Classes and objects

Chapter 2: Head First Java: 2nd Edition, K. Sierra, B. Bates

A foundation for programming

any program you might want to write

http://www.flickr.com/photos/vermegrigio/5923415248/

objects

build even bigger programs and reuse code

functions and modules

graphics, sound, and image I/O

arrays

conditionals and loops

Math | text I/O

primitive data types | assignment statements

Overview

- Primitive types
- Creating your own data types
  - Classes
  - Objects
  - Instance variables
  - Instance methods
  - Constructors
  - Arrays of objects

Java primitive types

Java type	what it stores	examples
`byte`	tiny integer values -128 to 127	3 -87
`short`	small integer values -32768 to 32767	-3433 123
`int`	integer values -2,147,483,648 to 2,147,483,647	42 1234
`long`	big integer values -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807	5454 -43984938
`double`	floating-point values	9.95 3.0e8
`float`	less precise floating-point values	9.95f 3.0e8f
`boolean`	truth values	true false
`char`	characters	'a', 'b', '!'

Primitive type limitations

- Primitive types
  - Limited to basic set of operations
    - Example: `int` data type operations: add, subtract, multiple, divide, modulo
  - Can't combine related information together in one package
    - Example: need two `double`'s to represent your Mars lander's position, another two for velocity, etc.
    - Example: three parallel arrays to track easting, northing, and call sign of airplanes in `RadarContacts`

Your own types

- Create your our own types
  - Class
    - ***Blueprint*** for a custom data type
  - Object
    - ***Instance*** of a class
    - May be multiple objects for a particular class blueprint
    - Objects have a set of things they know
      - Lander's position, velocity
    - Objects have a set of things they can do
      - Draw the lander
      - Update lander's position using its current velocity
      - See if the lander is out of fuel

Let's build a simple class

- Goal: represent a ball in 2D
  - What does a ball need to know?
    - x-coordinate
    - y-coordinate
    - radius
  - What can a ball do?
    - Draw itself
    - Print out its position and radius

Setting up the Ball class

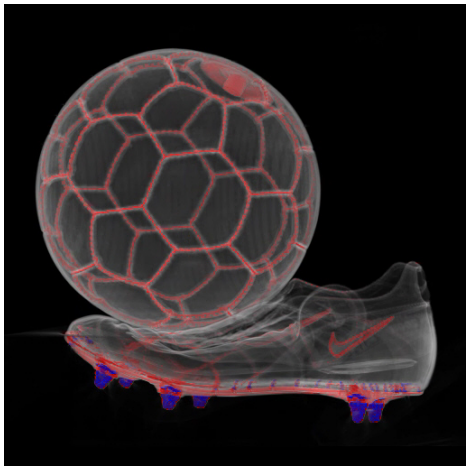
- Create `Ball.java` containing `Ball` class
- Add instance variables for what a `Ball` knows

```
public class Ball
{
   private double posX   = 0.0;
   private double posY   = 0.0;
   private double radius = 0.0;
}
```

instance variables:
variables declared inside class but outside any method

access modifier:
`private` = only methods in this class can see and change these instance variables

We almost always declare our instance variables as private.



Adding an instance method

- Add instance methods for what a `Ball` can do

```
public class Ball
{
   private double posX   = 0.0;
   private double posY   = 0.0;
   private double radius = 0.0;

   public void draw()
   {
      StdDraw.filledCircle(posX, posY, radius);
   }

   public String toString()
   {
      return "(" + posX + ", " + posY + ") r = " + radius;
   }
}
```

instance variables:
available (in scope) in any instance method of Ball

Adding an instance method

- Add instance methods for what a `Ball` can do

```
public class Ball
{
   private double posX   = 0.0;
   private double posY   = 0.0;
   private double radius = 0.0;

   public void draw()
   {
      StdDraw.filledCircle(posX, posY, radius);
   }

   public String toString()
   {
      return "(" + posX + ", " + posY + ") r = " + radius;
   }
}
```

toString()
Special method, called whenever object printed with `System.out.println`

instance methods:
declared *without* the `static` keyword

Let's try out our new class!

