6.092: Introduction to Java

6: Design, Debugging, Interfaces

Assignment 5: main()

Programs start at a main() method, but many classes can have main()

```
public class SimpleDraw {
 /* ... stuff ... */
 public static void main(String args[]) {
   SimpleDraw content = new SimpleDraw(new DrawGraphics());
   /* ... more stuff ... */
 }
}
```

Assignment 5: main()

Programs start at a main() method, but many classes can have main()

```
public class SimpleDraw {
 /* ... stuff ... */
 public static void main(String args[]) {
   SimpleDraw content = new SimpleDraw(new DrawGraphics());
   /* ... more stuff ... */
 }
}
```

```java
public class DrawGraphics {
    BouncingBox box;

    public DrawGraphics() {
        box = new BouncingBox(200, 50, Color.RED);
    }

    public void draw(Graphics surface) {
        surface.drawLine(50, 50, 250, 250);
        box.draw(surface);
    }
}
```

```
public class DrawGraphics {
    BouncingBox box;  // a field or member variable

    public DrawGraphics() {
        box = new BouncingBox(200, 50, Color.RED);
    }

    public void draw(Graphics surface) {
        surface.drawLine(50, 50, 250, 250);
        box.draw(surface);
    }
}
```

```java
public class DrawGraphics {
    BouncingBox box;

    public DrawGraphics() {  // constructor
        box = new BouncingBox(200, 50, Color.RED);
    }

    public void draw(Graphics surface) {
        surface.drawLine(50, 50, 250, 250);
        box.draw(surface);
    }
}
```

```
public class DrawGraphics {
    public void draw(Graphics surface) {
        surface.drawLine(50, 50, 250, 250);
        box.draw(surface);
        surface.fillRect (150, 100, 25,  40);
        surface.fillOval (40, 40, 25, 10);
        surface.setColor (Color.YELLOW);
        surface.drawString ("Mr. And Mrs. Smith", 200, 10);
    }
}
```

```java
public class DrawGraphics {
    ArrayList<BouncingBox> boxes = new ArrayList<BouncingBox>();

    public DrawGraphics() {
        boxes.add(new BouncingBox(200, 50, Color.RED));
        boxes.add(new BouncingBox(10, 10, Color.BLUE));
        boxes.add(new BouncingBox(100, 100, Color.GREEN));
        boxes.get(0).setMovementVector(1, 0);
        boxes.get(1).setMovementVector(-3, -2);
        boxes.get(2).setMovementVector(1, 1);
    }

    public void draw(Graphics surface) {
        for (BouncingBox box : boxes) {
            box.draw(surface);
        }
    }
}
```

Outline

Good program design

Debugging

Interfaces

What is a good program?

Correct / no errors

Easy to understand

Easy to modify / extend

Good performance (speed)

Consistency

Writing code in a consistent way makes it easier to write and understand

Programming “style” guides: define rules about how to do things

Java has some widely accepted “standard” style guidelines

Naming

Variables: Nouns, lowercase first letter, capitals separating words

x, shape, highScore, fileName

Methods: Verbs, lowercase first letter

getSize(), draw(), drawWithColor()

Classes: Nouns, uppercase first letter

Shape, WebPage, EmailAddress

Good Class Design

Good classes: easy to understand and use

- Make fields and methods private by default
- Only make methods public if you need to
- If you need access to a field, create a method:

```
public int getBar() { return bar; }
```

Debugging

The process of finding and correcting an error in a program

A fundamental skill in programming

Step 1: Don’t Make Mistakes

Don’t introduce errors in the first place

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Don’t introduce errors in the first place

- Reuse: find existing code that does what you want
- Design: think before you code
- Best Practices: Recommended procedures/techniques to avoid common problems

Design: Pseudocode

A high-level, understandable description of what a program is supposed to do

Don’t worry about the details, worry about the structure

Pseudocode: Interval Testing

Example:

Is a number within the interval [*x*, *y*)?

