Object-Oriented Programming in Java: More Capabilities

For additional materials, please see http://www.coreservlets.com/. The Java tutorial section contains complete source code for all examples in this tutorial series, plus exercises and exercise solutions for each topic.

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Marty is also available for consulting and development support

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Topics in This Section

• Overloading
• Best practices for “real” classes
  – Encapsulation and accessor methods
  – JavaDoc
• Inheritance
• Packages
• The toString method
• More iterations of the Person class

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Overview

• Idea
  – Classes can have more than one method with the same name, or more than one constructor
  – The methods or constructors have to differ from each other by having different number or types of arguments

• Syntax example

```java
public class MyClass {
    public double randomNum() { ... }; // Range 1-10
    public double randomNum(double range) { ... }
}
```

Motivation

• Overloading methods
  – Lets you have similar names for similar operations
    • MathUtils.arraySum(arrayOfInts)
    • MathUtils.arraySum(arrayOfDoubles)
    • MathUtils.log(number) // Assumes log_e(number)
    • MathUtils.log(number, base) // log_base(number)

• Overloading constructors
  – Lets you build instances in different ways
    • new Ship(someName) // Default x, y, speed, direction
    • new Ship(someX, someY, someSpeed, someDirection, someName)
package ship4;

public class Ship {
    public double x=0.0, y=0.0, speed=1.0, direction=0.0;
    public String name;

    public Ship(double x, double y, double speed, double direction, String name) {
        this.x = x;
        this.y = y;
        this.speed = speed;
        this.direction = direction;
        this.name = name;
    }

    public Ship(String name) {
        this.name = name;
    }

    public void move() {
        move(1);
    }

    public void move(int steps) {
        double angle = degreesToRadians(direction);
        x = x + steps * speed * Math.cos(angle);
        y = y + steps * speed * Math.sin(angle);
    }

    // degreesToRadians and printLocation as before
}

Overloading (Continued)
package ship4;

public class ShipTest {
    public static void main(String[] args) {
        Ship s1 = new Ship("Ship1");
        Ship s2 = new Ship(0.0, 0.0, 2.0, 135.0, "Ship2");
        s1.move();
        s2.move(3);
        s1.printLocation();
        s2.printLocation();
    }
}

Overloading: Results

• Compiling and running in Eclipse (common)
  – Save Ship.java and ShipTest.java
  – R-click inside ShipTest.java, Run As → Java Application

• Compiling and running manually (rare)
  > javac ship4\ShipTest.java
  > java ship4.ShipTest

• Output:
  Ship1 is at (1.0,0.0).
  Ship2 is at (-4.24264...,4.24264...).
OOP Design: Best Practices

“Always code as if the guy who ends up maintaining your code will be a violent psychopath who knows where you live.”
– John F. Woods

Overview

• Ideas
  – Instance variables should always be private
    • And hooked to outside world with getBlah and/or setBlah
  – From very beginning, put in JavaDoc-style comments

• Syntax example

    /** Short summary. More detail. Can use HTML. */
    public class MyClass {
        private String firstName;
        public String getFirstName() { return(firstName); }
        public void setFirstName(String s) { firstName = s; }
    }
**Motivation**

- **Supports secondary goal of OOP**
  - Limits ripple effect, where changes to one class requires changes to the classes that use it, that require changes to the classes that use that, and so forth
    - Lets you make changes to internal representation of classes without changing its public interface
    - Makes code more maintainable

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**OOP Principles**

- **Basic OOP principles**
  - Primary goal: avoid needing to repeat identical or almost-identical code
    - DRY: Don’t Repeat Yourself
    - Code reuse
  - Secondary goal: limit ripple effect
    - Where changes to one piece of code requires changes to the pieces that use it

- **Advanced OOP principles**
  - SOLID
    - [http://williamdurand.fr/2013/07/30/from-stupid-to-solid-code/](http://williamdurand.fr/2013/07/30/from-stupid-to-solid-code/)
/** Ship example to demonstrate OOP in Java. */

public class Ship {
    private double x=0.0, y=0.0, speed=1.0, direction=0.0;
    private String name;
    ...
    /** Get current X location. */
    public double getX() {
        return(x);
    }
    /** Set current X location. */
    public void setX(double x) {
        this.x = x;
    }
    ...
}

package ship5;

/** Small example to test the Ship class.
 *<p>
 * From <a href="http://www.coreservlets.com/">the
 * coreservlets.com Java tutorials</a>.
 *<p>
 *public class ShipTest {
 public static void main(String[] args) {
     Ship s1 = new Ship("Ship1");
     Ship s2 = new Ship(0.0, 0.0, 2.0, 135.0, "Ship2");
     s1.move();
     s2.move(3);
     s1.printLocation();
     s2.printLocation();
 }
}
Results

- Compiling and running in Eclipse (common)
  - Save Ship.java and ShipTest.java
  - R-click inside ShipTest.java, Run As → Java Application
  - Select project, go to Project menu and choose “Generate Javadoc”
    - If it asks you where javadoc.exe is located, you can find it in the bin folder of your Java installation (e.g., C:\Program Files\Java\jdk1.8.0_75\bin)

