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# Essentials of the Java™ Programming Language: A Hands-On Guide, Part 1

*by Monica Pawla*

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If you are new to programming in the Java™ language, have some experience with other languages, and are familiar with things like displaying text or graphics or performing simple calculations, this tutorial could be for you. It walks through how to use the Java® 2 Platform software to create and run three common types of programs written for the Java platform—applications, applets, and servlets.

You will learn how applications, applets, and servlets are similar and different, how to build a basic user interface that handles simple end user input, how to read data from and write data to files and databases, and how to send and receive data over the network. This tutorial is not comprehensive, but instead takes you on a straight and uncomplicated path through the more common programming features available in the Java platform.

If you have no programming experience at all, you might still find this tutorial useful; but you also might want to take an introductory programming course or read [Teach Yourself Java 2 Online in Web Time](#) before you proceed.

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# Java™ Programming Language Basics, Part 1

## Lesson 1: Compiling and Running A Simple Program

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The computer age is here to stay. Households and businesses all over the world use computers in one way or another because computers help individuals and businesses perform a wide range of tasks with speed, accuracy, and efficiency. Computers can perform all kinds of tasks ranging from running an animated 3D graphics application with background sound to calculating the number of vacation days you have coming to handling the payroll for a Fortune 500 company.

When you want a computer to perform tasks, you write a program. A program is a sequence of instructions that define tasks for the computer to execute. This lesson explains how to write, compile, and run a simple program written in the Java™ language (Java program) that tells your computer to print a one-line string of text on the console.

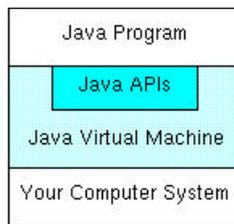
But before you can write and compile programs, you need to understand what the Java platform is, and set your computer up to run the programs.

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- [Setting Up Your Computer](#)
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## A Word About the Java Platform

The Java platform consists of the Java application programming interfaces (APIs) and the Java<sup>1</sup> virtual machine (JVM).



Java APIs are libraries of compiled code that you can use in your programs. They let you add ready-made and customizable functionality to save you programming time.

The simple program in this lesson uses a Java API to print a line of text to the console. The console printing capability is provided in the API ready for you to use; you supply the text to be printed.

Java programs are run (or interpreted) by another program called the Java VM. If you are familiar with Visual Basic or another interpreted language, this concept is probably familiar to you. Rather than running directly on the native operating system, the program is interpreted by the Java VM for the native operating system. This means that any computer system with the Java VM installed can run Java programs regardless of the computer system on which the applications were originally developed.

For example, a Java program developed on a Personal Computer (PC) with the Windows NT operating system should run equally well without modification on a Sun Ultra workstation with the Solaris operating system, and vice versa.

## Setting Up Your Computer

Before you can write and run the simple Java program in this lesson, you need to install the Java platform on your computer system.

The Java platform is available free of charge from the [java.sun.com](http://java.sun.com) web site. You can choose between the Java® 2 Platform software for Windows 95/98/NT or for Solaris. The download page contains the information you need to install and configure the Java platform for writing and running Java programs.

---

**Note:** Make sure you have the Java platform installed and configured for your system before you try to write and run the simple program presented next.

---

## Writing a Program

The easiest way to write a simple program is with a text editor. So, using the text editor of your choice, create a text file with the following text, and be sure to name the text file `ExampleProgram.java`. Java programs are case sensitive, so if you type the code in yourself, pay particular attention to the capitalization.

```
//A Very Simple Example
class ExampleProgram {
    public static void main(String[] args){
        System.out.println("I'm a Simple Program");
    }
}
```

```
}
```

Here is the [ExampleProgram.java](#) source code file if you do not want to type the program text in yourself.

## Compiling the Program

A program has to be converted to a form the Java VM can understand so any computer with a Java VM can interpret and run the program. Compiling a Java program means taking the programmer-readable text in your program file (also called source code) and converting it to bytecodes, which are platform-independent instructions for the Java VM.

