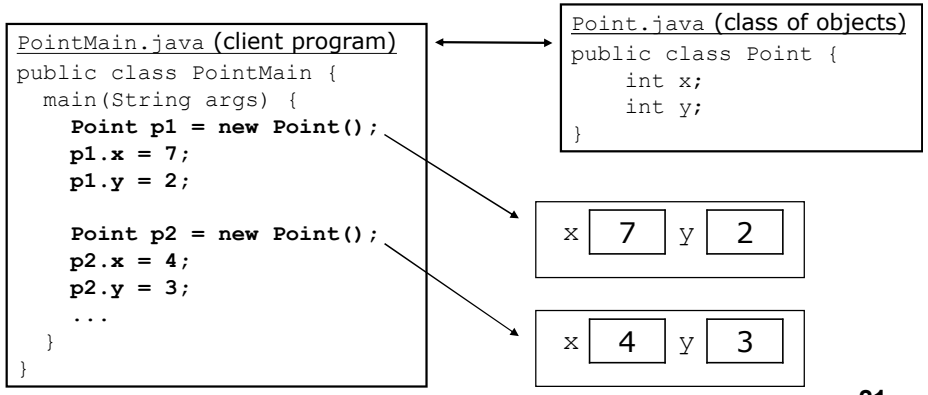
- Other classes can access/modify an object's fields.
  - *depending on the access modifier*
  - access: **variable.field**
  - modify: **variable.field = value;**

- 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.
  - A class can be used by **client** programs.



Object behavior: Methods

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);
```

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 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) {
    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 {
    private int x;
    private int y;

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

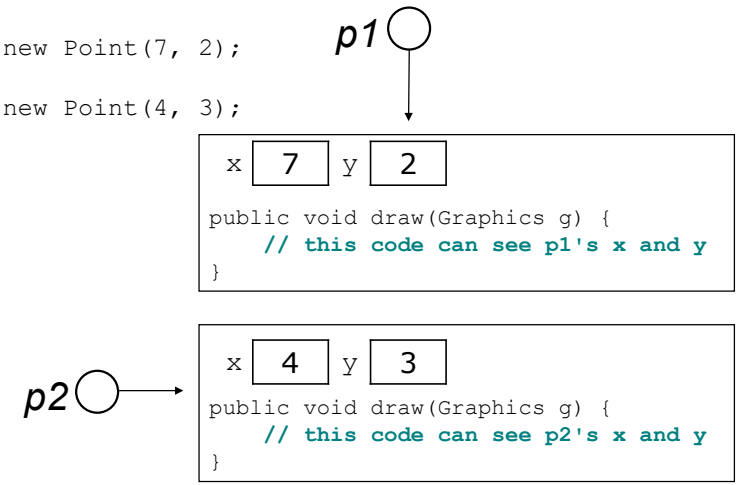
- The `draw` method no longer has a `Point p` parameter.
- How will the method know which point to draw?
  - How will the method access that point's x/y data?

`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(7, 2);
Point p2 = new Point(4, 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);
    }
}
```

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

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.

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);
    }
}
```