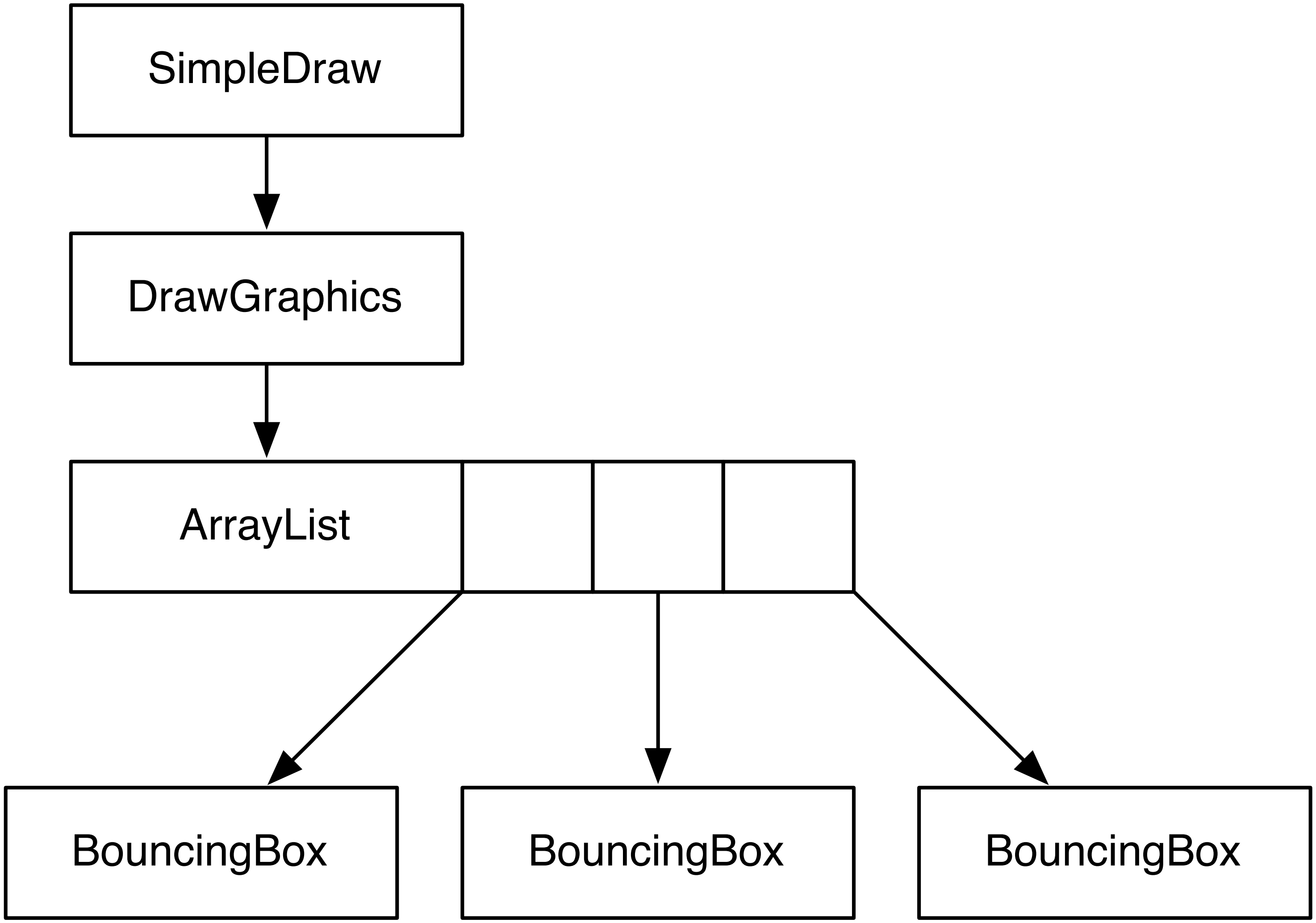
```
If number < x return false
If number > y return false
Return true
```

Design

Visual design for objects, or how a program works

Don’t worry about specific notation, just do something that makes sense for you

Scrap paper is useful


SimpleDraw
DrawGraphics
ArrayList
BouncingBox
BouncingBox
BouncingBox

Step 2: Find Mistakes Early

Easier to fix errors the earlier you find them

- Test your design
- Tools: detect potential errors
- Test your implementation
- Check your work: assertions

Testing: Important Inputs

Want to check all “paths” through the program.

Think about one example for each “path”

Example:

Is a number within the interval [*x*, *y*)?

Intervals: Important Cases

Below the lower bound

Equal to the lower bound

Within the interval

Equal to the upper bound

Above the upper bound

Intervals: Important Cases

What if lower bound > upper bound?

What if lower bound == upper bound?

(hard to get right!)

Pseudocode: Interval Testing

Is a number within the interval $[x, y)$?

```
If number $< x$ return false
If number $> y$ return false
Return true
```

Pseudocode: Interval Testing

Is a number within the interval [*x*, *y*)?

Is 5 in the interval [3, 5)?

```
If $number < x$ return false
If $number > y$ return false
Return true
```

Pseudocode: Interval Testing

Is a number within the interval $[x, y)$?