The Java compiler is invoked at the command line on Unix and DOS shell operating systems as follows:

```
javac ExampleProgram.java
```

---

**Note:** Part of the configuration process for setting up the Java platform is setting the class path. The class path can be set using either the `-classpath` option with the `javac` compiler command and `java` interpreter command, or by setting the `CLASSPATH` environment variable. You need to set the class path to point to the directory where the `ExampleProgram` class is so the compiler and interpreter commands can find it. See [Java 2 SDK Tools](#) for more information.

---

## Interpreting and Running the Program

Once your program successfully compiles into Java bytecodes, you can interpret and run applications on any Java VM, or interpret and run applets in any Web browser with a Java VM built in such as Netscape or Internet Explorer. Interpreting and running a Java program means invoking the Java VM byte code interpreter, which converts the Java byte codes to platform-dependent machine codes so your computer can understand and run the program.

The Java interpreter is invoked at the command line on Unix and DOS shell operating systems as follows:

```
java ExampleProgram
```

At the command line, you should see:

```
I'm a Simple Program
```

Here is how the entire sequence looks in a terminal window:

```
>javac ExampleProgram.java
>java ExampleProgram
I'm a Simple Program
```

## Common Compiler and Interpreter Problems

If you have trouble compiling or running the simple example in this lesson, refer to the [Common Compiler and Interpreter Problems](#) lesson in [The Java Tutorial](#) for troubleshooting help.

## Code Comments

Code comments are placed in source files to describe what is happening in the code to someone who might be reading the file, to comment-out lines of code to isolate the source of a problem for debugging purposes, or to generate API documentation. To these ends, the Java language supports three kinds of comments: double slashes, C-style, and doc comments.

### Double Slashes

Double slashes (//) are used in the C++ programming language, and tell the compiler to treat everything from the slashes to the end of the line as text.

```
//A Very Simple Example
class ExampleProgram {
    public static void main(String[] args){
        System.out.println("I'm a Simple Program");
    }
}
```

### C-Style Comments

Instead of double slashes, you can use C-style comments (/ \* \*/) to enclose one or more lines of code to be treated as text.

```
/* These are
C-style comments
*/
class ExampleProgram {
    public static void main(String[] args){
        System.out.println("I'm a Simple Program");
    }
}
```

### Doc Comments

To generate documentation for your program, use the doc comments (/ \*\* \*/) to enclose lines of text for the javadoc tool to find. The javadoc tool locates the doc comments embedded in source files and uses those comments to generate API documentation.

```
/** This class displays a text string at
 * the console.
 */
class ExampleProgram {
    public static void main(String[] args){
        System.out.println("I'm a Simple Program");
    }
}
```

With one simple class, there is no reason to generate API documentation. API documentation makes sense when you have an application made up of a number of complex classes that need documentation. The tool generates HTML files (Web pages) that describe the class structures and contain the text enclosed by doc comments. The [javadoc Home Page](#) has more information on the javadoc command and its output.

## API Documentation

The Java platform installation includes API Documentation, which describes the APIs available for you to use in your programs. The files are stored in a doc directory beneath the directory where you installed the platform. For example, if the platform is installed in /usr/local/java/jdk1.2, the API Documentation is in /usr/local/java/jdk1.2/doc/api.

## More Information

See [Java 2 SDK Tools](#) for more information on setting the class path and using the javac, and java commands.

See [Common Compiler and Interpreter Problems](#) lesson in [The Java Tutorial](#) for troubleshooting help.

The [javadoc Home Page](#) has more information on the javadoc command and its output.

You can also view the API Documentation for the Java 2 Platform on the [java.sun.com](#) site.

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<sup>1</sup> As used on this web site, the terms "Java virtual machine" or "JVM" mean a virtual machine for the Java platform.