- Instantiating objects
  - Like arrays, we must declare and create using new

```
public class BallClient
{
   public static void main(String [] args)
   {
      Ball big   = new Ball();
      Ball small = new Ball();

      big.draw();
      small.draw();

      System.out.println("big: " + big);
      System.out.println("small: " + small);
   }
}
```

"Build me a Ball object, I'm not sending you any input about how to do it."

Let's try out our new class!

- Instantiating objects
  - Like arrays, we must declare and create using new

```
public class BallClient
{
   public static void main(String [] args)
   {
      Ball big   = new Ball();
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      big.draw();
      small.draw();

      System.out.println("big: " + big);
      System.out.println("small: " + small);
   }
}
```
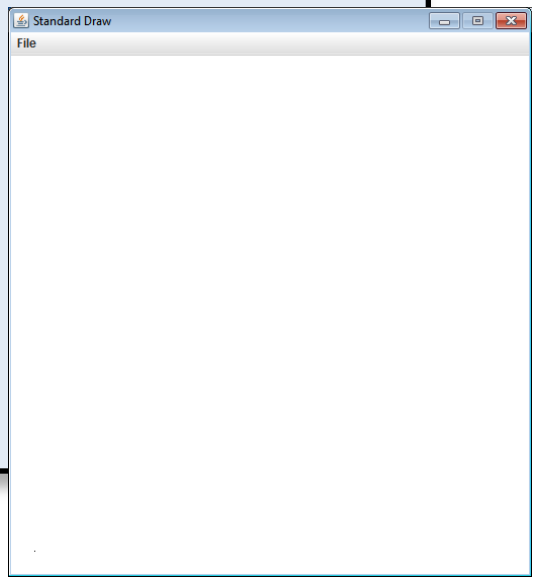




```
% java BallClient
big: (0.0, 0.0) r = 0.0
small: (0.0, 0.0) r = 0.0
```

Hello constructors

- Add a constructor method, sets instance vars

```
public class Ball
{
   private double posX      = 0.0;
   private double posY      = 0.0;
   private double radius    = 0.0;

   public Ball(double x, double y, double r)
   {
      posX   = x;
      posY   = y;
      radius = r;
   }

   public void draw()
   {
      StdDraw.filledCircle(posX, posY, radius);
   }

   public String toString()
   {
      return "(" + posX + ", " + posY + ") r = " + radius;
   }
}
```

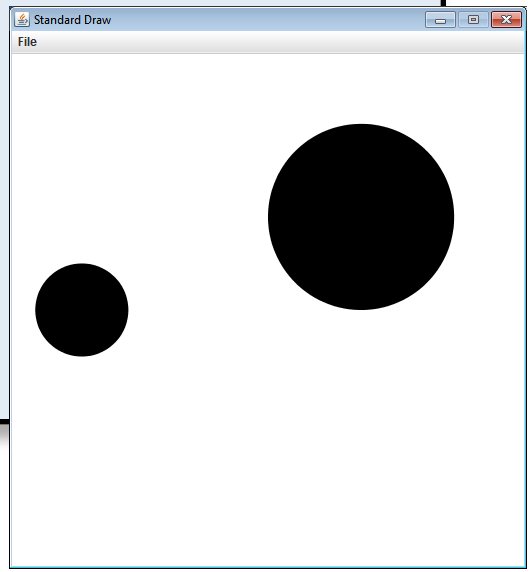
constructor:
No return type.
Method name same as class.
These are requirements!

