Java™ Programming Language

SL-275

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Preface

About This Course

Course Goals

This course provides you with knowledge and skills to:

- Program and run advanced Java™ applications and applets
- Help you prepare for the Sun Microsystems™ Certified Java Programmer and Developer examinations

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Course Overview

This course covers the following areas:

- Syntax of the Java programming language
- Object-oriented concepts as they apply to the Java programming language
- Graphical user interface (GUI) programming
- Applet creation
- Multithreading
- Networking

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Course Map

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Module-by-Module Overview

- Module 1 – "Getting Started"
- Module 2 – "Object-Oriented Programming"
- Module 3 – "Identifiers, Keywords, and Types"
- Module 4 – "Expressions and Flow Control"
- Module 5 – "Arrays"
- Module 6 – "Inheritance"
- Module 7 – "Advanced Class Features"
- Module 8 – "Exceptions"
- Module 9 – "Text-Based Applications"

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Module-by-Module Overview

- Module 10 – "Building Java GUIs"
- Module 11 – "GUI Event Handling"
- Module 12 – "Introduction to Java Applets"
- Module 13 – "GUI-Based Applications"
- Module 14 – "Threads"
- Module 15 – "Advanced I/O Streams"
- Module 16 – "Networking"

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Course Objectives

- Describe key language features
- Compile and run a Java application
- Understand and use the online hypertext Java technology documentation
- Describe language syntactic elements and constructs
- Understand the object-oriented paradigm
- Use object-oriented features of Java
- Understand and use exceptions
- Understand and use the Collections API
- Read and write to files

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Course Objectives

- Develop a graphical user interface
- Describe the Java technology Abstract Window Toolkit (AWT)
- Develop a program to take input from a GUI
- Understand event handling
- Develop Java applets
- Understand and use the `java.io` package
- Understand the basics of multithreading
- Develop multithreaded Java applications and applets
- Develop Java client and server programs using Transmission Control Protocol/Internet Protocol

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Skills Gained by Module

Skills Gained	Module															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Describe key language features	■															
Compile and run a Java application	■															
Understand and use the online hypertext Java technology documentation		▒							■							
Describe language syntactic elements and constructs		■	■	■	■	■										
Understand the object-oriented paradigm		■	▒			■	■									
Use object-oriented features of Java		■	▒			■	■									
Understand and use exceptions								■								
Understand and use the Collections API									■							
Read and write to files									■							
Develop a GUI										■	■	▒	■			
Describe the Java technology platform's Abstract Window Toolkit										■	■		■			
Create a program to take input from a graphical user interface											■		■			
Understand event handling											■					
Develop Java applets												■	▒			
Understand and use the `java.io` package														■		
Understand the basics of multithreading															■	
Develop multithreaded Java applications and applets															■	
Develop Java client and server programs using TCP/IP																■

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Guidelines for Module Pacing

Module	Day 1	Day 2	Day 3	Day 4	Day 5
About This Course	A.M.				
Module 1 – "Getting Started"	A.M.				
Module 2 – "Object-Oriented Programming"	P.M.				
Module 3 – "Identifiers, Keywords, and Types"	P.M.				
Module 4 – "Expressions and Flow Control"		A.M.			
Module 5 – "Arrays"		A.M.			
Module 6 – "Inheritance"		P.M.			
Module 7 – "Advanced Class Features"			A.M.		
Module 8 – "Exceptions"			A.M.		
Module 9 – "Text-Based Applications"			P.M.		
Module 10 – "Building Java GUIs"				A.M.	
Module 11 – "GUI Event Handling"				A.M.	
Module 12 – "Introduction to Java Applets"				P.M.	
Module 13 – "GUI-Based Applications"				P.M.	
Module 14 – "Threads"					A.M.
Module 15 – "Advanced I/O Streams"					P.M.
Module 16 – "Networking"					P.M.

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Topics Not Covered

- General programming concepts. This is not a course for people who have never programmed before.
- General object-oriented concepts.

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How Prepared Are You?

Before attending this course, you should have completed:

- SL-110: *Java Programming For Non-Programmers*

or have:

- Created compiled programs with C or C++
- Created and edited text files using a text editor
- Used a World Wide Web (WWW) browser, such as Netscape Navigator™

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Introductions

- Name
- Company affiliation
- Title, function, and job responsibility
- Programming experience
- Reasons for enrolling in this course
- Expectations for this course

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How to Use Course Materials

- Course Map
- Relevance
- Overhead Image
- Lecture
- Exercise
- Check Your Progress
- Think Beyond

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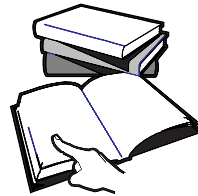
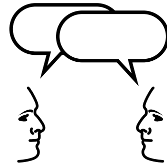
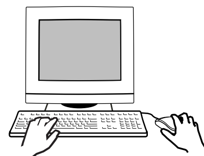
Course Icons

- Reference 
- Discussion 
- Exercise 

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Typographical Conventions

- `Courier` – Commands, files and directories, and on-screen computer output
- **`Courier bold`** – Input you type
- *`Courier italic`* – Variables and command-line placeholders
- *Palatino italics* – Book titles, new words or terms, and words that are emphasized

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Module 1

Getting Started

Objectives

- Describe key features of Java technology
- Define the terms *class* and *applications*
- Write, compile, and run a simple Java application
- Describe the Java virtual machine's (JVM™) function
- Describe how garbage collection works
- List the three tasks performed by the Java platform that handle code security

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Relevance

- Is the Java programming language a complete language or is it just useful for writing programs for the Web?
- Why is another programming language needed?
- How does the Java technology platform improve on other language platforms?

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What Is the Java Technology?

- Java technology is:
  - A programming language
  - A development environment
  - An application environment
  - A deployment environment
- It is similar in syntax to C++; similar in semantics to SmallTalk
- It is used for developing both *applets* and *applications*

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Primary Goals of the Java Technology

- Provides an easy-to-use language by:
  - Avoiding the pitfalls of other languages
  - Being object-oriented
  - Enabling users to create streamlined and clear code

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Primary Goals of the Java Technology

- Provides an interpreted environment for:
  - Improved speed of development
  - Code portability
- Enables users to run more than one thread of activity
- Loads classes dynamically, that is, at the time they are actually needed
- Supports dynamically changing programs during runtime by loading classes from disparate sources
- Furnishes better security

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Primary Goals of the Java Technology

The following features fulfill these goals:

- The Java virtual machine (JVM)
- Garbage collection
- Code security

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A Basic Java Application

TestGreeting.java

```
1   //
2   // Sample "Hello World" application
3   //
4   public class TestGreeting{
5     public static void main (String args[]) {
6       Greeting hello = new Greeting("Hello");
7       hello.greet("World");
8     }
9   }
```

Greeting.java

```
1   // The Greeting class declaration
2   public class Greeting {
3     private String salutation;
4
5     public Greeting(String s) {
6       salutation = s;
7     }
8
9     public void greet(String whom) {
10      System.out.println(salutation + " " + whom);
11    }
12  }
```


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Compiling and Running `TestGreeting`

- Compiling `TestGreeting.java`

```
javac TestGreeting.java
```

- `Greeting.java` is compiled automatically
- Running an application

```
java TestGreeting
```

- Locating common compile and runtime errors

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Compile-Time Errors

- `javac: Command not found`
- `Greeting.java:10: Method printl(java.lang.String) not found in class java.io.PrintStream.`
  ```
  System.out.printl^(salutation + " " + whom);
  ```
- `TestGreet.java:4: Public class TestGreeting must be defined in a file called "TestGreeting.java".`

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Runtime Errors

- `Can’t find class TestGreeting`
- `Exception in thread "main" java.lang.NoSuchMethodError: main`

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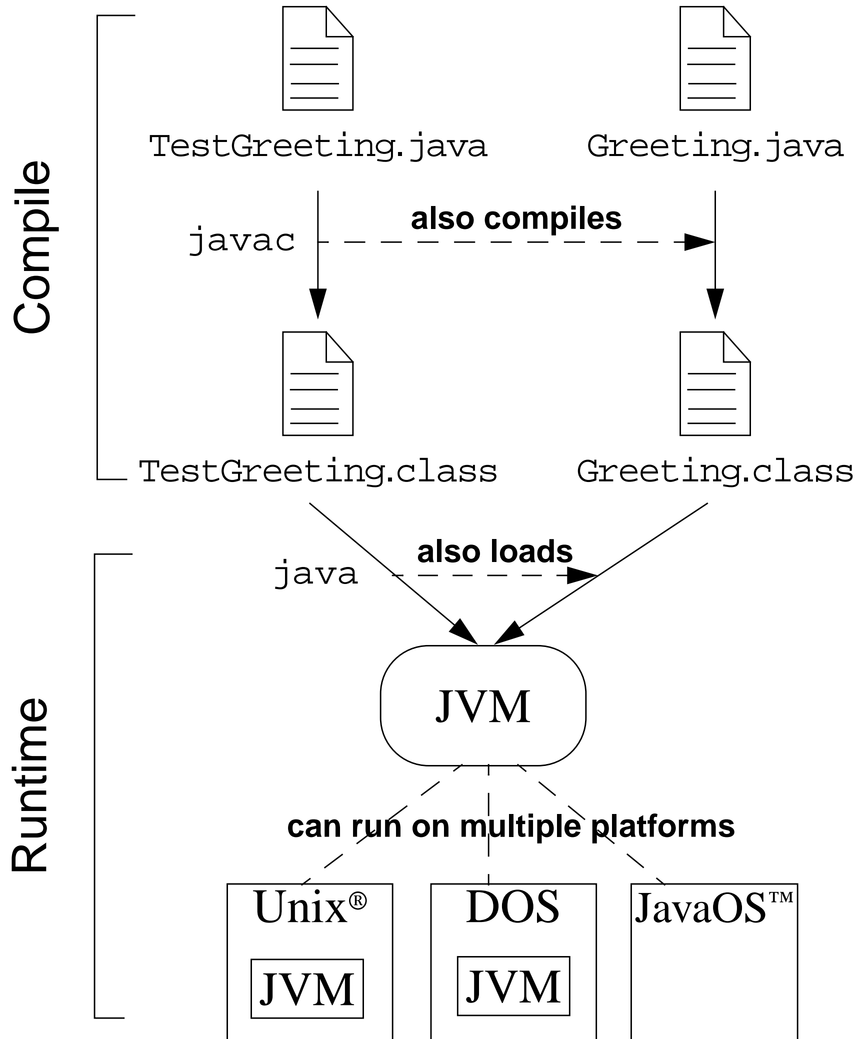
Java Runtime Environment



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The Java Virtual Machine

- Provides hardware platform specifications
- Reads compiled byte codes that are platform independent
- Is implemented as software or hardware
- Is implemented in a Java technology development tool or a Web browser

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The Java Virtual Machine

- JVM provides definitions for the:
  - Instruction set (central processing unit [CPU])
  - Register set
  - Class file format
  - Stack
  - Garbage-collected heap
  - Memory area

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The Java Virtual Machine

- The majority of type checking is done when the code is compiled.
- Every Sun Microsystems approved implementation of the JVM must be able to run any compliant class file.

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Garbage Collection

- Allocated memory that is no longer needed should be deallocated
- In other languages, deallocation is the programmer’s responsibility
- The Java programming language provides a system-level thread to track memory allocation
- Garbage collection:
  - Checks for and frees memory no longer needed
  - Is done automatically
  - Can vary dramatically across JVM implementations

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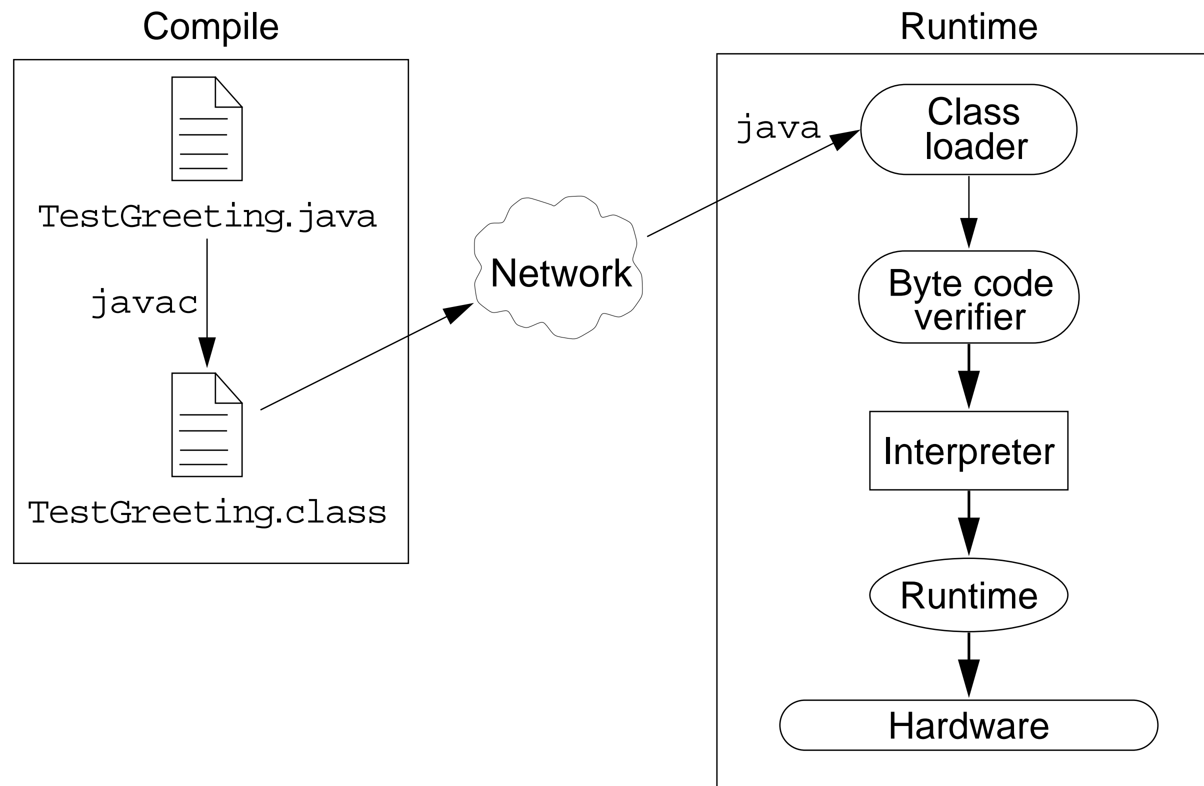
Code Security

The Java application environment performs as follows:



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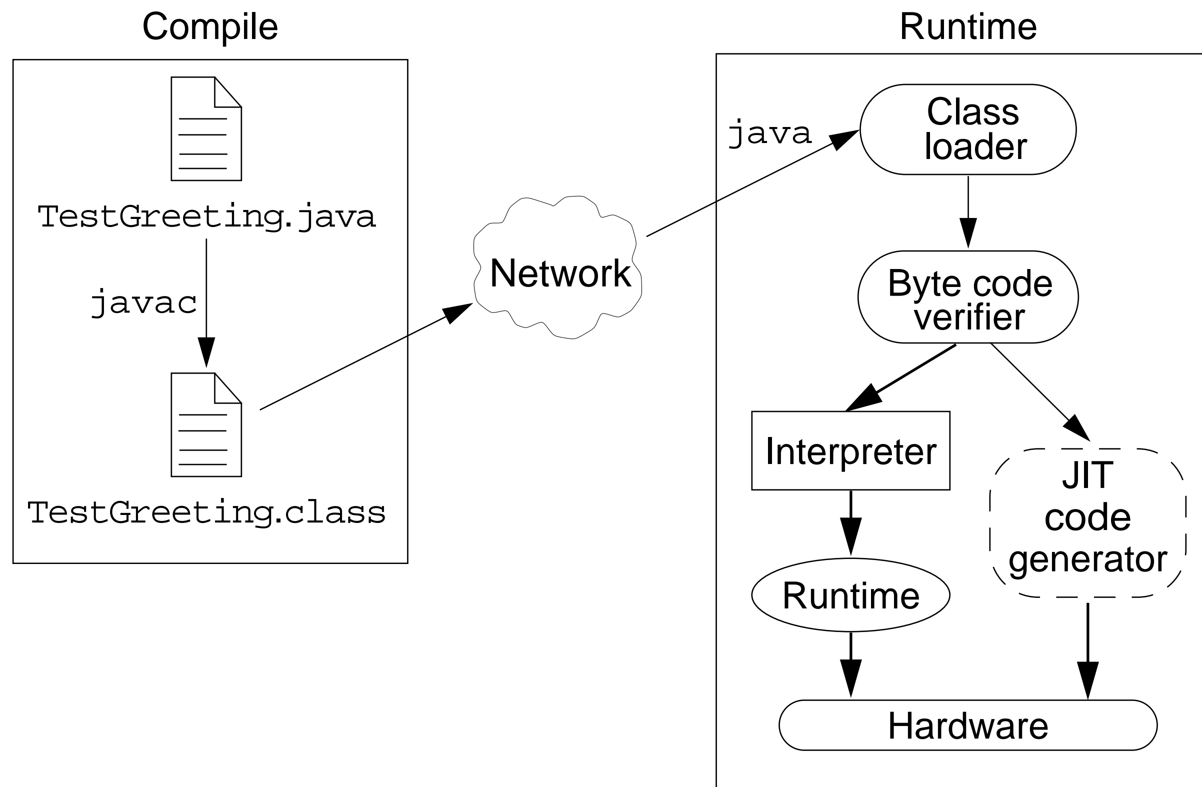
Just-In-Time Code Generator



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Java Runtime Environment

- Performs three main tasks:
  - Loads code
  - Verifies code
  - Executes code

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Class Loader

- Loads all classes necessary for the execution of a program
- Maintains classes of the local file system in separate "namespaces"
- Prevents spoofing

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Bytecode Verifier

Ensures that:

- The code adheres to the JVM specification
- The code does not violate system integrity
- The code causes no operand stack overflows or underflows
- The parameter types for all operational code are correct
- No illegal data conversions (the conversion of integers to pointers) have occurred

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Exercise: Performing Basic Java Tasks

- Exercise objectives:
  - Write, compile, and run a simple application
- Tasks:
  - Explore compile and runtime errors
  - Create a Java application

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Check Your Progress

- Describe key features of Java technology
- Define the terms *class* and *applications*
- Write, compile, and run a simple Java application
- Describe the Java virtual machine's (JVM) function
- Describe how garbage collection works
- List the three tasks performed by the Java platform that handle code security

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Think Beyond

- How can you benefit from using this programming language in your work environment?

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Module 2

Object-Oriented Programming

Objectives

- Define modeling concepts: *abstraction*, *encapsulation*, and *packages*
- Discuss why Java application code is reusable
- Define *class*, *member*, *attribute*, *method*, *constructor*, and *package*
- Use the access modifiers `private` and `public` as appropriate for the guidelines of encapsulation
- Invoke a method on a particular object

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Objectives

- In a Java program, identify the following:
  - The `package` statement
  - The `import` statements
  - Classes, methods, and attributes
  - Constructors
- Use the Java technology application programming interface (API) online documentation

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Relevance

- What is your understanding of software analysis and design?
- What is your understanding of design and code reuse?
- What features does the Java programming language possess to make it an object-oriented language?
- What does the term *object-oriented* really mean?

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Software Engineering

Toolkits / Frameworks / Object APIs (90's - up)				
Java 2 SDK	AWT / Swing	Jini	Java Beans	JDBC

Object-Oriented Languages (80's - up)					
SELF	Smalltalk	Common Lisp Object System	Effiel	C++	Java

Libraries / Functional APIs (60's - early 80's)				
NASTRAN	TCP/IP	ISAM	X-Windows	OpenLook

High-Level Languages (50's - up)				Operating Systems (60's - up)			
Fortran	LISP	C	COBOL	OS/360	UNIX	MacOS	MS-Windows

Machine Code (late 40's - up)

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Analysis and Design

- Analysis describes *what* the system needs to do
  - Modeling the real-world: actors and activities, objects and behaviors
- Design describes *how* the system does it
  - Modeling the relationships and interactions between objects and actors in the system
  - Finding useful abstractions to help simplify the problem or solution

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Abstraction

- Functions – Write an algorithm once to be used in many situations
- Objects – Group a related set of attributes and behaviors into a class
- Frameworks and APIs – Large groups of objects that support a complex activity
  - Frameworks can be used "as is" or be modified to extend the basic behavior

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Classes as Blueprints for Objects

- In manufacturing, a blueprint is a description of a device from which many physical devices are constructed
- In software, a class is a description of an object:
  - A class describes the data that each object includes
  - A class describes the behaviors that each object exhibits
- In Java, classes support three key features of OOP:
  - encapsulation
  - inheritance
  - polymorphism

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Declaring Java Classes

- Basic syntax of a Java class:

```
<class_declaration> ::=
  <modifier> class <name> {
    <attribute_declaration>*
    <constructor_declaration>*
    <method_declaration>*
  }
```

- Example:

```
public class Vehicle {
  private double maxLoad;
  public void setMaxLoad(double value) {
    maxLoad = value;
  }
}
```


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Declaring Attributes

- Basic syntax of an attribute:

```
<attribute_declaration> ::=
  <modifier> <type> <name> [= <default_value>];

<type> ::= byte | short | int | long | char
           float | double | boolean | <class>
```

- Examples:

```
public class Foo {
  public  int     x;
  private float   y = 10000.0F;
  private String name = "Fred Flintstone";
}
```


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Declaring Methods

- Basic syntax of a method:

```
<method_declaration> ::=
   <modifier> <return_type> <name> (<parameter>*) {
      <statement>*
   }
<parameter> ::= <parameter_type> <parameter_name>,
```

- Examples:

```
public class Thing {
   private int x;
   public int getX() {
      return x;
   }
   public void setX(int new_x) {
      x = new_x;
   }
}
```


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Accessing Object Members

- The "dot" notation: *<object>.<member>*
- This is used to access object members including attributes and methods
- Examples:

```
thing1.setX(47);
thing1.x = 47;   // only permissible if x is public
```


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Information Hiding

The Problem:

MyDate
+day : int +month : int +year : int

Client code has direct access to internal data:

```
MyDate d = new MyDate()

d.day = 32;
// invalid day

d.month = 2; d.day = 30;
// plausible but wrong

d.day = d.day + 1;
// no check for wrap around
```


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Information Hiding

The Solution:

MyDate
-day : int -month : int -year : int
+getDay() : int +getMonth() : int +getYear() : int +setDay(d : int) : boolean +setMonth(m : int) : boolean +setYear(y : int) : boolean -validDay(d: int) : boolean

verify days in month

Client code must use setters/getters to access internal data:

```
MyDate d = new MyDate()

d.setDay(32);
// invalid day, returns false

d.setMonth(2);
d.setDay(30);
// plausible but wrong, setDay returns false

d.setDay(d.getDay() + 1);
// this will return false if wrap around
// needs to occur
```


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Encapsulation

- Hides the implementation details of a class
- Forces the user to use an interface to access data
- Makes the code more maintainable

MyDate
-date : long
+getDay() : int +getMonth() : int +getYear() : int +setDay(d : int) : boolean +setMonth(m : int) : boolean +setYear(y : int) : boolean -validDay(d: int) : boolean

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Declaring Constructors

- Basic syntax of a constructor:

```
<constructor_declaration> ::=
   <modifier> <class_name> (<parameter>*) {
      <statement>*
   }
```

- Examples:

```
public class Thing {
   private int x;
   public Thing() {
      x = 47;
   }
   public Thing(int new_x) {
      x = new_x;
   }
}
```


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Declaring Constructors

```
public class Thing {
  private int x;
  public Thing() {
    x = 47;
  }
  public Thing(int new_x) {
    x = new_x;
  }
  public int getX() {
    return x;
  }
  public void setX(int new_x) {
    x = new_x;
  }
}
```

Example usage:

```
public class TestThing {
  public static void main(String[] args) {
    Thing  thing1 = new Thing();
    Thing  thing2 = new Thing(42);

    System.out.println("thing1.x is " + thing1.getX());
    System.out.println("thing2.x is " + thing2.getX());
  }
}
```

Output:

```
thing1.x is 47
thing2.x is 42
```


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The Default Constructor

- There is always at least one constructor in every class
- If the writer does not supply any constructors, the default constructor will be present automatically
  - The default constructor takes no arguments
  - The default constructor has no body
- Enables you to create object instances with `new` *`Xxx`*`()` without having to write a constructor

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Source File Layout

- Basic syntax of a Java source file:

```
<source_file> ::=
  [<package_declaration>]
  <import_declaration>*
  <class_declaration>+
```

- Example, the `VehicleCapacityReport.java` file:

```
package shipping.reports.Web;

import shipping.domain.*;
import java.util.List;
import java.io.*;

public class VehicleCapacityReport {
  private List  vehicles;
  public void generateReport(Writer output) {...}
}
```


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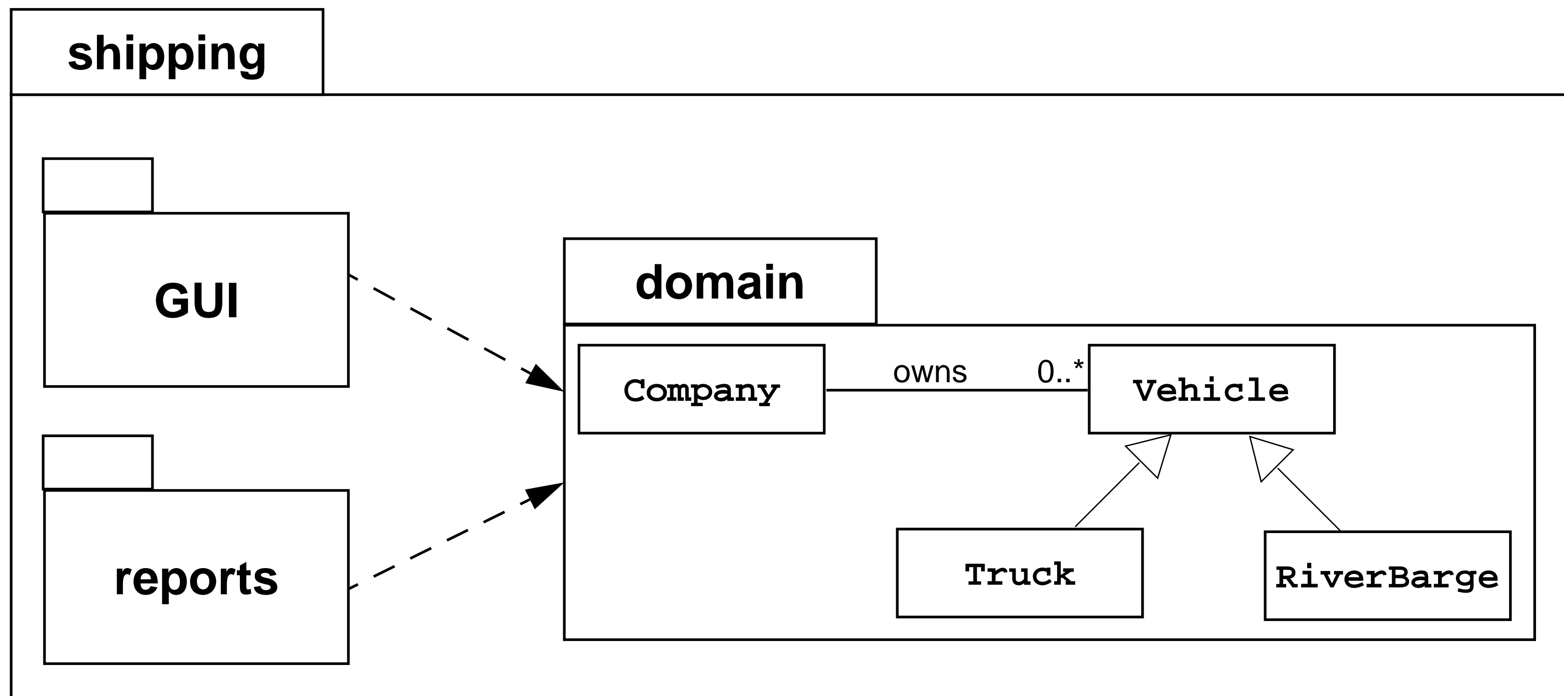
Software Packages

- Packages help manage large software systems
- Packages can contain classes and sub-packages



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The package Statement

- Basic syntax of the package statement:

```
<package_declaration> ::=
  package <top_pkg_name>[.<sub_pkg_name>]*;
```

- Example:

```
package shipping.reports.Web;
```

- Specify the package declaration at the beginning of the source file
- Only one package declaration per source file
- If no package is declared, then the class "belongs" to the default package
- Package names must be hierarchical and separated by dots

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The `import` Statement

- Basic syntax of the package statement:

```
<import_declaration> ::=
  import <pkg_name>[.<sub_pkg_name>]*.<class_name | *>;
```

- Examples:

```
import shipping.domain.*;
import java.util.List;
import java.io.*;
```

- Precedes all class declarations
- Tells the compiler where to find classes to use

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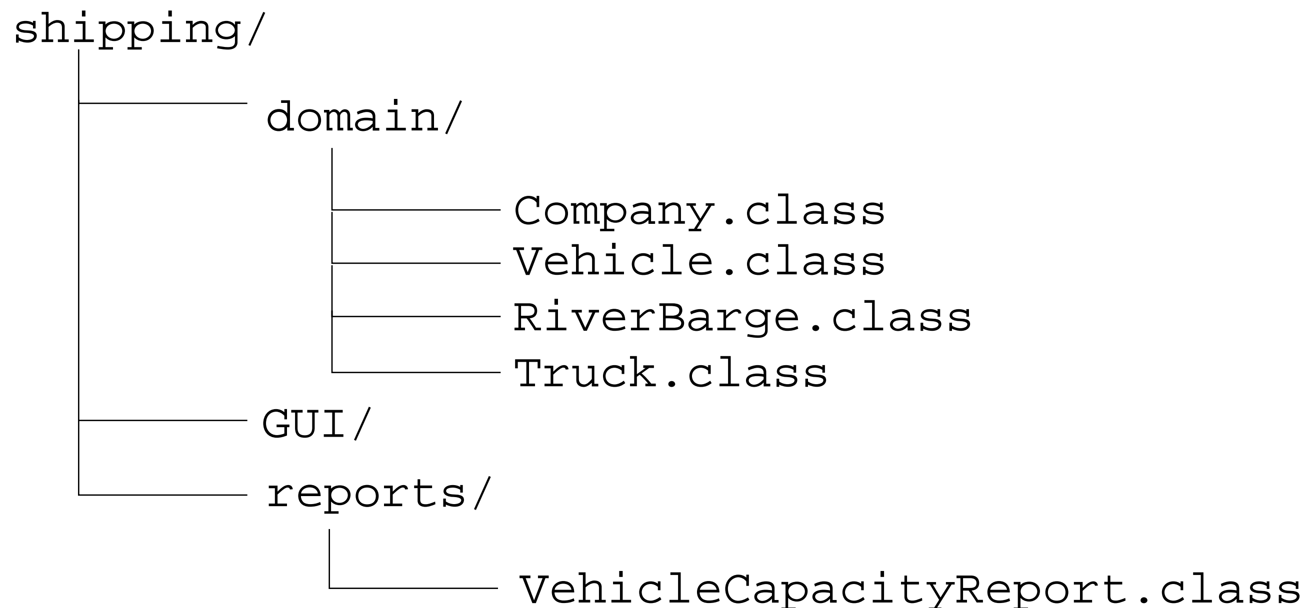
Directory Layout and Packages

- Packages are stored in the directory tree containing the package name
- Example, the "shipping" application packages:



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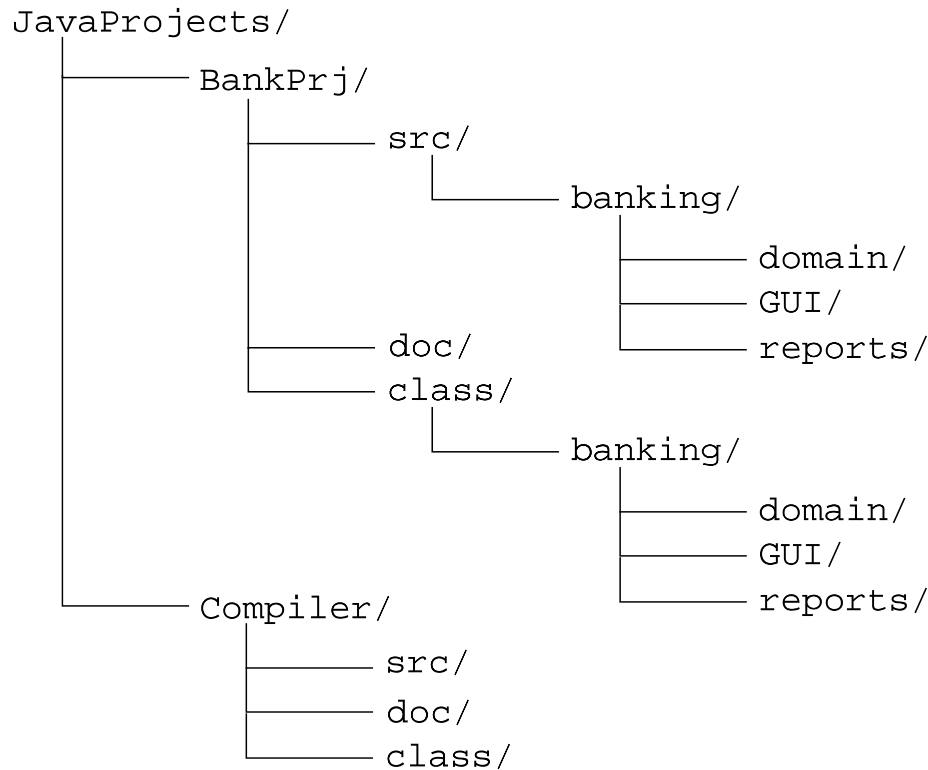
Directory Layout and Packages



Compiling using `-sourcepath` and `-d`

```
> cd JavaProjects/BankPrj/src/banking/domain
> javac -sourcepath JavaProjects/BankPrj/src
        -d JavaProjects/BankPrj/class *.java
```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Terminology Recap

- Class – The source-code blueprint for a run-time object
- Object – An entity of a class
  AKA: instance
- Attribute – A data element of an object
  AKA: data member, instance variable, data field
- Method – A behavioral element of an object
  AKA: algorithm, function, procedure
- Constructor – A "method-like" construct used to initialize a new object
- Package – A grouping of classes and/or sub-packages

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Using the Java API Documentation

- A set of hypertext markup language (HTML) files provides information about the API
- One package contains hyperlinks to information on all of the classes
- A class document includes the class hierarchy, a description of the class, a list of member variables, a list of constructors, and so on

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Example API Documentation Page

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Exercise: Using Objects and Classes

- Exercise objectives:
  - Become familiar with the Java 2 SDK API
  - Using the correct Java keywords, create a class and an object from the class
  - Compile and run a program
- Tasks:
  - Use a browser to explore the Java 2 SDK API
  - Explore encapsulation
  - Create the basic `Account` class for the Banking project

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Check Your Progress

- Define modeling concepts: *abstraction*, *encapsulation*, and *packages*
- Discuss why Java application code is reusable
- Define *class*, *member*, *attribute*, *method*, *constructor*, and *package*
- Use the access modifiers `private` and `public` as appropriate for the guidelines of encapsulation
- Invoke a method on a particular object

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Check Your Progress

- In a Java software program, identify the following:
  - The `package` statement
  - The `import` statements
  - Classes, methods, and attributes
  - Constructors
- Use the Java technology application programming interface (API) online documentation

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Think Beyond

- Does your organization spend enough time on analysis and design?
- What domain objects and relationships appear in your existing applications?