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# Java™ Programming Language Basics, Part 1

## Lesson 2: Building Applications

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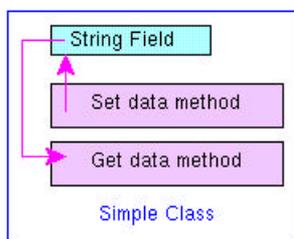
All programs written in the Java™ language (Java programs) are built from classes. Because all classes have the same structure and share common elements, all Java programs are very similar.

This lesson describes the structure and elements of a simple application created from one class. The next lesson covers the same material for applets.

- [Application Structure and Elements](#)
- [Fields and Methods](#)
- [Constructors](#)
- [More Information](#)

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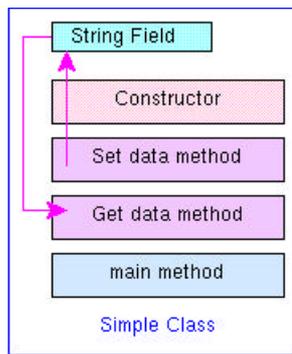
### Application Structure and Elements



An application is created from classes. A `class` is similar to a `RECORD` in the Pascal language or a `struct` in the C language in that it stores related data in *fields*, where the fields can be different types. So you could, for example, store a text string in one field, an integer in another field, and a floating point in a third field. The difference

between a class and a `RECORD` or `struct` is that a class also defines the *methods* to work on the data.

For example, a very simple class might store a string of text and define one method to set the string and another method to get the string and print it to the console. Methods that work on the data are called *accessor* methods.



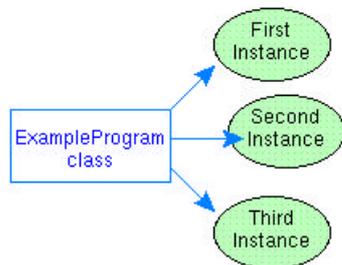
Every application needs one class with a `main` method. This class is the entry point for the program, and is the class name passed to the `java` interpreter command to run the application.

The code in the `main` method executes first when the program starts, and is the control point from which the controller class accessor methods are called to work on the data.

Here, again, is the [example program](#) from Lesson 1. It has no fields or accessor methods, but because it is the only class in the program, it has a `main` method.

```
class ExampleProgram {
    public static void main(String[] args){
        System.out.println("I'm a Simple Program");
    }
}
```

The `public static void` keywords mean the Java<sup>1</sup> virtual machine (JVM) interpreter can call the program's `main` method to start the program (`public`) without creating an instance of the class (`static`), and the program does not return data to the Java VM interpreter (`void`) when it ends.



An instance of a class is an executable copy of the class. While the class describes the data and behavior, you need a class instance to acquire and work on data. The diagram at the left shows three instances of the `ExampleProgram` class by the names: `FirstInstance`, `SecondInstance` and `ThirdInstance`.

The `main` method is static to give the Java VM interpreter a way to start the class without creating an instance of the control class first. Instances of the control class are created in the `main` method after the program starts.

The `main` method for the simple example does not create an instance of the `ExampleProgram` class because none is needed. The `ExampleProgram` class has no other methods or fields, so no class instance is needed to access them from the `main` method. The Java platform lets you execute a class without creating an instance of that class as long as its static methods do not call any non-static methods or fields.

The `ExampleProgram` class just calls `System.out.println`. The `java.lang.System` class, among other things, provides functionality to send text to the terminal window where the program was started. It has all static fields and methods. The static `out` field in the `System` class is type `PrintStream`, which is a class that provides various forms of print methods, including the `println` method.

The static fields and methods of a class can be called by another program without creating an instance of the class. So, just as the Java VM interpreter command could call the `static main` method in the `ExampleProgram` class without creating an instance of the `ExampleProgram` class, the `ExampleProgram` class can call the `static println` method in the `System` class, without creating an instance of the `System` class.

However, a program must create an instance of a class to access its non-static fields and methods. Accessing static and non-static fields and methods is discussed further with several examples in the next section.