BallClient take two

- Constructor called when we new objects

```
public class BallClient
{
   public static void main(String [] args)
   {
      Ball big   = new Ball(0.7, 0.7, 0.2);
      Ball small = new Ball(0.1, 0.5, 0.1);

      big.draw();
      small.draw();

      System.out.println("big: " + big);
      System.out.println("small: " + small);
   }
```

```
% java BallClient
big: (0.1, 0.5) r = 0.1
small: (0.7, 0.7) r = 0.2
```

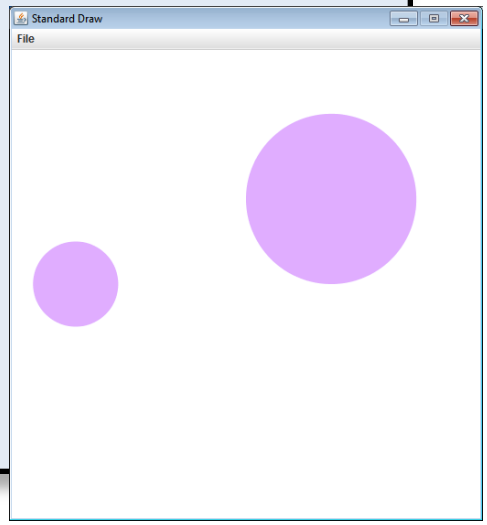


Colored balls

- Goal: make each Ball object have a color specified by an red-green-blue (RGB) value
- Call `StdDraw.setPenColor()` in `draw()`
  - Create a new `Color` object for a given RGB value
  - `Color` is a class in the Java API
  - Default color for our Ball objects: mauve

Ball in living color

```
import java.awt.*;

public class Ball
{
   private double posX   = 0.0;
   private double posY   = 0.0;
   private double radius = 0.0;
   private Color  color  = new Color(0.88f, 0.68f, 1.0f);

   public Ball(double x, double y, double r)
   {
      posX   = x;
      posY   = y;
      radius = r;
   }
   public void draw()
   {
      StdDraw.setPenColor(color);
      StdDraw.filledCircle(posX, posY, radius);
   }
   ...
}
```