- Compiling and running manually (rare)
  > javac ship5\ShipTest.java
  > java ship5.ShipTest
  > javadoc *.java

- Output:
  Ship1 is at (1.0,0.0).
  Ship2 is at (-4.24264...,4.24264...).
### Major Points

**Encapsulation**
- Lets you change internal representation and data structures *without users of your class changing their code*
- Lets you put constraints on values *without users of your class changing their code*
- Lets you perform arbitrary side effects *without users of your class changing their code*

**Comments and JavaDoc**
- Comments marked with /** ... */ will be part of the online documentation
  - These should go before every public class, every public method, and every public constructor
- To build online documentation within Eclipse, do Project ➔ Generate Javadoc
- To build the documentation from command line, use “javadoc *.java”

### More Details on Getters and Setters

**Eclipse will automatically build getters/setters from instance variables**
- R-click anywhere in code
- Choose Source ➔ Generate Getters and Setters
- However, if you later click on instance variable and do Refactor ➔ Rename, Eclipse will not automatically rename the accessor methods
• There need not be both getters and setters
  – It is common to have fields that can be set at instantiation, but never changed again (immutable field). It is even quite common to have classes containing only immutable fields (immutable classes)

```java
public class Ship {
    private final String shipName;

    public Ship(...) {  shipName = ...; ... }

    public String getName() { return(shipName); }

    // No setName method
}
```

• Getter/setter names need not correspond to instance var names
  – Common to do so if there is a simple correspondence, but this is not required
    • Notice on previous page that instance variable was “shipName”, but methods were “getName” and “setName”
  – In fact, there doesn’t even have to be a corresponding instance variable

```java
public class Customer {
    ...

    public String getFirstName() { getFromDatabase(...); }
    public void setFirstName(...) { storeInDatabase(...); }
    public double getBonus() { return(Math.random()); }
}
```
Overview

• **Ideas**
  – You can make a class that “inherits” characteristics of another class
    • The original class is called “parent class”, “super class”, or “base class”
    • The new class is called “child class”, “subclass”, or “extended class”
  – The child class has access to all non-private methods of the parent class
    • No special syntax need to call inherited methods

• **Syntax example**
  ```java
  public class ChildClass extends ParentClass {
      ...
  }
  ```
Motivation

- **Supports primary goal of OOP**
  - Supports the key OOP principle of code reuse
    - I.e., don’t write identical or nearly-identical code twice
  - You can design class hierarchies so that shared behavior is inherited by all classes that need it

Simple Example

- **Person**
  ```java
  public class Person {
    public String getFirstName() { ... }
    public String getLastName() { ... }
  }
  ```

- **Employee**
  ```java
  public class Employee extends Person {
    public double getSalary() { ... }

    public String getEmployeeInfo() {
      return(getFirstName() + " " + getLastName() + " earns " + getSalary());
    }
  }
  ```
Ship Example: Inheritance

```java
public class Speedboat extends Ship {
    private String color = "red";

    public Speedboat(String name) {
        super(name);
        setSpeed(20);
    }

    public Speedboat(double x, double y, double speed, double direction,
                      String name, String color) {
        super(x, y, speed, direction, name);
        setColor(color);
    }

    @Override
    // Optional but useful -- discussed later
    public void printLocation() {
        System.out.print(getColor().toUpperCase() + " ");
        super.printLocation();
    }
    ...
}
```

Inheritance Example: Testing

```java
public class SpeedboatTest {
    public static void main(String[] args) {
        Speedboat s1 = new Speedboat("Speedboat1");
        Speedboat s2 = new Speedboat(0.0, 0.0, 2.0, 135.0,
                                      "Speedboat2", "blue");
        Ship s3 = new Ship(0.0, 0.0, 2.0, 135.0, "Ship1");
        s1.move();
        s2.move();
        s3.move();
        s1.printLocation();
        s2.printLocation();
        s3.printLocation();
    }
}
```
Inheritance Example: Result

• Compiling and running in Eclipse
  – Save SpeedBoatTest.java
  – R-click, Run As → Java Application
• Compiling and running manually
  > javac ship5\SpeedboatTest.java
    • The above calls javac on Speedboat.java and Ship.java automatically
  > java ship5.SpeedboatTest

• Output
  RED Speedboat1 is at (20,0).
  BLUE Speedboat2 is at (-1.41421,1.41421).
  Ship1 is at (-1.41421,1.41421).

Ship Inheritance Example: Major Points

• Format for defining subclasses
  – And nomenclature (parent/child, super/sub, base/extended)
• Using inherited methods
  – No special syntax required
• Using super(...) for inherited constructors
  – Only when the zero-arg constructor is not OK
    • The most common case is to omit super and use zero-arg constructor of parent, but super is used moderately often
• Using super.someMethod(...) for inherited methods
  – Only when there is a name conflict
    • Used rarely
Review of Packages

Overview

• Idea
  – Organize classes in groups.

