Object-Oriented Design & Patterns

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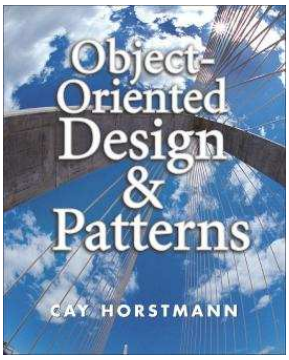
Chapter 1

A Crash Course in Java



Chapter Topics

- Hello, World in Java
- Documentation Comments
- Primitive Types
- Control Flow Statements
- Object References
- Parameter Passing
- Packages
- Basic Exception Handling
- Strings
- Reading Input
- Array Lists and Linked Lists
- Arrays
- Static Fields and Methods
- Programming Style

"Hello, World" in Java

- Simple but typical class

  Ch1/helloworld/Greeter.java

- Features:
  - Constructor `Greeter(String aName)`
  - Method `sayHello()`
  - Instance field `name`
- Each feature is tagged `public` or `private`


```
01: /**
02:    A class for producing simple greetings.
03: */
04:
05: public class Greeter
06: {
07:    /**
08:       Constructs a Greeter object that can greet a person or
09:       entity.
10:       @param aName the name of the person or entity who should
11:       be addressed in the greetings.
12:    */
13:    public Greeter(String aName)
14:    {
15:       name = aName;
16:    }
17:
18:    /**
19:       Greet with a "Hello" message.
20:       @return a message containing "Hello" and the name of
21:       the greeted person or entity.
22:    */
23:    public String sayHello()
24:    {
25:       return "Hello, " + name + "!";
26:    }
27:
28:    private String name;
29: }
```

"Hello, World" in Java

- Construct new objects with `new` operator
  `new Greeter("World")`
- Can invoke method on newly constructed object
  `new Greeter("World").sayHello()`
- More common: store object reference in object variable
  `Greeter worldGreeter = new Greeter("World");`
- Then invoke method on variable:
  `String greeting = worldGreeter.sayHello();`

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"Hello, World" in Java

- Construct separate class to test your class

Ch1/helloworld/GreeterTest.java

- `main` method is called when program starts
- `main` is `static`: it doesn't operate on any objects
- There are no objects yet when `main` starts
- In OO program, `main` constructs objects and invokes methods

