core WEB programming

Advanced Object-Oriented Programming in Java

Agenda

- **Overloading**
- **Designing "real" classes**
- **Inheritance**
- **Advanced topics**
  - Abstract classes
  - Interfaces
  - Understanding polymorphism
  - Setting a CLASSPATH and using packages
  - Visibility modifiers
  - Creating on-line documentation using JavaDoc

Example 4: Overloading

```
class Ship4 {
  public double x=0.0, y=0.0, speed=1.0, direction=0.0;
  public String name;

  public Ship4(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 Ship4(String name) {
    this.name = name;
  }

  private double degreesToRadians(double degrees) {
    return(degrees * Math.PI / 180.0);
  }
...
```

Overloading (Continued)

```
  ...

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

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

  public void printLocation() {
    System.out.println(name + " is at ("
                       + x + "," + y + ").");
  }
}
```

Overloading: Testing and Results

```
public class Test4 {
  public static void main(String[] args) {
    Ship4 s1 = new Ship4("Ship1");
    Ship4 s2 = new Ship4(0.0, 0.0, 2.0, 135.0, "Ship2");
    s1.move();
    s2.move(3);
    s1.printLocation();
    s2.printLocation();
  }
}
```

- **Compiling and Running:**

```
javac Test4.java
java Test4
```

- **Output:**

```
Ship1 is at (1,0).
Ship2 is at (-4.24264,4.24264).
```

Overloading: Major Points

- **Idea**
  - Allows you to define more than one function or constructor with the same name
    - Overloaded functions or constructors must differ in the number or types of their arguments (or both), so that Java can always tell which one you mean
- **Simple examples:**
  - Here are two `square` methods that differ only in the type of the argument; they would both be permitted inside the same class definition.

```
// square(4) is 16
public int square(int x) { return(x*x); }

// square("four") is "four four"
public String square(String s) {
  return(s + " " + s);
}
```

Example 5: OOP Design and Usage

```
/** 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;
  }
```

Example 5: 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**
  - See later slides (or book) for details

Example 6: Inheritance

```
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);
  }

  public void printLocation() {
    System.out.print(getColor().toUpperCase() + " ");
    super.printLocation();
  }

  ...
}
```

Inheritance Example: Testing

```
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:**

```
javac SpeedboatTest.java
```

  - The above calls javac on **`Speedboat.java`** and **`Ship.java`** automatically

```
java SpeedboatTest
```

- **Output**

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

Example 6: Major Points

- **Format for defining subclasses**
- **Using inherited methods**
- **Using super(…) for inherited constructors**
  - *Only* when the zero-arg constructor is not OK
- **Using super.someMethod(…) for inherited methods**
  - *Only* when there is a name conflict

Inheritance

- **Syntax for defining subclasses**

```
public class NewClass extends OldClass {
   ...
}
```

- **Nomenclature:**
  - The existing class is called the superclass, base class or parent class
  - The new class is called the subclass, derived class or child class
- **Effect of inheritance**
  - Subclasses automatically have all public fields and methods of the parent class
  - You don't need any special syntax to access the inherited fields and methods; you use the exact same syntax as with locally defined fields or methods.
  - You can also add in fields or methods not available in the superclass
- **Java doesn't support multiple inheritance**

Inherited constructors and super(...)

- **When you instantiate an object of a subclass, the system will automatically call the superclass constructor first**
  - By default, the zero-argument superclass constructor is called unless a different constructor is specified
  - Access the constructor in the superclass through

```
super(args)
```

  - If `super(...)` is used in a subclass constructor, then `super(...)` must be the first statement in the constructor
- **Constructor life-cycle**
  - Each constructor has three phases:
    1. Invoke the constructor of the superclass
    2. Initialize all instance variables based on their initialization statements
    3. Execute the body of the constructor

Overridden methods and super.method(...)

- **When a class defines a method using the same name, return type, and arguments as a method in the superclass, then the class *overrides* the method in the superclass**
  - Only non-static methods can be overridden

- **If there is a locally defined method and an inherited method that have the same name and take the same arguments, you can use the following to refer to the inherited method**