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Module 3

Identifiers, Keywords, and Types

Objectives

- Use comments in a source program
- Distinguish between valid and invalid identifiers
- Recognize Java technology keywords
- List the eight primitive types
- Define literal values for numeric and textual types
- Define the terms *primitive variable* and *reference variable*

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Objectives

- Declare variables of class type
- Construct an object using `new`
- Describe default initialization
- Describe the significance of a reference variable
- State the consequences of assigning variables of class type

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Relevance

- Do you know the primitive Java types?
- Can you describe the difference between variables holding primitive values as compared with object references?

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Comments

- Three permissible styles of comment in a Java technology program are:

```
// comment on one line

/* comment on one
or more lines */

/** documentation comment */
```


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Semicolons, Blocks, and Whitespace

- A *statement* is one or more lines of code terminated by a semicolon (`;`):

```
totals = a + b + c
         + d + e + f;
```

- A *block* is a collection of statements bound by opening and closing braces:

```
{
  x = y + 1;
  y = x + 1;
}
```


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Semicolons, Blocks, and Whitespace

- You can use a *block* in a *class* definition:

```
public class MyDate {
   private int day;
   private int month;
   private int year;
}
```

- You can nest block statements
- Any amount of *whitespace* is allowed in a Java program

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Identifiers

- Are names given to a variable, class, or method
- Can start with a Unicode letter, underscore(_), or dollar sign($)
- Are case sensitive and have no maximum length
- Examples:

```
identifier
userName
user_name
_sys_var1
$change
```


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Java Keywords

abstract	do	implements	private	this
boolean	double	import	protected	throw
break	else	instanceof	public	throws
byte	extends	int	return	transient
case	false	interface	short	true
catch	final	long	static	try
char	finally	native	strictfp	void
class	float	new	super	volatile
continue	for	null	switch	while
default	if	package	synchronized	

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Primitive Types

- The Java programming language defines eight primitive types:
  - Logical `boolean`
  - Textual `char`
  - Integral `byte`, `short`, `int`, and `long`
  - Floating `double` and `float`

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Logical – boolean

- The boolean data type has two literals, true and false.
- For example, the statement:

```
boolean truth = true;
```

declares the variable truth as boolean type and assigns it a value of true.

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Textual – `char` and `String`

`char`

- Represents a 16-bit Unicode character
- Must have its literal enclosed in single quotes(’ ’)
- Uses the following notations:

`'a'`	The letter *a*
`'\t'`	A tab
`'\u????'`	A specific Unicode character, `????`, is replaced with exactly four hexadecimal digits (for example, `’\u03A6’` is the Greek letter phi Φ)

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Textual – char and String

String

- Is not a primitive data type; it is a class
- Has its literal enclosed in double quotes (" ")

```
"The quick brown fox jumps over the lazy dog."
```

- Can be used as follows:

```
String greeting = "Good Morning !! \n";
String errorMessage = "Record Not Found !";
```


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Integral – `byte`, `short`, `int`, and `long`

- Uses three forms – Decimal, octal, or hexadecimal

`2`	The decimal value is two
`077`	The leading zero indicates an octal value
`0xBAAC`	The leading 0x indicates a hexadecimal value

- Has a default `int`
- Defines `long` by using the letter `L` or `l`

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Integral – `byte`, `short`, `int`, and `long`

- Integral data types have the following ranges:

Integer Length	Name or Type	Range
8 bits	`byte`	-2^{7} to $2^{7}-1$
16 bits	`short`	-2^{15} to $2^{15}-1$
32 bits	`int`	-2^{31} to $2^{31}-1$
64 bits	`long`	-2^{63} to $2^{63}-1$

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Floating Point – `float` and `double`

- Default is `double`
- Floating point literal includes either a decimal point or one of the following:
  - `E` or `e` (add exponential value)
  - `F` or `f` (`float`)
  - `D` or `d` (`double`)

`3.14`	A simple floating-point value (a `double`)
`6.02E23`	A large floating-point value
`2.718F`	A simple `float` size value
`123.4E+306D`	A large `double` value with redundant *D*

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Floating Point – `float` and `double`

- Floating point data types have the following ranges:

Float Length	Name or Type
32 bits	`float`
64 bits	`double`

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Variables, Declarations, and Assignments

```
1  public class Assign {
2    public static void main(String args []) {
3
4      int x, y; // declare int variables
5      float z = 3.414f;// declare and assign float
6      double w = 3.1415;// declare and assign double
7      boolean truth = true;// declare and assign boolean
8      char c;// declare character variable
9      String str;// declare String
10     String str1 = "bye";// declare and assign String variable
11     c = 'A';// assign value to char variable
12     str = "Hi out there!";// assign value to String variable
13     x = 6;
14     y = 1000;// assign values to int variables
15   ...
16   }
17 }
```


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Java Reference Types

- Beyond primitive types all others are reference types
- A *reference variable* contains a "handle" to an object
- Example:

```
1   public class MyDate {
2     private int day = 1;
3     private int month = 1;
4     private int year = 2000;
5   }
```

```
1   public class TestMyDate {
2     public static void main(String[] args) {
3       MyDate today = new MyDate();
4     }
5   }
```


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Constructing and Initializing Objects

- Calling `new Xxx()` to allocate space for the new object results in:
  - Memory Allocation: Space for the new object is allocated and instance variables are initialized to their default values (e.g. `0`, `false`, `null`, and so on)
  - Explicit attribute initialization is performed
  - A constructor is executed
  - Variable assignment is made to reference the object
- Example:

```
MyDate my_birth = new MyDate(22, 7, 1964);
```


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Memory Allocation and Layout

- A declaration allocates storage only for a reference:

```
MyDate my_birth = new MyDate(22, 7, 1964);
```

my_birth	????

- Use the `new` operator to allocate space for `MyDate`:

```
MyDate my_birth = new MyDate(22, 7, 1964);
```

my_birth	????
day	0
month	0
year	0

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Explicit Attribute Initialization

- Initialize the attributes:

```
MyDate my_birth = new MyDate(22, 7, 1964);
```

my_birth	????
day	1
month	1
year	2000

- The default values are taken from the attribute declaration in the class

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Executing the Constructor

- Execute the matching constructor:

```
MyDate my_birth = new MyDate(22, 7, 1964);
```

my_birth	????

day	22
month	7
year	1964

- In the case of an overloaded constructor, the first constructor may call another

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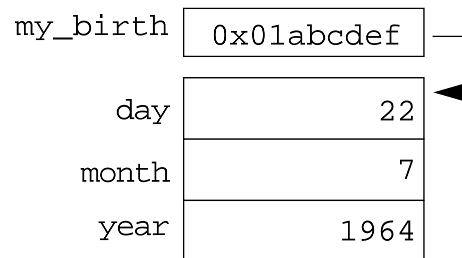
Variable Assignment

- Assign newly created object to reference variable:

```
MyDate my_birth = new MyDate(22, 7, 1964);
```



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Assignment of Reference Variables

- Consider the following code fragment:

```
int x = 7;
int y = x;
MyDate s = new MyDate(22, 7, 1964);
MyDate t = s;
t = new MyDate(22, 12, 1964);
```


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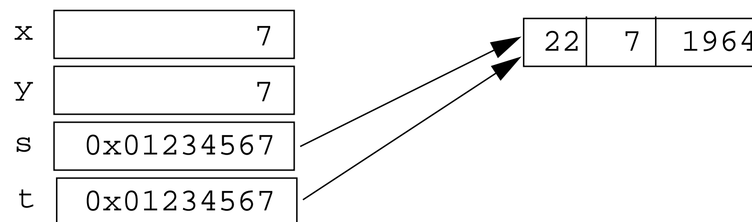
Assignment of Reference Variables

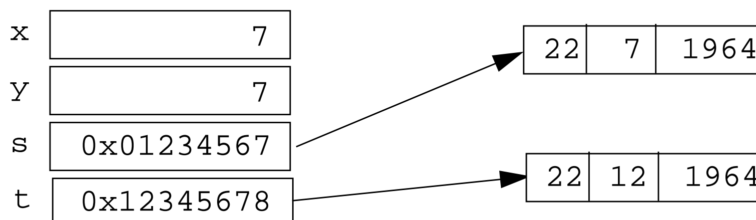
```
int x = 7;
int y = x;
MyDate s = new MyDate(22, 7, 1964);
MyDate t = s;
```

- Two variables refer to a single object




```
t = new MyDate(22, 12, 1964);
```

- Reassignment makes two variables point to two objects



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Pass-by-Value

- The Java programming language only passes arguments by value
- When an object instance is passed as an argument to a method, the value of the argument is a *reference* to the object
- The *contents* of the object can be changed in the called method, but the object reference is never changed

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Pass-by-Value

```
1   public class PassTest {
2
3     // Methods to change the current values
4     public static void changeInt(int value) {
5       value = 55;
6     }
7     public static void changeObjectRef(MyDate ref) {
8       ref = new MyDate(1, 1, 2000);
9     }
10    public static void changeObjectAttr(MyDate ref) {
11      ref.setDay(4);
12    }
13
14    public static void main(String args[]) {
15      MyDate date;
16      int val;
17
18      // Assign the int
19      val = 11;
20      // Try to change it
21      changeInt(val);
22      // What is the current value?
23      System.out.println("Int value is: " + val);
24
25      // Assign the date
26      date = new MyDate(22, 7, 1964);
27      // Try to change it
28      changeObjectRef(date);
29      // What is the current value?
30      date.print();
31
32      // Now change the day attribute
33      // through the object reference
34      changeObjectAttr(date);
35      // What is the current value?
36      date.print();
37    }
38  }
39
```


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The `this` Reference

Here are a few uses of the `this` keyword:

- To reference local attribute and method members within a local method or constructor
  - This is used to disambiguate a local method or constructor variable from an instance variable
- To pass the current object as a parameter to another method or constructor

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The `this` Reference

```
1   public class MyDate {
2     private int day = 1;
3     private int month = 1;
4     private int year = 2000;
5
6     public MyDate(int day, int month, int year) {
7       this.day   = day;
8       this.month = month;
9       this.year  = year;
10    }
11    public MyDate(MyDate date) {
12      this.day   = date.day;
13      this.month = date.month;
14      this.year  = date.year;
15    }
16
17    public MyDate addDays(int more_days) {
18      MyDate new_date = new MyDate(this);
19
20      new_date.day = new_date.day + more_days;
21      // Not Yet Implemented: wrap around code...
22
23      return new_date;
24    }
25    public void print() {
26      System.out.println("MyDate: " + day + "-" + month +
27                         "-" + year);
28    }
29  }
```

```
1   public class TestMyDate {
2     public static void main(String[] args) {
3       MyDate my_birth = new MyDate(22, 7, 1964);
4       MyDate the_next_week = my_birth.addDays(7);
5
6       the_next_week.print();
7     }
8   }
```


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Java Coding Conventions

- Packages:

```
package banking.domain;
```

- Classes:

```
class SavingsAccount
```

- Interfaces:

```
interface Account
```

- Methods:

```
balanceAccount()
```


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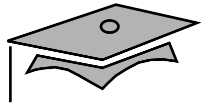

Java Coding Conventions

- Variables:

```
currentCustomer
```

- Constants:

```
HEAD_COUNT
MAXIMUM_SIZE
```


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Exercise: Using Identifiers, Keywords, and Types

- Exercise objectives:
  - Verify that the references are assigned and manipulated as described in this module
- Tasks:
  - Investigate reference assignments
  - Extend the Banking project to use object references

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Check Your Progress

- Use comments in a source program
- Distinguish between valid and invalid identifiers
- Recognize Java technology keywords
- List the eight primitive types
- Define literal values for numeric and textual types
- Define the terms *primitive variable* and *reference variable*

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Check Your Progress

- Declare variables of class type
- Construct an object using `new`
- Describe default initialization
- Describe the significance of a reference variable
- State the consequences of assigning variables of class type

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Think Beyond

- Can you think of examples of classes and objects in your existing applications?

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Module 4

Expressions and Flow Control

Objectives

- Distinguish between instance and local variables
- Describe how instance variables are initialized
- Identify and correct a `Possible reference before assignment` compiler error
- Recognize, describe, and use Java software operators
- Distinguish between legal and illegal assignments of primitive types

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Objectives

- Identify `boolean` expressions and their requirements in control constructs
- Recognize assignment compatibility and required casts in fundamental types
- Use `if`, `switch`, `for`, `while`, and `do` constructions and the labeled forms of `break` and `continue` as flow control structures in a program

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Relevance

- What types of variables are useful to programmers?
- Can multiple classes have variables with the same name and, if so, what is their scope?
- What types of control structures are used in other languages? What methods do these languages use to control flow?

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Variables and Scope

Local variables are:

- Variables that are defined inside a method and are called *local*, *automatic*, *temporary*, or *stack* variables
- Variables that are created when the method is executed are destroyed when the method is exited
- Variables that must be initialized before they are used or compile-time errors will occur

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Variable Scope Example

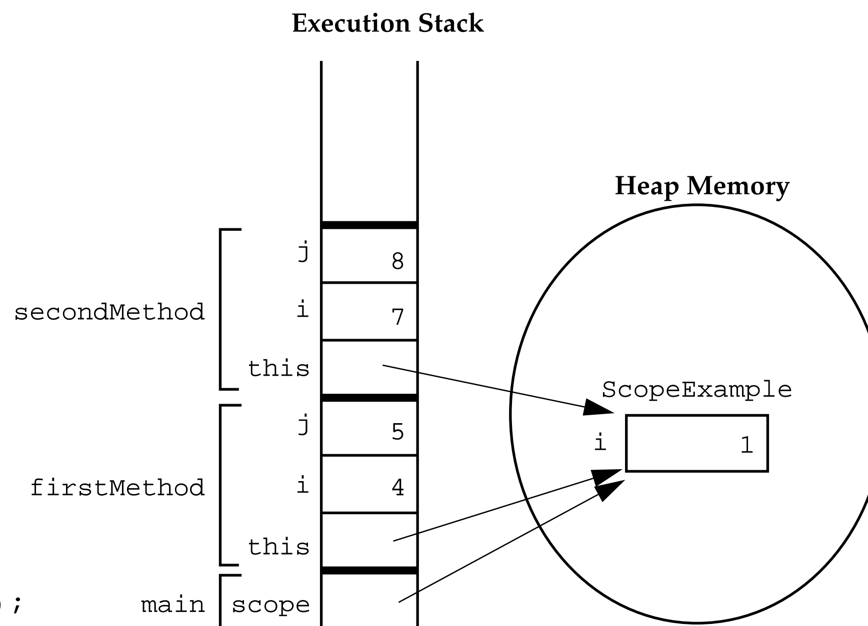
```
public class ScopeExample {
  private int i=1;

  public void firstMethod() {
    int i=4, j=5;

    this.i = i + j;
    secondMethod(7);
  }
  public void secondMethod(int i) {
    int j=8;
    this.i = i + j;
  }
}

public class TestScoping {
  public static void main(String[] args) {
    ScopeExample scope = new ScopeExample();

    scope.firstMethod();
  }
}
```



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Variable Initialization

Variable	**Value**
`byte`	`0`
`short`	`0`
`int`	`0`
`long`	`0L`
`float`	`0.0f`
`double`	`0.0d`
`char`	`'\u0000'`
`boolean`	`false`
All reference types	`null`

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Operators

<table>
<tr><td>Separator</td><td>.   [ ]   ( )   ;   ,</td></tr>
</table>

<table>
<tr><th>Associative</th><th>Operators</th></tr>
<tr><td>R to L</td><td>++ -- + - ~ ! (data type)</td></tr>
<tr><td>L to R</td><td>* / %</td></tr>
<tr><td>L to R</td><td>+ -</td></tr>
<tr><td>L to R</td><td><< >> >>></td></tr>
<tr><td>L to R</td><td>< > <= >= instanceof</td></tr>
<tr><td>L to R</td><td>== !=</td></tr>
<tr><td>L to R</td><td>&</td></tr>
<tr><td>L to R</td><td>^</td></tr>
<tr><td>L to R</td><td>|</td></tr>
<tr><td>L to R</td><td>&&</td></tr>
<tr><td>L to R</td><td>||</td></tr>
<tr><td>R to L</td><td>?:</td></tr>
<tr><td>R to L</td><td>= *= /= %= += -= <<=
>>= >>>= &= ^= |=</td></tr>
</table>

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Logical Operators

- The boolean operators are:

```
! - NOT            & - AND
| - OR             ^ - XOR
```

- The Short-Circuit boolean operators are:

```
&& - AND           || - OR
```

- These operators can be used as follows:

```
MyDate d;
if ((d != null) && (d.day > 31)) {
  // do something with d
}
```


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Bitwise Logical Operators

- The Integer *bitwise* operators are:

```
~ - Complement        & - AND
^ - XOR               | - OR
```

- Byte-sized examples:

~	0	1	0	0	1	1	1	1
	1	0	1	1	0	0	0	0

	0	0	1	0	1	1	0	1
&	0	1	0	0	1	1	1	1
	0	0	0	0	1	1	0	1

	0	0	1	0	1	1	0	1
^	0	1	0	0	1	1	1	1
	0	1	1	0	0	0	1	0

	0	0	1	0	1	1	0	1
		0	1	0	0	1	1	1	1
	0	1	1	0	1	1	1	1

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Right-Shift Operators >> and >>>

- *Arithmetic* or *signed* right shift `(>>)` is used as follows:

```
128 >> 1 returns 128/2^1 = 64
256 >> 4 returns 256/2^4 = 16
-256 >> 4 returns -256/2^4 = -16
```

  - The sign bit is copied during the shift
- A *logical* or *unsigned right shift* operator (>>>) is:
  - Used for bit patterns
  - Not copied during the shift

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Left-Shift Operator (<<)

- Left-shift works as follows:

```
128 << 1 returns 128 * 2^1 = 256
16  << 2 returns 16 * 2^2 = 64
```


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Shift Operator Examples

`1357 =`	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1
`-1357 =`	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	1	1
`1357 >> 5 =`	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
`-1357 >> 5 =`	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
`1357 >>> 5 =`	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
`-1357 >>> 5 =`	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
`1357 << 5 =`	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1	0	0	0	0	0
`-1357 << 5 =`	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	1	1	0	0	0	0	0

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String Concatenation With +

- The + operator:
  - Performs `String` concatenation
  - Produces a new `String`:

```
String salutation = "Dr.";
String name = "Pete" + " " + "Seymour";
String title = salutation + " " + name;
```

- One argument must be a `String` object
- Non-strings are converted to `String` objects automatically

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Casting

- If information is lost in an assignment, the programmer must confirm the assignment with a typecast.
- The assignment between `long` and `int` requires an explicit cast.

```
long bigValue = 99L;
int squashed = bigValue; // Wrong, needs a cast
int squashed = (int) bigValue; // OK

int squashed = 99L; // Wrong, needs a cast
int squashed = (int) 99L; // OK, but...
int squashed = 99;  // default integer literal
```


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Promotion and Casting of Expressions

- Variables are automatically promoted to a longer form (such as `int` to `long`).
- Expression is *assignment compatible* if the variable type is at least as large (the same number of bits) as the expression type.

```
long bigval = 6;    // 6 is an int type, OK
int smallval = 99L; // 99L is a long, illegal

double z = 12.414F;  // 12.414F is float, OK
float z1 = 12.414;   // 12.414 is double, illegal
```


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Branching Statements

The `if, else` statement syntax:

```
if (boolean expression) {
   statement or block;
}

if (boolean expression) {
  statement or block;
} else if (boolean expression) {
  statement or block;
} else {
  statement or block;
}
```


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Branching Statements

An `if`, `else` statement example:

```
int count;
count = getCount(); // a method defined in the program
if (count < 0) {
  System.out.println("Error: count value is negative.");
} else if (count > getMaxCount()) {
  System.out.println("Error: count value is too big.");
} else {
  System.out.println("There will be " + count +
                     " people for lunch today.");
}
```


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Branching Statements

The `switch` statement syntax:

```
switch (expr1) {
   case constant2:
      statements;
      break;
   case constant3:
      statements;
      break;
   default:
      statements;
      break;
}
```


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Branching Statements

A `switch` statement example:

```
switch ( carModel ) {
  case DELUXE:
    addAirConditioning();
    addRadio();
    addWheels();
    addEngine();
    break;
  case STANDARD:
    addRadio();
    addWheels();
    addEngine();
    break;
  default:
    addWheels();
    addEngine();
}
```


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Branching Statements

A `switch` statement example:

```
switch ( carModel ) {
  case THE_WORKS:
    addGoldPackage();
    add7WayAdjustableSeats();
  case DELUXE:
    addFloorMats();
    addAirConditioning();
  case STANDARD:
    addRadio();
    addDefroster();
  default:
    addWheels();
    addEngine();
}
```


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Looping Statements

The `for` statement:

```
for (init_expr; boolean testexpr; alter_expr) {
  statement or block;
}
```

Example:

```
for (int i = 0; i < 10; i++) {
     System.out.println("Are you finished yet?");
}
System.out.println("Finally!");
```


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Looping Statements

The `while` loop:

```
while (boolean) {
   statement or block;
}
```

Example:

```
int i = 0;

while (i < 10) {
   System.out.println("Are you finished yet?");
   i++;
}
System.out.println("Done");
```


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Looping Statements

The `do/while` statement:

```
do {
   statement or block;
} while (boolean test);
```

Example:

```
int i = 0;

do {
   System.out.println("Are you finished yet?");
   i++;
} while (i < 10);
System.out.println("Done");
```


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Special Loop Flow Control

- `break [label];`
- `continue [label];`
- `label: statement; // Where statement should`
  `// be a loop`

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Special Loop Flow Control

The `break` statement:

```
do {
  statement;
  if (condition is true) {
    break;
  }
  statement;
} while (boolean expression);
```


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Special Loop Flow Control

The `continue` statement:

```
do {
  statement;
  if (condition is true) {
    continue;
  }
  statement;
} while (boolean expression);
```


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Special Loop Flow Control

Using break with labels:

```
outer:
  do {
    statement;
    do {
      statement;
      if (boolean expression) {
        break outer;
      }
      statement;
    } while (boolean expression);
    statement;
  } while (boolean expression);
```


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Special Loop Flow Control

Using `continue` with labels:

```
test:
  do {
    statement;
    do {
      statement;
      if (condition is true) {
        continue test;
      }
      statement;
    } while (condition is true);
    statement;
  } while (condition is true);
```


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Exercise: Using Expressions

- Exercise objective:
  - Write, compile, and run three programs that use identifiers, expressions, and control structures
- Tasks:
  - Use a loop
  - Modify the `Account` class `withdraw` method
  - Use nested loops and special control flow

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Check Your Progress

- Distinguish between instance and local variables
- Describe how instance variables are initialized
- Identify and correct a `Possible reference before assignment` compiler error
- Recognize, describe, and use Java operators
- Distinguish between legal and illegal assignments of primitive types

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Check Your Progress

- Identify `boolean` expressions and their requirements in control constructs
- Recognize assignment compatibility and required casts in fundamental types
- Use `if`, `switch`, `for`, `while`, and `do` constructions and the labeled forms of `break` and `continue` as flow control structures in a program

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Think Beyond

- What data types do most programming languages use to group similar data elements together?
- How do you perform the same operation on all elements of a group (for example, a matrix)?
- What data types does the Java programming language use?

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Module 5

Arrays

Objectives

- Declare and create arrays of primitive, class, or array types
- Explain why elements of an array are initialized
- Explain how to initialize the elements of an array
- Determine the number of elements in an array
- Create a multi-dimensional array
- Write code to copy array values from one array type to another

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Relevance

- What is the purpose of an array?

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Declaring Arrays

- Group data objects of the same type
- Declare arrays of primitive or class types

```
char s[];
Point p[];

char [] s;
Point [] p;
```

- Create space for a reference
- An array is an object; it is created with `new`

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Creating Arrays

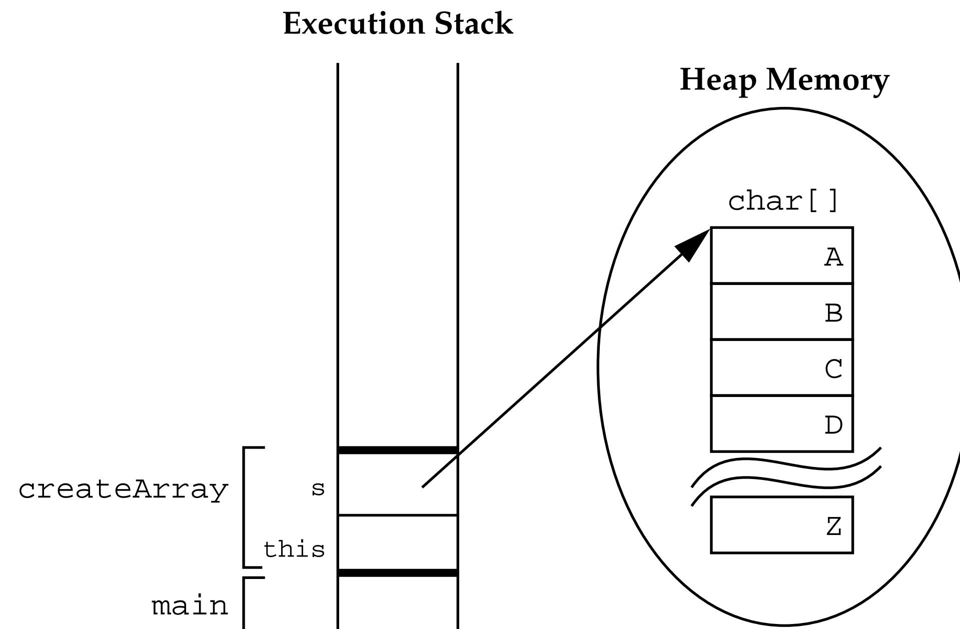
Use the new keyword to create an array object.

For example, a primitive (char) array:

```
public char[] createArray() {
  char[] s;

  s = new char[26];
  for ( int i=0; i<26; i++ ) {
    s[i] = 'A' + i;
  }

  return p;
}
```



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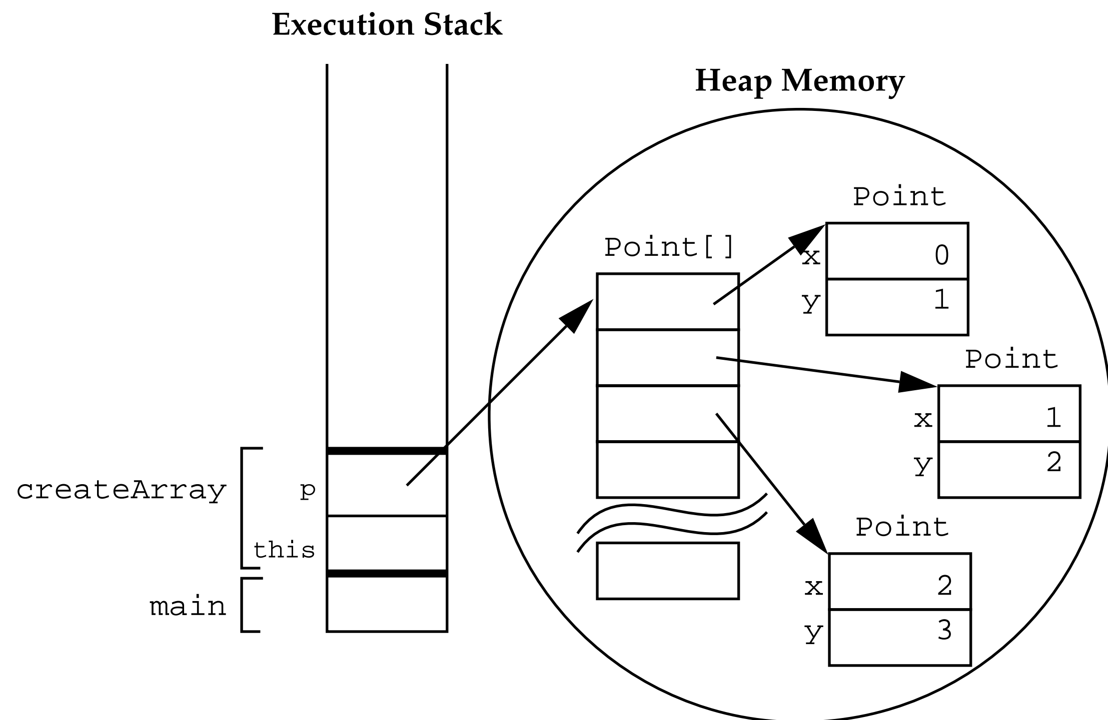
Creating Arrays

Another example, an object array:

```
public Point[] createArray() {
  Point[] p;

  p = new char[10];
  for ( int i=0; i<10; i++ ) {
    p[i] = new Point(i, i+1);
  }

  return p;
}
```



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Initializing Arrays

- Initialize an array element
- Create an array with initial values:

```
String names[];
names = new String[3];
names[0] = "Georgianna";
names[1] = "Jen";
names[2] = "Simon";
```

```
String names[] = {
    "Georgianna",
    "Jen",
    "Simon"
};
```

```
MyDate dates[];
dates = new MyDate[3];
dates[0] = new MyDate(22, 7, 1964);
dates[1] = new MyDate(1, 1, 2000);
dates[2] = new MyDate(22, 12, 1964);
```

```
MyDate dates[] = {
    new MyDate(22, 7, 1964),
    new MyDate(1, 1, 2000),
    new MyDate(22, 12, 1964)
};
```


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Multi-Dimensional Arrays

- Arrays of arrays:

```
int twoDim [][] = new int [4][];
twoDim[0] = new int[5];
twoDim[1] = new int[5];

int twoDim [][] = new int [][4]; illegal
```


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Multi-Dimensional Arrays

- Non-rectangular arrays of arrays:

```
twoDim[0] = new int[2];
twoDim[1] = new int[4];
twoDim[2] = new int[6];
twoDim[3] = new int[8];
```

- Array of four arrays of five integers each:

```
int twoDim[][] = new int[4][5];
```


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Array Bounds

All array subscripts begin at 0:

```
int list[] = new int [10];
for (int i = 0; i < list.length; i++) {
  System.out.println(list[i]);
}
```


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Array Resizing

- Cannot resize an array
- Can use the same reference variable to refer to an entirely new array:

```
int elements[] = new int[6];
elements = new int[10];
```


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Copying Arrays

The `System.arraycopy()` method:

```
1   //original array
2   int elements[] = { 1, 2, 3, 4, 5, 6 };
3
4   // new larger array
5   int hold[] = { 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 };
6
7   // copy all of the elements array to the hold
8   // array, starting with the 0th index
9   System.arraycopy(elements, 0, hold, 0, elements.length);
```


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Exercise: Using Arrays

- Exercise objectives:
  - Define and initialize an array
  - Write a program that defines, initializes, and uses arrays
- Tasks:
  - Declare, create, and manipulate one- and two-dimensional arrays
  - Use arrays to represent the multiplicity of relation-ships between objects in the banking project

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Check Your Progress

- Declare and create arrays of primitive, class, or array types
- Explain why elements of an array are initialized
- Explain how to initialize the elements of an array
- Determine the number of elements in an array
- Create a multi-dimensional array
- Write code to copy array values from one array type to another

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Think Beyond

- How can you create a three-dimensional array?
- What is one disadvantage of using arrays?

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Module 6

Inheritance

Objectives

- Define *inheritance*, *polymorphism*, *overloading*, *overriding*, and *virtual method invocation*
- Use the access modifiers `protected` and "package-friendly"
- Describe constructor and method overloading
- Describe the complete object construction and initialization operation

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Objectives

- In a Java program, identify the following:
  - Overloaded methods and constructors
  - The use of `this` to call overloaded constructors
  - Overridden methods
  - The use of `super` to call parent class methods
  - Parent class constructors
  - The use of `super` to call parent class constructors

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Relevance

- How does the Java programming language support object inheritance?