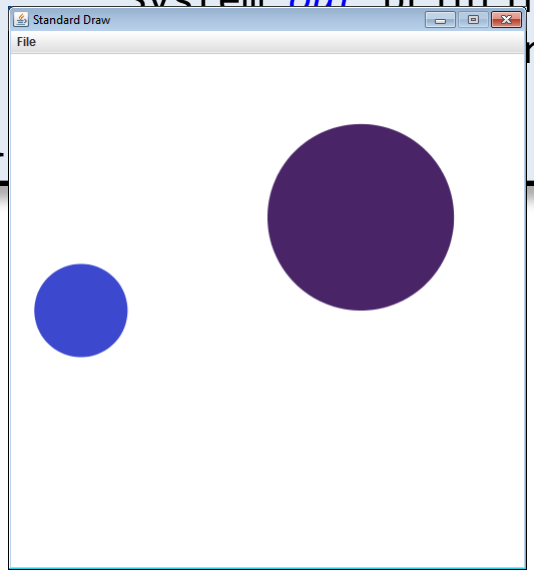


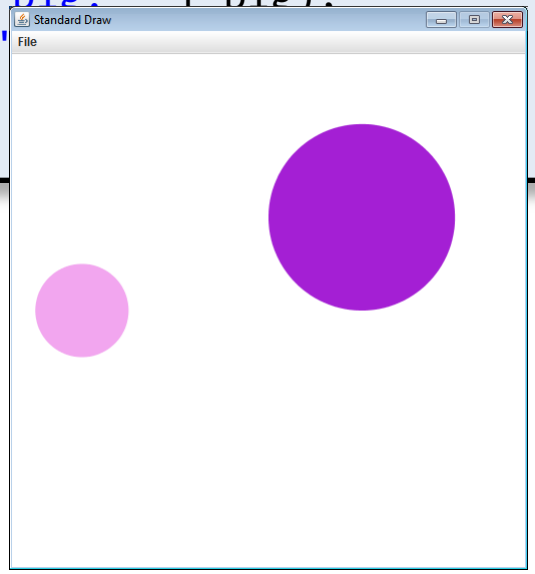
Allowing clients to change color

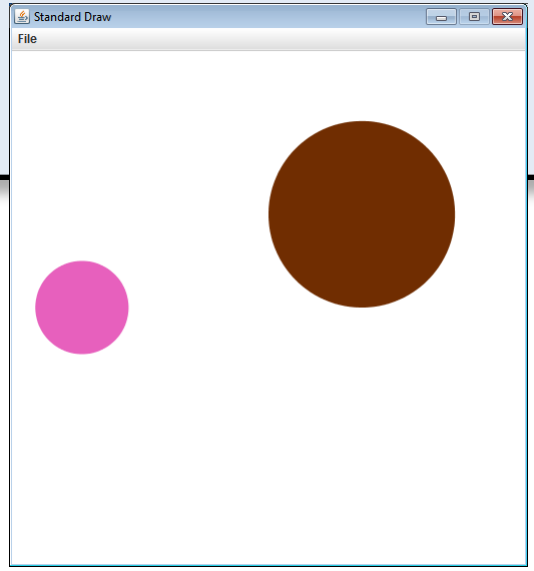
```
import java.awt.*;

public class Ball
{
   private double posX   = 0.0;
   private double posY   = 0.0;
   private double radius = 0.0;
   private Color  color  = new Color(0.88f, 0.68f, 1.0f);

   public Ball(double x, double y, double r)
   {
      posX   = x;
      posY   = y;
      radius = r;
   }
   public void setColor(double r, double g, double b)
   {
      color = new Color((float) r, (float) g, (float) b);
   }
   ...
}
```

Client setting random color

```
public class BallClient
{
   public static void main(String [] args)
   {
      Ball big   = new Ball(0.7, 0.7, 0.2);
      Ball small = new Ball(0.1, 0.5, 0.1);

      big.setColor(Math.random(), Math.random(), Math.random());
      small.setColor(Math.random(), Math.random(), Math.random());

      big.draw();
      small.draw();

      System.out.println("big: " + big);
      System.out.println("
}
```



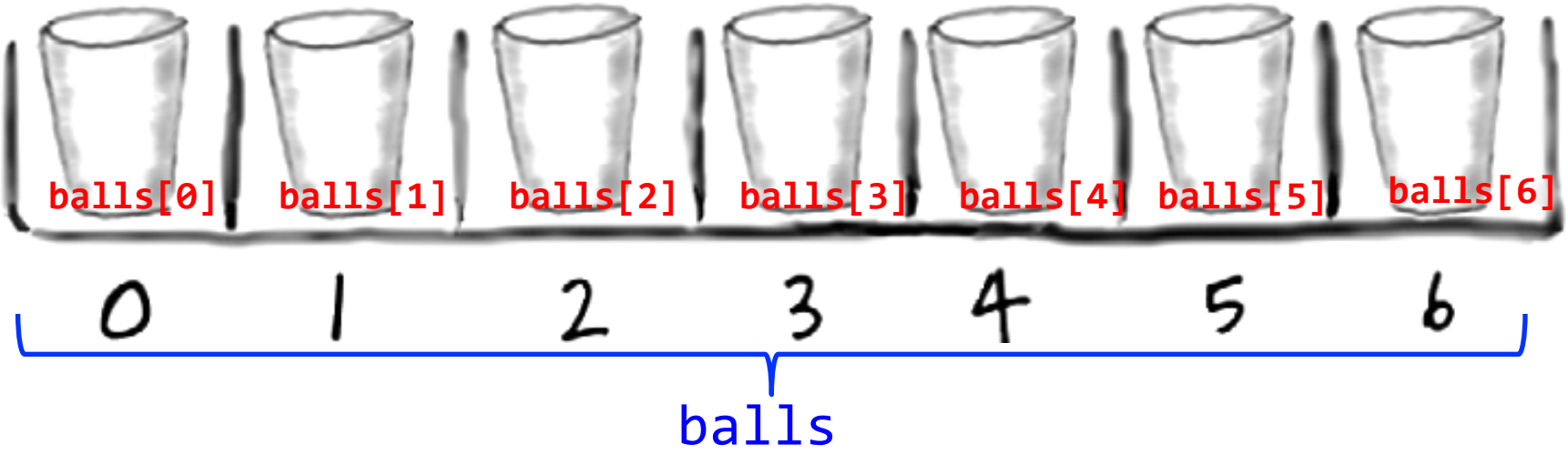




Creating lots of balls

- We can have an array of objects
- Step 1: create an array to hold `Ball` objects