```
super.methodName(...)
```

  - Successive use of `super` (super.super.methodName) will not access overridden methods higher up in the hierarchy; `super` can only be used to invoke overridden methods from within the class that does the overriding

Advanced OOP Topics

- Abstract classes
- Interfaces
- Polymorphism details
- CLASSPATH
- Packages
- Visibility other than public or private
- JavaDoc details

Abstract Classes

- **Idea**
  - Abstract classes permit declaration of classes that define only part of an implementation, leaving the subclasses to provide the details
- **A class is considered abstract if at least one method in the class has no implementation**
  - An abstract method has no implementation (known in C++ as a pure virtual function)
  - Any class with an abstract method must be declared abstract
  - If the subclass overrides all the abstract methods in the superclass, than an object of the subclass can be instantiated
- **An abstract class can contain instance variables and methods that are fully implemented**
  - Any subclass can override a concrete method inherited from the superclass and declare the method abstract

Abstract Classes (Continued)

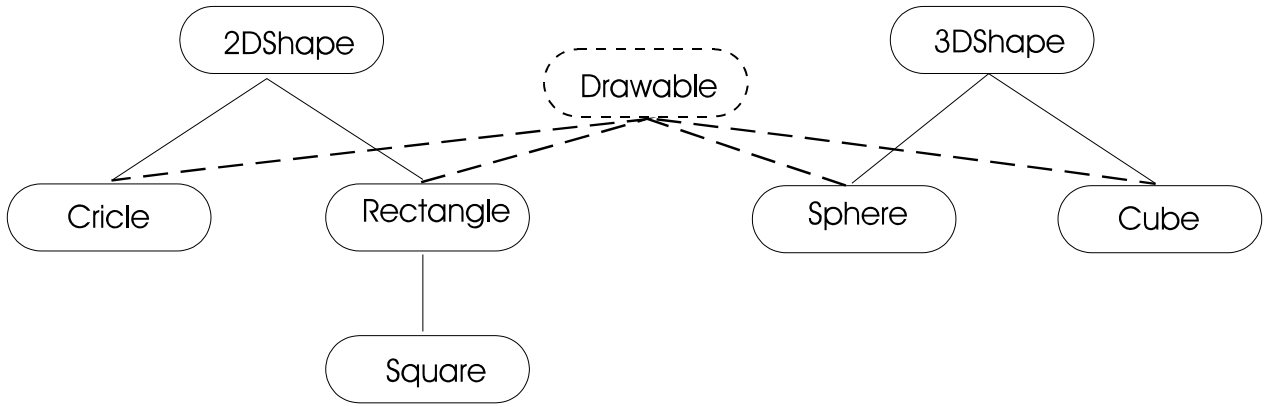
- An abstract class cannot be instantiated, however references to an abstract class can be declared

```
public abstract ThreeDShape {
   public abstract void drawShape(Graphics g);
   public abstract void resize(double scale);
}

ThreeDShape  s1;
ThreeDShape[] arrayOfShapes
   = new ThreeDShape[20];
```

- Classes from which objects can be instantiated are called concrete classes

Interfaces

- **Idea**
  - Interfaces define a Java type consisting *purely* of constants and abstract methods
  - An interface does not implement any of the methods, but imposes a design structure on any class that uses the interface
  - A class that implements an interface must either provide definitions for all methods or declare itself abstract



Interfaces (Continued)

- **Modifiers**
  - All methods in an interface are implicitly abstract and the keyword abstract is not required in a method declaration
  - Data fields in an interface are implicitly `static final` (constants)
  - All data fields and methods in an interface are implicitly `public`

```
public interface Interface1 {
  DataType CONSTANT1 = value1;
  DataType CONSTANT2 = value2;