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The `is a` Relationship

The `Employee` class:

Employee
+name : String = "" +salary : double +birthDate : Date
+getDetails() : String

```
public class Employee {
  public String name = "";
  public double salary;
  public Date birthDate;

  public String getDetails() {...}
}
```


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The `is a` Relationship

The `Manager` class:

Manager
+name : String = ""   +salary : double   +birthDate : Date   +department : String
+getDetails() : String

```
public class Manager {
  public String name = "";
  public double salary;
  public Date birthDate;
  public String department;

  public String getDetails() {...}
}
```


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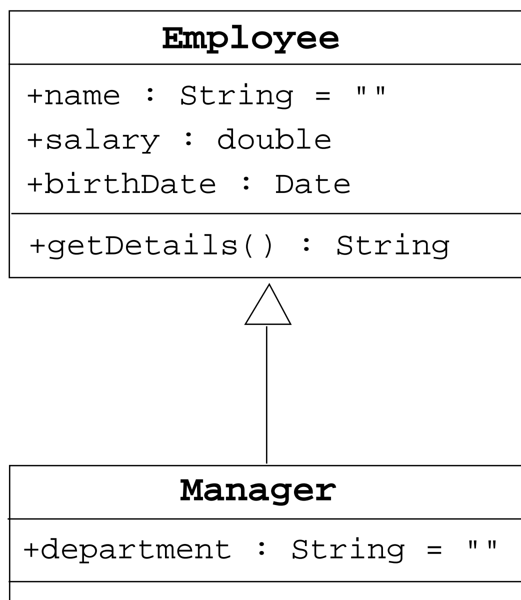
The is a Relationship




```
public class Employee {
  public String name = "";
  public double salary;
  public Date birthDate;

  public String getDetails() {...}
}
```

```
public class Manager extends Employee {
  public String department = "";
}
```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Single Inheritance

- When a class inherits from only one class, it is called *single inheritance*.
- Single inheritance makes code more reliable.
- *Interfaces* provide the benefits of multiple inheritance without drawbacks.
- Syntax of a Java class:

```
<class_declaration> ::=
  <modifier> class <name> [extends <superclass>] {
    <declarations>*
  }
```


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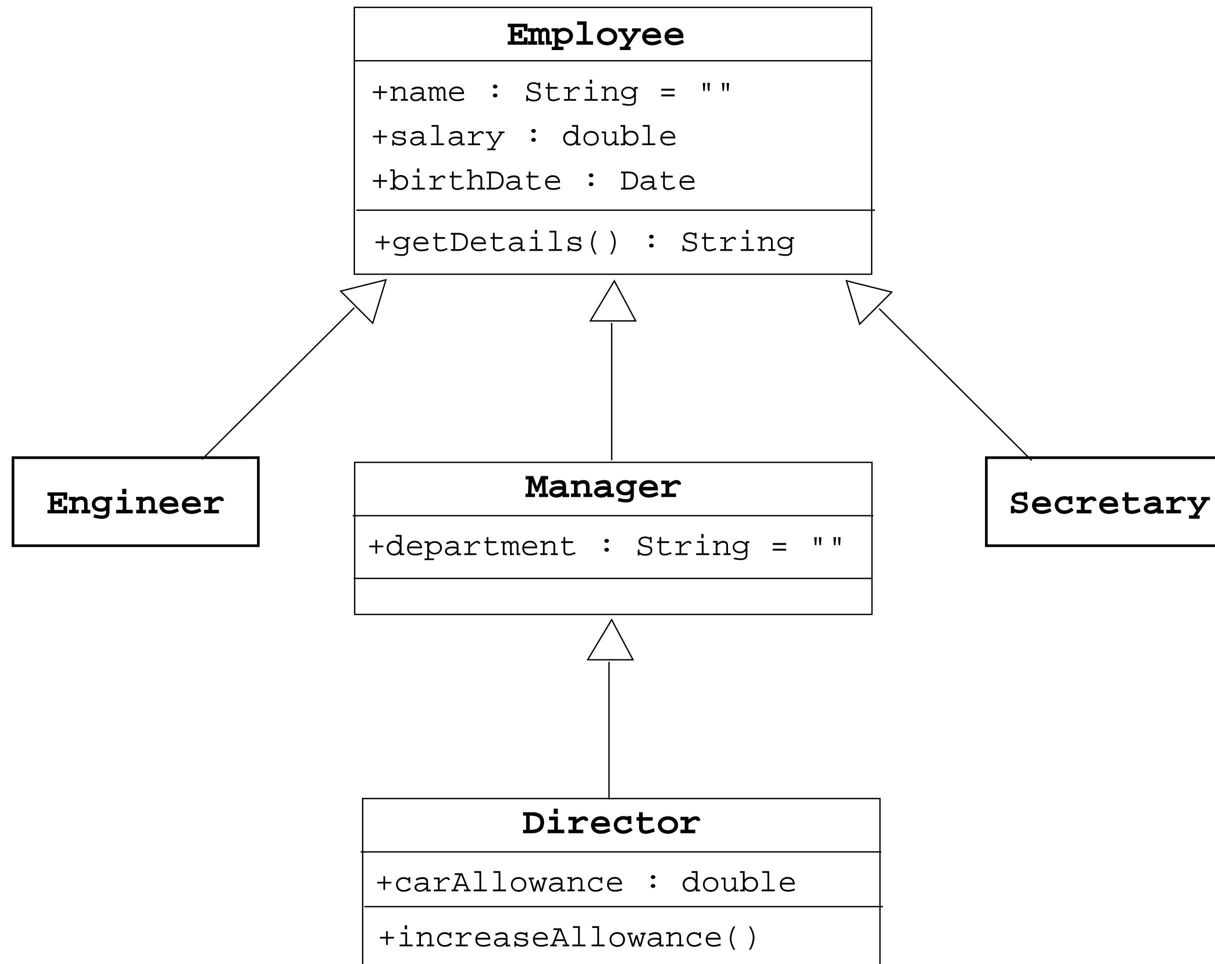
Single Inheritance



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Constructors Are Not Inherited

- A subclass inherits all methods and variables from the superclass (parent class)
- A subclass does not inherit the constructor from the superclass
- Two ways to include a constructor are:
  - Use the default constructor
  - Write one or more explicit constructors

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Polymorphism

- *Polymorphism* is the ability to have many different forms; for example, the `Manager` class has access to methods from `Employee` class
- An object has only one form
- A reference variable can refer to objects of different forms

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Polymorphism

```
Employee employee = new Manager() //legal

// Illegal attempt to assign Manager attribute
employee.department = "Sales";
// the variable is declared as a Employee type,
// even though the Manager object has that attribute
```


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Polymorphic Arguments

- Because a `Manager` is an `Employee`:

```
// In the Employee class
public TaxRate findTaxRate(Employee e) {
}
// Meanwhile, elsewhere in the application class
Manager m = new Manager();
:
TaxRate t = findTaxRate(m);
```


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Heterogeneous Collections

- Collections of objects with the same class type are called *homogenous* collections.

```
MyDate[]  dates = new MyDate[2];
dates[0] = new MyDate(22, 12, 1964);
dates[1] = new MyDate(22, 7, 1964);
```

- Collections of objects with different class types are called *heterogeneous* collections.

```
Employee [] staff = new Employee[1024];
staff[0] = new Manager();
staff[1] = new Employee();
staff[2] = new Engineer();
```


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The instanceof Operator

```
public class Employee extends Object
public class Manager extends Employee
public class Engineer extends Employee
----------------------------------------

public void doSomething(Employee e) {
  if (e instanceof Manager) {
    // Process a Manager
  } else if (e instanceof Engineer) {
    // Process an Engineer
  } else {
    // Process any other type of Employee
  }
}
```


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Casting Objects

- Use `instanceof` to test the type of an object
- Restore full functionality of an object by casting
- Check for proper casting using the following guidelines:
  - Casts up hierarchy are done implicitly
  - Downward casts must be to a subclass and checked by the compiler
  - The object type is checked at runtime when runtime errors can occur

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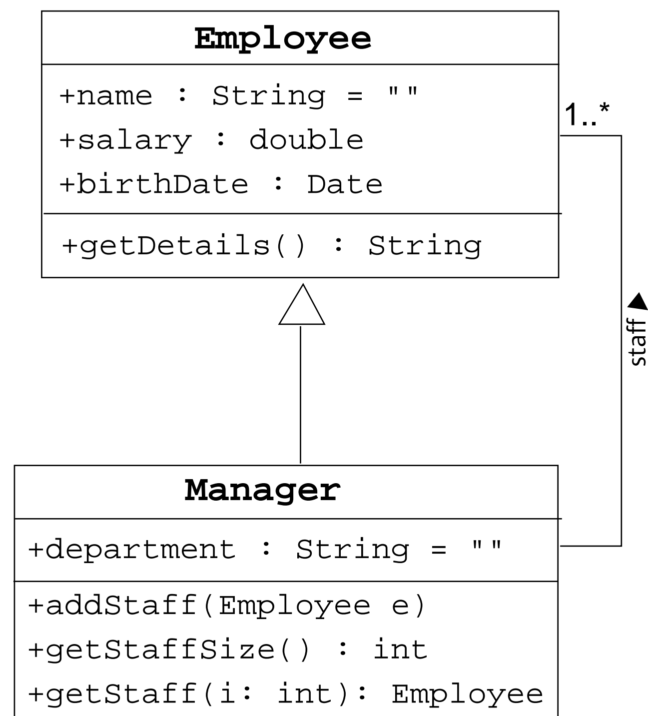
The has a Relationship

```
public class Vehicle {
  private Engine theEngine;
  public Engine getEngine() {
    return theEngine;
  }
}
```




```
public class Manager extends Employee {
  public String department = "";
  public Employee[] staff = new Employee[20];
  public int staffSize = 0;

  public void addStaff(Employee e) {
    staff[staffSize++] = e;
  }
  public int getStaffSize() {
    return staffSize;
  }
  public Employee getStaff(int i) {
    return staff[i];
  }
  ...
}
```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Access Control

Modifier	Same Class	Same Package	Subclass	Universe
`public`	Yes	Yes	Yes	Yes
`protected`	Yes	Yes	Yes	
default	Yes	Yes		
`private`	Yes			

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Overloading Method Names

- It can be used as follows:

```
public void println(int i)
public void println(float f)
public void println(String s)
```

- Argument lists *must* differ
- Return types *can* be different

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Overloading Constructors

- As with methods, constructors can be overloaded
- Example:

```
public Employee(String name, double salary, Date DoB)
public Employee(String name, double salary)
public Employee(String name, Date DoB)
```

- Argument lists *must* differ
- The `this` reference can be used at the first line of a constructor to call another constructor

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Overloading Constructors

```
1   public class Employee {
2     private static final double BASE_SALARY = 15000.00;
3     private String name;
4     private double salary;
5     private Date   birthDate;
6
7     public Employee(String name, double salary, Date DoB) {
8       this.name = name;
9       this.salary = salary;
10      this.birthDate = DoB;
11    }
12    public Employee(String name, double salary) {
13      this(name, salary, null);
14    }
15    public Employee(String name, Date DoB) {
16      this(name, BASE_SALARY, DoB);
17    }
18    public Employee(String name) {
19      this(name, BASE_SALARY);
20    }
21    // more Employee code...
22  }
```


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Overriding Methods

- A subclass can modify behavior inherited from a parent class
- A subclass can create a method with different functionality than the parent's method but with the same:
  - Name
  - Return type
  - Argument list

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Overriding Methods

```
public class Employee {
  protected String name;
  protected double salary;
  protected Date birthDate;

  public String getDetails() {
    return "Name: " + name + "\n" +
           "Salary: " + salary;
  }
}


public class Manager extends Employee {
  protected String department;

  public String getDetails() {
    return "Name: " + name + "\n" +
           "Salary: " + salary + "\n" +
           "Manager of: " + department;
  }
}
```


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Overriding Methods

- Virtual method invocation:

```
Employee e = new Manager();
e.getDetails();
```

- Compile-time type and runtime type

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Rules About Overridden Methods

- Must have a return type that is identical to the method it overrides
- Cannot be less accessible than the method it overrides

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Rules About Overridden Methods

```
public class Parent {
  public void doSomething() {}
}

public class Child extends Parent {
  private void doSomething() {}
}

public class UseBoth {
  public void doOtherThing() {
    Parent p1 = new Parent();
    Parent p2 = new Child();
    p1.doSomething();
    p2.doSomething();
  }
}
```


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The `super` Keyword

- `super` is used in a class to refer to its superclass
- `super` is used to refer to the members of superclass, both data attributes and methods
- Behavior invoked does not have to be in the superclass; it can be further up in the hierarchy

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The super Keyword

```
public class Employee {
   private String name;
   private double salary;
   private Data birthDate;
   public String getDetails() {
      return Name: " + name + "\nSalary: " + salary;
   }
}
public class Manager extends Employee {
   private String department;
   public String getDetails() {
      // call parent method
      return super.getDetails() + "\n" +
        "Manager of: " + department;
   }
}
```


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Invoking Parent Class Constructors

- To invoke a parent constructor you must place a call to `super` in the first line of the constructor
- You can call a specific parent constructor by the arguments that you use in the call to `super`
- If no `this` or `super` call is used in a constructor, then the compiler adds an implicit call to `super()` which calls the parent "default" constructor
  - If the parent class does not supply a non-private "default" constructor, then a compiler warning will be issued

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Invoking Parent Class Constructors

```
1   public class Employee {
2     private static final double BASE_SALARY = 15000.00;
3     private String name;
4     private double salary;
5     private Date   birthDate;
6
7     public Employee(String name, double salary, Date DoB) {
8       this.name = name;
9       this.salary = salary;
10      this.birthDate = DoB;
11    }
12    public Employee(String name, double salary) {
13      this(name, salary, null);
14    }
15    public Employee(String name, Date DoB) {
16      this(name, BASE_SALARY, DoB);
17    }
18    public Employee(String name) {
19      this(name, BASE_SALARY);
20    }
21    // more Employee code...
22  }
```

```
1   public class Manager extends Employee {
2     private String department;
3
4     public Manager(String name, double salary, String dept) {
5       super(name, salary);
6       department = dept;
7     }
8     public Manager(String n, String dept) {
9       super(name);
10      department = dept;
11    }
12    public Manager(String dept) { // This code fails: no super()
13      department = d;
14    }
15  }
```


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Constructing and Initializing Objects: A Slight Reprise

- Memory is allocated and default initialization occurs
- Instance variable initialization uses these steps recursively:

1. Bind constructor parameters.
2. If explicit `this()`, call recursively and then skip to step 5.
3. Call recursively the implicit or explicit `super` call, except for `Object`.
4. Execute explicit instance variable initializers.
5. Execute body of current constructor.

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An Example

```
public class Object {
   ...
  public Object() {}
   ...
}

public class Employee extends Object {
  private String name;
  private double salary = 15000.00;
  private Date   birthDate;

  public Employee(String n, Date DoB) {
    // implicit super();
    name = n;
    birthDate = DoB;
  }
  public Employee(String n) {
    this(n, null);
  }
}

public class Manager extends Employee {
  private String department;

  public Manager(String n, String d) {
    super(n);
    department = d;
  }
}
```


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An Example

`0` basic initialization

  `0.1` allocate memory for the complete `Manager` object

  `0.2` initialize all instance variables to their default values

`1` call constructor: `Manager("Joe Smith", "Sales")`

  `1.1` bind constructor parameters: `n="Joe Smith", d="Sales"`

  `1.2` no explicit `this()` call

  `1.3` call `super(n)` for `Employee(String)`

    `1.3.1` bind constructor parameters: `n="Joe Smith"`

    `1.3.2` call `this(n, null)` for `Employee(String, Date)`

      `1.3.2.1` bind constructor parameters: `n="Joe Smith", DoB=null`

      `1.3.2.2` no explicit `this()` call

      `1.3.2.3` call `super()` for `Object()`

        `1.3.2.3.1` no binding necessary

        `1.3.2.3.2` no `this()` call

        `1.3.2.3.3` no `super()` call (`Object` is the root)

        `1.3.2.3.4` no explicit variable initialization for `Object`

        `1.3.2.3.5` no method body to call

      `1.3.2.4` initialize explicit Employee variables: `salary=15000.00;`

      `1.3.2.5` execute body: `name="Joe Smith"; date=null;`

    `1.3.3 - 1.3.4` steps skipped

    `1.3.5` execute body: no body in `Employee(String)`

  `1.4` no explicit initializers for `Manager`

  `1.5` execute body: `department="Sales"`

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Implications of the Initialization Process

```
1  public class Employee extends Object {
2    private String name;
3    private double salary = 15000.00;
4    private Date   birthDate;
5    private String summary;
6
7    public Employee(String n, Date DoB) {
8      name = n;
9      birthDate = DoB;
10     summary = getDetails();
11   }
12   public Employee(String n) {
13      this(n, null);
14   }
15
16   public String getDetails() {
17     return "Name: " + name + "\nSalary: " + salary
18            + "\nBirth Date: " + birthDate;
19   }
20 }
```

```
1  public class Manager extends Employee {
2    private String department;
3
4    public Manager(String n, String d) {
5      super(n);
6      department = d;
7    }
8
9    public String getDetails() {
10     return super.getDetails() + "\nDept: " + department;
11   }
12 }
```


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The `Object` Class

- The `Object` class is the root of all classes in Java
- A class declaration with no extends clause, implicitly uses "extends Object"

```
public class Employee {
  ...
}
```

is equivalent to:

```
public class Employee extends Object {
  ...
}
```


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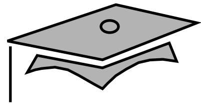

The == Operator Compared With the `equals` Method

- The == operator determines if two references are identical to each other (that is, refer to the same object)
- The `equals` method determines if objects are "equal" but not necessarily identical
- The `Object` implementation of the `equals` method uses the == operator
- User classes can override the `equals` method to implement a domain-specific test for equality
- Note: You should override the `hashCode` method, if you override the `equals` method

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equals Example

```
1   class Employee {
2
3     private String name;
4     private MyDate birthDate;
5     private float  salary;
6
7     // Constructor
8     public Employee(String name, MyDate DoB, float salary) {
9       this.name = name;
10      this.birthDate = DoB;
11      this.salary = salary;
12    }
13
14    public boolean equals(Object o) {
15      boolean result = false;
16      if ( (o != null) && (o instanceof Employee) ) {
17        Employee e = (Employee) o;
18        if (   name.equals(e.name)
19            && birthDate.equals(e.birthDate) ) {
20          result = true;
21        }
22      }
23      return result;
24    }
25
26    public int hashCode() {
27      return ( name.hashCode() ^ birthDate.hashCode() );
28    }
29  }
30
```


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`equals` Example

```
1   class TestEquals {
2     public static void main(String[] args) {
3       Employee  emp1 = new Employee("Fred Smith",
4                                     new MyDate(14, 3, 1976),
5                                     25000.0F);
6       Employee  emp2 = new Employee("Fred Smith",
7                                     new MyDate(14, 3, 1976),
8                                     25000.0F);
9
10      if ( emp1 == emp2 ) {
11        System.out.println("emp1 is identical to emp2");
12      } else {
13        System.out.println("emp1 is not identical to emp2");
14      }
15
16      if ( emp1.equals(emp2) ) {
17        System.out.println("emp1 is equal to emp2");
18      } else {
19        System.out.println("emp1 is not equal to emp2");
20      }
21
22      emp2 = emp1;
23      System.out.println("set emp2 = emp1;");
24      if ( emp1 == emp2 ) {
25        System.out.println("emp1 is identical to emp2");
26      } else {
27        System.out.println("emp1 is not identical to emp2");
28      }
29    }
30  }
```

generates the output:

```
emp1 is not identical to emp2
emp1 is equal to emp2
set emp2 = emp1;
emp1 is identical to emp2
```


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`toString` Method

- Converts an object to a `String`
- Used during string concatenation
- Override this method to provide information about a user-defined object in readable format
- Primitive types are converted to a `String` using the wrapper class's `toString` static method

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Wrapper Classes

- Look at primitive data elements as objects

Primitive Data Type	Wrapper Class
`boolean`	`Boolean`
`byte`	`Byte`
`char`	`Character`
`short`	`Short`
`int`	`Integer`
`long`	`Long`
`float`	`Float`
`double`	`Double`

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Wrapper Classes

```
int pInt = 500;
Integer wInt = new Integer(pInt);

int p2 = wInt.intValue();
```


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Exercise: Using Objects and Classes

- Exercise objective:
  - Write, compile, and run two programs that use the object-oriented concepts of inheritance and heterogeneous collections within the Banking project
- Tasks:
  - Create several account types
  - Implement a heterogeneous collection of accounts within the customer

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Check Your Progress

- Define *inheritance*, *polymorphism*, *overloading*, *overriding*, and *virtual method invocation*
- Use the access modifiers `protected` and "package-friendly"
- Describe constructor and method overloading
- Describe the complete object construction and initialization operation

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Check Your Progress

- In a Java program, identify the following:
  - Overloaded methods and constructors
  - The use of this to all overloaded constructors
  - Overridden methods
  - Invocation of super class methods
  - Parent class constructors
  - Invocation of parent class constructors

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Think Beyond

- Now that you understand inheritance and polymorphism, how can you use this information on a current or future project?

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Module 7

Advanced Class Features

Objectives

- Describe `static` variables, methods, and initializers
- Describe `final` classes, methods, and variables
- Explain how and when to use `abstract` classes and methods
- Explain how and when to use inner classes
- Distinguish between static and non-static inner classes
- Explain how and when to use an `interface`

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Objectives

- In a Java software program, identify:
  - `static` methods and attributes
  - `final` methods and attributes
  - inner classes
  - `interface` and `abstract` classes
  - `abstract` methods

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Relevance

- How can you create a constant?
- How can you create an instance variable that is set once and can not be reset, even internally?
- How can you declare data that is shared by all instances of a given class?
- How can you keep a class or method from being subclassed or overridden?
- How can you create several classes that implement a common interface yet not be part of a common inheritance tree?

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The `static` Keyword

- The `static` keyword is used as a modifier on variables, methods, and inner classes
- The `static` keyword declares the attribute or method is associated with the class as a whole rather than any particular instance of that class
- Thus static members are often called "class members," such as "class attributes" or "class methods"

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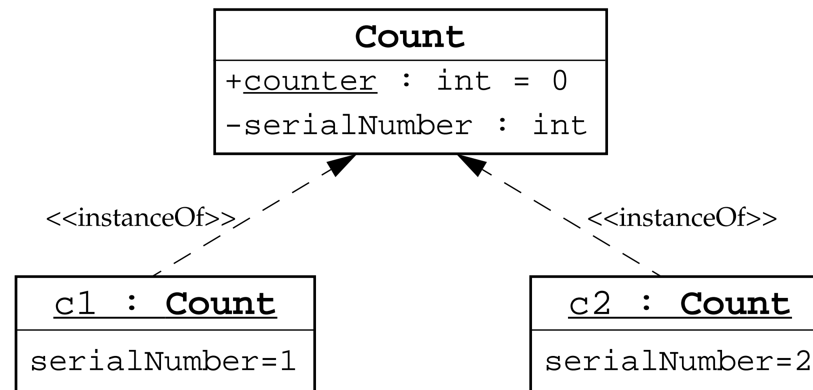
Class Attributes

- Are shared among all instances of a class




```
1   public class Count {
2     private int serialNumber;
3     public static int counter = 0;
4
5     public Count() {
6       counter++;
7       serialNumber = counter;
8     }
9   }
```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Class Attributes

- Can be accessed from outside the class if marked as `public` without an instance of the class

```
1   public class OtherClass {
2     public void incrementNumber() {
3       Count.counter++;
4     }
5   }
```


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Class Methods

- You can invoke `static` method without any instance of the class to which it belongs.

```
1   public class Count {
2     private int serialNumber;
3     private static int counter = 0;
4
5     public static int getTotalCount() {
6       return counter;
7     }
8
9     public Count() {
10      counter++;
11      serialNumber = counter;
12    }
13  }
```

```
1   public class TestCounter {
2     public static void main(String[] args) {
3       System.out.println("Number of counter is "
4                          + Count.getTotalCount());
5       Count count1 = new Count();
6       System.out.println("Number of counter is "
7                          + Count.getTotalCount());
8     }
9   }
```

The output of the `TestCounter` program is:

```
Number of counter is 0
Number of counter is 1
```


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Static Initializers

- A class can contain code in a *static block* that does not exist within a method body
- Static block code executes only once, when the class is loaded
- A static block is usually used to initialize static (class) attributes

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Static Initializers

```
1   public class Count {
2     public static int counter;
3     static {
4       counter = Integer.getInteger("myApp.Count.counter").intValue();
5     }
6   }
```

```
1   public class TestStaticInit {
2     public static void main(String args[]) {
3       System.out.println("counter = " + Count.counter);
4     }
5   }
```

The output of the `TestStaticInit` program is:

```
> java -DmyApplication.counter=47 TestStaticInit
counter = 47
```


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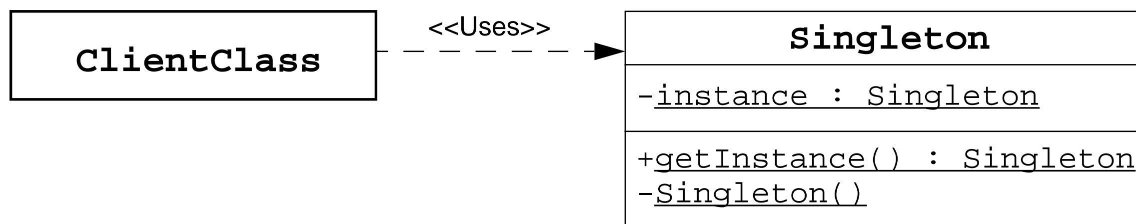
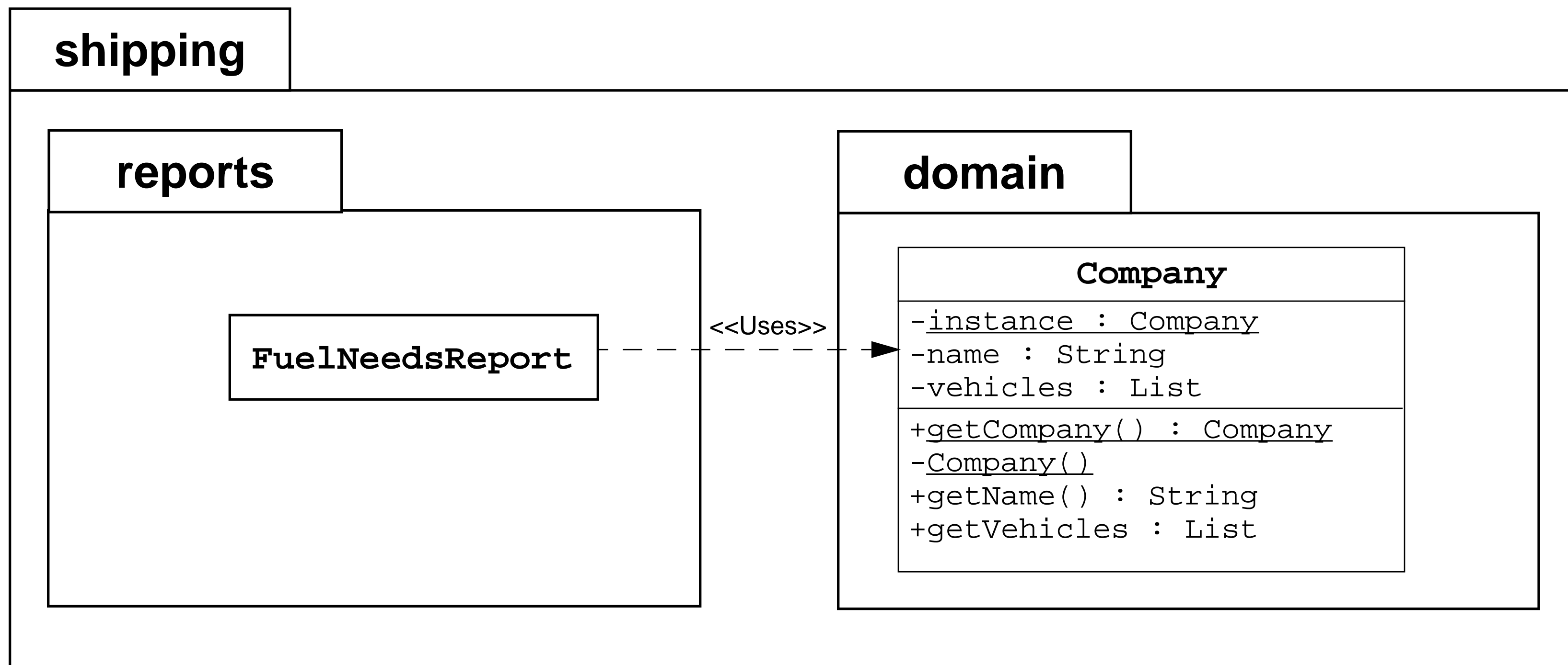
The Singleton Design Pattern





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Implementing the Singleton Design Pattern

The Singleton code:

```
1  package shipping.domain;
2
3  public class Company {
4    private static Company instance = new Company();
5    private String name;
6    private Vehicle[] fleet;
7
8    public static Company getCompany() {
9      return instance;
10   }
11
12   private Company() {...}
13
14   // more Company code ...
15 }
```

Usage code:

```
1  package shipping.reports;
2
3  import shipping.domain.*;
4
5  public class FuelNeedsReport {
6    public void generateText(PrintStream output) {
7      Company c = Company.getCompany();
8      // use Company object to retrieve the fleet vehicles
9    }
10 }
```


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The `final` Keyword

- You cannot subclass a `final` class
- You cannot override a `final` method
- A `final` variable is a constant
- A `final` variable can only be set once, but that assignment can occur independently of the declaration; this is called "blank final variable"
  - A blank final instance attribute must be set in every constructor
  - A blank final method variable must be set in the method body before being used

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Final Variables

Constants:

```
public class Bank {
  private static final double  DEFAULT_INTEREST_RATE=3.2; // percent
  ... // more declarations
}
```

Blank Final Instance Attribute:

```
public class Customer {
  private final long  customerID;

  public Customer() {
    customerID = createID();
  }
  public long getID() {
    return customerID;
  }
  private long createID() {
    return ... // generate new ID
  }
  ... // more declarations
}
```


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Exercise: Working With the `static` and `final` Keywords

- Preparation:
  - You must be familiar with the use of the `static` and `final` keywords
- Task:
  - In this exercise you will modify the `Bank` class to implement the Singleton design pattern

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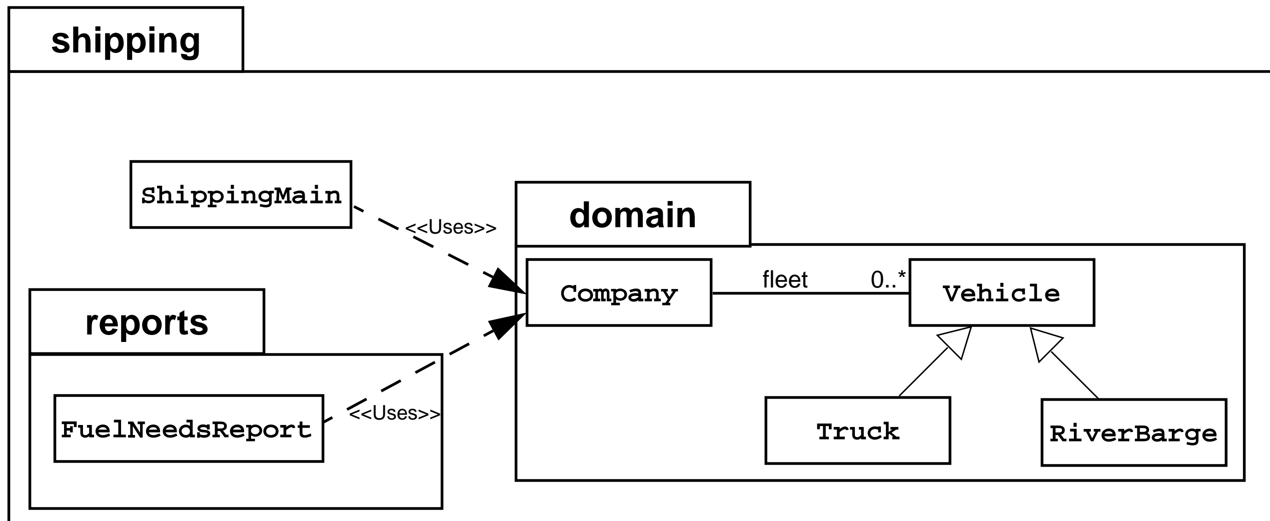
Abstract Classes: Scenario



Fleet initialization code:

```
1  public class ShippingMain {
2    public static void main(String[] args) {
3      Company c = Company.getCompany();
4
5      // populate the company with a fleet of vehicles
6      c.addVehicle( new Truck(10000.0) );
7      c.addVehicle( new Truck(15000.0) );
8      c.addVehicle( new RiverBarge(500000.0) );
9      c.addVehicle( new Truck(9500.0) );
10     c.addVehicle( new RiverBarge(750000.0) );
11
12     FuelNeedsReport report = new FuelNeedsReport();
13     report.generateText(System.out);
14   }
15 }
```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Abstract Classes: Scenario

`FuelNeedsReport` code:

```
1  public class FuelNeedsReport {
2    public void generateText(PrintStream output) {
3      Company c = Company.getCompany();
4      Vehicle v;
5      double fuel;
6      double total_fuel = 0.0;
7
8      for ( int i = 0; i < c.getFleetSize(); i++ ) {
9        v = c.getVehicle(i);
10
11       // Calculate the fuel needed for this trip
12       fuel = v.calcTripDistance() / v.calcFuelEfficency();
13
14       output.println("Vehicle " + v.getName() + " needs "
15                      + fuel + " liters of fuel.");
16       total_fuel += fuel;
17     }
18     output.println("Total fuel needs is " + total_fuel + " liters.");
19   }
20 }
```


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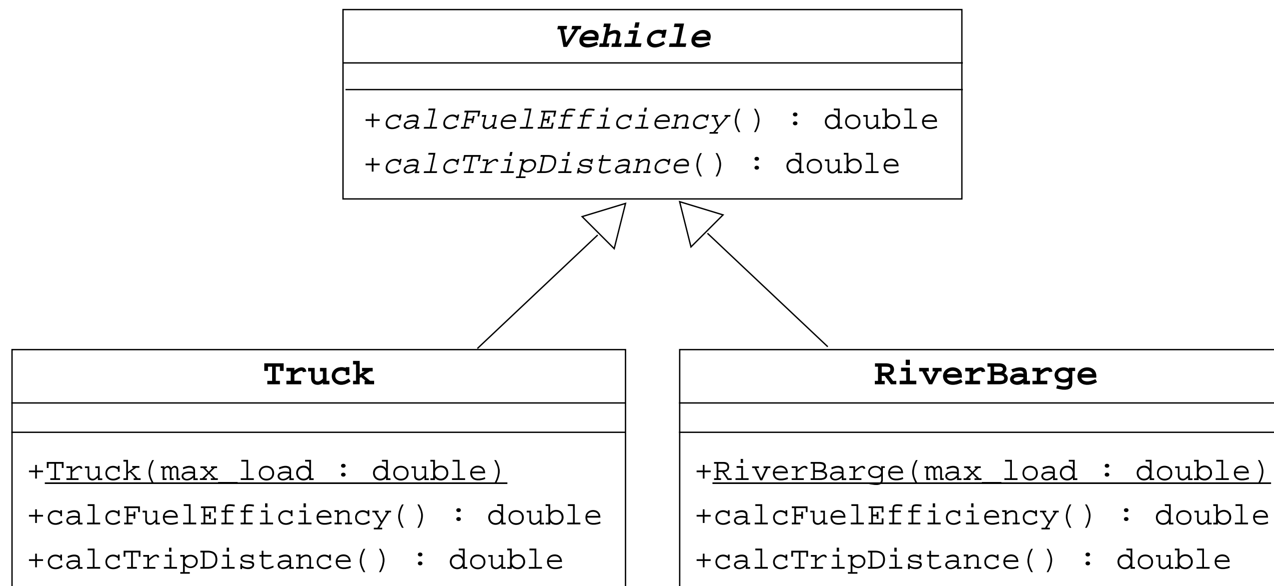
Abstract Classes: Solution

- An abstract class is used to model a class of objects where the full implementation is not known, but is supplied by the concrete subclasses



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Abstract Classes: Solution

```
1  public abstract class Vehicle {
2    public abstract double calcFuelEfficiency();
3    public abstract double calcTripDistance();
4  }

1  public class Truck extends Vehicle {
2    public Truck(double max_load) {...}
3
4    public double calcFuelEfficiency() {
5      /* calculate the fuel consumption of a truck at a given load */
6    }
7    public double calcTripDistrance() {
8      /* calculate the distance of this trip on highway */
9    }
10 }

1  public class RiverBarge extends Vehicle {
2    public RiverBarge(double max_load) {...}
3
4    public double calcFuelEfficiency() {
5      /* calculate the fuel efficiency of a river barge */
6    }
7    public double calcTripDistrance() {
8      /* calculate the distance of this trip along the river-ways */
9    }
10 }
```


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Template Method Design Pattern

Vehicle
-load : double = 0 -maxLoad : double = 0
#Vehicle(max_load : double) +getLoad() : double +getMaxLoad() : double +addBox(weight : double) +calcFuelNeeds() : double #*calcFuelEfficiency*() : double #*calcTripDistance*() : double

Note (attached to calcFuelNeeds): This is a Template Method that uses `calcFuelEfficiency` and `calcTripDistance` to determine the fuel needs for the complete shipping trip.