## Fields and Methods

The [LessonTwoA.java](#) program alters the simple example to store the text string in a static field called `text`. The `text` field is static so its data can be accessed directly by the static call to `out.println` without creating an *instance* of the `LessonTwoA` class.

```
class LessonTwoA {
    static String text = "I'm a Simple Program";
    public static void main(String[] args){
        System.out.println(text);
    }
}
```

The [LessonTwoB.java](#) and [LessonTwoC.java](#) programs add a `getText` method to the program to retrieve and print the text.

The [LessonTwoB.java](#) program accesses the non-static `text` field with the non-static `getText` method. Non-static methods and fields are called instance methods and fields. This approach requires that an instance of the `LessonTwoB` class be created in the `main` method. To keep things interesting, this example includes a static text field and a non-static instance method (`getStaticText`) to retrieve it.

---

**Note:** The field and method return values are all type `String`.

---

```
class LessonTwoB {

    String text = "I'm a Simple Program";
    static String text2 = "I'm static text";

    String getText(){
        return text;
    }

    String getStaticText(){
        return text2;
    }

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

```

LessonTwoB progInstance = new LessonTwoB();
String retrievedText = progInstance.getText();
String retrievedStaticText =
    progInstance.getStaticText();
System.out.println(retrievedText);
System.out.println(retrievedStaticText);
    }
}

```

The [LessonTwoC.java](#) program accesses the static `text` field with the static `getText` method. Static methods and fields are called class methods and fields. This approach allows the program to call the static `getText` method directly without creating an instance of the `LessonTwoC` class.

```

class LessonTwoC {
    static String text = "I'm a Simple Program";

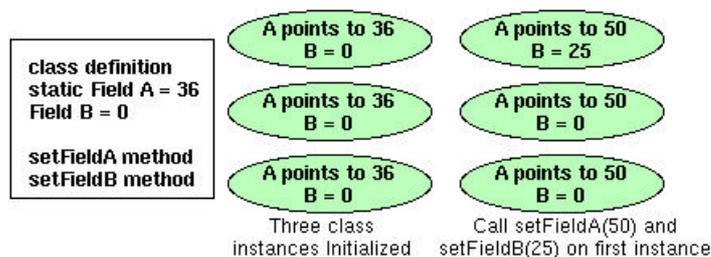
    //Accessor method
    static String getText(){
        return text;
    }

    public static void main(String[] args){
        String retrievedText = getText();
        System.out.println(retrievedText);
    }
}

```

So, class methods can operate only on class fields, and instance methods can operate on class and instance fields.

You might wonder what the difference means. In short, there is only one copy of the data stored or set in a class field but each instance has its own copy of the data stored or set in an instance field.



The figure above shows three class instances with one static field and one instance field. At runtime, there is one copy of the value for static Field A and each instance points to the one copy. When `setFieldA(50)` is called on the first instance, the value of the one copy changes from 36 to 50 and all three instances point to the new value. But, when `setFieldB(25)` is called on the first instance, the value for Field B changes from 0 to 25 for the first instance only because each instance has its own copy of Field B.

See [Understanding Instance and Class Members](#) lesson in [The Java tutorial](#) for a thorough discussion of this topic.

## Constructors

Classes have a special method called a *constructor* that is called when a class instance is created. The class constructor always has the same name as the class and no return type. The [LessonTwoD](#) program converts the `LessonTwoB` program to use a constructor to initialize the text string.

---

**Note:** If you do not write your own constructor, the compiler adds an empty constructor, which calls the no-arguments constructor of its parent class. The empty constructor is called the default constructor. The default constructor initializes all non-initialized fields and variables to zero.

---

```
class LessonTwoD {  
  
    String text;  
  
    //Constructor  
    LessonTwoD(){  
        text = "I'm a Simple Program";  
    }  
  