• Syntax
  – Make folder called somepackage
    • In Eclipse, R-click on “src” and do New → Package
  – Put “package somepackage” at top of file
    • Automatic in Eclipse
  – To use code from another package
    • put “import somepackage.*” below your package statement
Motivation

• **Avoiding name conflicts**
  – Team members can work on different parts of project without worrying about what class names other teams use

• **Different versions for testing**
  – For example, in next section, I have three packages: shapes1, shapes1, shapes3. They have variations on ways to make shapes where you can sum their areas.
    • But I use same core class names (Circle, Rectangle, etc.) in each of the packages

Running Packaged Code that has “main”

• **From Eclipse**
  – Same as always: R-click, Run As → Application

• **From command line**
  – Go to top-level of package hierarchy, i.e., for simple packages, the folder above the one containing the Java code
  – Use the fully-qualified name, i.e., including package
    > java packagename.Classname ...
The toString Method

Overview

• Idea
  – If you give a class a toString method, that method is automatically called whenever
    • An object of that class is converted to a String
    • An object of that class is printed

• Example

```java
public class Person {
    // Main code covered earlier

    @Override
    public String toString() {
        return("PERSON: " + getFullName());
    }
}
```
• **Oddities of toString**
  – We write the method, but we never call it
  – If we spell method wrong, we don’t know until run time
    • @Override useful for both issues; more details later

• What will be printed on final line below?

```java
public class Person {
    ...
    public void toString() { return(getFullName()); } }
...
Person p = new Person(...);
System.out.println(p);
```

Example:
Person Class

[For additional materials, please see http://www.coreservlets.com/. The Java tutorial section contains complete source code for all examples in this tutorial series, plus exercises and exercise solutions for each topic.]
Iterations of Person

• Last lecture: four iterations of Person
  – Instance variables
  – Methods
  – Constructors
  – Constructors with “this” variable

• This lecture
  – Person class
    • Change instance vars to private, add accessor methods
    • Add JavaDoc comments
    • Use toString
  – Employee class
    • Make a class based on Person that has all of the information of a Person, plus new data

Person Class (Part 1)

/** A class that represents a person's given name
  * and family name.
  */
public class Person {
    private String firstName, lastName;

    public Person(String firstName,
                   String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
    }
Person Class (Part 2)

/** The person's given (first) name. */

public String getFirstName() {
    return (firstName);
}

public void setFirstName(String firstName) {
    this.firstName = firstName;
}

Person Class (Part 3)

/** The person's family name (i.e., last name or surname). */

public String getLastName() {
    return (lastName);
}

public void setLastName(String lastName) {
    this.lastName = lastName;
}

/** The person's given name and family name, printed
 * in American style, with given name first and
 * a space in between.
 */

public String getFullName() {
    return (firstName + " " + lastName);
}
Employee Class (Part 1)

```java
/** Represents people that work at a company. */

public class Employee extends Person {
    private int employeeId;
    private String companyName;

    public Employee(String firstName, String lastName,
                  int employeeId, String companyName) {
        super(firstName, lastName);
        this.employeeId = employeeId;
        this.companyName = companyName;
    }
```

Employee Class (Part 2)

```java
/** The ID of the employee, with the assumption that
* lower numbers are people that started working at
* the company earlier than those with higher ids.
*/

public int getEmployeeId() {
    return employeeId;
}

public void setEmployeeId(int employeeId) {
    this.employeeId = employeeId;
}
```
Employee Class (Part 3)

/** The name of the company that the person
 * works for.
 */
public String getCompanyName() {
    return (companyName);
}

public void setCompanyName(String companyName) {
    this.companyName = companyName;
}

Wrap-Up
Java OOP References

- **Online**
  - “OOP Concepts” section in Oracle Java Tutorial. See also “Classes and Objects” and “Interfaces and Inheritance”.
    - [http://docs.oracle.com/javase/tutorial/java/](http://docs.oracle.com/javase/tutorial/java/)

- **Books**
  - *Murach's Java SE* (Murach, Steelman, and Lowe)
    - Excellent Java intro for beginners to Java (but not first-time programmers). Very good OOP section.
  - *Thinking in Java* (Bruce Eckel)
    - Perhaps not quite as good as Murach’s book in general, but possibly the best OOP coverage of any Java programming book.
  - *Effective Java, 2nd Edition* (Josh Bloch)
    - In my opinion, by far the best Java best-practices book ever written. Fantastic coverage of OOP best practices.
      - However, very advanced. Other than the OOP chapter, you won’t understand much unless you have been doing Java fulltime for at least a year.
      - Even experts will learn a lot from this book.

Summary

- **Overloading**
  - You can have multiple methods or constructors with the same name. They must differ in argument signatures

- **Best practices**
  - Make all instance variables private. Hook them to the outside with getBlah and/or setBlah
  - Use JavaDoc-style comments from the very beginning

- **Inheritance**
  - `public class Subclass extends Superclass { ... }`
    - Non-private methods available with no special syntax

- **Organization**
  - Put all code in packages
  - Make output more readable by implementing toString
Questions?

More info:
http://www.coreservlets.com/JavaTutorials/Java8Tutorials/Java8-Tutorial-
Java-8-Tutorial

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