  ReturnType1 method1(ArgType1 arg);
  ReturnType2 method2(ArgType2 arg);
}
```

Interfaces (Continued)

- **Extending Interfaces**
  - Interfaces can extend other interfaces, which brings rise to sub-interfaces and super-interfaces
  - Unlike classes, however, an interface can extend more than one interface at a time

```
public interface Displayable extends Drawable, Printable {
  // Additonal constants and abstract methods
  ...
}
```

- **Implementing Multiple Interfaces**
  - Interfaces provide a *form* of multiple inheritance because a class can implement more than one interface at a time

```
public class Circle extends TwoDShape
                    implements Drawable, Printable {
  ...
}
```

Polymorphism

- **"Polymorphic" literally means "of multiple shapes" and in the context of object-oriented programming, polymorphic means "having multiple behavior"**
- **A polymorphic method results in different actions depending on the object being referenced**
  - Also known as *late binding* or *run-time binding*
- **In practice, polymorphism is used in conjunction with reference arrays to loop through a collection of objects and to access each object's polymorphic method**

Polymorphism: Example

```
public class PolymorphismTest {
  public static void main(String[] args) {

    Ship[] ships = new Ship[3];

    ships[0] = new Ship(0.0, 0.0, 2.0, 135.0, "Ship1");
    ships[1] = new Speedboat("Speedboat1");
    ships[2] = new Speedboat(0.0, 0.0, 2.0, 135.0,
                             "Speedboat2", "blue");
    for(int i=0; i<ships.length ; i++) {
      ships[i].move();
      ships[i].printLocation();
    }
  }
}
```

Polymorphism: Result

- **Compiling and Running:**

```
javac PolymorphismTest.java
java PolymorphismTest
```

- **Output**

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

CLASSPATH

- **The `CLASSPATH` environment variable defines a list of directories in which to look for classes**
  - Default = current directory and system libraries
  - Best practice is to not set this when first learning Java!
- **Setting the CLASSPATH**

```
set CLASSPATH = .;C:\java;D:\cwp\echoserver.jar
setenv CLASSPATH .:~/java:/home/cwp/classes/
```

  - **The period indicates the current working directory**
- **Supplying a CLASSPATH**

```
javac -classpath .;D:\cwp  WebClient.java
java -classpath .;D:\cwp WebClient
```

Creating Packages

- **A package lets you group classes in subdirectories to avoid accidental name conflicts**
  - To create a package:
    1. Create a subdirectory with the same name as the desired package and place the source files in that directory
    2. Add a package statement to each file

```
package packagename;
```

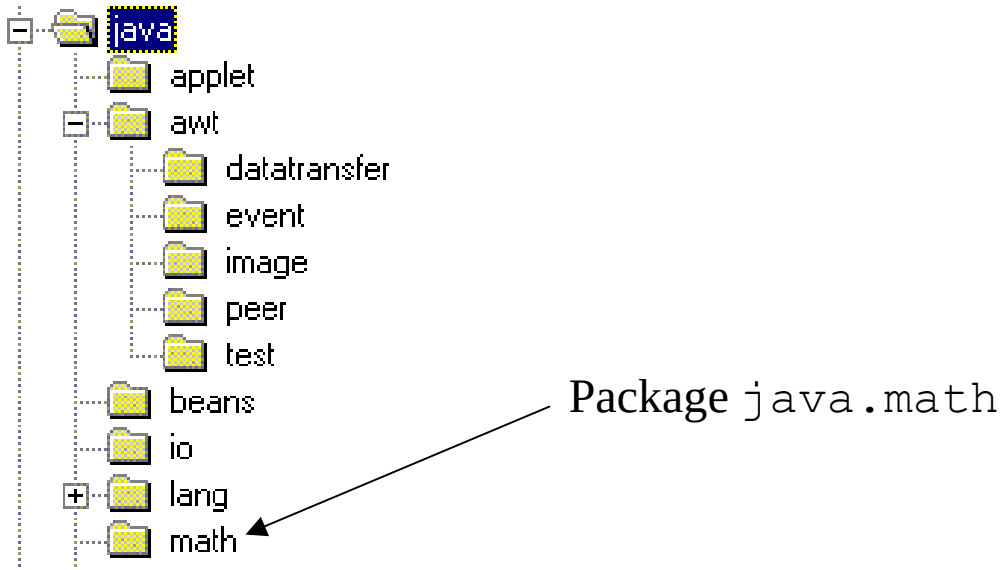
    3. Files in the main directory that want to use the package should include