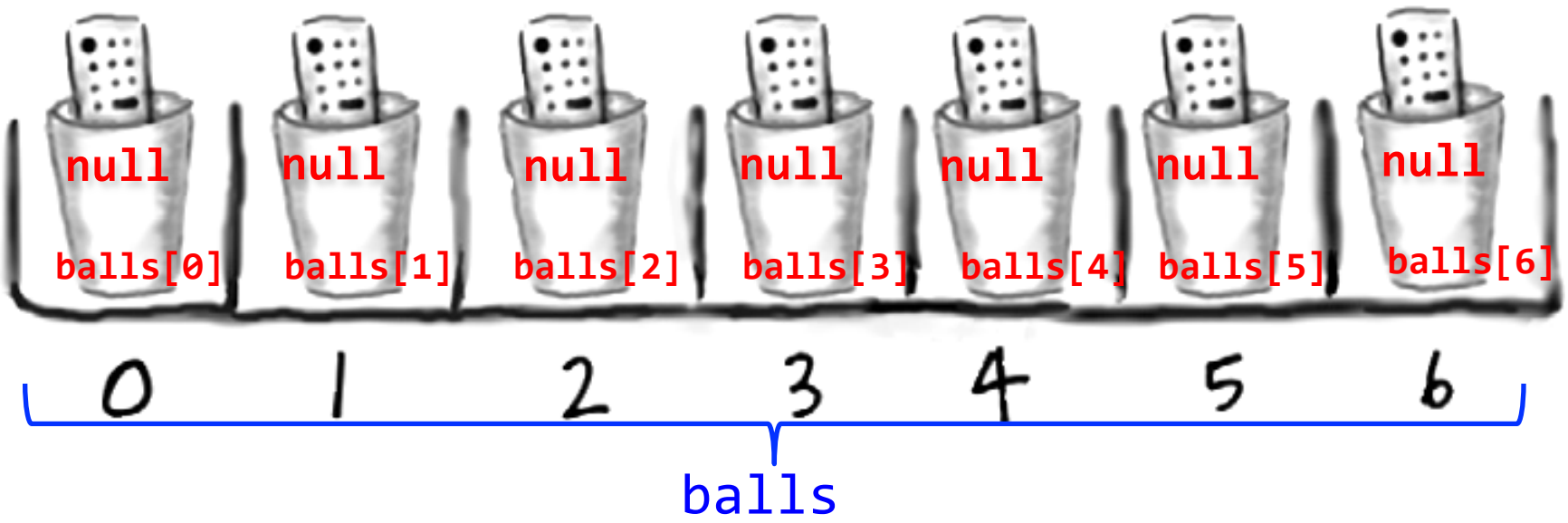
```
Ball [] balls = new Ball[7];
```



The value null

- What is in each location of the array?
  - Special value `null`
  - Default value for reference types (non-primitives)
  - Like an unprogrammed remote control