    //Accessor method  
    String getText(){  
        return text;  
    }  
  
    public static void main(String[] args){  
        LessonTwoD progInst = new LessonTwoD();  
        String retrievedText = progInst.getText();  
        System.out.println(retrievedText);  
    }  
}
```

## To Summarize

A simple program that prints a short text string to the console would probably do everything in the `main` method and do away with the constructor, `text` field, and `getText` method. But, this lesson used a very simple program to show you the structure and elements in a basic Java program.

## More Information

See [Understanding Instance and Class Members](#) lesson in [The Java tutorial](#) for a thorough discussion of this topic.

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<sup>1</sup> As used on this web site, the terms "Java virtual machine" or "JVM" mean a virtual machine for the Java platform.

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# Java™ Programming Language Basics, Part 1

## Lesson 3: Building Applets

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Like applications, applets are created from classes. However, applets do not have a `main` method as an entry point, but instead, have several methods to control specific aspects of applet execution.

This lesson converts an application from Lesson 2 to an applet and describes the structure and elements of an applet.

- [Application to Applet](#)
- [Run the Applet](#)
- [Applet Structure and Elements](#)
- [Packages](#)
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## Application to Applet

The following code is the [applet](#) equivalent to the `LessonTwoB` application from Lesson 2. The figure below shows how the running applet looks. The structure and elements of the applet code are discussed after the section on how to run the applet just below.



```
import java.applet.Applet;
import java.awt.Graphics;
import java.awt.Color;

public class SimpleApplet extends Applet{

    String text = "I'm a simple applet";

    public void init() {
        text = "I'm a simple applet";
        setBackground(Color.cyan);
    }
}
```

```
}
public void start() {
    System.out.println("starting...");
}
public void stop() {
    System.out.println("stopping...");
}
public void destroy() {
    System.out.println("preparing to unload...");
}
public void paint(Graphics g){
    System.out.println("Paint");
    g.setColor(Color.blue);
    g.drawRect(0, 0,
               getSize().width -1,
               getSize().height -1);
    g.setColor(Color.red);
    g.drawString(text, 15, 25);
}
}
```

The `SimpleApplet` class is declared `public` so the program that runs the applet (a browser or `appletviewer`), which is not local to the program can access it.

## Run the Applet

To see the applet in action, you need an HTML file with the Applet tag as follows:

```
<HTML>
<BODY>
<APPLET CODE=SimpleApplet.class WIDTH=200 HEIGHT=100>
</APPLET>
</BODY>
</HTML>
```

The easiest way to run the applet is with `appletviewer` shown below where `simpleApplet.html` is a file that contains the above HTML code:

```
appletviewer simpleApplet.html
```

---

**Note:** To run an applet written with Java™ 2 APIs in a browser, the browser must be enabled for the Java 2 Platform. If your browser is not enabled for the Java 2 Platform, you have to use `appletviewer` to run the applet or install [Java Plug-in](#). Java Plug-in lets you run applets on web pages under the 1.2 version of the Java VM instead of the web browser's default Java VM.

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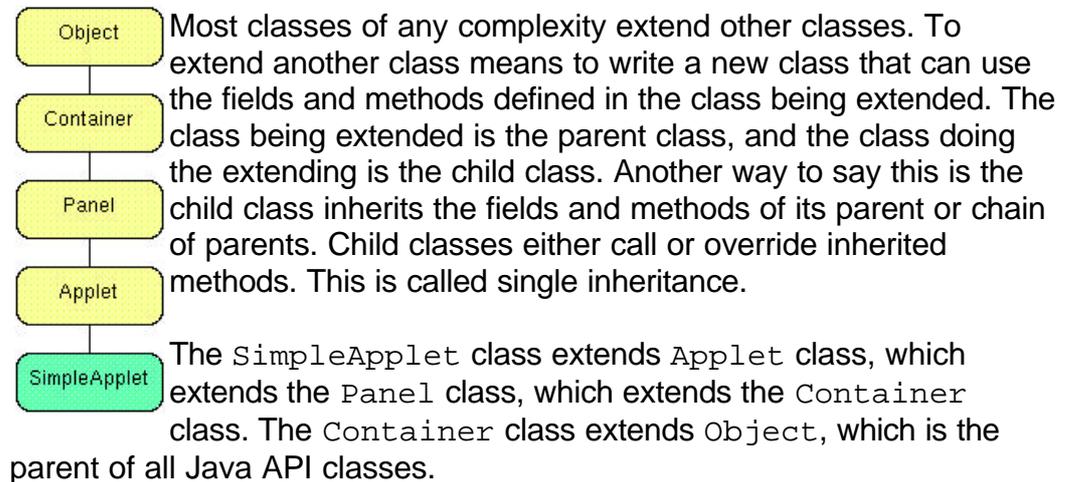
## Applet Structure and Elements

The Java API `Applet` class provides what you need to design the appearance and manage the behavior of an applet. This class provides a graphical user interface (GUI) component called a `Panel` and a number of

methods. To create an applet, you extend (or subclass) the `Applet` class and implement the appearance and behavior you want.

The applet's appearance is created by drawing onto the `Panel` or by attaching other GUI components such as push buttons, scrollbars, or text areas to the `Panel`. The applet's behavior is defined by implementing the methods.

### Extending a Class



The `Applet` class provides the `init`, `start`, `stop`, `destroy`, and `paint` methods you saw in the example applet. The `SimpleApplet` class overrides these methods to do what the `SimpleApplet` class needs them to do. The `Applet` class provides no functionality for these methods.

However, the `Applet` class does provide functionality for the `setBackground` method, which is called in the `init` method. The call to `setBackground` is an example of calling a method inherited from a parent class in contrast to overriding a method inherited from a parent class.

You might wonder why the Java language provides methods without implementations. It is to provide conventions for everyone to use for consistency across Java APIs. If everyone wrote their own method to start an applet, for example, but gave it a different name such as `begin` or `go`, the applet code would not be interoperable with other programs and browsers, or portable across multiple platforms. For example, Netscape and Internet Explorer know how to look for the `init` and `start` methods.

### Behavior

An applet is controlled by the software that runs it. Usually, the underlying software is a browser, but it can also be `appletviewer` as you saw in the example. The underlying software controls the applet by calling the methods the applet inherits from the `Applet` class.

**The `init` Method:** The `init` method is called when the applet is first

created and loaded by the underlying software. This method performs one-time operations the applet needs for its operation such as creating the user interface or setting the font. In the example, the `init` method initializes the text string and sets the background color.

**The start Method:** The `start` method is called when the applet is visited such as when the end user goes to a web page with an applet on it. The example prints a string to the console to tell you the applet is starting. In a more complex applet, the `start` method would do things required at the start of the applet such as begin animation or play sounds.

After the `start` method executes, the event thread calls the `paint` method to draw to the applet's `Panel`. A thread is a single sequential flow of control within the applet, and every applet can run in multiple threads. `Applet` drawing methods are always called from a dedicated drawing and event-handling thread.

**The stop and destroy Methods:** The `stop` method stops the applet when the applet is no longer on the screen such as when the end user goes to another web page. The example prints a string to the console to tell you the applet is stopping. In a more complex applet, this method should do things like stop animation or sounds.

The `destroy` method is called when the browser exits. Your applet should implement this method to do final cleanup such as stop live threads.

## Appearance

The `Panel` provided in the `Applet` class inherits a `paint` method from its parent `Container` class. To draw something onto the Applet's `Panel`, you implement the `paint` method to do the drawing.

The `Graphics` object passed to the `paint` method defines a *graphics context* for drawing on the `Panel`. The `Graphics` object has methods for graphical operations such as setting drawing colors, and drawing graphics, images, and text.

The `paint` method for the `SimpleApplet` draws the *I'm a simple applet* string in red inside a blue rectangle.