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```
1: public class GreeterTest
2: {
3:    public static void main(String[] args)
4:    {
5:       Greeter worldGreeter = new Greeter("World");
6:       String greeting = worldGreeter.sayHello();
7:       System.out.println(greeting);
8:    }
9: }
```


Using the SDK

- Create a new directory to hold your files
- Use a text editor to prepare files (Greeter.java, GreeterTest.java)
- Open a shell window
- `cd` to directory that holds your files
- Compile and run
  ```
  javac GreeterTest.java
  java GreeterTest
  ```
  Note that Greeter.java is automatically compiled.
- Output is shown in shell window

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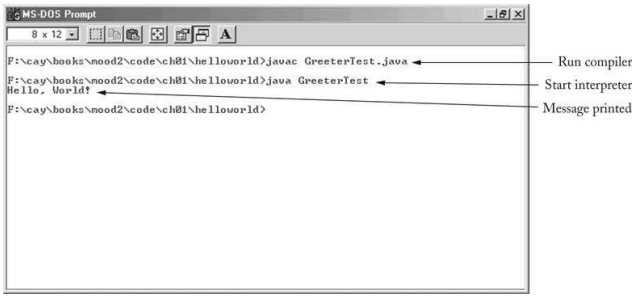
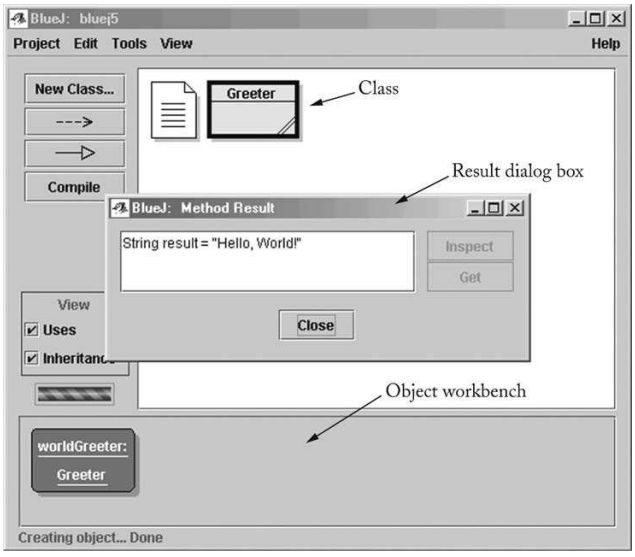
Using the SDK



Using BlueJ

- Download BlueJ from http://www.bluej.org
- No test program required
- Select Project->New and supply directory name
- Click on New Class... and type in Greeter class
- Compile the class
- Right-click the class to construct an object
- Right-click the object to invoke a method

Using BlueJ

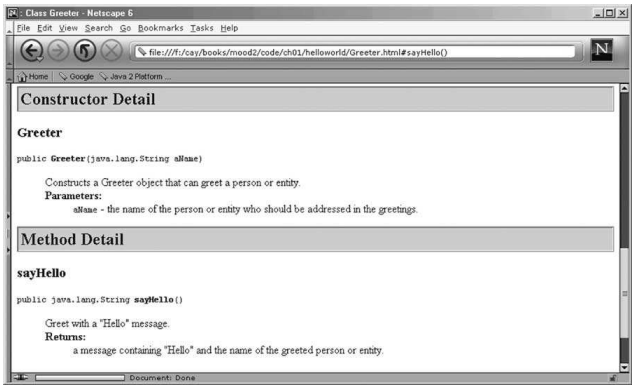


Documentation Comments

- Delimited by `/** ... */`
- First sentence = summary
- `@param` *`parameter`* *explanation*
- `@return` *explanation*
- Javadoc utility extracts HTML file

Documentation Comments - Summary

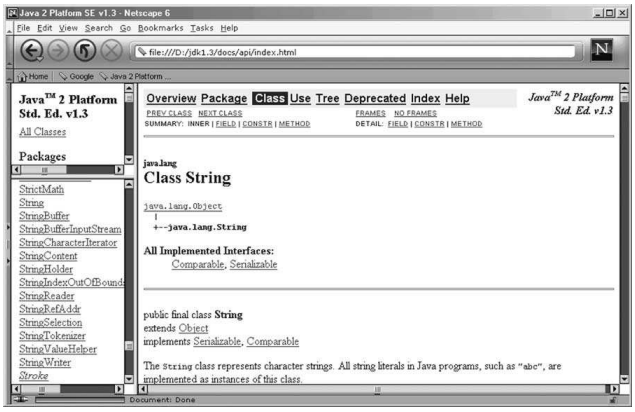
Documentation Comments - Detail



Documentation Comments

- Easy to keep documentation in sync with code
- You must document *all* classes and methods
- The pros do it--check out the API docs
- Install and bookmark the API docs *now*!

Documentation Comments - API Docs



Primitive Types

- 8 primitive types
- int, long, short, byte
- double, float
- char
- boolean
- suffixes L = long, F = float
- character constants 'a', '\n', '\x2122'
- Casts (int) x, (float) x
- Math class has methods that operate on numbers:
  `y = Math.sqrt(x);`

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Control Flow

- if
- while
- do/while
- for
- Variable can be declared in `for` loop:

```
for (int i = 1; i <= n; i++)
{ . . .
}
// i no longer defined here
```

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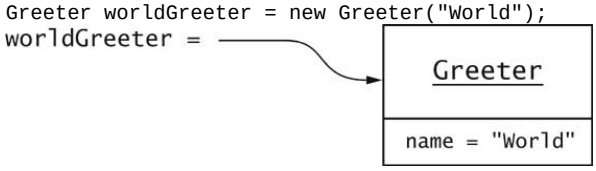
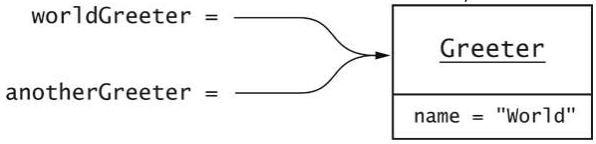
Object References

- Object variable holds a *reference*
  `Greeter worldGreeter = new Greeter("World");`



- Can have multiple references to the same object
  `Greeter anotherGreeter = worldGreeter;`



- After applying mutator method, all references access modified object