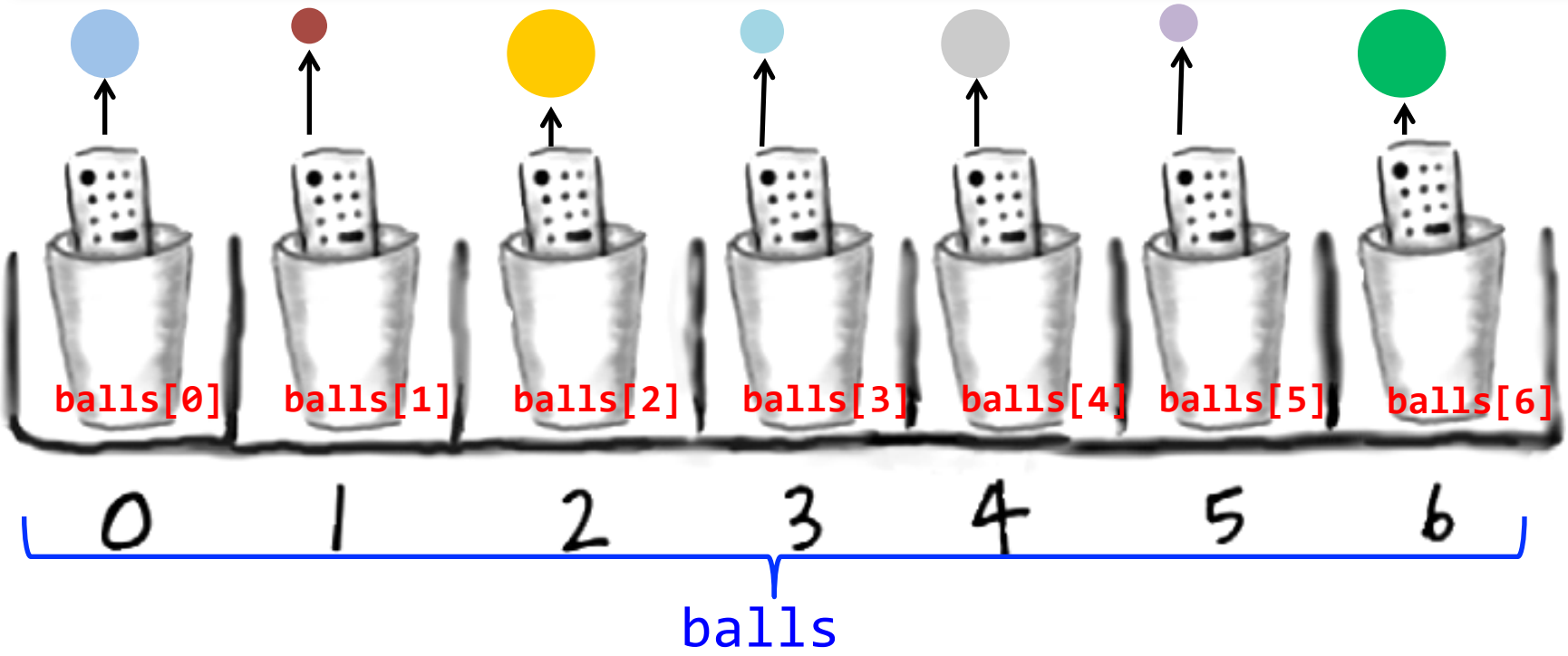
```
Ball [] balls = new Ball[7];
```



Creating all the Ball objects

- Each array location needs a new object

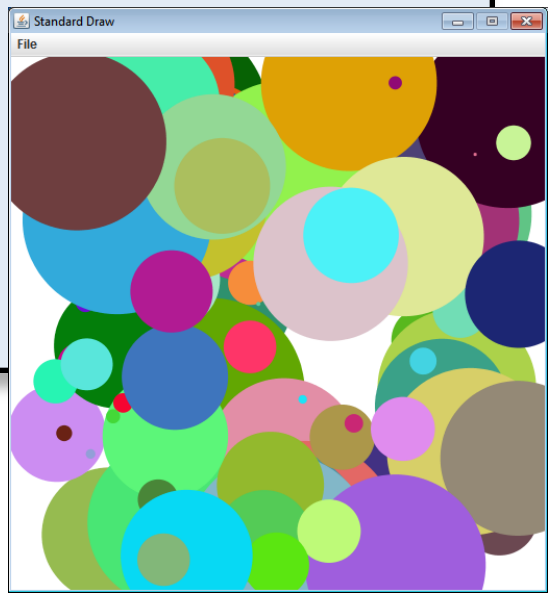
```
Ball [] balls = new Ball[7];
for (int i = 0; i < balls.length; i++)
{
   balls[i] = new Ball(Math.random(), Math.random(),
                       Math.random() * 0.2);
   balls[i].setColor(Math.random(), Math.random(), Math.random());
}
```