Truck
+Truck(max_load : double) #calcFuelEfficiency() : double #calcTripDistance() : double

RiverBarge
+RiverBarge(max_load : double) #calcFuelEfficiency() : double #calcTripDistance() : double

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Interfaces

- A "public interface" is a contract between client code and the class that implements that interface
- A Java *interface* is a formal declaration of such a contract in which all methods contain no implementation
- Many, unrelated classes can implement the same interface
- A class can implement many, unrelated interfaces
- Syntax of a Java class:

```
<class_declaration> ::=
  <modifier> class <name> [extends <superclass>]
        [implements <interface> [,<interface>]* ] {
    <declarations>*
  }
```


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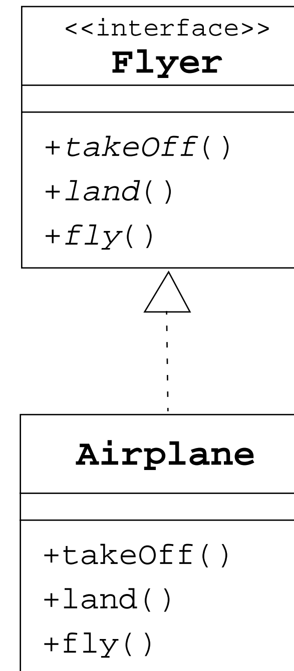
Interface Example

```
public interface Flyer {
  public void takeOff();
  public void land();
  public void fly();
}

public class Airplane implements Flyer {
  public void takeOff() {
    // accelerate until lift-off
    // raise landing gear
  }
  public void land() {
    // lower landing gear
    // deccelerate and lower flaps until touch-down
    // apply breaks
  }
  public void takeOff() {
    // keep those engines running
  }
}
```



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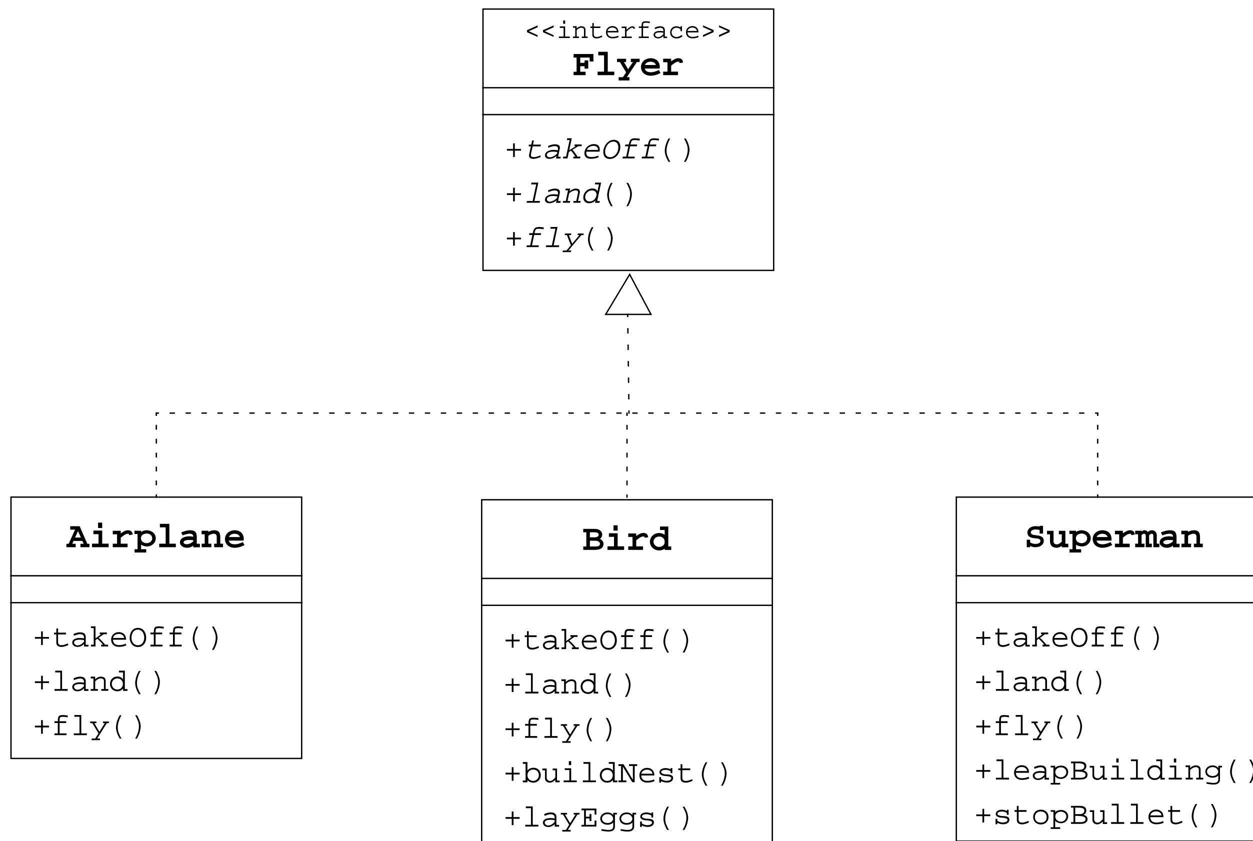
Interface Example



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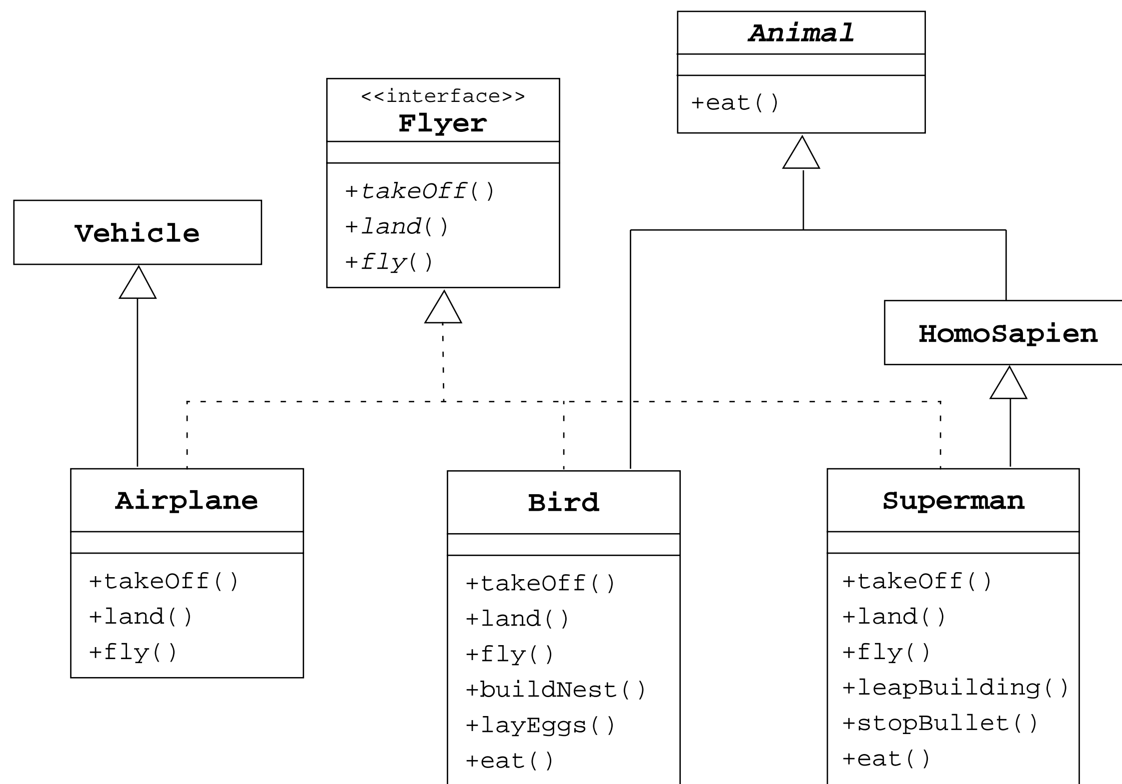
Interface Example



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Interface Example

```
public class Bird extends Animal implements Flyer {
  public void takeOff()   { /* take-off implementation  */ }
  public void land()      { /* landing implementation   */ }
  public void fly()       { /* fly implementation       */ }
  public void buildNest() { /* nest building behavior   */ }
  public void layEggs()   { /* egg laying behavior      */ }
  public void eat()       { /* override eating behavior */ }
}
```


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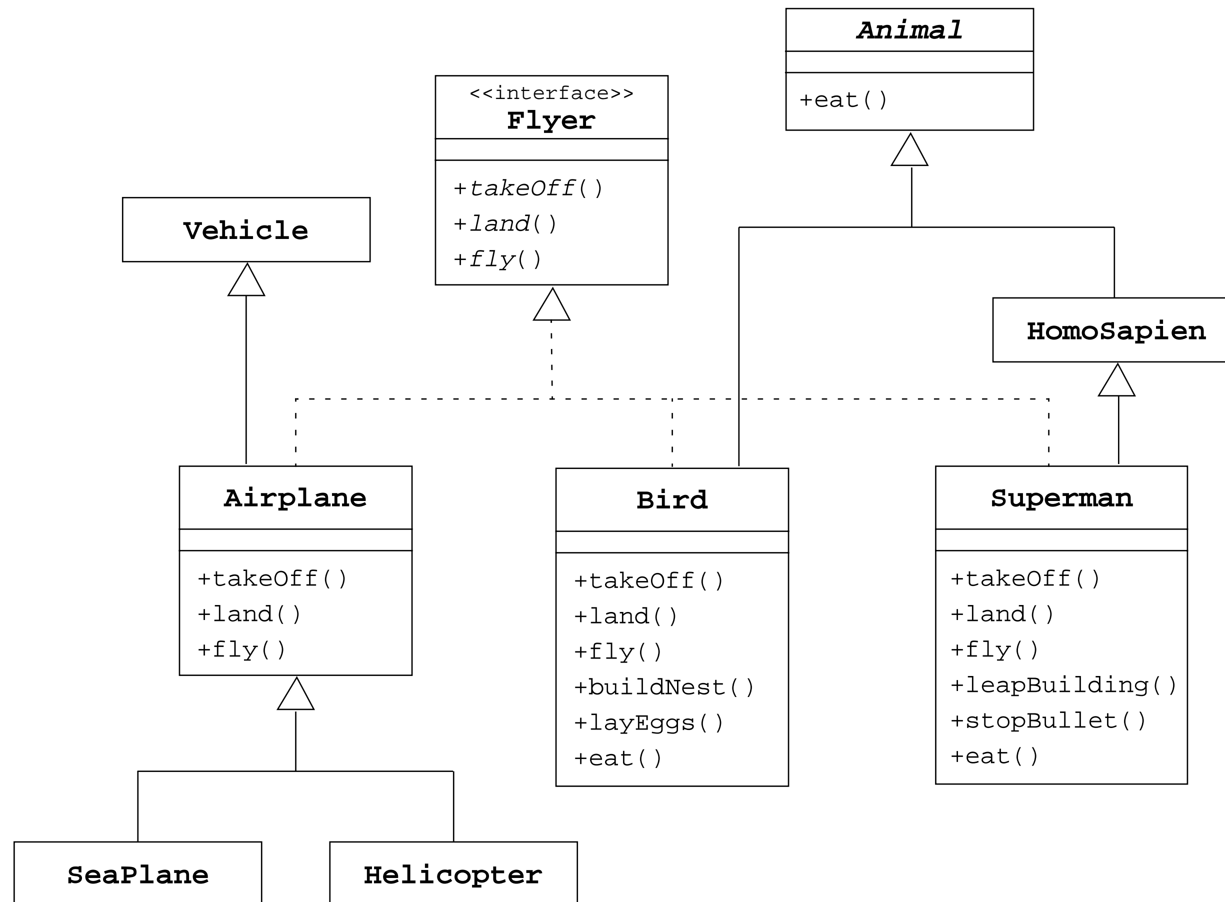
Interface Example



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Interface Example

```
public class Airport {
  public static void main(String[] args) {
    Airport metropolisAirport = new Airport();
    Helicopter copter = new Helicopter();
    SeaPlane sPlane = new SeaPlane();
    Flyer S = Superman.getSuperman(); // Superman is a Singleton

    metropolisAirport.givePermissionToLand(copter);
    metropolisAirport.givePermissionToLand(sPlane);
    metropolisAirport.givePermissionToLand(S);
  }

  private void givePermissionToLand(Flyer f) {
    f.land();
  }
}
```


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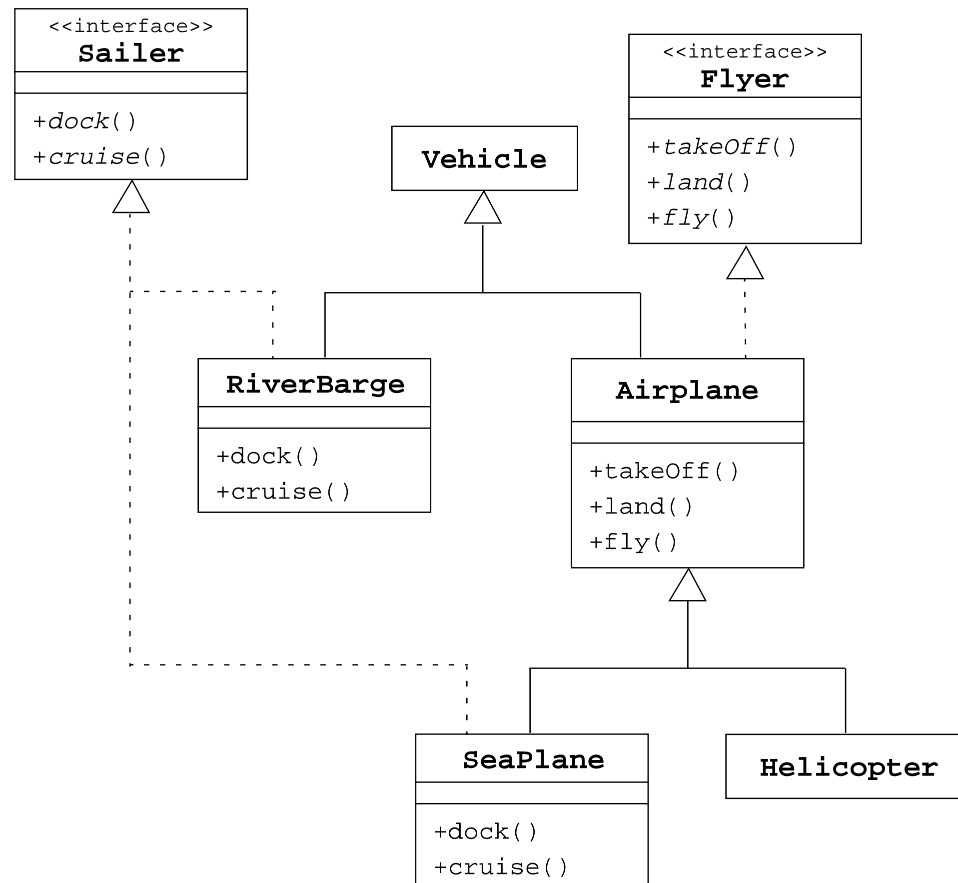
Multiple Interface Example



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Multiple Interface Example

```
public class Harbor {
  public static void main(String[] args) {
    Harbor bostonHarbor = new Harbor();
    RiverBarge barge = new RiverBarge();
    SeaPlane sPlane = new SeaPlane();

    bostonHarbor.givePermissionToDock(barge);
    bostonHarbor.givePermissionToDock(sPlane);
  }

  private void givePermissionToDock(Sailer s) {
    s.dock();
  }
}
```


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Uses of Interfaces

- Declaring methods that one or more classes are expected to implement
- Determining an object's programming interface without revealing the actual body of the class
- Capturing similarities between unrelated classes without forcing a class relationship
- Simulating multiple inheritance by declaring a class that implements several interfaces

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Inner Classes

- Added to JDK 1.1
- Allow a class definition to be placed inside another class definition
- Group classes that logically belong together
- Have access to their enclosing class's scope

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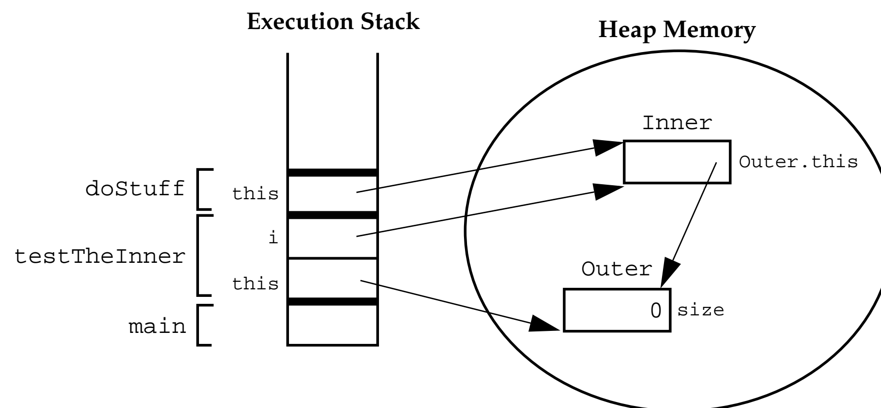
Inner Class Example

```
1   public class Outer1 {
2     private int size;
3
4     /* Declare an inner class called "Inner" */
5     public class Inner {
6       public void doStuff() {
7         // The inner class has access to 'size' from Outer
8         size++;
9       }
10    }
11
12    public void testTheInner() {
13      Inner i = new Inner();
14      i.doStuff();
15    }
16  }
```



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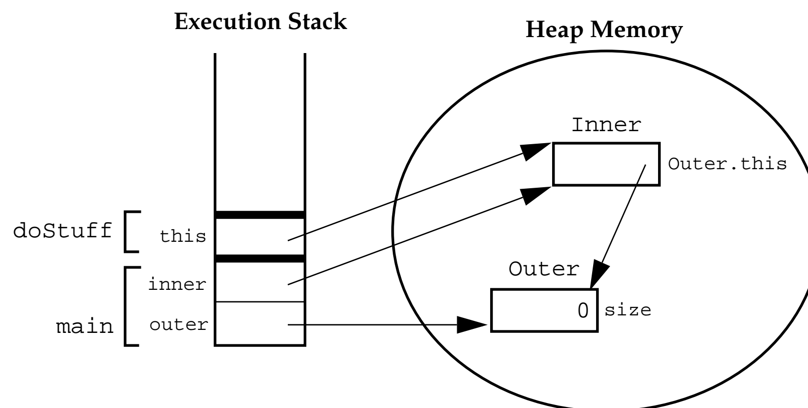
Inner Class Example




```
1   public class Outer2 {
2     private int size;
3
4     public class Inner {
5       public void doStuff() {
6         size++;
7       }
8     }
9   }
```

```
1   public class TestInner {
2     public static void main(String[] args) {
3       Outer2 outer = new Outer2();
4
5       // Must create an Inner object relative to an Outer
6       Inner inner = outer.new Inner();
7       inner.doStuff();
8     }
9   }
```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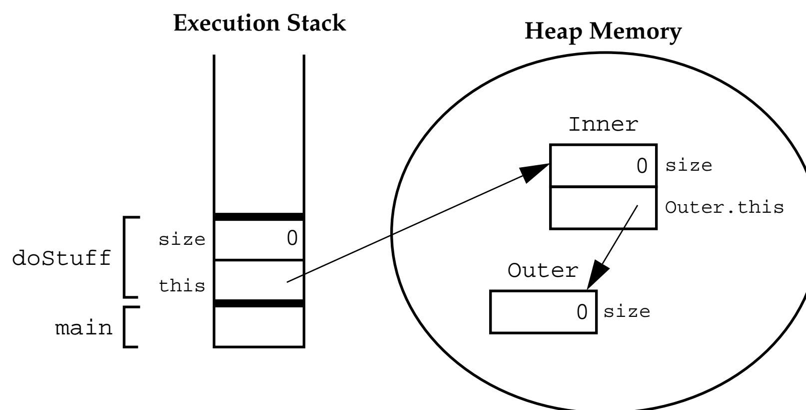
Inner Class Example

```
1   public class Outer3 {
2     private int size;
3
4     public class Inner {
5       private int size;
6
7       public void doStuff(int size) {
8         size++;              // the local parameter
9         this.size++;         // the Inner object attribute
10        Outer.this.size++;   // the Outer object attribute
11      }
12    }
13  }
```



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Inner Class Example

```
1   public class Outer4 {
2     private int size = 5;
3
4     public Object makeTheInner(int localVar) {
5       final int finalLocalVar = 6;
6
7       // Declare a class within a method!?!
8       class Inner {
9         public String toString() {
10          return ("#<Inner size=" + size +
11                  // " localVar=" + localVar + // ERROR: ILLEGAL
12                  "finalLocalVar=" + finalLocalVar + ">");
13        }
14      }
15
16      return new Inner();
17    }
18
19    public static void main(String[] args) {
20      Outer4 outer = new Outer4();
21      Object obj = outer.makeTheInner(47);
22      System.out.println("The object is " + obj);
23    }
24  }
```


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Properties of Inner Classes

- You can use the class name only within the defined scope, except when used in a qualified name. The name of the inner class must differ from the enclosing class
- The inner class can be defined inside a method. Only local variables marked as `final`, can be accessed by methods within an inner class.

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Properties of Inner Classes

- The inner class can use both class and instance variables of enclosing classes and local variables of enclosing blocks
- The inner class can be defined as `abstract`
- The inner class can have any access mode
- The inner class can act as an interface implemented by another inner class

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Properties of Inner Classes

- Inner classes that are declared `static` automatically become top-level classes
- Inner classes cannot declare any `static` members; only top-level classes can declare `static` members
- An inner class wanting to use a `static` member must be declared `static`

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Exercise: Working With Interfaces and Abstract Classes

- Exercise objective:
  - Rewrite, compile, and run a program that uses an abstract class and an interface
- Tasks:
  - In this exercise you will create a hierarchy of animals that is rooted in an abstract class `Animal`. Several of the animal classes will implement an interface called `Pet`. You will experiment with variations of these animals, their methods, and polymorphism.

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Check Your Progress

- Describe `static` variables, methods, and initializers
- Describe `final` classes, methods, and variables
- Explain how and when to use `abstract` classes and methods
- Explain how and when to use inner classes
- Distinguish between static and non-static inner classes
- Explain how and when to use an `interface`

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Check Your Progress

- In a Java software program, identify:
  - `static` methods and attributes
  - `final` methods and attributes
  - inner classes
  - `interface` and `abstract` classes
  - `abstract` methods

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Think Beyond

- What features of the Java programming language are used to deal with runtime error conditions?

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Module 8

Exceptions

Objectives

- Define exceptions
- Use `try`, `catch`, and `finally` statements
- Describe exception categories
- Identify common exceptions
- Develop programs to handle your own exceptions

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Relevance

- In most programming languages, how are runtime errors resolved?

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Exceptions

- The `Exception` class defines mild error conditions that your program encounters
- Exceptions can occur when:
  - The file you try to open does not exist
  - The network connection is disrupted
  - Operands being manipulated are out of prescribed ranges
  - The class file you are interested in loading is missing
- An error class defines serious error conditions

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Exception Example

```
1   public class HelloWorld {
2     public static void main (String args[]) {
3       int i = 0;
4
5       String greetings [] = {
6         "Hello world!",
7         "No, I mean it!",
8         "HELLO WORLD!!"
9       };
10
11      while (i < 4) {
12        System.out.println (greetings[i]);
13        i++;
14      }
15    }
16  }
```


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`try` and `catch` Statements

```
1   try {
2      // code that might throw a particular exception
3   } catch (MyExceptionType myExcept) {
4      // code to execute if a MyExceptionType exception is thrown
5   } catch (Exception otherExcept) {
6      // code to execute if a general Exception exception is thrown
7   }
```


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Call Stack Mechanism

- If an exception is not handled in the current `try-catch` block, it is thrown to the caller of that method.
- If the exception gets back to the main method and is not handled there, the program is terminated abnormally.

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finally Statement

```
1      try {
2        startFaucet();
3        waterLawn();
4      } catch (BrokenPipeException e) {
5        logProblem(e);
6      } finally {
7        stopFaucet();
8      }
```


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Exception Example Revisited

```
1   public class HelloWorld2 {
2     public static void main (String args[]) {
3       int i = 0;
4
5       String greetings [] = {
6         "Hello world!",
7         "No, I mean it!",
8         "HELLO WORLD!!"
9       };
10
11      while (i < 4) {
12        try {
13          System.out.println (greetings[i]);
14        } catch (ArrayIndexOutOfBoundsException e){
15          System.out.println("Re-setting Index Value");
16          i = -1;
17        } finally {
18          System.out.println("This is always printed");
19        }
20
21        i++;
22      }
23    }
24  }
```


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Exception Categories

- Throwable
  - Error
    - VirtualMachineError
      - StackOverflowError
      - ...
      - OutOfMemoryError
    - ...
    - AWTError
  - Exception
    - RuntimeException
      - ArithmeticException
      - ...
      - NullPointerException
      - IndexOutOfBoundsException
    - ...
    - IOException
      - EOFException
      - ...
      - FileNotFoundException

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Common Exceptions

- `ArithmeticException`
- `NullPointerException`
- `NegativeArraySizeException`
- `ArrayIndexOutOfBoundsException`
- `SecurityException`

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The Handle or Declare Rule

- Handle the exception by using the `try-catch-finally` block
- Declare that the code causes an exception by using the `throws` clause
- A method may declare that it throws more than one exception

```
1   public void readDatabaseFile(String file)
2          throws FileNotFoundException, UTFDataFormatException {
3     // open file stream; may cause FileNotFoundException
4     FileInputStream fis = new FileInputStream(file);
5     // read a string from fis may cause UTFDataFormatException...
6   }
```

- You do not need to handle or declare runtime exceptions or errors

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Method Overriding and Exceptions

- Must throw exceptions that are the same class as the exceptions being thrown by the overridden method
- May throw exceptions that are subclasses of the exceptions being thrown by the overridden method
- If a superclass method throws multiple exceptions, the overriding method must throw a proper subset of exceptions thrown by the overridden method

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Method Overriding Examples

```
1   public class TestA {
2     public void methodA() throws RuntimeException {
3       // do some number crunching
4     }
5   }
```

```
1   public class TestB1 extends TestA {
2     public void methodA() throws ArithmeticException {
3       // do some number crunching
4     }
5   }
```

```
1   public class TestB2 extends TestA {
2     public void methodA() throws Exception {
3       // do some number crunching
4     }
5   }
```


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Method Overriding Examples

```
1   import java.io.*;
2
3   public class TestMultiA {
4     public void methodA()
5          throws IOException, RuntimeException {
6       // do some IO stuff
7     }
8   }
```

```
1   import java.io.*;
2
3   public class TestMultiB1 extends TestMultiA {
4     public void methodA()
5          throws FileNotFoundException, UTFDataFormatException,
6            ArithmeticException {
7       // do some IO and number crunching stuff
8     }
9   }
```

```
1   import java.io.*;
2   import java.sql.*;
3
4   public class TestMultiB2 extends TestMultiA {
5     public void methodA()
6          throws FileNotFoundException, UTFDataFormatException,
7            ArithmeticException, SQLException {
8       // do some IO, number crunching, and SQL stuff
9     }
10  }
```

```
1   public class TestMultiB3 extends TestMultiA {
2     public void methodA() throws java.io.FileNotFoundException {
3       // do some file IO
4     }
5   }
```


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Creating Your Own Exceptions

```
1   public class ServerTimedOutException extends Exception {
2     private int port;
3
4     public ServerTimedOutException(String message, int port) {
5       super(message);
6       this.port = port;
7     }
8
9   // Use getMessage method to get the reason the exception was made
10
11    public int getPort() {
12      return port;
13    }
14  }
```


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Handling User-Defined Exceptions

```
1   public void connectMe(String serverName)
2       throws ServerTimedOutException {
3     int success;
4     int portToConnect = 80;
5
6     success = open(serverName, portToConnect);
7
8     if (success == -1) {
9       throw new ServerTimedOutException("Could not connect",
10                                        portToConnect);
11    }
12  }
```

```
1   public void findServer() {
2       try {
3         connectMe(defaultServer);
4       } catch (ServerTimedOutException e) {
5         System.out.println("Server timed out, trying alternative");
6         try {
7           connectMe(alternativeServer);
8         } catch (ServerTimedOutException e1) {
9           System.out.println("Error: " + e1.getMessage() +
10                              " connecting to port " + e1.getPort());
11        }
12      }
13    }
```


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Exercise: Working With Exceptions

- Exercise objective:
  - Write, compile, and run a program that catches an exception. Write, compile, and run a program that uses a user-defined exception.
- Tasks:
  - In this exercise you will use the try-catch block to handle a simple run-time exception.
  - In this exercise you will create an `OverdraftException` that is thrown by the `withdraw` method in the `Account` class.

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Check Your Progress

- Define exceptions
- Use `try`, `catch`, and `finally` statements
- Describe exception categories
- Identify common exceptions
- Develop programs to handle your own exceptions

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Think Beyond

- How many situations can you think of that would require you to create new classes of exceptions?
- Can you think of situations where a constructor would throw an exception?

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Module 9

Text-Based Applications

Objectives

- Write a program that uses command-line arguments and system properties
- Write a program that reads from *standard input*
- Write a program that can create, read, and write files
- Describe the basic hierarchy of collections in Java 2 SDK
- Write a program that uses sets and lists
- Write a program to iterate over a collection

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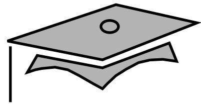

Objectives

- Write a program to sort an array or a list
- Describe the collection classes that existed before Java 2 SDK
- Describe and use the `javadoc` and `jar` tools
- Identify deprecated classes and explain how to migrate from JDK 1.0 to JDK 1.1 to Java 2 JDK

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Relevance

- It is often the case that certain elements of a program should not be hardcoded, such as file names or the name of a database. How can a program be coded to supply these elements at runtime?
- Simple arrays are far too static for most collections (that is, a fixed number of elements). What Java technology features exist to support more flexible collections?
- Besides computation, what are key elements of any text-based application?
- Documentation is a key source of technology transfer. What Java technology tools support package and class API documentation?