```
anotherGreeter.setName("Dave");
// now worldGreeter.sayHello() returns "Hello,
Dave!"
```

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The `null` Reference

- `null` refers to no object
- Can assign `null` to object variable:
  `worldGreeter = null;`
- Can test whether reference is `null`
  `if (worldGreeter == null) . . .`
- Dereferencing `null` causes `NullPointerException`

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The `this` Reference

- Refers to implicit parameter of method call
- Example: Equality testing

```
public boolean equals(Greeter other)
{
   if (this == other) return true;
   return name.equals(other.name);
}
```

- Example: Constructor

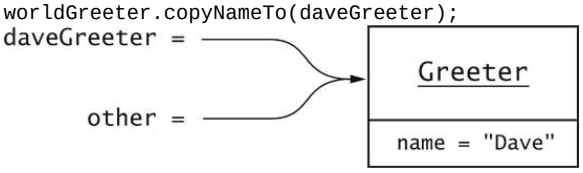
```
public Greeter(String name)
{
   this.name = name;
}
```


Parameter Passing

- Java uses "call by value":
  Method receives copy of parameter value
- Copy of object reference lets method modify object

```
public void copyNameTo(Greeter other)
{
    other.name = this.name;
}
```

-
```
Greeter worldGreeter = new Greeter("World");
Greeter daveGreeter = new Greeter("Dave");
worldGreeter.copyNameTo(daveGreeter);
```



No Reference Parameters

- Java has no "call by reference"
-
```
public void copyLengthTo(int n)
{
    n = name.length();
}
public void copyGreeterTo(Greeter other)
{
    other = new Greeter(name);
}
```

- Neither call has any effect after the method returns

```
int length = 0;
worldGreeter.copyLengthTo(length); // length
still 0
worldGreeter.copyGreeterTo(daveGreeter) //
daveGreeter unchanged
```


Packages

- Classes are grouped into packages
- Package names are dot-separated identifier sequences

```
java.util
javax.swing
com.sun.misc
edu.sjsu.cs.cs151.alice
```

- Unique package names: start with reverse domain name

Packages

- Add `package` statement to top of file
  ```
  package edu.sjsu.cs.cs151.alice;
  public class Greeter { . . . }
  ```
- Class without package name is in "default package"
- Full name of class = package name + class name
  ```
  java.util.ArrayList
  javax.swing.JOptionPane
  ```


Importing Packages

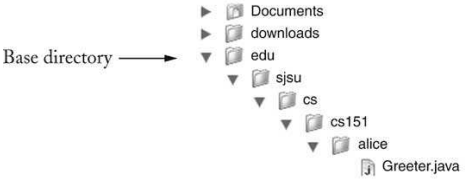
- Tedious to use full class names
- `import` allows you to use short class name
  ```
  import java.util.ArrayList;
  . . .
  ArrayList a; // i.e. java.util.ArrayList
  ```
- Can import all classes from a package
  ```
  import java.util.*;
  ```


Importing Packages

- Cannot import from multiple packages
  ```
  import java.*.*; // NO
  ```
- If a class occurs in two imported packages, `import` is no help.
  ```
  import java.util.*;
  import java.sql.*;
  . . .
  java.util.Date d; // Date also occurs in
  java.sql
  ```
- Never need to import `java.lang`.

Packages and Directories

- Package name must match subdirectory name.
  `edu.sjsu.cs.sjsu.cs151.alice.Greeter`
  must be in subdirectory
  `basedirectory``/edu/sjsu/cs/sjsu/cs151/alice`



- Always compile from the base directory
  ```
  javac edu/sjsu/cs/sjsu/cs151/alice/Greeter.java
  ```
  or
  ```
  javac edu\sjsu\cs\sjsu\cs151\alice\Greeter.java
  ```
- Always run from the base directory
  ```
  java edu.sjsu.cs.cs151.alice.GreeterTest
  ```

Exception Handling

- Example: `NullPointerException`
  ```
  String name = null;
  int n = name.length(); // ERROR
  ```
- Cannot apply a method to `null`
- Virtual machine *throws* exception
- Unless there is a handler, program exits with *stack trace*
  ```
  Exception in thread "main"
  java.lang.NullPointerException
  at Greeter.sayHello(Greeter.java:25)
  at GreeterTest.main(GreeterTest.java:6)
  ```


Checked and Unchecked Exceptions

- Compiler tracks only *checked* exceptions
- `NullPointerException` is not checked
- `IOException` is checked
- Generally, checked exceptions are thrown for reasons beyond the programmer's control
- Two approaches for dealing with checked exceptions
  - Declare the exception in the method header (preferred)
  - Catch the exception

Declaring Checked Exceptions

- Example: Opening a file may throw `FileNotFoundException`:

```
public void read(String filename) throws FileNotFoundException{
  FileReader reader = new FileReader(filename);
  ...
}
```

- Can declare multiple exceptions

```
public void read(String filename)
   throws IOException, ClassNotFoundException

public static void main(String[] args)
   throws IOException, ClassNotFoundException
```


Catching Exceptions

-
```
try
  { code that might throw an IOException
  }
catch (IOException exception)
  { take corrective action
  }
```

- Corrective action can be:
  - Notify user of error and offer to read another file
  - Log error in error report file
  - In student programs: print stack trace and exit
    ```
    exception.printStackTrace();
    System.exit(1);
    ```

The finally Clause

- Cleanup needs to occur during normal and exceptional processing
- Example: Close a file

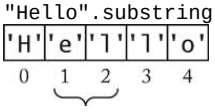
```
FileReader reader = null;
try
  {
    reader = new FileReader(name);
    ...
  }
finally
  {
    if (reader != null) reader.close();
  }
```


Strings

- Sequence of Unicode characters
- `length` method yields number of characters
- `""` is the empty string of length 0, different from `null`
- `charAt` method yields characters:
  `char c = s.charAt(i);`

Strings

- `substring` method yields substrings:
  `"Hello".substring(1, 3)` is `"el"`



- Use `equals` to compare strings
  `if (greeting.equals("Hello"))`
- `==` only tests whether the object references are identical:
  `if ("Hello".substring(1, 3) == "el") ... // NO!`

`StringTokenizer`

- Use `StringTokenizer` to break string into substrings

```
String countries = "Germany,France,Italy";
StringTokenizer tokenizer = new StringTokenizer(countries, ",");
while (tokenizer.hasMoreTokens())
  {
     String country = tokenizer.nextToken();
     ...
  }
```

String concatenation

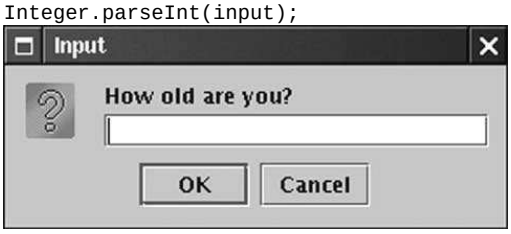
- + operator concatenates strings:
  `"Hello, " + name`
- If one argument of + is a string, the other is converted into a string:
```
int n = 7;
String greeting = "Hello, " + n;
// yields "Hello, 7"
```
- `toString` method is applied to objects
```
Date now = new Date();
String greeting = "Hello, " + now;
// concatenates now.toString()
// yields "Hello, Wed Jan 17 16:57:18 PST 2001"
```


Converting Strings to Numbers

- Use static methods
  `Integer.parseInt`
  `Double.parseDouble`
- Example:
```
String input = "7";
int n = Integer.parseInt(input);
// yields integer 7
```
- If string doesn't contain a number, throws a `NumberFormatException`(unchecked)

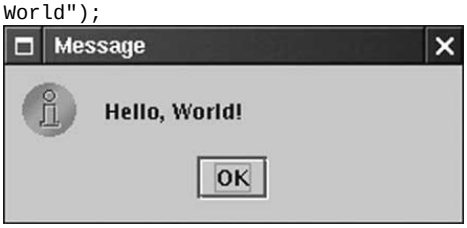
Reading Input

- Use input dialog:
```
String input = JOptionPane.showInputDialog("How
old are you?");
```
- If user cancels, result is `null`:
```
if (input != null) age =
Integer.parseInt(input);
```



Reading Input

- Must call `System.exit(0)`
- **Ch1/input1/InputTest.java**
- Also have message dialog
```
JOptionPane.showMessageDialog(null, "Hello,
World");
```