Client to draw lots of `Ball` objects

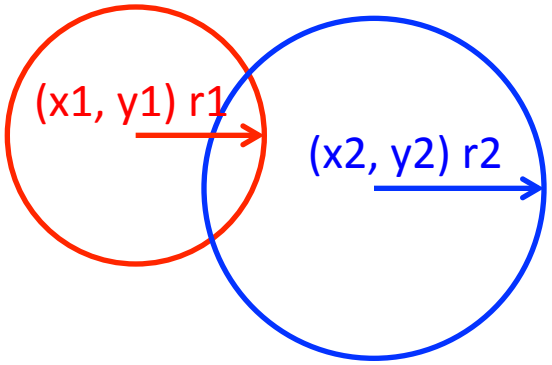
```
public class BallClientDeluxe
{
   public static void main(String[] args)
   {
      Ball [] balls = new Ball[Integer.parseInt(args[0])];
      for (int i = 0; i < balls.length; i++)
      {
         balls[i] = new Ball(Math.random(),
                             Math.random(),
                             Math.random() * 0.2);
         balls[i].setColor(Math.random(),
                           Math.random(),
                           Math.random());
         balls[i].draw();
      }
   }
}
```

```
% java BallClientDeluxe 100
```



Overlap detection

- Goal: draw many `Ball` objects without overlap
  - When do two balls overlap?



Euclidean distance between centers:

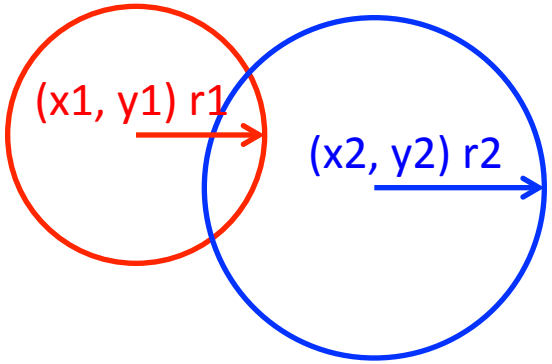
$$d = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

Balls overlap if:

$d < (r1 + r2)$

Implementing overlap detection

- Overlap detection is something a `Ball` can do
  - We can add a method to `Ball` class for this!



Euclidean distance between centers:

$$d = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

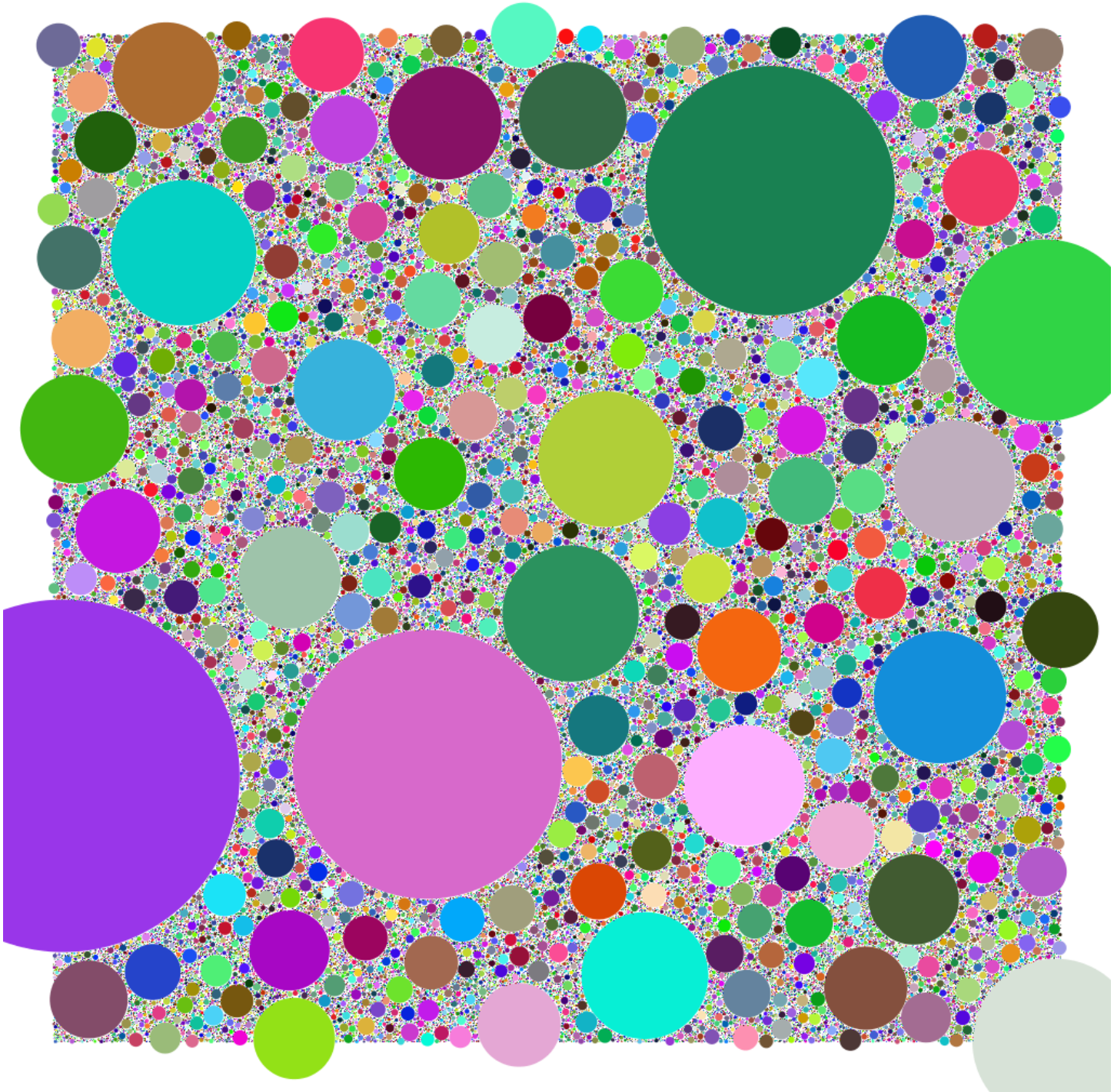
Balls overlap if:

$d < (r1 + r2)$

```
public boolean overlap(Ball other)
{
   double deltaX = posX - other.posX;
   double deltaY = posY - other.posY;
   double d = Math.sqrt(deltaX * deltaX + deltaY * deltaY);
   if (d < (radius + other.radius))
      return true;
   return false;
}
```

BallClientSuperDeluxe

```
public class BallClientSuperDeluxe
{
   public static void main(String[] args)
   {
      Ball [] balls = new Ball[Integer.parseInt(args[0])];
      for (int i = 0; i < balls.length; i++)
      {
         boolean overlap = false;
         do
         {
            balls[i] = new Ball(Math.random(),
                                Math.random(),
                                Math.random() * 0.2);
            int j = 0;
            overlap = false;
            while ((j < i) && (!overlap))
            {
               overlap = balls[i].overlap(balls[j]);
               j++;
            }
         } while (overlap);
         balls[i].setColor(Math.random(),
                           Math.random(),
                           Math.random());
         balls[i].draw();
      }
   }
}
```



Summary

- Creating your own data types
  - Object-oriented programming (OOP)
  - Design classes encapsulating:
    - What objects know
    - What objects can do
  - Prevalent concept in most modern programming languages