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Command-Line Arguments

- Any Java technology application can use command-line arguments
- These string arguments are placed on the command line to launch the Java interpreter, after the class name:

```
java TestArgs arg1 arg2 "another arg"
```

- Each command-line argument is placed in the `args` array that is passed to the static `main` method:

```
public static main(String[] args)
```


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Command-Line Args

```
1   public class TestArgs {
2     public static void main(String[] args) {
3       for ( int i = 0; i < args.length; i++ ) {
4         System.out.println("args[" + i + "] is '" + args[i] + "'");
5       }
6     }
7   }
```

```
> java TestArgs arg1 arg2 "another arg"
```

Here is an excerpt of the output:

```
args[0] is 'arg1'
args[1] is 'arg2'
args[2] is 'another arg'
```


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System Properties

- System properties is a feature that replaces the concept of *environment variables* (which is platform-specific)
- The `System.getProperties` method returns a `Properties` object
- The `getProperty` method returns a `String` representing the value of the named property
- Use the `-D` option to include a new property

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The `Properties` Class

- The `Properties` class implements a mapping of names to values (a `String` to `String` map)
- The `propertyNames` method returns an `Enumeration` of all property names
- The `getProperty` method returns a `String` representing the value of the named property
- You can also read and write a properties collection into a file using `load` and `store`

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System Properties

```
1   import java.util.Properties;
2   import java.util.Enumeration;
3
4   public class TestProperties {
5     public static void main(String[] args) {
6       Properties props = System.getProperties();
7       Enumeration prop_names = props.propertyNames();
8
9       while ( prop_names.hasMoreElements() ) {
10        String prop_name = (String) prop_names.nextElement();
11        String property = props.getProperty(prop_name);
12        System.out.println("property '" + prop_name
13           + "' is '" + property + "'");
14      }
15    }
16  }
```

```
> java -DmyProp=theValue TestProperties
```

Here is an excerpt of the output:

```
property 'java.vm.version' is '1.2.2'
property 'java.compiler' is 'NONE'
property 'path.separator' is ':'
property 'file.separator' is '/'
property 'user.home' is '/home/basham'
property 'java.specification.vendor' is 'Sun Microsystems Inc.'
property 'user.language' is 'en'
property 'user.name' is 'basham'
property 'myProp' is 'theValue'
```


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Console I/O

- `System.out` allows you to write to "standard output"
  - It is an object of type `PrintStream`
- `System.in` allows you to read from "standard input"
  - It is an object of type `InputStream`
- `System.err` allows you to write to "standard error"
  - It is an object of type `PrintStream`

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Writing to Standard Output

- The `println` methods print the argument and a newline (`\n`)
- The `print` methods print the argument without a newline
- The `print` and `println` methods are overloaded for most primitive types (`boolean`, `char`, `int`, `long`, `float`, and `double`) and for `char[]`, `Object`, and `String`
- The `print(Object)` and `println(Object)` methods call the `toString` method on the argument

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Reading From Standard Input

```
1   import java.io.*;
2
3   public class KeyboardInput {
4     public static void main (String args[]) {
5       String s;
6       // Create a buffered reader to read
7       // each line from the keyboard.
8       InputStreamReader ir = new InputStreamReader(System.in);
9       BufferedReader in = new BufferedReader(ir);
10
11      System.out.println("Type ctrl-d or ctrl-c to exit.");
12
13      try {
14        // Read each input line and echo it to the screen.
15        s = in.readLine();
16        while ( s != null ) {
17          System.out.println("Read: " + s);
18          s = in.readLine();
19        }
20
21        // Close the buffered reader.
22        in.close();
23      } catch (IOException e) { // Catch any IO exceptions.
24        e.printStackTrace();
25      }
26    }
27  }
```


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Files and File I/O

- The `java.io` package
- Creating `File` objects
- Manipulating `File` objects
- Reading and writing to file streams

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Creating a New `File` Object

- `File myFile;`
- `myFile = new File("myfile.txt");`
- `myFile = new File("MyDocs", "myfile.txt");`
- Directories are treated just like files in Java; the `File` class supports methods for retrieving an array of files in the directory
- `File myDir = new File("MyDocs");`
  `myFile = new File(myDir, "myfile.txt");`

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`File` Tests and Utilities

- `File` names:

```
String getName()
String getPath()
String getAbsolutePath()
String getParent()
boolean renameTo(File newName)
```

- `File` tests:

```
boolean exists()
boolean canWrite()
boolean canRead()
boolean isFile()
boolean isDirectory()
boolean isAbsolute();
```


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`File` Tests and Utilities

- General file information and utilities:

```
long lastModified()
long length()
boolean delete()
```

- Directory utilities:

```
boolean mkdir()
String[] list()
```


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File Stream I/O

- File Input:
  - Use the `FileReader` class to read characters
  - Use the `BufferedReader` class to use the `readLine` method
- File Output:
  - Use the `FileWriter` class to write characters
  - Use the `PrintWriter` class to use the `print` and `println` methods

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File Input Example

```
1   import java.io.*;
2   public class ReadFile {
3     public static void main (String args[]) {
4       // Create file
5       File file = new File(args[0]);
6
7       try {
8         // Create a buffered reader to read each line from a file.
9         BufferedReader in = new BufferedReader(new FileReader(file));
10        String s;
11
12        // Read each line from the file and echo it to the screen.
13        s = in.readLine();
14        while ( s != null ) {
15          System.out.println("Read: " + s);
16          s = in.readLine();
17        }
18        // Close the buffered reader, which also closes the file reader.
19        in.close();
20
21      } catch (FileNotFoundException e1) {
22      // If this file does not exist
23        System.err.println("File not found: " + file);
24
25      } catch (IOException e2) {
26      // Catch any other IO exceptions.
27        e2.printStackTrace();
28      }
29    }
30  }
```


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File Output Example

```
1   import java.io.*;
2
3   public class WriteFile {
4     public static void main (String args[]) {
5       // Create file
6       File file = new File(args[0]);
7
8       try {
9        // Create a buffered reader to read each line from standard
in.
10        BufferedReader in
11         = new BufferedReader(new InputStreamReader(System.in));
12        // Create a print writer on this file.
13        PrintWriter out
14          = new PrintWriter(new FileWriter(file));
15        String s;
16
17        System.out.print("Enter file text.  ");
18        System.out.println("[Type ctrl-d to stop.]");
19
20        // Read each input line and echo it to the screen.
21        while ((s = in.readLine()) != null) {
22          out.println(s);
23        }
24
25        // Close the buffered reader and the file print writer.
26        in.close();
27        out.close();
28
29      } catch (IOException e) {
30      // Catch any IO exceptions.
31        e.printStackTrace();
32      }
33    }
34  }
```


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Exercise: Writing User Input to a File

- Exercise objectives:
  - Become familiar with using command-line arguments
  - Become familiar with reading text from standard input and writing text to a file
- Tasks:
  - Create a program to read text from standard input and write it to a file
  - Create a program to perform a directory listing

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The `Math` Class

The `Math` class contains a group of static math functions:

- truncation: `ceil`, `floor`, and `round`
- variations on `max`, `min`, and `abs` (absolute value)
- trigonometry: `sin`, `cos`, `tan`, `asin`, `acos`, `atan`, `toDegrees`, and `toRadians`
- logarithms: `log` and `exp`
- others: `sqrt`, `pow`, and `random`
- constants: `PI` and `E`

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The `String` Class

- `String` objects are *immutable* sequences of Unicode characters
- Operations that create new strings: `concat`, `replace`, `substring`, `toLowerCase`, `toUpperCase`, and `trim`
- Search operations: `endsWith`, `startsWith`, `indexOf`, and `lastIndexOf`
- Comparisons: `equals`, `equalsIgnoreCase`, and `compareTo`
- Others: `charAt` and `length`

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The `StringBuffer` Class

- `StringBuffer` objects are mutable sequences of Unicode characters
- Constructors:
  - `StringBuffer()` – Creates an empty buffer
  - `StringBuffer(int capacity)` – Creates an empty buffer with a specified initial capacity
  - `StringBuffer(String initialString)` – Creates a buffer that initially contains the specified string
- Modification operations: `append`, `insert`, `reverse`, `setCharAt`, and `setLength`

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The Collections API

- What is a Collection, Set, and List?
- What are Iterators?
- What are Maps?
- How to sort arrays and collections
- Collections in JDK 1.1

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Collections

- A *collection* is a single object representing a group of objects known as its elements
- The Collection API contains interfaces that group objects as a:
  - `Collection` – A group of objects with no specific ordering; duplicates are permitted
  - `Set` – An unordered collection; no duplicates are permitted
  - `List` – An ordered collection; duplicates are permitted

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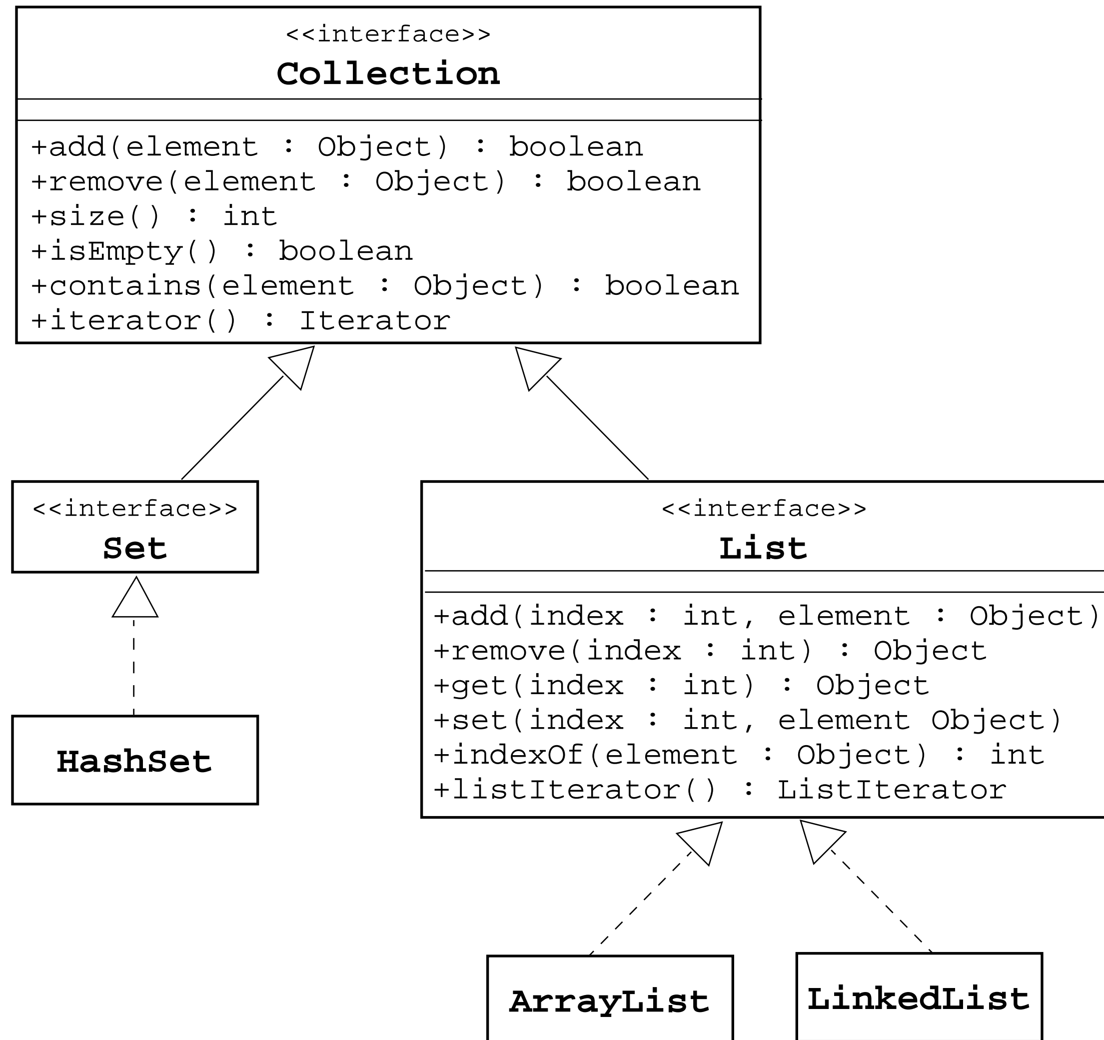

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A Set Example

```
1   import java.util.*
2
3   public class SetExample {
4     public static void main(String[] args) {
5       Set set = new HashSet();
6       set.add("one");
7       set.add("second");
8       set.add("3rd");
9       set.add(new Integer(4));
10      set.add(new Float(5.0F));
11      set.add("second");        // duplicate, not added
12      set.add(new Integer(4));  // duplicate, not added
13      System.out.println(set);
14    }
15  }
```

The output generated from this program is:

```
[one, second, 5.0, 3rd, 4]
```


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A List Example

```
1   import java.util.*
2
3   public class ListExample {
4     public static void main(String[] args) {
5       List list = new ArrayList();
6       list.add("one");
7       list.add("second");
8       list.add("3rd");
9       list.add(new Integer(4));
10      list.add(new Float(5.0F));
11      list.add("second");        // duplicate, is added
12      list.add(new Integer(4));  // duplicate, is added
13      System.out.println(list);
14    }
15  }
```

The output generated from this program is:

```
[one, second, 3rd, 4, 5.0, second, 4]
```


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Iterators

- Iteration is the process of retrieving every element in a collection
- An `Iterator` of a `Set` is unordered
- A `ListIterator` of a `List` can be scanned forwards (using the `next` method) or backwards (using the `previous` method)

```
List list = new ArrayList();
// add some elements
Iterator elements = list.iterator();
while ( elements.hasNext() ) {
  System.out.println(elements.next());
}
```


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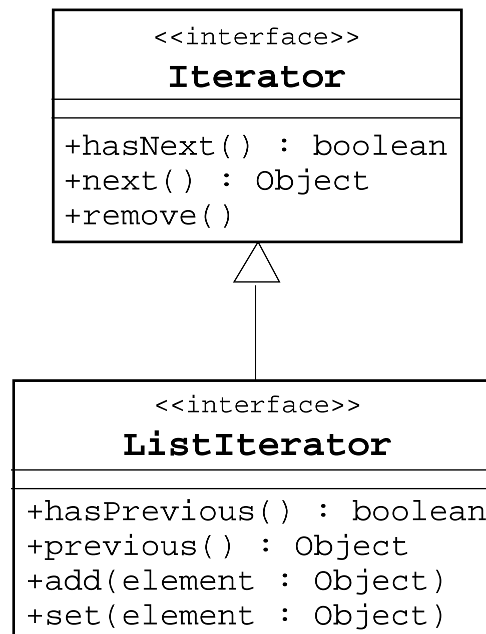
The Iterator Interface Hierarchy



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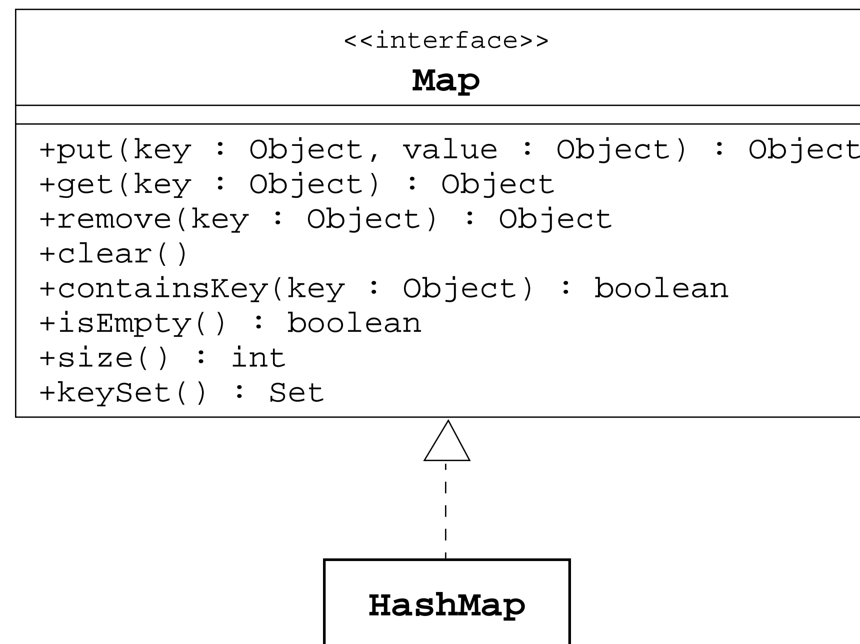
Maps

- A map is a collection of *key* and *value* pairs, where the keys and values can be any arbitrary `Object`; thus, a heterogeneous mapping



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Map: Word Counter

```
1    import java.util.Map
2    import java.util.HashMap;
3    import java.util.Iterator;
4    import java.io.FileReader;
5
6    public class MapExample {
7      public static void main(String[] args)
8            throws java.io.FileNotFoundException {
9        Map        word_count_map = new HashMap();
10       FileReader reader = new FileReader(args[0]);
11       Iterator   words = new WordStreamIterator(reader);
12
13       while ( words.hasNext() ) {
14         String word = (String) words.next();
15         String word_lowercase = word.toLowerCase();  // this is the key
16         Integer frequency = (Integer)word_count_map.get(word_lowercase);
17
18         if ( frequency == null ) {
19           frequency = new Integer(1);
20         } else {
21           int value = frequency.intValue();
22           frequency = new Integer(value + 1);
23         }
24         word_count_map.put(word_lowercase, frequency);
25       }
26       System.out.println(word_count_map);
27     }
28   }
```

This program might produce the following output:

```
{unclean=1, with=2, scene=1, passage=1, our=3, ancient=1, two=3, these=1,
mark'd=1, patient=1, do=1, cross'd=1, where=2, lovers=1, fatal=1, stage=1,
verona=1, new=1, bury=1, forth=1, strife=1, lay=1, fair=1, we=1, alike=1,
could=1, piteous=1, is=1, hands=1, mend=1, in=2, nought=1, both=1,
continuance=1, life=1, if=1, shall=2, the=5, traffic=1, and=1, a=1, toil=1,
take=1, which=2, loins=1, of=5, here=1, end=1, what=1, civil=2, their=6, love=1,
but=1, makes=1, miss=1, rage=1, foes=1, you=1, ears=1, whose=1, now=1, to=2,
dignity=1, fearful=1, pair=1, star=1, strive=1, households=1, hours'=1,
grudge=1, break=1, misadventured=1, mutiny=1, attend=1, overthrows=1,
parents'=2, blood=1, from=2, children's=1, remove=1, death=2}
```


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Sorting Arrays and Collections

- Sorting arrays using `Arrays.sort` methods:
  - `void sort(`<*type*>` array[])`
  - `void sort(`<*type*>` array[], int fromIndex,`
    `int toIndex)`
    where <*type*> is any primitive type (except `boolean`)
- Sorting lists using `Collections.sort` methods:
  - `void sort(List)`
  - `void sort(List, Comparator)`
- The `Comparable` and `Comparator` interfaces
- Sorting a `Set` using a `SortedSet` implementation

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Sorting Arrays

```
1   import java.util.Arrays;
2   import java.text.DecimalFormat;
3
4   public class SortingExample1 {
5     public static void main(String[] args) {
6       double[]  random_values = new double[10];
7
8       // populate the array with random numbers
9       for ( int i = 0; i < random_values.length; i++ ) {
10        random_values[i] = Math.random();
11      }
12
13      // print out unsorted array
14      System.out.println("Unsorted Array:");
15      printArray(random_values);
16
17      // print out sorted array
18      Arrays.sort(random_values);
19      System.out.println("Sorted Array:");
20      printArray(random_values);
21    }
22
23    private static void printArray(double array[]) {
24      System.out.print('[');
25      for ( int i = 0; i < array.length; i++ ) {
26        System.out.print(FORMAT.format(array[i]));
27        if ( (i + 1) < array.length ) {
28          System.out.print(", ");
29        }
30      }
31      System.out.println(']');
32    }
33    private static DecimalFormat FORMAT
34      = new DecimalFormat("0.000");
35  }
```


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Sorting Lists

```
1   import java.util.*;
2
3   public class SortingExample2 {
4     public static void main(String[] args) {
5       Map   word_count_map = new WordCountMap(System.in);
6       Set   entry_set = word_count_map.entrySet();
7
8       System.out.println("Unsorted Entry Set:\n" + entry_set);
9
10      // Create a list of the entries and sort it alphabetically
11      List      entry_list = new ArrayList(entry_set);
12      Collections.sort(entry_list, new AlphaComparator());
13      System.out.println("\nEntry Set (sorted alpha):\n" + entry_list);
14
15      // Sort the list by frequency
16      Collections.sort(entry_list, new FreqComparator());
17      System.out.println("\nEntry Set (sorted by freq):\n" + entry_list);
18    }
19
20    private static class AlphaComparator implements Comparator {
21      public int compare(Object e1, Object e2) {
22        String word1 = (String) ((Map.Entry) e1).getKey();
23        String word2 = (String) ((Map.Entry) e2).getKey();
24        return word1.compareTo(word2);
25      }
26    }
27    private static class FreqComparator implements Comparator {
28      public int compare(Object e1, Object e2) {
29        Integer freq1 = (Integer) ((Map.Entry) e1).getValue();
30        Integer freq2 = (Integer) ((Map.Entry) e2).getValue();
31        return freq2.compareTo(freq1);
32      }
33    }
34  }
```


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Collections in JDK 1.1

- `Vector` implements the `List` interface
- `Stack` is a subclass of `Vector` and supports the `push`, `pop`, and `peek` methods
- `Hashtable` implements the `Map` interface
- `Enumeration` is a variation on the `Iterator` interface
  - An enumeration is returned by the `elements` method in `Vector`, `Stack`, and `Hashtable`
- These classes are thread-safe, and therefore, "heavy-weight"

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Exercise: Using Collections to Represent Aggregation

- Exercise objectives:
  - Become familiar with collections and iterators by rewriting the bank project to use the Java 2 SDK Collections API instead of arrays
- Tasks:
  - Use an `ArrayList` to implement the multiplicity of the association between the `Bank` object and set of customers
  - Sort the bank's list of customers, in lexicographical order by name, to produce an ordered summary report

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Using the javadoc Tool

- This Java 2 SDK tool generates HTML documentation pages
- Usage: `javadoc [options] [packages|files]`

  This example generates the API documentation for the complete Banking project:

```
javadoc -d ../doc/api banking banking.domain /
   banking.reports
```

Option	Value	Description
`-d`	output path	The directory where the generated HTML files should be placed.
`-sourcepath`	directory path	The root directory where the source file package tree.
`-public`		Specifies that only public declarations be included. (*default*)
`-private`		Specifies that all declarations be included.

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Documentation Tags

- Comments starting with `/**` are parsed by the `javadoc` tool
- These comments should immediately precede the declaration they reflect

Tag	Purpose	class/ interface	constructor	method	attribute
`@see`	To create a link to another declaration (or any other HTML page)	✓	✓	✓	✓
`@deprecated`	Documents that the declaration has been deprecated in this release	✓	✓	✓	✓
`@author`	The author of the class or interface	✓			
`@param`	Documents a parameter		✓	✓	
`@throws` `@exception`	Documents why an exception might be thrown		✓	✓	
`@return`	Documents the return value/type			✓	

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Example Java File

```
1    /*
2     * This is an example using javadoc tags.
3     */
4
5    package mypack;
6
7    import java.util.List;
8
9    /**
10    * This class contains a bunch of documentation tags.
11    * @author Bryan Basham
12    * @version 0.5(beta)
13    */
14   public class DocExample {
15
16     /** A simple attribute tag. */
17     private int x;
18
19     /**
20      * This variable a list of stuff.
21      * @see #getStuff()
22      */
23     private List stuff;
24
25     /**
26      * This constructor initializes the x attribute.
27      * @param x_value  the value of x
28      */
29     public DocExample(int x_value) {
30       this.x = x_value;
31     }
32
33     /**
34      * This method return some stuff.
35      * @throws IllegalStateException if no stuff is found
36      * @return List the list of stuff
37      */
38     public List getStuff()
39          throws IllegalStateException {
40       if ( stuff == null ) {
41         throw new java.lang.IllegalStateException("ugh, no stuff");
42       }
43       return stuff;
44     }
45   }
```


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Public Documentation

```
> javadoc -d doc/api/public DocExample.java
```


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Private Documentation

```
> javadoc -private -d doc/api/private DocExample.java
```


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Deprecation

- Deprecation makes classes, attributes, methods, constructors, and so on, obsolete
- Obsolete declarations are replaced by methods with a more standardized naming convention
- When migrating code, compile the code with the `-deprecation` flag:

```
javac -deprecation MyFile.java
```


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Deprecation

JDK 1.1 code, before deprecation is as follows:

```
1   package myutilities;
2
3   import java.util.*;
4   import java.text.*;
5
6   public final class DateConverter {
7     private static final String DAY_OF_THE_WEEK [] =
8       {"Sunday", "Monday", "Tuesday", "Wednesday",
9       "Thursday", "Friday", "Saturday"};
10
11    public static String getDayOfWeek (String theDate){
12      int month, day, year;
13
14      StringTokenizer st = new StringTokenizer (theDate, "/");
15
16      month = Integer.parseInt(st.nextToken ());
17      day = Integer.parseInt(st.nextToken());
18      year = Integer.parseInt(st.nextToken());
19      Date d = new Date (year, month, day);
20
21      return (DAY_OF_THE_WEEK[d.getDay()]);
22    }
23  }
```


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Deprecation

Compiling previous code with the `-deprecation` flag yields:

```
% javac -deprecation DateConverter.java
DateConverter.java:19: Note: The constructor java.util.Date(int,int,int) has been
deprecated.
                Date d = new Date (year, month, day);
                         ^
DateConverter.java:21: Note: The method int getDay() in class java.util.Date has
been deprecated.
                return (day_of_the_week[d.getDay()]);
                                               ^
Note: DateConverter.java uses a deprecated API.Please consult the documentation for
a better alternative.
3 warnings
```


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Deprecation

A Java 2 SDK version rewritten is:

```
1   package myutilities;
2
3   import java.util.*;
4   import java.text.*;
5
6   public final class DateConverter2 {
7     private static String DAY_OF_THE_WEEK[] =
8         {"Sunday", "Monday", "Tuesday", "Wednesday",
9           "Thursday", "Friday", "Saturday"};
10
11    public static String getDayOfWeek (String theDate) {
12      Date d = null;
13      SimpleDateFormat sdf = new SimpleDateFormat("MM/dd/yy");
14
15      try {
16        d = sdf.parse (theDate);
17      } catch (ParseException e) {
18        System.out.println (e);
19        e.printStackTrace();
20      }
21
22      // Create a GregorianCalendar object
23      Calendar c =
24          new GregorianCalendar(
25              TimeZone.getTimeZone("EST"),Locale.US);
26      c.setTime (d);
27
28      return(
29          DAY_OF_THE_WEEK[(c.get(Calendar.DAY_OF_WEEK)-1)]);
30    }
31  }
```


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Using the jar Tool

- This Java 2 SDK tool generates a compressed archive of `.class` and media files
- Usage: `jar [options] [archive_file] [files]`

This generates an archive for the Banking project:

```
jar cvf banking.jar banking/domain/*.class banking/reports/*.class
```

This extracts an archive for the Banking project:

```
jar xvf banking.jar
```

Option	Value	Description
c		This option creates a new archive.
f	filepath	This option specifies the filepath of the JAR (Java archive) file.
x		This option extracts an archive to the current directory.
v		This option specifies verbose output from the `jar` tool.

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Exercise: Building a System

- Exercise objectives:
  - Become familiar with the `javadoc` tool
  - Become familiar with the `jar` tool
- Tasks:
  - Use the `javadoc` tool to build a set of HTML pages that document the banking system
  - Use the `jar` tool to build a JAR file that can be used to deploy the banking system

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Check Your Progress

- Write a program that uses command-line arguments and system properties
- Write a program that reads from *standard input*
- Write a program that can create, read, and write files
- Describe the basic hierarchy of collections in Java 2 SDK
- Write a program that uses sets and lists
- Write a program to iterate over a collection

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Check Your Progress

- Write a program to sort an array or a list
- Describe the collection classes that existed before Java 2 SDK
- Describe and use the `javadoc` and `jar` tools
- Identify deprecated classes and explain how to migrate from JDK 1.0 to JDK 1.1 to Java 2 JDK

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Think Beyond

- Most applications are text-based. What other styles of programs exist?
- What features does the Java application environment have that support user interface development?
- How were interfaces used in this module? Could they have been replaced by some other mechanism, such as abstract classes?

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Module 10

Building Java GUIs

Objectives

- Describe the AWT package and its components
- Define the terms *containers*, *components*, and *layout managers*, and how they work together to build a graphical user interface (GUI)
- Use layout managers
- Use the `FlowLayout`, `BorderLayout`, `GridLayout`, and `CardLayout` managers to achieve a desired dynamic layout
- Add components to a container
- Use the `Frame` and `Panel` containers appropriately

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Objectives

- Describe how complex layouts with nested containers work
- In a Java program, identify the following:
    - Containers
    - The associated layout managers
    - The layout hierarchy of all components

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Relevance

- As a platform-independent programming language, how is Java technology used to make the GUI platform independent?

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Abstract Window Toolkit (AWT)

- Provides graphical user interface (GUI) components that are used in all Java applets and applications
- Contains classes that can be extended and their properties inherited; classes can also be abstract
- Ensures that every GUI component that is displayed on the screen is a subclass of the abstract class `Component` or `MenuComponent`
- Has `Container`, which is an abstract subclass of `Component` and includes two subclasses:
  - `Panel`
  - `Window`

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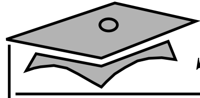

The `java.awt` Package

java.lang.**Object**

- **BorderLayout**
- CardLayout
- **CheckboxGroup**
- Color
- Dimension
- **Event**
- Font
- **FlowLayout**
- FontMetrics
- Graphics
- GridBagConstraints
- GridBagLayout
- **GridLayout**
- Image
- Insets
- Point
- Polygon
- Rectangle
- Toolkit
- MenuComponent
  - MenuBar
  - MenuItem
    - Menu – PopupMenu
    - CheckboxMenuItem
- **Component**
  - **Button**
  - Canvas
  - Checkbox
  - Choice
  - **Container**
    - **Panel**
      - **Applet** (java.applet package)
    - **Window**
      - Dialog – FileDialog
      - **Frame**
    - ScrollPane
  - Label
  - List
  - Scrollbar
  - TextComponent
    - TextArea
    - TextField

Exceptions – AWTException

Errors – AWTError

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Containers

- Add components with the `add()` method
- The two main types of containers are `Window` and `Panel`
- A `Window` is a free floating window on the display
- A `Panel` is a container of GUI components that must exist in the context of some other container, such as a window or applet

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Building Graphical User Interfaces

- The position and size of a component in a container is determined by a layout manager.
- You can control the size or position of components by disabling the layout manager.

  You must then use `setLocation()`, `setSize()`, or `setBounds()` on components to locate them in the container.