```
01: import javax.swing.JOptionPane;
02:
03: public class InputTest
04: {
05:    public static void main(String[] args)
06:    {
07:       String input = JOptionPane.showInputDialog("How old are you?");
08:       if (input != null)
09:       {
10:          int age = Integer.parseInt(input);
11:          age++;
12:          System.out.println("Next year, you'll be " + age);
13:       }
14:       System.exit(0);
15:    }
16: }
```


Reading Input

- Read console input from System.in
- System.in is an InputStream: reads bytes
- We want a Reader that reads characters
- Turn System.in into InputStreamReader
- Also want to read entire lines
- Use BufferedReader:

```
BufferedReader console = new BufferedReader(
new InputStreamReader(System.in));
System.out.println("How old are you?");
String input = console.readLine();
int age = Integer.parseInt(input);
```

- **Ch1/input2/InputTest.java**


```
01: import java.io.BufferedReader;
02: import java.io.IOException;
03: import java.io.InputStreamReader;
04:
05: public class InputTest
06: {
07:    public static void main(String[] args)
08:       throws IOException
09:    {
10:       BufferedReader console = new BufferedReader(
11:          new InputStreamReader(System.in));
12:       System.out.println("How old are you?");
13:       String input = console.readLine();
14:       if (input != null)
15:       {
16:          int age = Integer.parseInt(input);
17:          age++;
18:          System.out.println("Next year, you'll be " + age);
19:       }
20:    }
21: }
```


The `ArrayList` class

- Collects objects of any class type
- `add` appends to the end

```
ArrayList countries = new ArrayList();
countries.add("Belgium");
countries.add("Italy");
countries.add("Thailand");
```

- `size` method yields number of elements

```
for (int i = 0; i < countries.size(); i++) . .
.
```

- `get` gets an element; must cast to correct type:

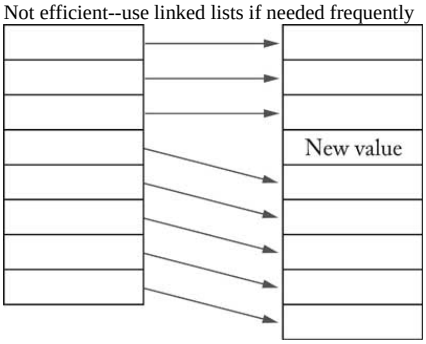
```
String country = (String)countries.get(i);
```

- `set` sets an element