```
import packagename.*;
```

- **The package statement must be the first statement in the file**
- **If a package statement is omitted from a file, then the code is part of the default package that has no name**

Package Directories

- **The package hierarchy reflects the file system directory structure**



  - The root of any package must be accessible through a Java system default directory or through the `CLASSPATH` environment variable

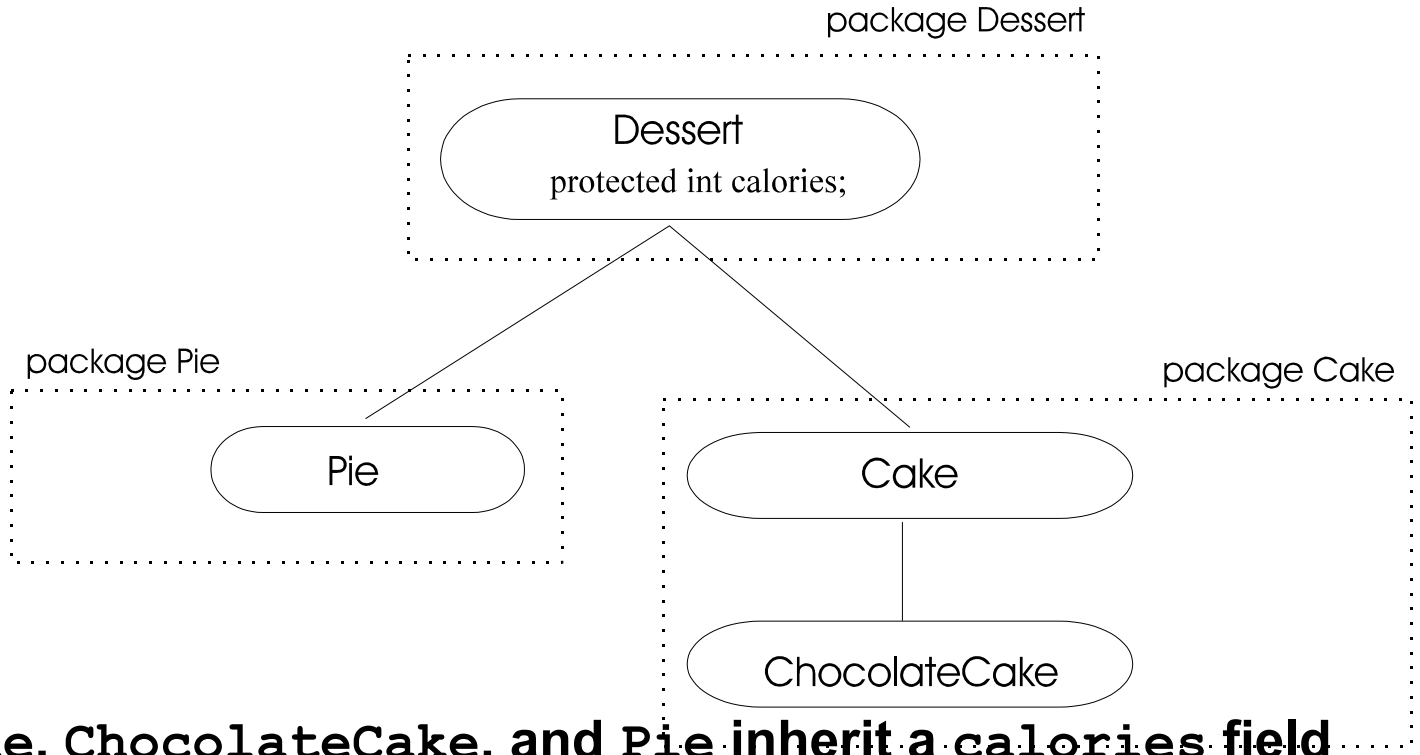
Visibility Modifiers

- **public**
  - This modifier indicates that the variable or method can be accessed anywhere an instance of the class is accessible
  - A class may also be designated `public`, which means that any other class can use the class definition
  - The name of a public class must match the filename, thus a file can have only one public class
- **private**
  - A `private` variable or method is only accessible from methods within the same class
  - Declaring a class variable private "hides" the data within the class, making the data available outside the class only through method calls

Visibility Modifiers, cont.

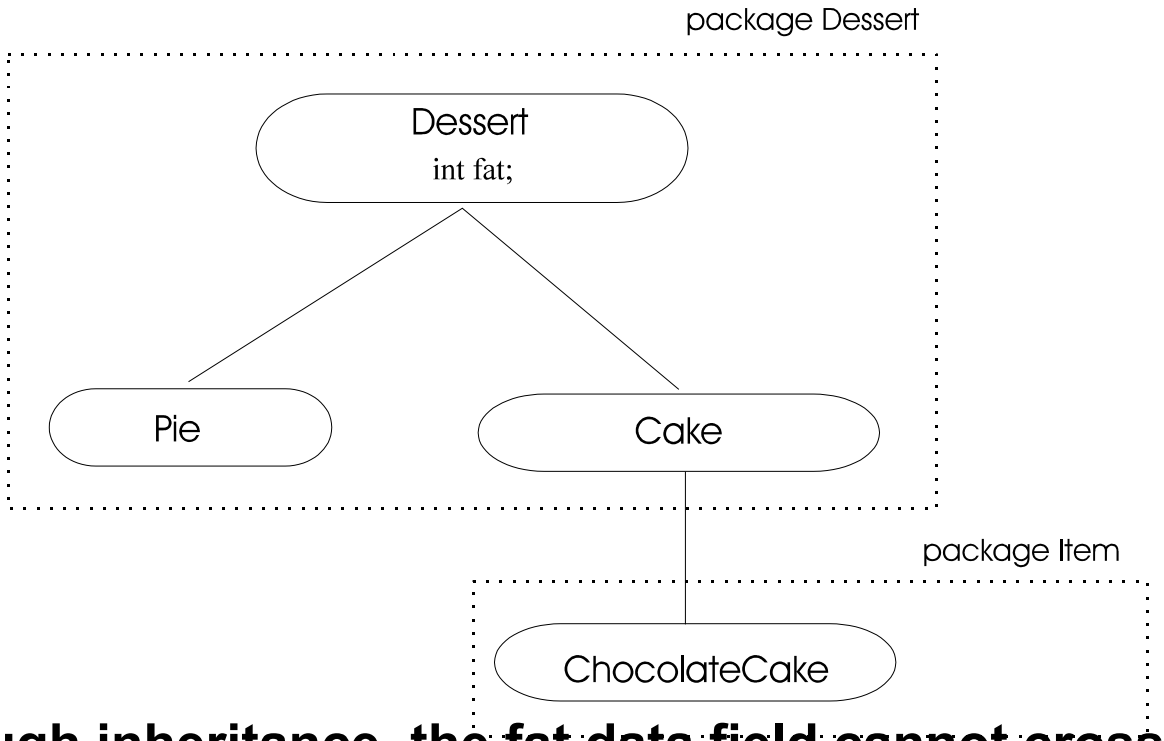
- **protected**
  - Protected variables or methods can only be accessed by methods within the class, within classes in the same package, and within subclasses
  - Protected variables or methods are inherited by subclasses of the same or different package
- **[default]**
  - A variable or method has default visibility if a modifier is omitted
  - Default visibility indicates that the variable or method can be accessed by methods within the class, and within classes in the same package
  - Default variables are inherited only by subclasses in the same package

Protected Visibility: Example



- **`Cake`, `ChocolateCake`, and `Pie` inherit a `calories` field**
- **However, if the code in the `Cake` class had a reference to object of type `Pie`, the protected calories field of the `Pie` object could not be accessed in the `Cake` class**