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Frames

- Are a subclass of `Window`
- Have title and resizing corners
- Are initially invisible, use `setVisible(true)` to expose the frame
- Have `BorderLayout` as the default layout manager
- Use the `setLayout` method to change the default layout manager

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FrameExample.java

```
1   import java.awt.*;
2
3   public class FrameExample {
4     private Frame f;
5
6     public FrameExample() {
7       f = new Frame("Hello Out There!");
8     }
9
10    public void launchFrame() {
11      f.setSize(170,170);
12      f.setBackground(Color.blue);
13      f.setVisible(true);
14    }
15
16    public static void main(String args[]) {
17      FrameExample guiWindow = new FrameExample();
18      guiWindow.launchFrame();
19    }
20  }
```


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FrameExample.java

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Panels

- Provide a space for components
- Allow subpanels to have their own layout manager

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FrameWithPanel.java

```
1   import java.awt.*;
2
3   public class FrameWithPanel {
4     private Frame f;
5     Panel pan;
6
7     public FrameWithPanel(String title) {
8       f = new Frame(title);
9       pan = new Panel();
10  }
11
12    public void launchFrame() {
13      f.setSize(200,200);
14      f.setBackground(Color.blue);
15      f.setLayout(null);  // Override default layout mgr
16
17      pan.setSize(100,100);
18      pan.setBackground(Color.yellow);
19      f.add(pan);
20      f.setVisible(true);
21    }
22
23    public static void main(String args[]) {
24      FrameWithPanel guiWindow =
25          new FrameWithPanel("Frame with Panel");
26      guiWindow.launchFrame();
27    }
28  }
```


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FrameWithPanel.java

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Container Layouts

- `FlowLayout`
- `BorderLayout`
- `GridLayout`
- `CardLayout`
- `GridBagLayout`

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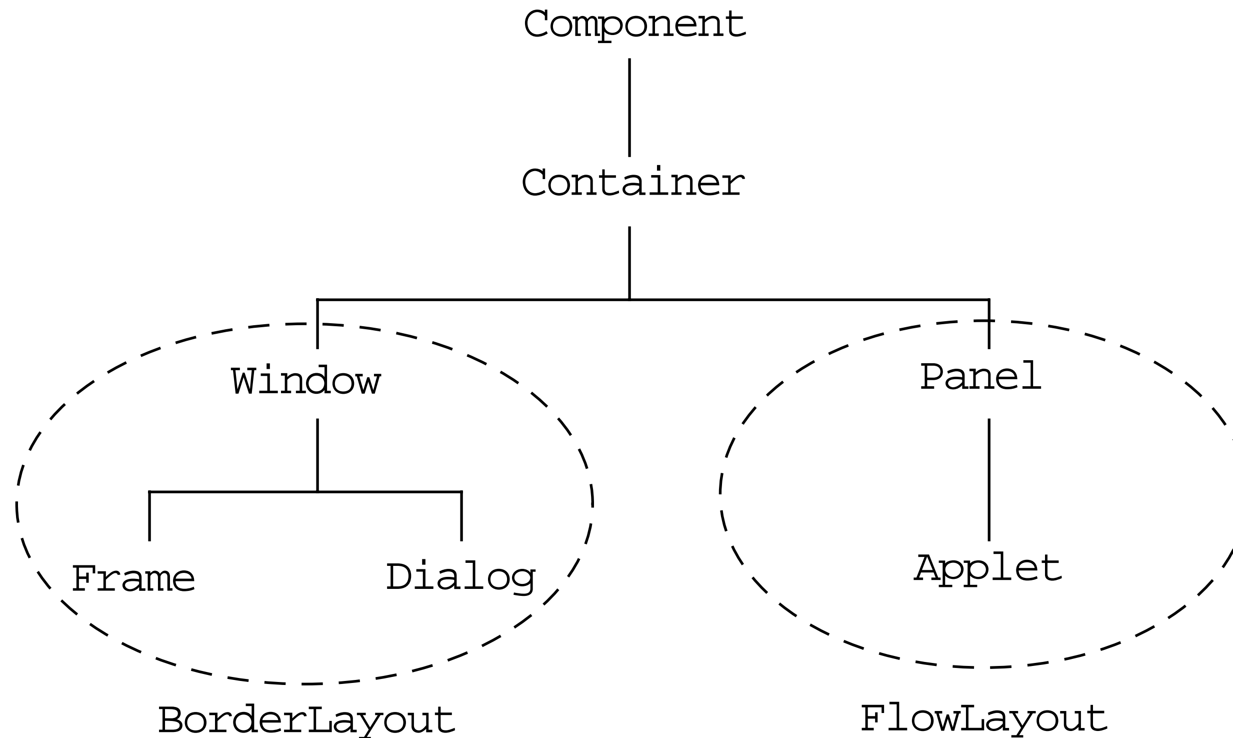
Default Layout Managers



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A Simple FlowLayout Example

```
1   import java.awt.*;
2
3   public class LayoutExample {
4     private Frame f;
5     private Button b1;
6     private Button b2;
7
8     public LayoutExample() {
9       f = new Frame("GUI example");
10      b1 = new Button("Press Me");
11      b2 = new Button("Don't press Me");
12    }
13
14    public void launchFrame() {
15      f.setLayout(new FlowLayout());
16      f.add(b1);
17      f.add(b2);
18      f.pack();
19      f.setVisible(true);
20    }
21
22    public static void main(String args[]) {
23      LayoutExample guiWindow = new LayoutExample();
24      guiWindow.launchFrame();
25    }
26  }
```


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`FlowLayout` Manager

- Default layout for the `Panel` class
- Components added from left to right
- Default alignment is centered
- Uses components' preferred sizes
- Uses the constructor to tune behavior

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FlowExample.java

```
1   import java.awt.*;
2
3   public class FlowExample {
4     private Frame f;
5     private Button button1;
6     private Button button2;
7     private Button button3;
8
9     public FlowExample() {
10      f = new Frame("Flow Layout");
11      button1 = new Button("Ok");
12      button2 = new Button("Open");
13      button3 = new Button("Close");
14    }
15
16    public void launchFrame() {
17      f.setLayout(new FlowLayout());
18      f.add(button1);
19      f.add(button2);
20      f.add(button3);
21      f.setSize(100,100);
22      f.setVisible(true);
23    }
24
25    public static void main(String args[]) {
26      FlowExample guiWindow = new FlowExample();
27      guiWindow.launchFrame();
28    }
29  }
```


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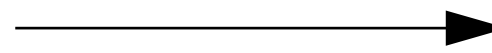
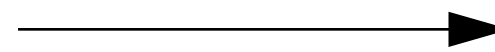
FlowExample.java

After user or
program resizes



After user or
program resizes



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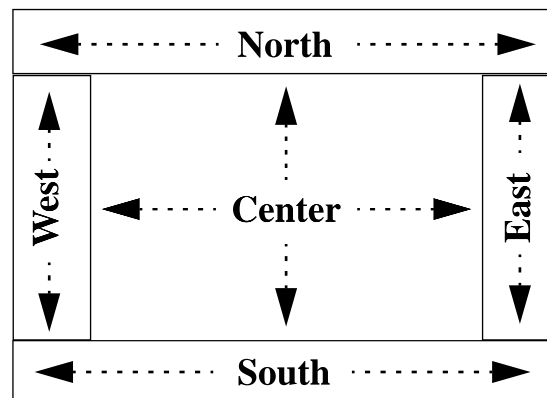
`BorderLayout` Manager

- Default layout for the `Frame` class
- Components added to specific regions
- The resizing behavior:
  - North, South, and Center regions adjust horizontally
  - East, West, and Center regions adjust vertically



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BorderExample.java

```
1   import java.awt.*;
2
3   public class BorderExample {
4     private Frame f;
5     private Button bn, bs, bw, be, bc;
6
7     public BorderExample() {
8       f = new Frame("Border Layout");
9       bn = new Button("B1");
10      bs = new Button("B2");
11      bw = new Button("B3");
12      be = new Button("B4");
13      bc = new Button("B5");
14    }
15
16    public void launchFrame() {
17      f.add(bn, BorderLayout.NORTH);
18      f.add(bs, BorderLayout.SOUTH);
19      f.add(bw, BorderLayout.WEST);
20      f.add(be, BorderLayout.EAST);
21      f.add(bc, BorderLayout.CENTER);
22      f.setSize(200,200);
23      f.setVisible(true);
24    }
25
26    public static void main(String args[]) {
27      BorderExample guiWindow2 = new BorderExample();
28      guiWindow2.launchFrame();
29    }
30  }
```


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BorderExample.java

After window is resized

After window is resized

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`GridLayout` Manager

- Components are added left to right, top to bottom
- All regions are equally sized
- The constructor specifies the rows and columns

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GridExample.java

```
1   import java.awt.*;
2
3   public class GridExample {
4     private Frame f;
5     private Button b1, b2, b3, b4, b5, b6;
6
7     public GridExample() {
8       f = new Frame("Grid Example");
9       b1 = new Button("1");
10      b2 = new Button("2");
11      b3 = new Button("3");
12      b4 = new Button("4");
13      b5 = new Button("5");
14      b6 = new Button("6");
15    }
16
17    public void launchFrame() {
18      f.setLayout (new GridLayout(3,2));
19
20      f.add(b1);
21      f.add(b2);
22      f.add(b3);
23      f.add(b4);
24      f.add(b5);
25      f.add(b6);
26
27      f.pack();
28      f.setVisible(true);
29    }
30
31    public static void main(String args[]) {
32      GridExample grid = new GridExample();
33      grid.launchFrame();
34    }
35  }
```


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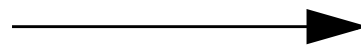
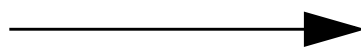
GridEx.java

After window is resized



After window is resized



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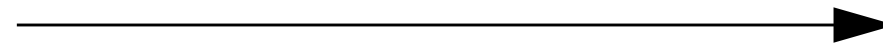
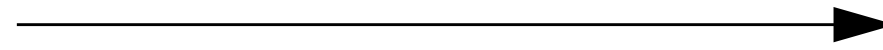
CardLayout Manager





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CardExample.java

```
1   import java.awt.*;
2   import java.awt.event.*;
3
4   public class CardExample implements MouseListener {
5     private Panel p1, p2, p3, p4, p5;
6     private Label lb1, lb2, lb3, lb4, lb5;
7
8     // Declare a CardLayout object to call its methods.
9     private CardLayout myCard;
10    private Frame f;
11
12    public CardExample() {
13      f = new Frame ("Card Test");
14      myCard = new CardLayout();
15
16      // Create the panels that I want to use as cards.
17      p1 = new Panel();
18      p2 = new Panel();
19      p3 = new Panel();
20      p4 = new Panel();
21      p5 = new Panel();
22
23      // Create a label to attach to each panel
24      lb1 = new Label("This is the first Panel");
25      lb2 = new Label("This is the second Panel");
26      lb3 = new Label("This is the third Panel");
27      lb4 = new Label("This is the fourth Panel");
28      lb5 = new Label("This is the fifth Panel");
29    }
30
```


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CardLayout Manager

```
31    public void launchFrame() {
32      f.setLayout(myCard);
33
34      // change the color of each panel, so they are
35      // easily distinguishable
36      p1.setBackground(Color.yellow);
37      p1.add(lb1);
38      p2.setBackground(Color.green);
39      p2.add(lb2);
40      p3.setBackground(Color.magenta);
41      p3.add(lb3);
42      p4.setBackground(Color.white);
43      p4.add(lb4);
44      p5.setBackground(Color.cyan);
45      p5.add(lb5);
46
47      // Set up the event handling here.
48      p1.addMouseListener(this);
49      p2.addMouseListener(this);
50      p3.addMouseListener(this);
51      p4.addMouseListener(this);
52      p5.addMouseListener(this);
53
54      // Add each panel to my CardLayout
55      f.add(p1, "First");
56      f.add(p2, "Second");
57      f.add(p3, "Third");
58      f.add(p4, "Fourth");
59      f.add(p5, "Fifth");
60
61      // Display the first panel.
62      myCard.show(f, "First");
63
64      f.setSize(200,200);
65      f.setVisible(true);
66    }
67
```


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CardLayout Manager

```
68    public void mousePressed(MouseEvent e) {
69      myCard.next(f);
70    }
71
72    public void mouseReleased(MouseEvent e) { }
73    public void mouseClicked(MouseEvent e) { }
74    public void mouseEntered(MouseEvent e) { }
75    public void mouseExited(MouseEvent e) { }
76
77    public static void main (String args[]) {
78      CardExample ct = new CardExample();
79      ct.launchFrame();
80    }
81  }
```


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`GridBagLayout` Manager

- Complex layout facilities can be placed in a grid
- A single component can take its preferred size
- A component can extend over more than one cell

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ComplexLayoutExample.java

```
1   import java.awt.*;
2
3   public class ComplexLayoutExample {
4     private Frame f;
5     private Panel p;
6     private Button bw, bc;
7     private Button bfile, bhelp;
8
9     public ComplexLayoutExample() {
10      f = new Frame("GUI example 3");
11      bw = new Button("West");
12      bc = new Button("Work space region");
13      bfile = new Button("File");
14      bhelp = new Button("Help");
15    }
16
17    public void launchFrame() {
18      // Add bw and bc buttons in the frame border
19      f.add(bw, BorderLayout.WEST);
20      f.add(bc, BorderLayout.CENTER);
21      // Create panel for the buttons in the north border
22      p = new Panel();
23      p.add(bfile);
24      p.add(bhelp);
25      f.add(p, BorderLayout.NORTH);
26      // Pack the frame and make it visible
27      f.pack();
28      f.setVisible(true);
29    }
30
31    public static void main(String args[]) {
32      ComplexLayoutExample gui = new ComplexLayoutExample();
33      gui.launchFrame();
34    }
35  }
```


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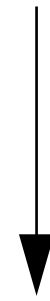
Output of `ComplexLayoutExample.java`



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Drawing in AWT

- You can draw in any `Component` (although AWT provides the `Canvas` class just for this purpose)
- Typically, you would create a subclass of `Canvas` and override the `paint` method
- The `paint` method is called every time the component is shown (for example, if another window was overlapping the component and then removed)
- Every component has a `Graphics` object
- The `Graphics` class implements many drawing methods

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Drawing With the Graphics Object

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Exercise: Building Java GUIs

- Exercise objective:
  - Develop two graphical user interfaces using the AWT
- Tasks:
  - Create a chat room GUI
  - Create a calculator GUI

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Check Your Progress

- Describe the AWT package and its components
- Define the terms *containers*, *components*, and *layout managers*, and how they work together to build a graphical user interface (GUI)
- Use layout managers
- Use the `FlowLayout`, `BorderLayout`, `GridLayout`, and `CardLayout` managers to achieve a desired dynamic layout
- Add components to a container
- Use the `Frame` and `Panel` containers appropriately

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Check Your Progress

- Describe how complex layouts with nested containers work
- In a Java program, identify the following:
  - Containers
  - The associated layout managers
  - The layout hierarchy of all components

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Think Beyond

- You now know how to display a GUI on the computer screen. What do you need to make the GUI useful?

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Module 11

GUI Event Handling

Objectives

- Define events and event handling
- Write code to handle events that occur in a GUI
- Describe the concept of adapter classes, including how and when to use them
- Determine the user action that originated the event from the event object details

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Objectives

- Identify the appropriate interface for a variety of event types
- Create the appropriate event handler methods for a variety of event types
- Understand the use of inner classes and anonymous classes in event handling

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Relevance

- What parts of a GUI are required to make it useful?
- How does a graphical program handle a mouse click or any other type of user interaction?

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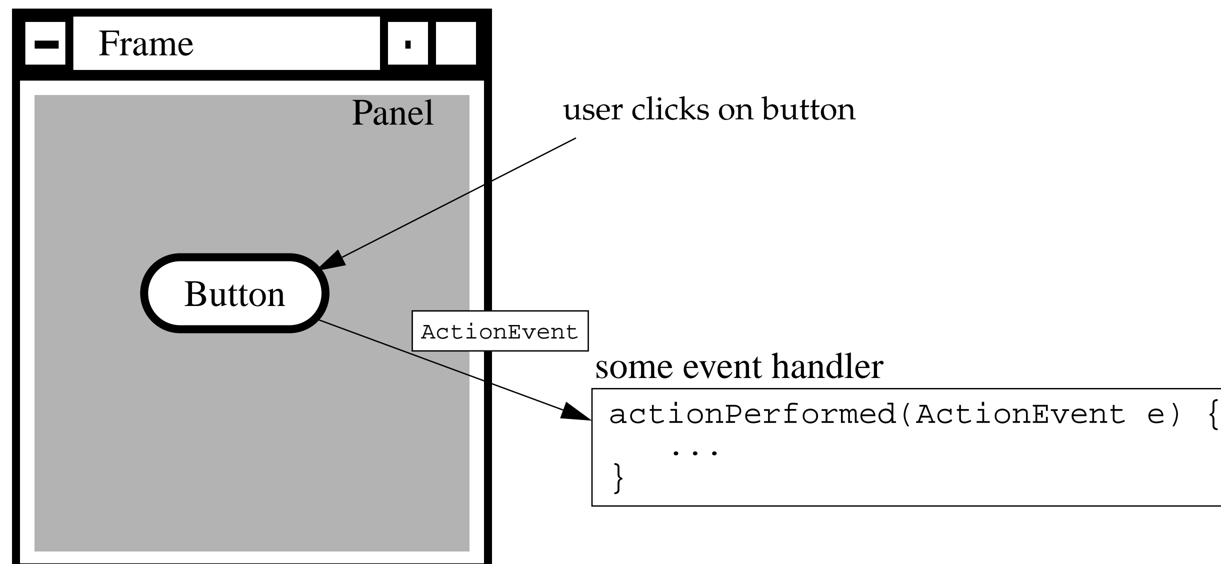
What Is an Event?

- Events – Objects that describe what happened
- Event sources – The generator of an event
- Event handlers – A method that receives an event object, deciphers it, and processes the user's interaction



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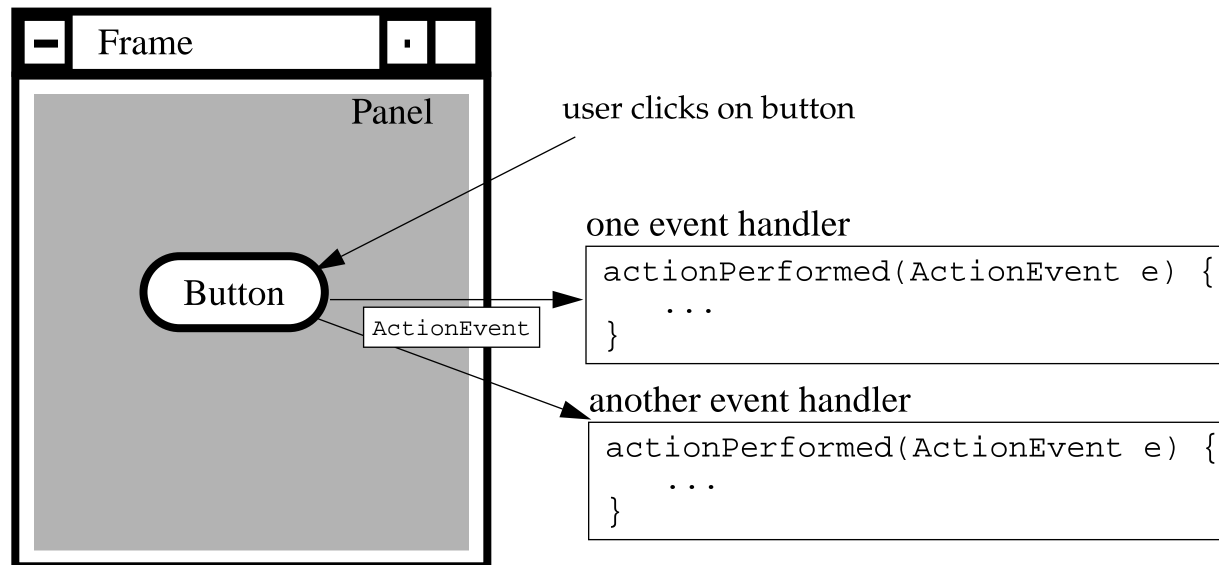
Delegation Model

- An event can be sent to many event handlers



- Event handlers register with components when they are interested in events generated by that component

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Delegation Model

```
1   import java.awt.*;
2
3   public class TestButton {
4     private Frame f;
5     private Button b;
6
7     public TestButton() {
8       f = new Frame("Test");
9       b = new Button("Press Me!");
10      b.setActionCommand("ButtonPressed");
11    }
12
13    public void launchFrame() {
14      b.addActionListener(new ButtonHandler());
15      f.add(b,BorderLayout.CENTER);
16      f.pack();
17      f.setVisible(true);
18    }
19
20    public static void main(String args[]) {
21      TestButton guiApp = new TestButton();
22      guiApp.launchFrame();
23    }
24  }
```

```
1   import java.awt.event.*;
2
3   public class ButtonHandler implements ActionListener {
4     public void actionPerformed(ActionEvent e) {
5       System.out.println("Action occurred");
6       System.out.println("Button’s command is: "
7                          + e.getActionCommand());
8     }
9   }
```


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Delegation Model

- Client objects (handlers) register with a GUI component they wish to observe
- GUI components only trigger the handlers for the type of event that has occurred
  - Most components can trigger more than one type of event
- Distributes the work among multiple classes

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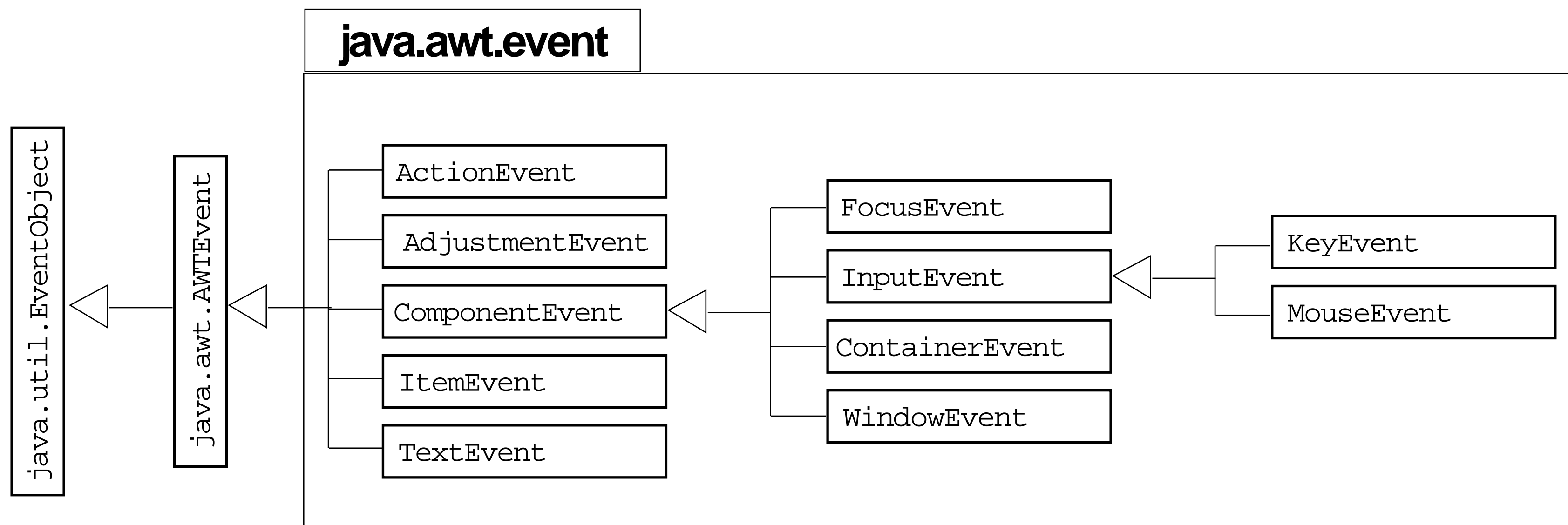
Event Categories



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Java GUI Behavior

Category	Interface Name	Methods
Action	`ActionListener`	`actionPerformed(ActionEvent)`
Item	`ItemListener`	`itemStateChanged(ItemEvent)`

Mouse	`MouseListener`	`mousePressed(MouseEvent)`
		`mouseReleased(MouseEvent)`
		`mouseEntered(MouseEvent)`
		`mouseExited(MouseEvent)`
		`mouseClicked(MouseEvent)`

Mouse Motion	`MouseMotionListener`	`mouseDragged(MouseEvent)` `mouseMoved(MouseEvent)`

Key	`KeyListener`	`keyPressed(KeyEvent)`
		`keyReleased(KeyEvent)`
		`keyTyped(KeyEvent)`

Focus	`FocusListener`	`focusGained(FocusEvent)` `focusLost(FocusEvent)`
Adjustment	`AdjustmentListener`	`adjustmentValueChanged` `(AdjustmentEvent)`

Component	`ComponentListener`	`componentMoved(ComponentEvent)`
		`componentHidden(ComponentEvent)`
		`componentResized(ComponentEvent)`
		`componentShown(ComponentEvent)`

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Java GUI Behavior

Category	Interface Name	Methods

Window	`WindowListener`	`windowClosing(WindowEvent)`
		`windowOpened(WindowEvent)`
		`windowIconified(WindowEvent)`
		`windowDeiconified(WindowEvent)`
		`windowClosed(WindowEvent)`
		`windowActivated(WindowEvent)`
		`windowDeactivated(WindowEvent)`

Container	`ContainerListener`	`componentAdded(ContainerEvent)` `componentRemoved(ContainerEvent)`
Text	`TextListener`	`textValueChanged(TextEvent)`

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Complex Example

```
1   import java.awt.*;
2   import java.awt.event.*;
3
4   public class TwoListener
5        implements MouseMotionListener,
6                   MouseListener {
7     private Frame f;
8     private TextField tf;
9
10    public TwoListener() {
11      f = new Frame("Two listeners example");
12      tf = new TextField(30);
13    }
14
15    public void launchFrame() {
16      Label label = new Label("Click and drag the mouse");
17      // Add components to the frame
18      f.add(label, BorderLayout.NORTH);
19      f.add(tf, BorderLayout.SOUTH);
20      // Add this object as a listener
21      f.addMouseMotionListener(this);
22      f.addMouseListener(this);
23      // Size the frame and make it visible
24      f.setSize(300, 200);
25      f.setVisible(true);
26    }
27
28    // These are MouseMotionListener events
29    public void mouseDragged(MouseEvent e) {
30      String s =  "Mouse dragging:  X = " + e.getX()
31                  + " Y = " + e.getY();
32      tf.setText(s);
33    }
34
35    public void mouseEntered(MouseEvent e) {
36      String s = "The mouse entered";
37      tf.setText(s);
38    }
```


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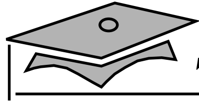

Complex Example

```
39
40    public void mouseExited(MouseEvent e) {
41      String s = "The mouse has left the building";
42      tf.setText(s);
43    }
44
45    // Unused MouseMotionListener method.
46    // All methods of a listener must be present in the
47    // class even if they are not used.
48    public void mouseMoved(MouseEvent e) { }
49
50    // Unused MouseListener methods.
51    public void mousePressed(MouseEvent e) { }
52    public void mouseClicked(MouseEvent e) { }
53    public void mouseReleased(MouseEvent e) { }
54
55    public static void main(String args[]) {
56      TwoListener two = new TwoListener();
57      two.launchFrame();
58    }
59  }
```


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Multiple Listeners

- Multiple listeners cause unrelated parts of a program to react to the same event
- The handlers of all registered listeners are called when the event occurs

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Event Adapters

- The listener classes that you define can extend adapter classes and override only the methods that you need
- Example:

```
1   import java.awt.*;
2   import java.awt.event.*;
3
4   public class MouseClickHandler extends MouseAdapter {
5
6     // We just need the mouseClick handler, so we use
7     // the an adapter to avoid having to write all the
8     // event handler methods
9
10    public void mouseClicked(MouseEvent e) {
11      // Do stuff with the mouse click...
12    }
13  }
```


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Inner Classes

```
1   import java.awt.*;
2   import java.awt.event.*;
3
4   public class TestInner {
5     private Frame f;
6     private TextField tf;
7
8     public TestInner() {
9       f = new Frame("Inner classes example");
10      tf = new TextField(30);
11    }
12
13    public void launchFrame() {
14      Label label = new Label("Click and drag the mouse");
15      // Add components to the frame
16      f.add(label, BorderLayout.NORTH);
17      f.add(tf, BorderLayout.SOUTH);
18      // Add a listener that uses an Inner class
19      f.addMouseMotionListener(new MyMouseMotionListener());
20      f.addMouseListener(new MouseClickHandler());
21      // Size the frame and make it visible
22      f.setSize(300, 200);
23      f.setVisible(true);
24    }
25
26    class MyMouseMotionListener extends MouseMotionAdapter {
27        public void mouseDragged(MouseEvent e) {
28          String s = "Mouse dragging:  X = "+ e.getX()
29                      + " Y = " + e.getY();
30          tf.setText(s);
31        }
32      }
33
34    public static void main(String args[]) {
35      TestInner obj = new TestInner();
36      obj.launchFrame();
37    }
38  }
39
```


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Anonymous Classes

```
1   import java.awt.*;
2   import java.awt.event.*;
3
4   public class TestAnonymous {
5     private Frame f;
6     private TextField tf;
7
8     public TestAnonymous() {
9       f = new Frame("Anonymous classes example");
10      tf = new TextField(30);
11    }
12
13    public void launchFrame() {
14      Label label = new Label("Click and drag the mouse");
15      // Add components to the frame
16      f.add(label, BorderLayout.NORTH);
17      f.add(tf, BorderLayout.SOUTH);
18      // Add a listener that uses an anonymous class
19      f.addMouseMotionListener(new MouseMotionAdapter() {
20        public void mouseDragged(MouseEvent e) {
21          String s = "Mouse dragging:  X = "+ e.getX()
22                      + " Y = " + e.getY();
23          tf.setText(s);
24        }
25      }); // <- note the closing parenthesis
26      f.addMouseListener(new MouseClickHandler());
27      // Size the frame and make it visible
28      f.setSize(300, 200);
29      f.setVisible(true);
30    }
31
32    public static void main(String args[]) {
33      TestAnonymous obj = new TestAnonymous();
34      obj.launchFrame();
35    }
36  }
```


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Exercise: Working With Events

- Exercise objective:
  - You will write, compile, and run the revised ChatClient GUI and Calculator GUI codes to include event handlers
- Tasks:
  - Add event handlers to the ChatClient GUI
  - Add event handlers to the Calculator GUI

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Check Your Progress

- Define events and event handling
- Write code to handle events that occur in a GUI
- Describe the concept of adapter classes, including how and when to use them
- Determine the user action that originated the event from the event object details

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Check Your Progress

- Identify the appropriate interface for a variety of event types
- Create the appropriate event handler methods for a variety of event types
- Understand the use of inner classes and anonymous classes in event handling

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Think Beyond

- You now know how to set up a Java GUI for both graphic output and interactive user input. However, only a few of the components from which GUIs can be built have been described. What other components would be useful in a GUI?

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Module 12

Introduction to Java Applets

Objectives

- Differentiate between a standalone application and an applet
- Write an HTML tag to call a Java applet
- Describe the class hierarchy of the applet and AWT classes
- Create the `HelloWorld.Java` applet
- List the major methods of an applet

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Objectives

- Describe and use the painting model of AWT
- Use applet methods to read images and files from URLs
- Handle various mouse events within the applet
- Pass parameters to an applet from an HTML file using the `<param>` tag

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Relevance

- What advantages do applets provide over standalone applications?

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What Is an Applet?

A Java class that can be:

- Embedded within an HTML page and downloaded and executed by a Web browser
- Loaded using the browser as follows:

  1. Browser loads URL.
  2. Browser loads HTML document.
  3. Browser loads applet classes.
  4. Browser runs applet.

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What Is An Applet?

http://someLocation/file.html

HTML file:

```
<HTML>
:
<APPLET CODE = ...>
</APPLET>
```

Applet Classes

Browser

Location: http://someLocation/file.html

Loading...

1. Browser loads URL.
2. Browser loads HTML document.
3. Browser loads applet classes.
4. Browser runs applet.

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Applet Security Restrictions

- Most browsers prevent the following:
  - Runtime execution of another program
  - File I/O
  - Calls to any native methods
  - Attempts to open a socket to any system except the host that provided the applet

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Applet Class Hierarchy

```
java.lang.Object
        |
java.awt.Component
        |
java.awt.Container
   /             \
java.awt.Window   java.awt.Panel
   |                  |
java.awt.Frame    java.applet.Applet
```


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Key Applet Methods

- `init()`
- `start()`
- `stop()`
- `destroy()`
- `paint()`

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The Applet Life Cycle

- `init()`
  - Called when the applet is created
  - Can be used to initialize data values
- `start()`
  - Called when the applet becomes visible
- `stop()`
  - Called when the applet becomes invisible

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Applet Display

- Applets are graphical in nature
- The browser environment calls the `paint()` method

```
1   import java.awt.*;
2   import java.applet.*;
3
4   public class HelloWorld extends Applet {
5     private paintCount;
6     public void init() {
7       paintCount = 0;
8     }
9     public void paint(Graphics g){
10      g.drawString("Hello World!", 25, 25);
11      paintCount++;
12      g.drawString("Number of times paint called: "
13                    + paintCount, 25, 50);
14    }
15  }
```


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AWT Painting

- `paint(Graphics g)` – Called when the component is "exposed". This is where the programmer implements the painting algorithm.
- `repaint()` – You call this method to ask the AWT thread to repaint the component.
- `update(Graphics g)` – This method is called by the AWT thread when a repaint has been requested.

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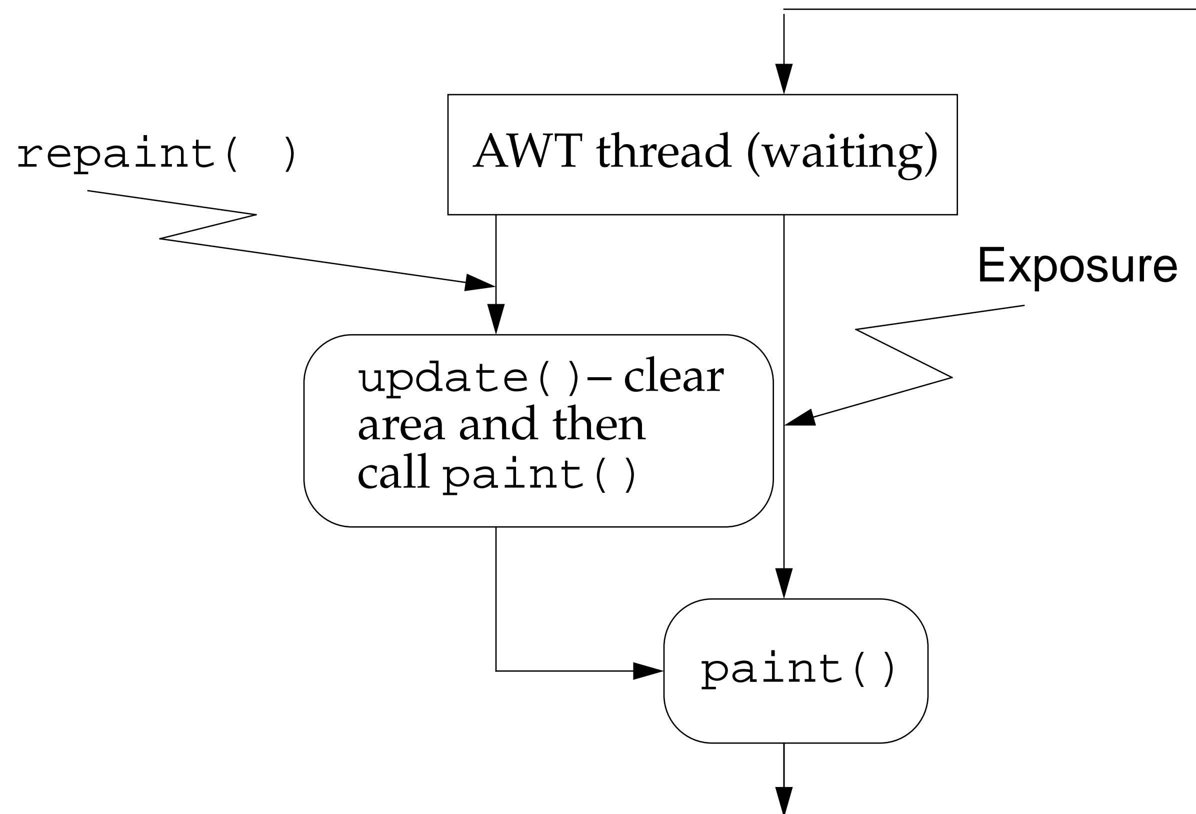
AWT Painting



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Applet Display Strategies

- Maintain a model of the display
- Use `paint()` to render the display based only on the model
- Update the model and call `repaint()` to change the display

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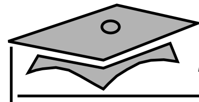

An Example Paint Model

- Requirement: Paint "`Hello World!`" wherever the user clicks.
- The model is the last user click point.

```
1   // <APPLET CODE="PaintModel1.class" WIDTH=200 HEIGHT=200></APPLET>
2
3   import java.applet.*;
4   import java.awt.event.*;
5   import java.awt.*;
6
7   public class PaintModel1 extends Applet {
8     // The paint model: the last click Point
9     private Point lastClick = null;
10
11    public void init() {
12      addMouseListener(new MyModelRecorder());
13    }
14
15    public void paint(Graphics g) {
16      if ( lastClick != null ) {
17        g.drawString("Hello World!", lastClick.x, lastClick.y);
18      }
19    }
20
21    private class MyModelRecorder extends MouseAdapter {
22      public void mousePressed(MouseEvent e) {
23        lastClick = e.getPoint();
24        repaint();
25      }
26    }
27  }
```


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An Example Paint Model

- The model is the last user click point.
- The update method is overridden to avoid clearing the screen.

```
1   // <APPLET CODE="PaintModel2.class" WIDTH=200 HEIGHT=200></APPLET>
2
3   import java.applet.*;
4   import java.awt.event.*;
5   import java.awt.*;
6
7   public class PaintModel2 extends Applet {
8     // The paint model: the last click Point
9     private Point lastClick = null;
10
11    public void init() {
12      addMouseListener(new MyModelRecorder());
13    }
14
15    public void update(Graphics g) {
16      paint(g);
17    }
18
19    public void paint(Graphics g) {
20      if ( lastClick != null ) {
21        g.drawString("Hello World!", lastClick.x, lastClick.y);
22      }
23    }
24
25    private class MyModelRecorder extends MouseAdapter {
26      public void mousePressed(MouseEvent e) {
27        lastClick = e.getPoint();
28        repaint();
29      }
30    }
31  }
```


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An Example Paint Model

- The model is a list of all user click points.

```
1   //<APPLET CODE="PaintModel3.class" WIDTH=200 HEIGHT=200></APPLET>
2
3   import java.applet.*;
4   import java.awt.event.*;
5   import java.awt.*;
6   import java.util.List;
7   import java.util.ArrayList;
8
9   public class PaintModel3 extends Applet {
10    // The paint model: a list of click Points
11    private List mouseClicks = new ArrayList(5);
12
13    public void init() {
14      addMouseListener(new MyModelRecorder());
15    }
16
17    public void update(Graphics g) {
18      paint(g);
19    }
20
21    public void paint(Graphics g) {
22      for(int x = 0; x < mouseClicks.size(); x++) {
23        Point p = (Point) mouseClicks.get(x);
24        g.drawString("Hello World!", p.x, p.y);
25      }
26    }
27
28    private class MyModelRecorder extends MouseAdapter {
29      public void mousePressed(MouseEvent e) {
30        mouseClicks.add(e.getPoint());
31        repaint();
32      }
33    }
34  }
```


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What Is the `appletviewer`?