```
countries.set(1, "France");
```

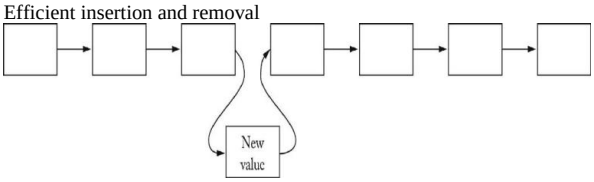
The `ArrayList` class

- Insert and remove elements in the middle
```
countries.add(1, "Germany");
countries.remove(0);
```
- Not efficient--use linked lists if needed frequently



Linked Lists

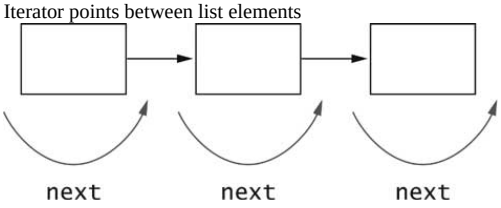
- Efficient insertion and removal



- `add` appends to the end
```
LinkedList countries = new LinkedList();
countries.add("Belgium");
countries.add("Italy");
countries.add("Thailand");
```
- Use iterators to edit in the middle

List Iterators

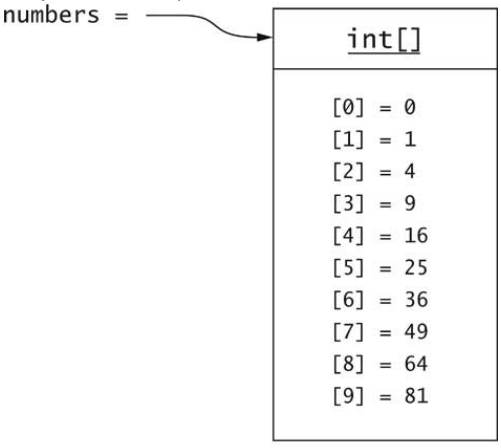
- Iterator points between list elements



- next retrieves element and advances iterator
```
ListIterator iterator = countries.listIterator();
while (iterator.hasNext())
{
  String country = (String) iterator.next();
  . . .
}
```
- add adds element before iterator position
- remove removes element returned by last call to next

Arrays

- Drawback of array lists: can't store numbers
- Arrays can store objects of any type, but their length is fixed
```
int[] numbers = new int[10];
```
- Array variable is a *reference*



Arrays

- `length` member yields number of elements
  `for (int i = 0; i < numbers.length; i++)`
- Can have array of length 0; *not* the same as `null`:
  `numbers = new int[0];`
- Array access with `[]` operator:
  `int n = numbers[i];`
- Multidimensional array
  `int[][] table = new int[10][20];`
  `int t = table[i][j];`

Command-Line Arguments

- `void main(String[] args)`
- `args` parameter of `main` is initialized with command-line arguments
- Example:
  `java GreeterTest Mars`
- `args.length` is 1
  `args[0]` is `"Mars"`

Static Fields

- Shared among all instances of a class
- Example: shared random number generator

```
public class Greeter
{
. . .
    private static Random generator;
}
```

- Example: shared constants

```
public class Math
{
. . .
    public static final double PI =
3.14159265358979323846;
}
```


Static Methods

- Don’t operate on objects
- Example: `Math.sqrt`
- Example: *factory method*

```
public static Greeter getRandomInstance()
{ if (generator.nextBoolean()) // note: generator is static field
    return new Greeter("Mars");
  else
    return new Greeter("Venus");
}
```

- Invoke through class:
  `Greeter g = Greeter.getRandomInstance();`
- Static fields and methods should be rare in OO programs

Programming Style: Case Convention

- variables, fields and methods:
  start with lowercase, use caps for new words:
  `name`
  `sayHello`
- Classes:
  start with uppercase, use caps for new words:
  `Greeter`
  `ArrayList`
- Constants:
  use all caps, underscores to separate words
  `PI`
  `MAX_VALUE`

Programming Style: Property Access

- Common to use `get/set` prefixes:
  `String getName()`
  `void setName(String newValue)`
- Boolean property has `is/set` prefixes:
  `public boolean isPolite()`
  `public void setPolite(boolean newValue)`

Programming Style: Braces

- "Allman" brace style: braces line up

```
public String sayHello()
{
  return "Hello, " + name + "!";
}
```

- "Kernighan and Ritchie" brace style: saves a line

```
public String sayHello() {
  return "Hello, " + name + "!";
}
```


Programming Style: Fields

- Some programmers put fields before methods:

```
public class Greeter
{
   private String name;
   public Greeter(String aName) { . . . }
   . . .
}
```

- From OO perspective, it is better to list the `public` interface first
- All fields should be `private`
- Don't use default (package) visibility

Programming Style: Miscellaneous

- Spaces around operators, after keywords, but not after method names
  `Good: if (x > Math.sqrt(y))`
  `Bad: if(x>Math.sqrt (y))`
- Don’t use C-style arrays:
  `Good: int[] numbers`
  `Bad: int numbers[]`
- No magic numbers
  `Good: h = HASH_MULTIPLIER * h + val[off];`
  `Bad: h = 31 * h + val[off];`