  - Protected fields of a class are not accessible outside its branch of the class hierarchy (unless the complete tree hierarchy is in the same package)

Default Visibility: Example



- **Even through inheritance, the fat data field cannot cross the package boundary**
  - Thus, the `fat` data field is accessible through any `Dessert`, `Pie`, and `Cake` object within any code in the `Dessert` package
  - However, the `ChocolateCake` class does not have a fat data field, nor can the fat data field of a `Dessert`, `Cake`, or `Pie` object be accessed from code in the `ChocolateCake` class

Visibility Summary

Data Fields and Methods	Modifiers			
	public	protected	default	private
Accessible from same class?	yes	yes	yes	yes
Accessible to classes (**nonsubclass**) from the **same package**?	yes	yes	yes	no
Accessible to **subclass** from the **same package**?	yes	yes	yes	no
Accessible to classes (**nonsubclass**) from **different package**?	yes	no	no	no
Accessible to **subclasses** from **different package**?	yes	no	no	no
Inherited by subclass in the same package?	yes	yes	yes	no
Inherited by subclass in different package?	yes	yes	no	no

Other Modifiers

- **final**
  - For a class, indicates that it cannot be subclassed
  - For a method or variable, cannot be changed at runtime or overridden in subclasses
- **synchronized**
  - Sets a lock on a section of code or method
  - Only one thread can access the same synchronized code at any given time
- **transient**
  - Variables are not stored in serialized objects sent over the network or stored to disk
- **native**
  - Indicates that the method is implement using C or C++

Comments and JavaDoc

- **Java supports 3 types of comments**
  - // Comment to end of line.
  - /* Block comment containing multiple lines.
    Nesting of comments in not permitted. */
  - /** A JavaDoc comment placed before class definition and nonprivate methods.
    Text may contain (most) HTML tags, hyperlinks, and JavaDoc tags. */
- **JavaDoc**
  - Used to generate on-line documentation