A Java application that:

- Enables you to run applets without using a Web browser
- Loads the HTML file supplied as an argument
- `appletviewer HelloWorld.html`
- Needs at least the following HTML code:

```
1   <applet code="HelloWorld.class" width=300 height=300>
2   </applet>
```


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Running the `appletviewer`

Synopsis:

```
appletviewer [-debug] URLs...
```

Example:

```
appletviewer HelloWorld.html
```


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The applet Tag

```
<applet
   [archive=archiveList]
   code=appletFile.class
   width=pixels
   height=pixels
   [codebase=codebaseURL]
   [alt=alternateText]
   [name=appletInstanceName]
   [align=alignment]
   [vspace=pixels] [hspace=pixels]
>
   [<param name=appletAttribute1 value=value>]
   [<param name=appletAttribute2 value=value>]
    . . .
   [alternateHTML]
</applet>
```


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Additional Applet Features

- `getDocumentBase()` – Returns a `URL` object that describes the directory of the current browser page
- `getCodeBase()` – Returns a `URL` object that describes the source directory of the applet class
- `getImage(URL base, String target)` and `getAudioClip(URL base, String target)` – Use the `URL` object as a starting point

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A Simple Image Test

```
1   // Applet which shows an image of Duke in surfing mode
2
3   import java.awt.*;
4   import java.applet.Applet;
5
6   public class HwImage extends Applet {
7     Image duke;
8
9     public void init() {
10      duke = getImage(getDocumentBase(),
11          "graphics/surferDuke.gif");
12    }
13
14    public void paint(Graphics g) {
15      g.drawImage(duke, 25, 25, this);
16    }
17  }
```


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Audio Clips

Playing a clip:

```
play(URL soundDirectory, String soundFile);
play(URL soundURL);
```

Example:

```
play(getDocumentBase(), "bark.au");
```


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A Simple Audio Test

```
1   // Applet which plays a sound on every mouse click
2
3   import java.awt.Graphics;
4   import java.awt.event.MouseAdapter;
5   import java.awt.event.MouseEvent;
6   import java.applet.Applet;
7
8   public class HwAudio extends Applet {
9     public void init() {
10      addMouseListener(new MouseAdapter() {
11        public void mouseClicked(MouseEvent event) {
12          play(getCodeBase(), "sounds/cuckoo.au");
13        }
14      });
15    }
16    public void paint(Graphics g) {
17      g.drawString("Audio Test", 25, 25);
18    }
19  }
```


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Looping an Audio Clip

- Loading an Audio Clip
- Playing an Audio Clip
- Stopping an Audio Clip

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A Simple Looping Test

```
1   // Applet which continuously repeats a sound
2
3   import java.awt.Graphics;
4   import java.applet.*;
5
6   public class HwLoop extends Applet {
7     AudioClip sound;
8
9     public void init() {
10      sound = getAudioClip(getCodeBase(), "sounds/cuckoo.au");
11    }
12
13    public void paint(Graphics g) {
14      g.drawString("Audio Test", 25, 25);
15    }
16
17    public void start() {
18      sound.loop();
19    }
20
21    public void stop() {
22      sound.stop();
23    }
24  }
```


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Mouse Input

- `mouseClicked` – The mouse has been clicked (mouse button pressed and then released in one motion)
- `mouseEntered` – The mouse cursor enters a component
- `mouseExited` – The mouse cursor leaves a component
- `mousePressed` – The mouse button is pressed down
- `mouseReleased` – The mouse button is later released

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A Simple Mouse Test

```
1   // This applet is HelloWorld extended to watch for mouse
2   // input. "Hello World!" is reprinted at the location of
3   // the mouse press.
4
5   import java.awt.Graphics;
6   import java.awt.event.*;
7   import java.applet.Applet;
8
9   public class HwMouse extends Applet {
10    // "paint model data"
11    private int mouseX = 25;
12    private int mouseY = 25;
13
14    // Register an anonymous mouse events handler.
15    public void init() {
16      addMouseListener(new MouseHandler());
17    }
18
19    public void paint(Graphics g) {
20      g.drawString("Hello World!", mouseX, mouseY);
21    }
22
23    private class MouseHandler extends MouseAdapter {
24      public void mousePressed(MouseEvent evt) {
25        // record the position of the mouse
26        // in the "paint model data"
27        mouseX = evt.getX();
28        mouseY = evt.getY();
29        // inform AWT to repaint the applet
30        repaint();
31      }
32    }
33  }
```


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Reading Parameters

- Applet code

```
1   <html>
2   <applet code="Parameters.class" width=200 height=200>
3     <param name=speed value="12">
4     <param name=distance value="500m">
5   </applet>
6   </html>
```

- Program code

```
1   // Parameter test applet. To see a change in "speed",
2   // you must supply it as a <param> tag in the HTML file
3   // which calls this applet.
4
5   import java.applet.Applet;
6   import java.awt.Graphics;
7
8   public class Parameters extends Applet {
9     private String toDisplay;
10    private int speed;
11
12    public void init() {
13      String pv;
14      pv = getParameter("speed");
15      if (pv == null){
16        speed = 10;
17      } else {
18        speed = Integer.parseInt (pv);
19      }
20      toDisplay = "Speed given: " + speed;
21    }
22
23    public void paint(Graphics g) {
24      g.drawString(toDisplay, 25, 25);
25    }
26  }
```


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Exercise: Creating Applets

- Exercise objective:
  - Become familiar with programming Java applets
- Tasks:
  - Write an applet
  - Create concentric squares
  - Create a rollover applet

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Check Your Progress

- Differentiate between a standalone application and an applet
- Write an HTML tag to call a Java applet
- Describe the class hierarchy of the applet and AWT classes
- Create the `HelloWorld.Java` applet
- List the major methods of an applet

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Check Your Progress

- Describe and use the painting model of AWT
- Use applet methods to read images and files from URLs
- Handle various mouse events within the applet
- Pass parameters to an applet from an HTML file using the `<param>` tag

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Think Beyond

- How can you use applets on your company’s Web page to improve the overall presentation?

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Module 13

GUI-Based Applications

Objectives

- Identify the key AWT components and the events that they trigger
- Describe how to construct a menu bar, menu, and menu items in a Java GUI
- Understand how to change the color and font of a component
- Use the Java printing mechanism
- Understand how to construct a GUI class that can be used within a Frame or within an Applet

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Relevance

- You now know how to set up a Java GUI for both graphic output and interactive user input. However, only a few of the components from which GUIs can be built have been described. What other components would be useful in a GUI?
- How can you create a menu for your GUI frame?

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AWT Components

Component Type	Description
Button	A named rectangular box used for receiving mouse clicks
Canvas	A panel used for drawing
Checkbox	A component allowing the user to select an item
CheckboxMenuItem	A checkbox within a menu
Choice	A pull-down static list of items
Component	The parent of all AWT components, except menu components
Container	The parent of all AWT containers
Dialog	The base class of all modal dialog boxes
Frame	The base class of all GUI windows with window manager controls
Label	A text string component
List	A component that contains a dynamic set of items
Menu	An element under the menu bar, which contains a set of menu items
MenuItem	An item within a menu
Panel	A basic container class used most often to create complex layouts
Scrollbar	A component which allows a user to "select from a range of values"
ScrollPane	A container class which implements automatic horizontal and/or vertical scrolling for a single child component
TextArea	A component that allows the user to enter a block of text
TextField	A component that allows the user to enter a single line of text
Window	The base class of all GUI windows, with no window manager controls

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Component Events

Component Type	Act	Adj	Cmp	Cnt	Foc	Itm	Key	Mou	MM	Text	Win
Button	✓		✓		✓		✓	✓	✓		
Canvas			✓		✓		✓	✓	✓		
Checkbox			✓		✓	✓	✓	✓	✓		
CheckboxMenuItem						✓					
Choice			✓		✓	✓	✓	✓	✓		
Component			✓		✓		✓	✓	✓		
Container			✓	✓	✓		✓	✓	✓		
Dialog			✓	✓	✓		✓	✓	✓		✓
Frame			✓	✓	✓		✓	✓	✓		✓
Label			✓		✓		✓	✓	✓		
List	✓		✓		✓	✓	✓	✓	✓		
MenuItem	✓										
Panel			✓	✓	✓		✓	✓	✓		
Scrollbar		✓	✓		✓		✓	✓	✓		
ScrollPane			✓	✓	✓		✓	✓	✓		
TextArea			✓		✓		✓	✓	✓	✓	
TextField	✓		✓		✓		✓	✓	✓	✓	
Window			✓	✓	✓		✓	✓	✓		✓

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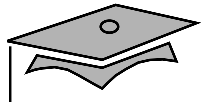

How to Create a Menu

1. Create a `MenuBar` object and set it into a menu container such as a `Frame`.
2. Create one or more `Menu` objects and add them to the menu bar object.
3. Create one or more `MenuItem` objects and add them to the menu object.

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Creating a MenuBar

```
1  Frame f = new Frame("MenuBar");
2  MenuBar mb = new MenuBar();
3  f.setMenuBar(mb);
```


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Creating a Menu

```
1      Frame f = new Frame("Menu");
2      MenuBar mb = new MenuBar();
3      Menu m1 = new Menu("File");
4      Menu m2 = new Menu("Edit");
5      Menu m3 = new Menu("Help");
6      mb.add(m1);
7      mb.add(m2);
8      mb.setHelpMenu(m3);
9      f.setMenuBar(mb);
```


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Creating a `MenuItem`

```
1       MenuItem mi1 = new MenuItem("New");
2       MenuItem mi2 = new MenuItem("Save");
3       MenuItem mi3 = new MenuItem("Load");
4       MenuItem mi4 = new MenuItem("Quit");
5       mi1.addActionListener(this);
6       mi2.addActionListener(this);
7       mi3.addActionListener(this);
8       mi4.addActionListener(this);
9       m1.add(mi1);
10      m1.add(mi2);
11      m1.add(mi3);
12      m1.addSeparator();
13      m1.add(mi4);
```


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Creating a CheckBoxMenuItem

```
1       MenuBar mb = new MenuBar();
2       Menu m1 = new Menu("File");
3       Menu m2 = new Menu("Edit");
4       Menu m3 = new Menu("Help");
5       mb.add(m1);
6       mb.add(m2);
7       mb.setHelpMenu(m3);
8       f.setMenuBar(mb);
9       .....
10      MenuItem mi2 = new MenuItem("Save");
11      mi2.addActionListener(this);
12      m1.add(mi2);
13      ......
14      CheckboxMenuItem mi5 = new CheckboxMenuItem("Persistent");
15      mi5.addItemListener(this);
16      m1.add(mi5);
```


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Controlling Visual Aspects

- Colors:
  - `setForeground()`
  - `setBackground()`
- Example:

```
int r = 255;
Color c = new Color(r, 0, 0);
```


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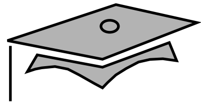

Controlling Visual Aspects

- Fonts:
  - You can use the `setFont()` method to specify the font used for displaying text
  - `Dialog`, `DialogInput`, `Serif`, and `SansSerif` are valid font names
- Example:

```
Font font = new Font("TimesRoman", Font.PLAIN, 14);
```

- Use the `GraphicsEnvironment` class to retrieve the set of all available fonts:

```
GraphicsEnvironment ge =
  GraphicsEnvironment.getLocalGraphicsEnvironment();
Font[] fonts = ge.getAllFonts();
```


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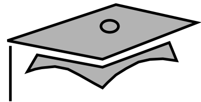

Controlling Visual Aspects

- The `Toolkit` class is an abstract superclass of all actual implementations of the Abstract Window Toolkit
- Subclasses of `Toolkit` are used to bind the various components to particular native toolkit implementations
- Useful methods:

```
getDefaultToolkit
getImage(String filename)
getScreenResolution
getScreenSize
getPrintJob
```


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Printing

- The follow code fragment prints a Frame:

```
1   Frame f = new Frame("Print test");
2   Toolkit toolkit = frame.getToolkit();
3   PrintJob job = toolkit.getPrintJob(frame, "Test Printing", null);
4   Graphics g = job.getGraphics();
5   frame.printComponents(g);
6   g.dispose();
7   job.end();
```

1. Obtain graphics object (line 4).
2. Draw on the graphics object (line 5).
3. Send the graphics object to printer (line 6).
4. End the print job (line 7).

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Dual-Purpose Code

- You can write GUI code that can be used as a stand-alone application or an applet
- GUI code can be written as a panel independent of being embedded in a frame or applet

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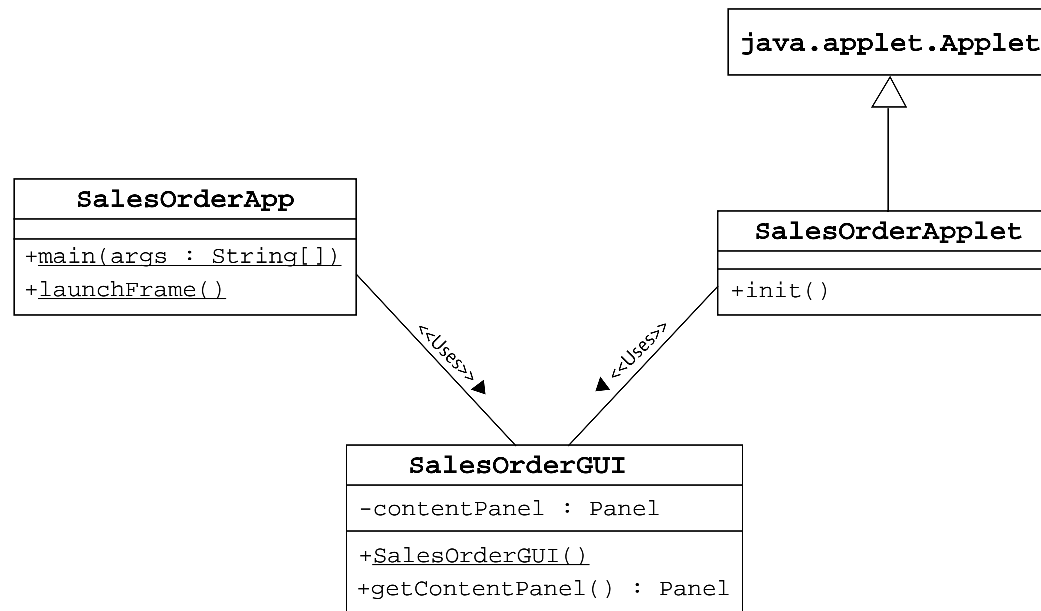
UML Model of the SalesOrderGUI



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The GUI Mediator Code

Fragments of the `SalesOrderGUI` code:

```
import java.awt.*;
import java.awt.event.*;

public class SalesOrderGUI {
  // declaration of GUI components
    ...
  private Panel contentPanel = null;

  public SalesOrderGUI() {
    // initialize GUI components
    ...
  }

  public Panel getContentPanel() {
    // return the panel if it has already been created
    if ( contentPanel != null ) {
      return contentPanel;
    }
    contentPanel = new Panel();

    // construction and layout of GUI components
    ...

    // Set up event handling
    ...

    return contentPanel;
  }
  // Event handler inner class declarations
  ...
}
```


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The App and Applet Code

```
1  import java.awt.Frame;
2  import java.awt.BorderLayout;
3  import java.awt.event.WindowAdapter;
4  import java.awt.event.WindowEvent;
5
6  public class SalesOrderApp {
7
8    private static void launchFrame() {
9      SalesOrderGUI salesGUI = new SalesOrderGUI();
10     Frame f = new Frame("Sales Order Entry");
11
12     f.addWindowListener(new WindowAdapter() {
13       public void windowClosing(WindowEvent event) {
14         System.exit(0);
15       }
16     });
17     f.setSize(200, 200);
18     f.add(salesGUI.getContentPanel(), BorderLayout.CENTER);
19     f.setVisible (true);
20   }
21
22   public static void main(String args[]) {
23     launchFrame();
24   }
25 }
```

```
1  import java.applet.Applet;
2  import java.awt.BorderLayout;
3
4  public class SalesOrderApplet extends Applet {
5    public void init() {
6      SalesOrderGUI salesGUI = new SalesOrderGUI();
7      setLayout(new BorderLayout());
8      add(salesGUI.getContentPanel(), BorderLayout.CENTER);
9    }
10 }
```


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Discussion of Dual-Purpose Code

- Does your business wish to present the same application presentation (the GUI) within the company's intranet as well as over the internet?
- Security issues hinder applet functionality
- Firewall security hinders applet <-> server communication mechanisms (such as raw sockets)
- There are different methods for loading images
- There is some redundant code in the `XxxApp` and `XxxApplet` classes for initializing the GUI and the model

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Swing

- Swing is a second-generation GUI toolkit
- It builds on top of AWT, but supplants the components with "light-weight" versions
- There are several more components: `JTable`, `JTree`, and `JComboBox`

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Exercise:

- Exercise objective:
  - Add menus to a Frame
  - Create dual-purpose code
- Tasks:
  - Add menus to the ChatClient GUI
  - Convert the Calculator to dual-purpose code

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Check Your Progress

- Identify the key AWT components and the events that they trigger
- Describe how to construct a menu bar, menu, and menu items in a Java GUI
- Understand how to change the color and font of a component
- Use the Java printing mechanism
- Understand how to construct a GUI class that can be used within a Frame or within an Applet

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Think Beyond

- What problems occur when your GUI code must wait for the application logic to perform its job?
- What are the limitation of AWT?

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Module 14

Threads

Objectives

- Define a thread
- Create separate threads in a Java program, controlling the code and data that are used by that thread
- Control the execution of a thread and write platform-independent code with threads
- Describe the difficulties that might arise when multiple threads share data

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Objectives

- Use `wait` and `notify` to communicate between threads
- Use `synchronized` to protect data from corruption
- Explain why `suspend`, `resume`, and `stop` methods have been deprecated in JDK 1.2

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Relevance

- How do you get programs to perform multiple tasks concurrently?

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Threads

- What are threads?
  - Virtual CPU

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Three Parts of a Thread

- CPU
- Code
- Data

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Creating the Thread

```
1   public class ThreadTester {
2     public static void main(String args[]) {
3       HelloRunner r = new HelloRunner();
4       Thread t = new Thread(r);
5       t.start();
6     }
7   }
8
9   class HelloRunner implements Runnable {
10    int i;
11
12    public void run() {
13      i = 0;
14
15      while (true) {
16        System.out.println("Hello " + i++);
17        if ( i == 50 ) {
18          break;
19        }
20      }
21    }
22  }
```


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Creating the Thread

- Multithreaded programming:
  - Multiple threads from the same `Runnable` instance
  - Threads share the same data and code
- Example:

```
Thread t1 = new Thread(r);
Thread t2 = new Thread(r);
```


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Starting the Thread

- Using the `start` method
- Placing the thread in runnable state

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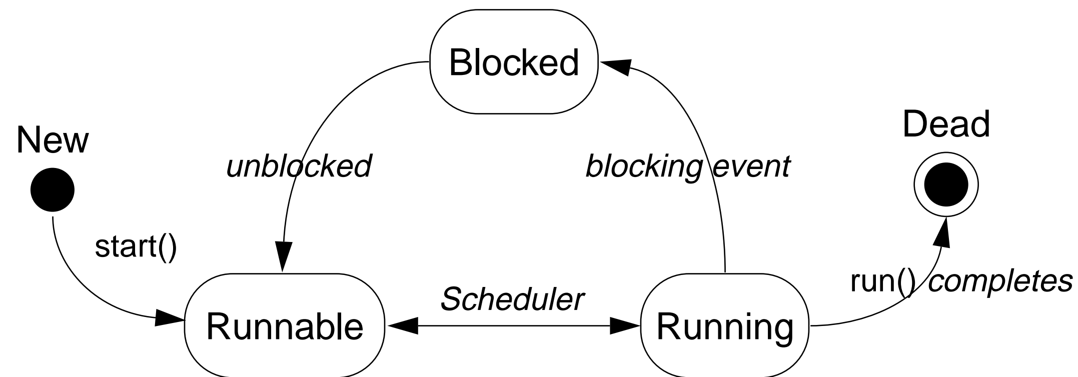
Thread Scheduling



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Thread Scheduling

```
1   public class Runner implements Runnable {
2     public void run() {
3       while (true) {
4         // do lots of interesting stuff
5         :
6         // Give other threads a chance
7         try {
8           Thread.sleep(10);
9         } catch (InterruptedException e) {
10          // This thread's sleep was interrupted
11          // by another thread
12        }
13      }
14    }
15  }
```


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Terminating a Thread

```
1   public class Runner implements Runnable {
2     private boolean timeToQuit=false;
3
4     public void run() {
5       while ( ! timeToQuit ) {
6         ...
7       }
8       // clean up before run() ends
9     }
10
11    public void stopRunning() {
12      timeToQuit=true;
13    }
14  }
15
16  public class ThreadController {
17    private Runner r = new Runner();
18    private Thread t = new Thread(r);
19
20    public void startThread() {
21      t.start();
22    }
23
24    public void stopThread() {
25      // use specific instance of Runner
26      r.stopRunning();
27    }
28  }
```


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Basic Control of Threads

- Testing threads:
  - `isAlive()`
- Thread priority:
  - `getPriority()`
  - `setPriority()`
- Putting threads on hold:
  - `Thread.sleep()`
  - `join()`
  - `Thread.yield()`

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Putting Threads on Hold

```
1   public class Runner implements Runnable {
2   ...
3     public void run() {
4       while (running) {
5         // do your task
6         try {
7           Thread.sleep((int)(Math.random() * 100));
8         } catch (InterruptedException e) {
9           // somebody woke me up
10        }
11        ...
12      }
13    }
14  }
15
16  public class ThreadTest {
17    public static void main(String args[]) {
18      Runnable r = new Runner();
19      Thread t1 = new Thread(r);
20      t1.start();
21    }
22  }
```


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Putting Threads on Hold

```
1  public static void main(String[] args) {
2    Thread t = new Thread(new Runner());
3    t.start();
4    ...
5    // Do stuff in parallel with the other thread for a while
6    ...
7    // Wait here for the timer thread to finish
8    try {
9      t.join();
10   } catch (InterruptedException e) {
11     // t came back early
12   }
13   ...
14   // Now continue in this thread
15   ...
16 }
```


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Extending the Thread Class

```
1   public class MyThread extends Thread {
2     public void run() {
3       while (running) {
4         // do lots of interesting stuff
5         try {
6           sleep(100);
7         } catch (InterruptedException e) {
8           // sleep interrupted
9         }
10      }
11    }
12
13    public static void main(String args[]) {
14      Thread t = new MyThread();
15      t.start();
16    }
17  }
```


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Selecting a Way to Create Threads

- Implementing `Runnable`:
  - Better object-oriented design
  - Single inheritance
  - Consistency
- Extending `Thread`:
  - Simpler code

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Exercise: Using Basic Threads

- Exercise objectives:
  - Become familiar with the basic thread concepts
- Tasks:
  - Create three threads

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Using the `synchronized` Keyword

```
1   public class MyStack {
2     int idx = 0;
3     char [] data = new char[6];
4
5     public void push(char c) {
6       data[idx] = c;
7       idx++;
8     }
9
10    public char pop() {
11      idx--;
12      return data[idx];
13    }
14  }
```


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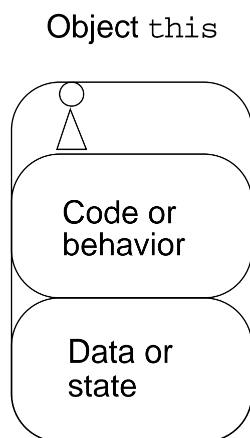
The Object Lock Flag

- Every object has a flag that can be thought of as a "lock flag"
- `synchronized` allows interaction with the lock flag

Object `this`



Thread before `synchronized(this)`

```
public void push(char c) {
  synchronized (this) {
    data[idx] = c;
    idx++;
  }
}
```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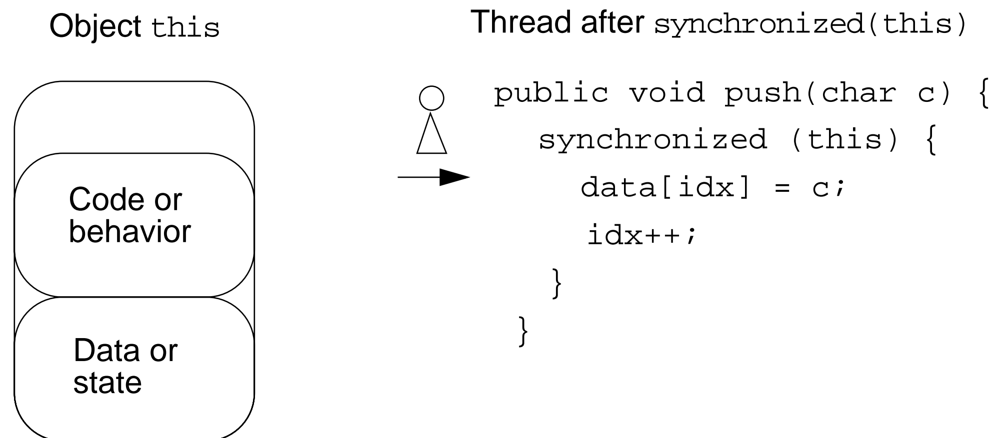
The Object Lock Flag



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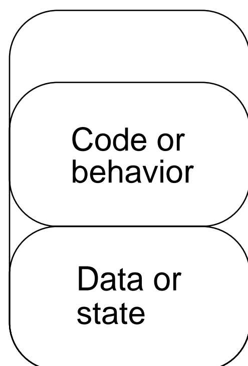
The Object Lock Flag



Thread, trying to execute `synchronized(this)`

Waiting for object lock

```
public char pop() {
  synchronized (this) {
    idx--;
    return data[idx];
  }
}
```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Releasing the Lock Flag

- Released when the thread passes the end of the `synchronized` code block
- Automatically released when a break or exception is thrown by the `synchronized` code block

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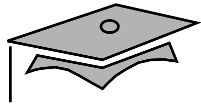

`synchronized` – Putting It Together

- *All* access to delicate data should be `synchronized`
- Delicate data protected by `synchronized` should be `private`

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synchronized – Putting It Together

- The following two code segments are equivalent:

```
public void push(char c) {
  synchronized(this) {
    :
    :
  }
}
```

```
public synchronized void push(char c) {
  :
  :
}
```


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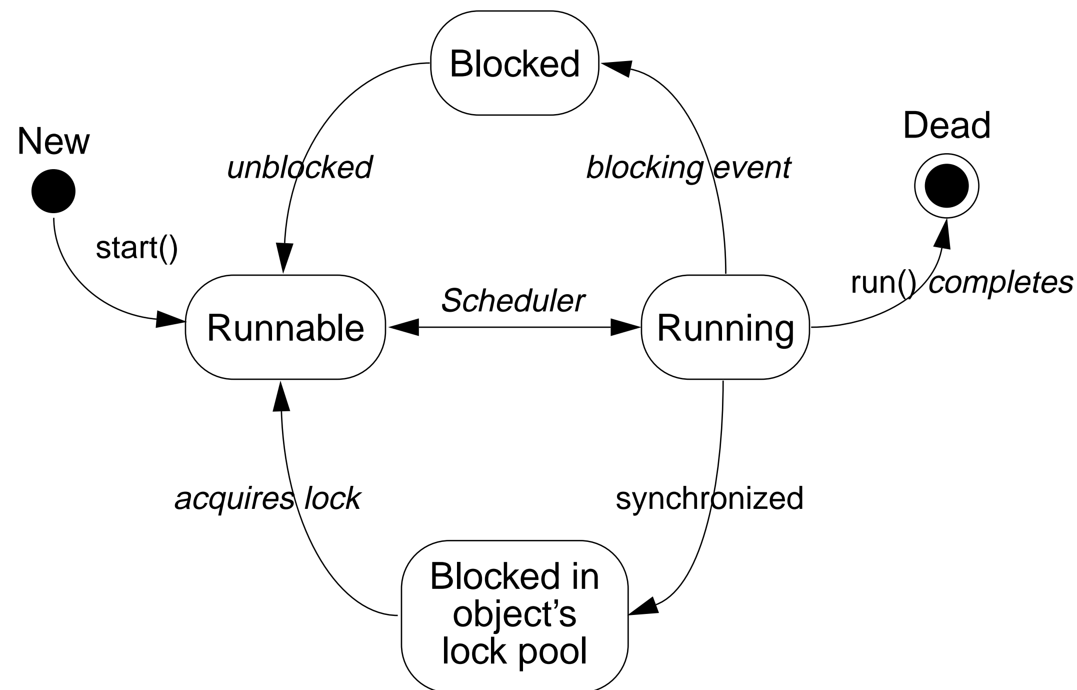
Threads State Diagram With Synchronization



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Deadlock

- Is two threads, each waiting for a lock from the other
- Is not detected or avoided
- Can be avoided by:
  - Deciding on the order to obtain locks
  - Adhering to this order throughout
  - Releasing locks in reverse order

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Thread Interaction – `wait` and `notify`

- Scenario:
  - Consider yourself and a cab driver as two threads
- The problem:
  - How to determine when you are at your destination
- The solution:
  - You notify the cabbie of your destination and relax
  - Cabbie drives and notifies you upon arrival at your destination

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Thread Interaction

- `wait` and `notify`
- The pools:
  - Wait pool
  - Lock pool

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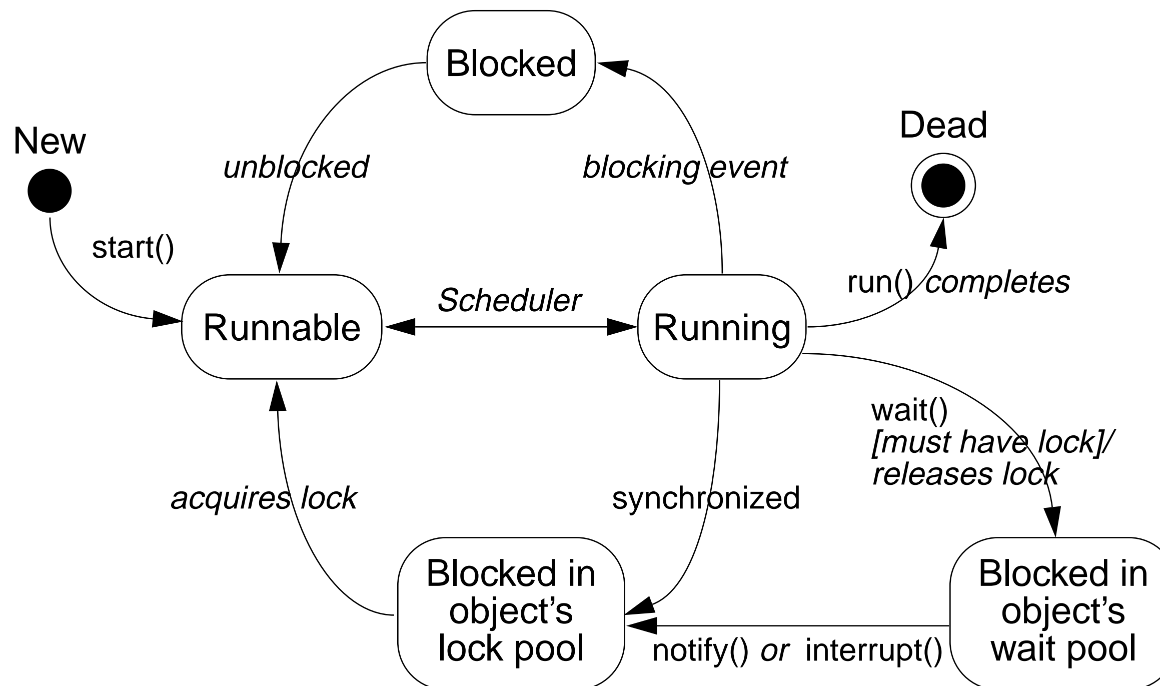
Threads State Diagram With `wait` and `notify`



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Monitor Model for Synchronization

- Leave shared data in a consistent state
- Ensure programs cannot deadlock
- Do not put threads expecting different notifications in the same wait pool

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Producer

```
1     public void run() {
2       char c;
3
4       for (int i = 0; i < 200; i++) {
5         c = (char)(Math.random() * 26 +'A');
6         theStack.push(c);
7         System.out.println("Producer" + num + ": " + c);
8         try {
9           Thread.sleep((int)(Math.random() * 300));
10        } catch (InterruptedException e) {
11          // ignore it
12        }
13      }
14    }
```


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Consumer

```
1      public void run() {
2        char c;
3        for (int i = 0; i < 200; i++) {
4          c = theStack.pop();
5          System.out.println("Consumer" + num + ": " + c);
6
7          try {
8            Thread.sleep((int)(Math.random() * 300));
9          } catch (InterruptedException e) { }
10
11       }
12     }
```


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`SyncStack` Class

```
public class SyncStack {
  private List buffer = new ArrayList(400);

  public synchronized char pop() {
  }

  public synchronized void push(char c) {
  }
}
```


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pop Method

```
1     public synchronized char pop() {
2       char c;
3       while (buffer.size() == 0) {
4         try {
5           this.wait();
6         } catch (InterruptedException e) {
7           // ignore it...
8         }
9       }
10      c = ((Character)buffer.remove(buffer.size()-1)).charValue();
11      return c;
12    }
```


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push Method

```
1    public synchronized void push(char c) {
2       this.notify();
3       Character charObj = new Character(c);
4       buffer.addElement(charObj);
5    }
```


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SyncTest.java

```
1   package threads;
2
3   public class SyncTest {
4
5     public static void main(String[] args) {
6
7       SyncStack stack = new SyncStack();
8
9       Producer p1 = new Producer(stack);
10      Thread prodT1 = new Thread (p1);
11      prodT1.start();
12
13      Producer p2 = new Producer(stack);
14      Thread prodT2 = new Thread (p2);
15      prodT2.start();
16
17      Consumer c1 = new Consumer(stack);
18      Thread consT1 = new Thread (c1);
19      consT1.start();
20
21      Consumer c2 = new Consumer(stack);
22      Thread consT2 = new Thread (c2);
23      consT2.start();
24    }
25  }
```


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Producer.java

```
1   package threads;
2
3   public class Producer implements Runnable {
4     private SyncStack theStack;
5     private int num;
6     private static int counter = 1;
7
8     public Producer (SyncStack s) {
9       theStack = s;
10      num = counter++;
11    }
12
13    public void run() {
14      char c;
15      for (int i = 0; i < 200; i++) {
16        c = (char)(Math.random() * 26 +'A');
17        theStack.push(c);
18        System.out.println("Producer" + num + ": " + c);
19        try {
20          Thread.sleep((int)(Math.random() * 300));
21        } catch (InterruptedException e) {
22          // ignore it
23        }
24      }
25    }
26  }
```


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Consumer.java

```
1   package threads;
2
3   public class Consumer implements Runnable {
4     private SyncStack theStack;
5     private int num;
6     private static int counter = 1;
7
8     public Consumer (SyncStack s) {
9       theStack = s;
10      num = counter++;
11    }
12
13    public void run() {
14      char c;
15      for (int i = 0; i < 200; i++) {
16        c = theStack.pop();
17        System.out.println("Consumer" + num + ": " + c);
18
19        try {
20          Thread.sleep((int)(Math.random() * 300));
21        } catch (InterruptedException e) { }
22
23      }
24    }
25  }
```


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SyncStack.java

```
1   package threads;
2
3   import java.util.*;
4
5   public class SyncStack {
6     private List buffer = new ArrayList(400);
7
8     public synchronized char pop() {
9       char c;
10      while (buffer.size() == 0) {
11        try {
12          this.wait();
13        } catch (InterruptedException e) {
14          // ignore it...
15        }
16      }
17      c = ((Character)buffer.remove(buffer.size()-1)).
18          charValue();
19      return c;
20    }
21
22    public synchronized void push(char c) {
23      this.notify();
24      Character charObj = new Character(c);
25      buffer.addElement(charObj);
26    }
27  }
```


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SyncStack Example

```
Producer2: F
Consumer1: F
Producer2: K
Consumer2: K
Producer2: T
Producer1: N
Producer1: V
Consumer2: V
Consumer1: N
Producer2: V
Producer2: U
Consumer2: U
Consumer2: V
Producer1: F
Consumer1: F
Producer2: M
Consumer2: M
Consumer2: T
```


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The `suspend` and `resume` Methods

- Have been deprecated in JDK 1.2
- Should be replaced with `wait` and `notify`

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The `stop` Method

- Releases the lock before it terminates
- Can leave shared data in an inconsistent state
- Should be replaced with `wait` and `notify`

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Proper Thread Control

```
1   public class ControlledThread extends Thread {
2     static final int SUSP = 1;
3     static final int STOP = 2;
4     static final int RUN = 0;
5     private int state = RUN;
6
7     public synchronized void setState(int s) {
8       state = s;
9       if ( s == RUN ) {
10        notify();
11      }
12    }
13
14    public synchronized boolean checkState() {
15      while ( state == SUSP ) {
16        try {
17          wait();
18        } catch (InterruptedException e) {
19          // ignore
20        }
21      }
22      if ( state == STOP ) {
23        return false;
24      }
25      return true;
26    }
27
28    public void run() {
29      while ( true ) {
30        // doSomething();
31
32        // Be sure shared data is in consistent state in
33        // case the thread is waited or marked for exiting
34        // from run()
35        if ( !checkState() ) {
36          break;
37        }
38      }
39    }} // just to fit it on this page
```


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Exercise: Using Multithreaded Programming

- Exercise objectives:
  - Become familiar with the concepts of multithreading by writing some multithreaded programs
  - Create a multithreaded applet
- Tasks:
  - Using threads to create animation
  - Using advanced thread control

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Check Your Progress

- Define a thread
- Create separate threads in a Java program, controlling the code and data that are used by that thread
- Control the execution of a thread and write platform-independent code with threads
- Describe the difficulties that might arise when multiple threads share data

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Check Your Progress

- Use `wait` and `notify` to communicate between threads
- Use `synchronized` to protect data from corruption
- Explain why `suspend`, `resume`, and `stop` methods have been deprecated in JDK 1.2

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Think Beyond

- Do you have applications that could benefit from being multithreaded?