Is 5 in the interval [3, 5)?

```
If number < x return false
If number >= y return false
Return true
```

Tools: Eclipse Warnings

Warnings: may not be a mistake, but it likely is.

Suggestion: always fix all warnings

Extra checks: FindBugs and related tools

Unit testing: JUnit makes testing easier

Assertions

Verify that code does what you expect

If true: nothing happens

If false: program crashes with error

Disabled by default (enable with `-ea`)

```
assert difference >= 0;
```

```java
void printDifferenceFromFastest(int[] marathonTimes) {
    int fastestTime = findMinimum(marathonTimes);

    for (int time : marathonTimes) {
        int difference = time - fastestTime;
        assert difference >= 0;
        System.out.println("Difference: " + difference);
    }
}
```

Step 3: Reproduce the Error

- Figure out how to repeat the error
- Create a minimal test case

Go back to a working version, and introduce changes one at a time until the error comes back

Eliminate extra stuff that isn’t used

Step 4: Generate Hypothesis

What is going wrong?

What might be causing the error?

Question your assumptions: “x can’t be possible:” What if it is, due to something else?

Step 5: Collect Information

If x is the problem, how can you verify? Need information about what is going on inside the program

System.out.println() is very powerful

Eclipse debugger can help

Step 6: Examine Data

Examine your data

Is your hypothesis correct?

Fix the error, or generate a new hypothesis

Why Use Methods?

Write and test code once, use it multiple times: avoid duplication

Eg. Library.addBook()

Why Use Methods?

Use it without understanding *how* it works:
encapsulation / **information hiding**

Eg. How does System.out.println() work?

Why Use Objects?

Objects combine a related set of variables and methods

Provide a simple *interface*

(encapsulation again)

Implementation / Interface

```
Library

Book[] books;
int numBooks;
String address;

void addBook(Book b) {
  books[numBooks] = b;
  numBooks++;
}
```

```
Library

void addBook(Book b);
```

Java Interfaces

Manipulate objects, without knowing how they work

Useful when you have similar but not identical objects

Useful when you want to use code written by others

Interface Example: Drawing

```
public class BouncingBox {
    public void draw(Graphics surface) {
        // … code to draw the box …
    }
}

// … draw boxes …
for (BouncingBox box : boxes) {
    box.draw(surface);
}
```

Interface Example: Drawing

```
public class Flower {
    public void draw(Graphics surface) {
        // … code to draw a flower …
    }
}

// … draw flowers …
for (Flower flower : flowers) {
    flower.draw(surface);
}
```

```
public class DrawGraphics {
    ArrayList<BouncingBox> boxes = new ArrayList<BouncingBox>();
    ArrayList<Flower> flowers = new ArrayList<Flower>();
    ArrayList<Car> cars = new ArrayList<Car>();

    public void draw(Graphics surface) {
        for (BouncingBox box : boxes) {
            box.draw(surface);
        }
        for (Flower flower : flowers) {
            flower.draw(surface);
        }
        for (Car car : cars) {
            car.draw(surface);
        }
    }
}
```

```
public class DrawGraphics {
    ArrayList<Drawable> shapes = new ArrayList<Drawable>();
    ArrayList<Flower> flowers = new ArrayList<Flower>();
    ArrayList<Car> cars = new ArrayList<Car>();

    public void draw(Graphics surface) {
        for (Drawable shape : shapes) {
            shape.draw(surface);
        }
        for (Flower flower : flowers) {
            flower.draw(surface);
        }
        for (Car car : cars) {
            car.draw(surface);
        }
    }
}
```

Interfaces

Set of classes that share methods

Declare an *interface* with the common methods

Can use the interface, without knowing an object’s specific type

Interfaces: Drawable

```
import java.awt.Graphics;

interface Drawable {
    void draw(Graphics surface);
    void setColor(Color color);
}
```

Implementing Interfaces

Implementations provide complete methods:

```
import java.awt.Graphics;
class Flower implements Drawable {
    // ... other stuff ...
    public void draw(Graphics surface) {
        // ... code to draw a flower here ...
    }
}
```

Interface Notes

Only have methods (mostly true)

Do not provide code, only the definition (called *signatures*)

A class can implement any number of interface

Using Interfaces

Can only access stuff in the interface.

```
Drawable d = new BouncingBox(…);
d.setMovementVector(1, 1);
```

The method setMovementVector(int, int)
is undefined for the type Drawable

Casting

If you know that a variable holds a specific type, you can use a cast:

```
Drawable d = new BouncingBox(…);
BouncingBox box = (BouncingBox) d;
box.setMovementVector(1, 1);
```

Assignment: More graphics

Start a new project: code has changed.

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