```
javadoc Foo.java Bar.java
```

  - JavaDoc 1.4 Home Page
    - http://java.sun.com/j2se/1.4/docs/tooldocs/javadoc/

Useful JavaDoc Tags

- **@author**
  - Specifies the author of the document
  - Must use `javadoc -author ...` to generate in output

```
/** Description of some class ...
 *
 * @author <A HREF="mailto:brown@lmbrown.com">
 *         Larry Brown</A>
 */
```

- **@version**
  - Version number of the document
  - Must use `javadoc -version ...` to generate in output
- **@param**
  - Documents a method argument
- **@return**
  - Documents the return type of a method

Useful JavaDoc Command-line Arguments

- **-author**
  - Includes author information (omitted by default)
- **-version**
  - Includes version number (omitted by default)
- **-noindex**
  - Tells `javadoc` not to generate a complete index
- **-notree**
  - Tells `javadoc` not to generate the tree.html class hierarchy
- **-link, -linkoffline**
  - Tells `javadoc` where to look to resolve links to other packages

```
-link http://java.sun.com/j2se/1.3/docs/api
-linkoffline http://java.sun.com/j2se/1.3/docs/api
             c:\jdk1.3\docs\api
```

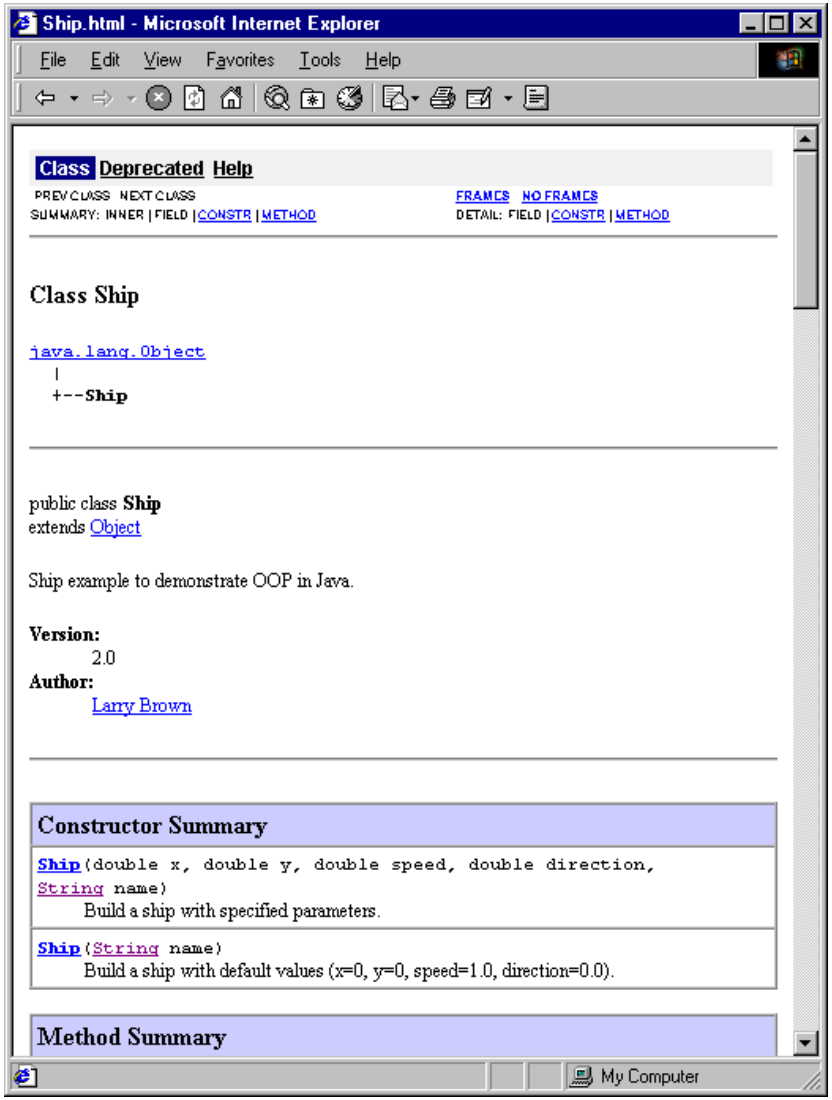
JavaDoc, Example

```
/** Ship example to demonstrate OOP in Java.
 *
 * @author <A HREF="mailto:brown@corewebprogramming.com">
 *         Larry Brown</A>
 * @version 2.0
 */

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

  /** Build a ship with specified parameters. */

  public Ship(double x, double y, double speed,
              double direction, String name) {
    setX(x);
    setY(y);
    setSpeed(speed);
    setDirection(direction);
    setName(name);
  }
```

JavaDoc, Example

```
> javadoc -linkoffline http://java.sun.com/j2se/1.3/docs/api
                        c:\jdk1.3\docs\api
          -author -version -noindex -notree Ship.java
```

JavaDoc: Result



Summary

- **Overloaded methods/constructors, except for the argument list, have identical signatures**
- **Use `extends` to create a new class that inherits from a superclass**
  - Java does not support multiple inheritance
- **An inherited method in a subclass can be overridden to provide custom behavior**
  - The original method in the parent class is accessible through `super.methodName(...)`
- **Interfaces contain only abstract methods and constants**
  - A class can `implement` more than one interface

Summary (Continued)

- **With polymorphism, binding of a method to a n object is determined at run-time**
- **The `CLASSPATH` defines in which directories to look for classes**
- **Packages help avoid namespace collisions**
  - The package statement must be first statement in the source file before any other statements
- **The four visibility types are: public, private, protected, and default (no modifier)**
  - Protected members can only cross package boundaries through inheritance
  - Default members are only inherited by classes in the same package

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Questions?