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Module 15

Advanced I/O Streams

Objectives

- Describe the main features of the `java.io` package
- Construct node and processing streams, and use them appropriately
- Distinguish readers and writers from streams, and select appropriately between them
- Use the `Serialization` interface to encode the state of an object

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Relevance

- What mechanisms are in place within the Java programming language to read and write from sources (or sinks) other than files?
- How are international character sets supported in I/O operations?
- What are the possible sources and sinks of character and byte streams?

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I/O Fundamentals

- A *stream* can be thought of as a flow of data from a source to a sink
- A *source* stream initiates the flow of data, also called an input stream
- A *sink* stream terminates the flow of data, also called an output stream
- Sources and sinks are both *node streams*
- Types of node streams are: files, memory, and pipes between threads or processes

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Fundamental Stream Classes

	byte streams	**character streams**
source streams	`InputStream`	`Reader`
sink streams	`OutputStream`	`Writer`

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Data Within Streams

- Java technology supports two types of streams: character and byte
- Input and output of character data is handled by readers and writers
- Input and output of byte data is handled by input streams and output streams
  - Normally, the term stream refers to a byte stream
  - The terms reader and writer refer to character streams

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`InputStream` Methods

- The three basic `read` methods:

```
int read()
int read(byte[] buffer)
int read(byte[] buffer, int offset, int length)
```

- The other methods:

```
void close()
int available()
skip(long n)
boolean markSupported()
void mark(int readlimit)
void reset()
```


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OutputStream Methods

- The three basic write methods:

```
void write(int c)
void write(byte[] buffer)
void write(byte[] buffer, int offset, int length)
```

- The other methods:

```
void close()
void flush()
```


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`Reader` Methods

- The three basic `read` methods:

```
int read()
int read(char[] cbuf)
int read(char[] cbuf, int offset, int length)
```

- The other methods:

```
void close()
boolean ready()
skip(long n)
boolean markSupported()
void mark(int readAheadLimit)
void reset()
```


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`Writer` Methods

- The three basic `write` methods:

```
void write(int c)
void write(char[] cbuf)
void write(char[] cbuf, int offset, int length)
void write(String string)
void write(String string, int offset, int length)
```

- The other methods:

```
void close()
void flush()
```


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Node Streams

Type	Character Streams	Byte Streams
File	`FileReader` `FileWriter`	`FileInputStream` `FileOutputStream`
Memory: Array	`CharArrayReader` `CharArrayWriter`	`ByteArrayInputStream` `ByteArrayOutputStream`
Memory: String	`StringReader` `StringWriter`	
Pipe	`PipedReader` `PipedWriter`	`PipedInputStream` `PipedOutputStream`

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A Simple Example

- This program performs a copy file operation:

```
> java TestNodeStreams file1 file2
```

```
1   import java.io.*;
2
3   public class TestNodeStreams {
4     public static void main(String[] args) {
5       try {
6         FileReader input = new FileReader(args[0]);
7         FileWriter output = new FileWriter(args[1]);
8         char[]     buffer = new char[128];
9         int        charsRead;
10
11        // read the first buffer
12        charsRead = input.read(buffer);
13
14        while ( charsRead != -1 ) {
15          // write the buffer out to the output file
16          output.write(buffer, 0, charsRead);
17
18          // read the next buffer
19          charsRead = input.read(buffer);
20        }
21
22        input.close();
23        output.close();
24      } catch (IOException e) {
25        e.printStackTrace();
26      }
27    }
28  }
```


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Buffered Streams

> **java TestBufferedStreams file1 file2**

```
1   import java.io.*;
2
3   public class TestBufferedStreams {
4     public static void main(String[] args) {
5       try {
6         FileReader     input     = new FileReader(args[0]);
7         BufferedReader bufInput  = new BufferedReader(input);
8         FileWriter     output    = new FileWriter(args[1]);
9         BufferedWriter bufOutput = new BufferedWriter(output);
10        String line;
11
12        // read the first line
13        line = bufInput.readLine();
14
15        while ( line != null ) {
16          // write the line out to the output file
17          bufOutput.write(line, 0, line.length());
18          bufOutput.newLine();
19
20          // read the next line
21          line = bufInput.readLine();
22        }
23
24        bufInput.close();
25        bufOutput.close();
26      } catch (IOException e) {
27        e.printStackTrace();
28      }
29    }
30  }
```


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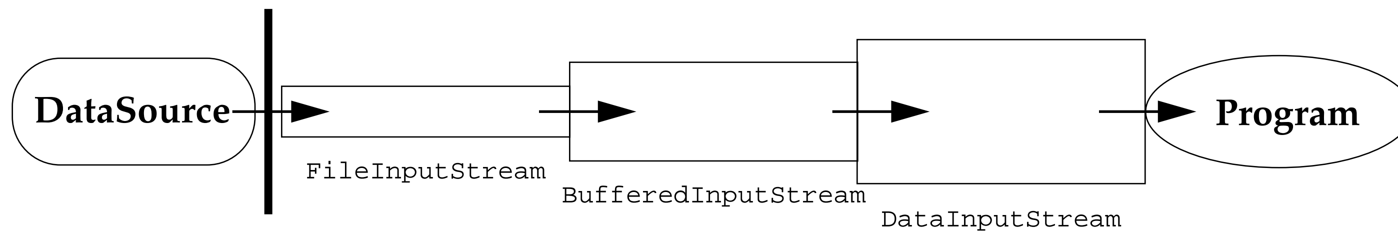
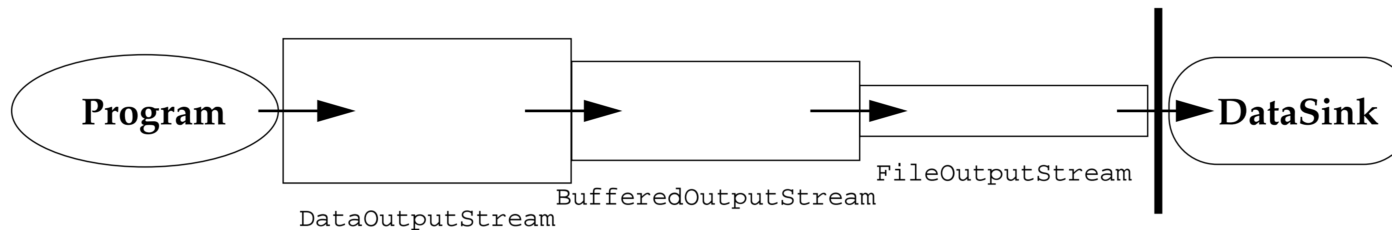
I/O Stream Chaining

Input Stream Chain



Output Stream Chain



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Processing Streams

Type	Character Streams	Byte Streams
Buffering	`BufferedReader` `BufferedWriter`	`BufferedInputStream` `BufferedOutputStream`
Filtering	*`FilterReader`* *`FilterWriter`*	*`FilterInputStream`* *`FilterOutputStream`*
Converting between bytes and character	`InputStreamReader` `OuptutStreamWriter`	
Object serialization		`ObjectInputStream` `ObjectOutputStream`
Data conversion		`DataInputStream` `DataOutputStream`
Counting	`LineNumberReader`	`LineNumberInputStream`
Peeking ahead	`PushbackReader`	`PushbackInputStream`
Printing	`PrintWriter`	`PrintStream`

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Processing Streams as Decorators

- A Decorator is a design pattern that allows one object (the decorator) to wrap around another object
- The `FilterXxx` classes provide a base class for you to extend to provide your own processing of an input or output stream
- For example, you could write a pair of classes, `RecordInputStream` and `RecordOutputStream`, that reads and writes database records to a stream
- A program could then decorate a file input stream with a record input stream to read database records

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Record Streams Classes

InputStream

FilterInputStream

#in : InputStream

#FilterInputStream(InputStream)

RecordInputStream

+RecordInputStream(DataInputStream)

+readRecord() : Record

OutputStream

FilterOutputStream

#out : OutputStream

#FilterOutputStream(OutputStream)

RecordOutputStream

+RecordOutputStream(DataOutputStream)

+writeRecord(record : Record)

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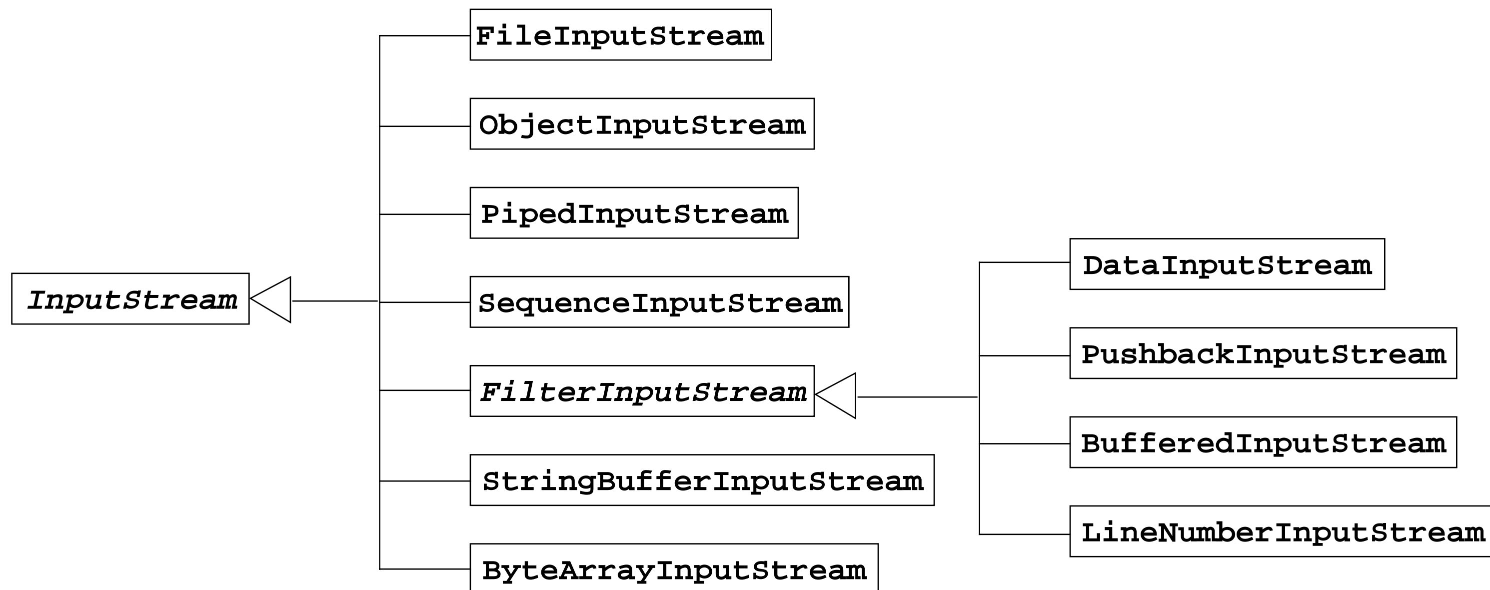
Input Stream Class Hierarchy



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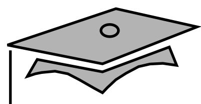
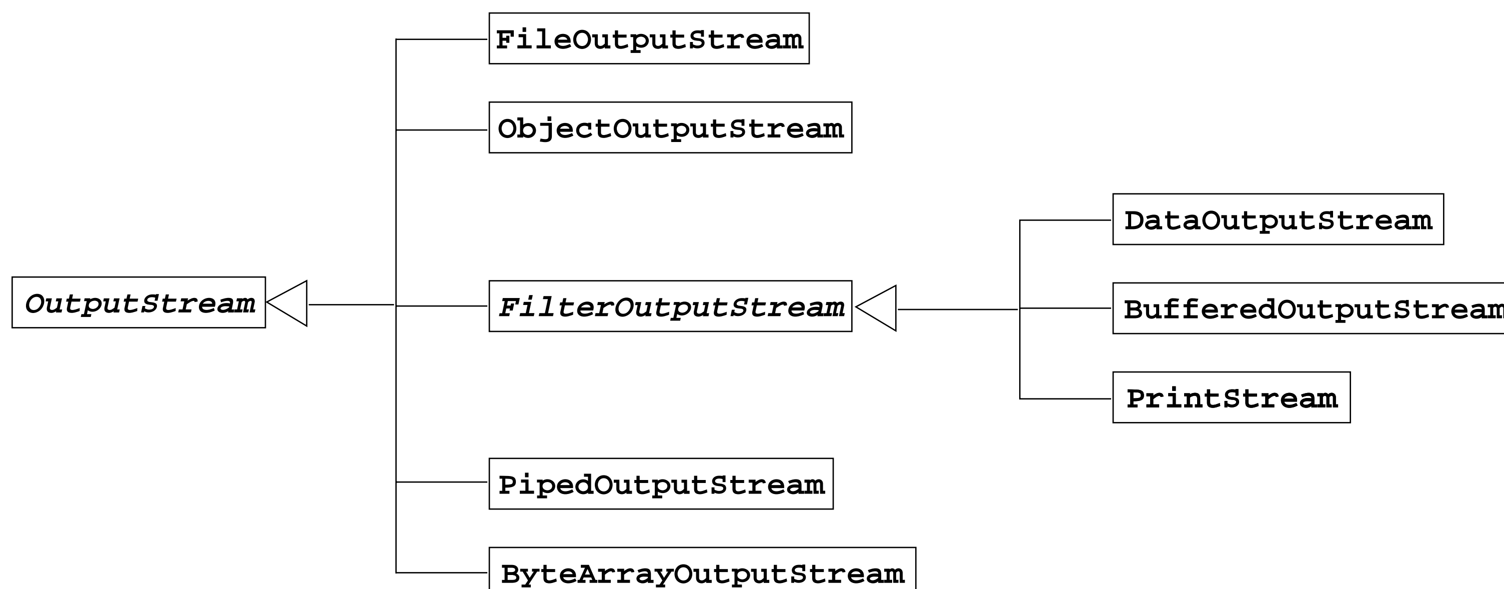


Output Stream Class Hierarchy



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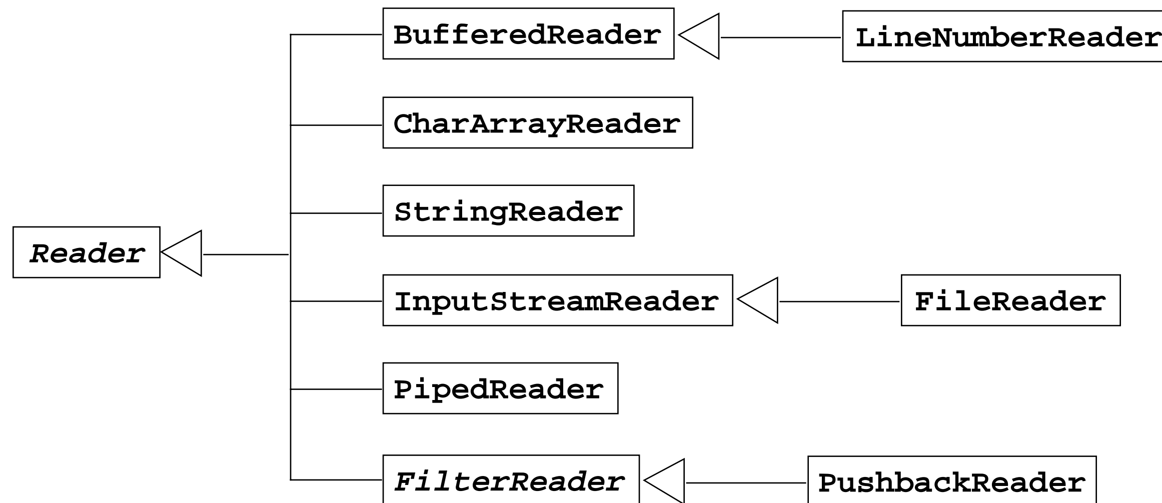
Reader Class Hierarchy



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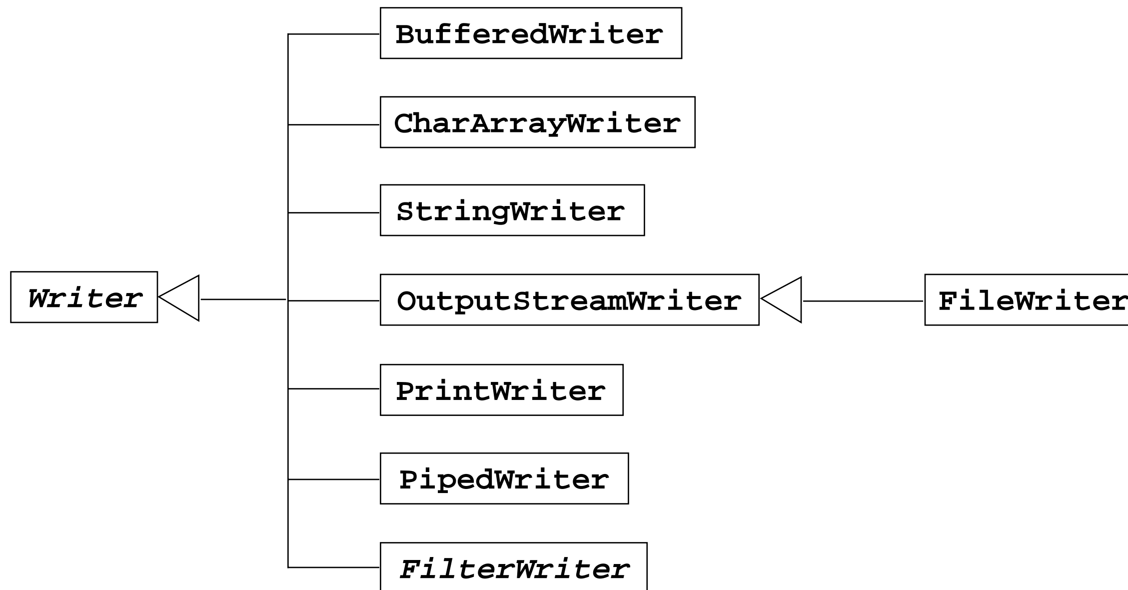
Writer Class Hierarchy



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URL Input Streams

```
1   java.net.URL imageSource;
2
3   try {
4     imageSource = new URL("http://mysite.com/~info");
5   } catch (MalformedURLException e) {
6     // ignore
7   }
8
9   images[0] = getImage(imageSource, "Duke/T1.gif");
```


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Opening a URL Input Stream

```
1  InputStream is = null;
2  String fileName = new String("Data/data.1-96");
3  byte buffer[] = new byte[24];
4
5  try {
6    // new URL throws a MalformedURLException
7    URL fileLocation = new URL(getDocumentBase(), fileName);
8
9    // URL.openStream() throws an IOException
10   is = fileLocation.openStream();
11 } catch (Exception e) {
12   // ignore
13 }
```

Now you can use the variable `is` to read information, just as with a `FileInputStream` object:

```
14 try {
15   is.read(buffer, 0, buffer.length);
16 } catch (IOException e1) {
17   // ignore
18 }
```


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Creating a Random Access File

- With the file name:

```
myRAFile = new RandomAccessFile(
                  String name, String mode);
```

- With a `File` object:

```
myRAFile = new RandomAccessFile(
                  File file, String mode);
```


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Random Access Files

- `long getFilePointer()`
- `void seek(long pos)`
- `long length()`

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Serialization

- Only the object's data are serialized
- Data marked with the `transient` keyword are not serialized

```
1   public class MyClass implements Serializable {
2     public transient Thread myThread;
3     private String customerID;
4     private int total;
5   }
```

```
1   public class MyClass implements Serializable {
2     public transient Thread myThread;
3     private transient String customerID;
4     private int total;
5   }
```

- Serialization is used to store the state of an object to a file; storing the state of an object is called *persistence*

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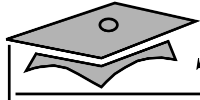

Writing an Object to a File Stream

```
1   import java.io.*;
2   import java.util.Date;
3
4   public class SerializeDate {
5
6     SerializeDate() {
7       Date d = new Date ();
8
9       try {
10        FileOutputStream f =
11            new FileOutputStream ("date.ser");
12        ObjectOutputStream s =
13            new ObjectOutputStream (f);
14        s.writeObject (d);
15        s.close ();
16      } catch (IOException e) {
17        e.printStackTrace ();
18      }
19    }
20
21    public static void main (String args[]) {
22      new SerializeDate();
23    }
24  }
```


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Reading an Object From a File Stream

```
1   import java.io.*;
2   import java.util.Date;
3
4   public class UnSerializeDate {
5
6     UnSerializeDate () {
7       Date d = null;
8
9       try {
10        FileInputStream f =
11            new FileInputStream ("date.ser");
12        ObjectInputStream s =
13            new ObjectInputStream (f);
14        d = (Date) s.readObject ();
15        s.close ();
16      } catch (Exception e) {
17        e.printStackTrace ();
18      }
19
20      System.out.println(
21        "Unserialized Date object from date.ser");
22      System.out.println("Date: "+d);
23    }
24
25    public static void main (String args[]) {
26      new UnSerializeDate();
27    }
28  }
```


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Exercise: Getting Acquainted With I/O

- Exercise objective:
  - Become familiar with stream I/O by writing programs that perform I/O operations
- Tasks:
  - Object serialization
  - Implementing a processing stream
  - Create a simple database program

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Check Your Progress

- Describe the main features of the `java.io` package
- Construct node and processing streams, and use them appropriately
- Distinguish readers and writers from streams, and select appropriately between them
- Use the `Serialization` interface to encode the state of an object

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Think Beyond

- Do you have applications that could benefit from creating specialized stream or character filters?

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Module 16

Networking

Objectives

- Develop code to set up the network connection
- Understand the TCP/IP protocol
- Use `ServerSocket` and `Socket` classes for implementing TCP/IP clients and servers

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Relevance

- How can a communication link between a client machine and a server on the network be established?

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Networking

- Sockets:
  - Sockets hold two streams
- Setting up the connection:
  - Set up is similar to a telephone system

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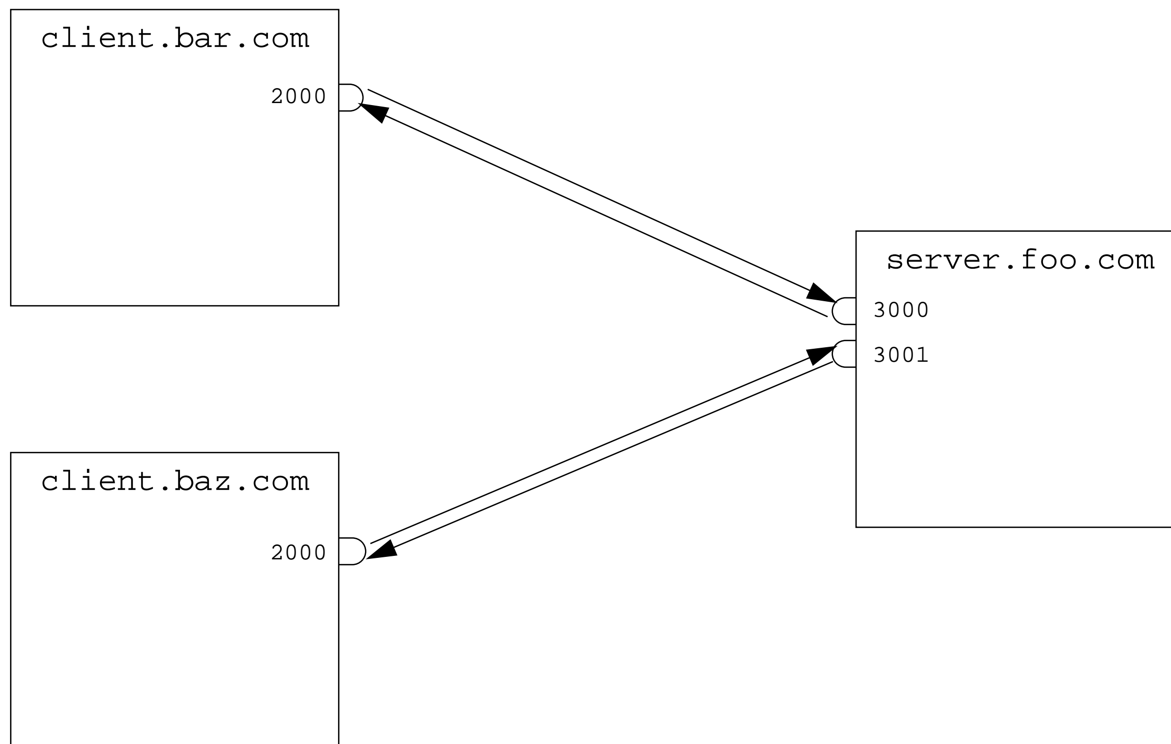
Networking



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Networking With Java Technology

- Addressing the connection:
  - Address or name of remote machine
  - Port number to identify purpose
- Port numbers:
  - Range from 0 to 65535

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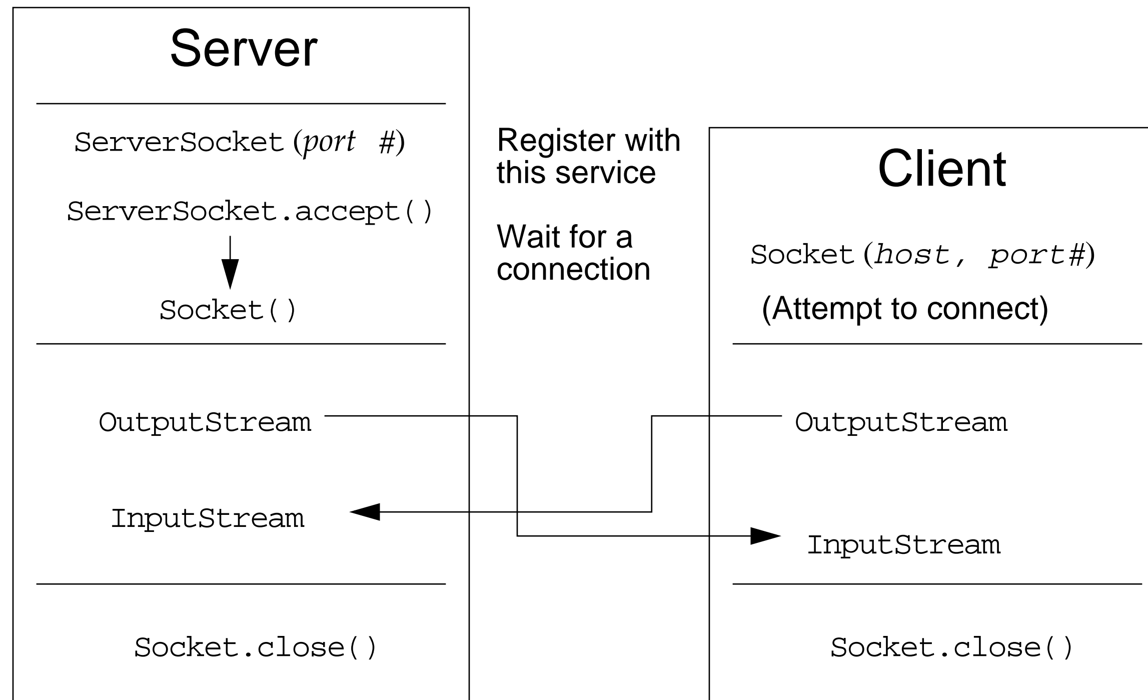
Java Networking Model



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Minimal TCP/IP Server

```
1   import java.net.*;
2   import java.io.*;
3
4   public class SimpleServer {
5     public static void main(String args[]) {
6       ServerSocket s;
7
8       // Register your service on port 5432
9       try {
10        s = new ServerSocket(5432);
11      } catch (IOException e) {
12        // ignore
13      }
14
15     // Run the listen/accept loop forever
16      while (true) {
17        try {
18          // Wait here and listen for a connection
19          Socket s1 = s.accept();
20
21          // Get output stream associated with the socket
22          OutputStream s1out = s1.getOutputStream();
23          DataOutputStream dos = new DataOutputStream(s1out);
24
25          // Send your string!
26          dos.writeUTF("Hello Net World!");
27
28          // Close the connection, but not the server socket
29          dos.close();
30          s1.close();
31        } catch (IOException e) {
32          // ignore
33        }
34      }
35    }
36  }
```


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Minimal TCP/IP Client

```
1   import java.net.*;
2   import java.io.*;
3
4   public class SimpleClient {
5     public static void main(String args[]) {
6       try {
7         // Open your connection to a server, at port 5432
8         // localhost used here
9         Socket s1 = new Socket("127.0.0.1", 5432);
10
11        // Get an input stream from the socket
12        InputStream is = s1.getInputStream();
13        // Decorate it with a "data" input stream
14        DataInputStream dis = new DataInputStream(is);
15
16        // Read the input and print it to the screen
17        System.out.println(dis.readUTF());
18
19        // When done, just close the steam and connection
20        dis.close();
21        s1.close();
22      } catch (ConnectException connExc) {
23        System.err.println("Could not connect to the server.");
24      } catch (IOException e) {
25        // ignore
26      }
27    }
28  }
```


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Exercise: Using Socket Programming

- Exercise objective:
  - Gain experience using sockets by implementing a client which communicates to a server using sockets
- Tasks:
  - Complete the ChatClient program using a TCP/IP server
  - Create a simple file transfer server and client

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Check Your Progress

- Develop code to set up the network connection
- Understand the TCP/IP protocol
- Use `ServerSocket` and `Socket` classes for implementing TCP/IP clients and servers

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Think Beyond

- How can you create a distributed object system using object serialization and these network protocols? Have you heard of Remote Method Invocation (RMI)?
- There are several advanced Java platform topics, many of which are addressed in other Sun Educational Services courses. Be sure and check out the JavaSoft™ web site (`www.javasoft.com`) as well.

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