```
public void paint(Graphics g){
    System.out.println("Paint");
    //Set drawing color to blue
    g.setColor(Color.blue);
    //Specify the x, y, width and height for a rectangle
    g.drawRect(0, 0,
               getSize().width -1,
               getSize().height -1);
    //Set drawing color to red
    g.setColor(Color.red);
    //Draw the text string at the (15, 25) x-y location
    g.drawString(text, 15, 25);
}
```

## Packages

The applet code also has three `import` statements at the top. Applications of any size and all applets use `import` statements to access ready-made Java API classes in *packages*. This is true whether the Java API classes come in the Java platform download, from a third-party, or are classes you write yourself and store in a directory separate from the program. At compile time, a program uses `import` statements to locate and reference compiled Java API classes stored in packages elsewhere on the local or networked system. A compiled class in one package can have the same name as a compiled class in another package. The package name differentiates the two classes.

The examples in Lessons 1 and 2 did not need a package declaration to call the `System.out.println` Java API class because the `System` class is in the `java.lang` package that is included by default. You never need an `import java.lang.*` statement to use the compiled classes in that package.

## More Information

You can find more information on applets in the [Writing Applets](#) trail in [The Java Tutorial](#).

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# Java™ Programming Language Basics, Part 1

## Lesson 4: Building A User Interface

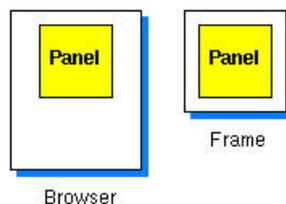
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In the last lesson you saw how the `Applet` class provides a `Panel` component so you can design the applet's user interface. This lesson expands the basic application from Lessons 1 and 2 to give it a user interface using the Java™ Foundation Classes (JFC) Project Swing APIs that handle user events.

- [Project Swing APIs](#)
- [Import Statements](#)
- [Class Declaration](#)
- [Instance Variables](#)
- [Constructor](#)
- [Action Listening](#)
- [Event Handling](#)
- [Main Method](#)
- [Applets Revisited](#)
- [More Information](#)

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## Project Swing APIs



In contrast to the applet in Lesson 3 where the user interface is attached to a panel object nested in a top-level browser, the Project Swing application in this lesson attaches its user interface to a panel object nested in a top-level frame object. A frame object is a top-level window that provides a title, banner, and methods to manage the appearance and behavior of the window.

The Project Swing code that follows builds this simple application. The window on the left appears when you start the application, and the window on the right appears when you click the button. Click again and you are back to the original window on the left.



When Application Starts



When Button Clicked

## Import Statements

Here is the [SwingUI.java](#) code. At the top, you have four lines of import statements. The lines indicate exactly which Java™ API classes the program uses. You could replace four of these lines with this one line: `import java.awt.*;` to import the entire `awt` package, but doing that increases compilation overhead than importing exactly the classes you need and no others.

```
import java.awt.Color;
import java.awt.BorderLayout;
import java.awt.event.*;
import javax.swing.*;
```

## Class Declaration

The class declaration comes next and indicates the top-level frame for the application's user interface is a `JFrame` that implements the `ActionListener` interface.

```
class SwingUI extends JFrame
    implements ActionListener{
```

The `JFrame` class extends the `Frame` class that is part of the Abstract Window Toolkit (AWT) APIs. Project Swing extends the AWT with a full set of GUI components and services, pluggable look and feel capabilities, and assistive technology support. For a more detailed introduction to Project Swing, see the [Swing Connection](#), and [Fundamentals of Swing, Part 1](#).

The Java APIs provide classes and interfaces for you to use. An interface defines a set of methods, but does not implement them. The rest of the `SwingUI` class declaration indicates that this class will implement the `ActionListener` interface. This means the `SwingUI` class must implement all methods defined in the `ActionListener` interface. Fortunately, there is only one, `actionPerformed`, which is discussed below.

## Instance Variables

These next lines declare the Project Swing component classes the `SwingUI` class uses. These are instance variables that can be accessed by any method in the instantiated class. In this example, they are built in the `SwingUI` constructor and accessed in the `actionPerformed` method implementation. The `private boolean` instance variable is

visible only to the `SwingUI` class and is used in the `actionPerformed` method to find out whether or not the button has been clicked.

```
JLabel text, clicked;
JButton button, clickButton;
JPanel panel;
private boolean _clickMeMode = true;
```

## Constructor

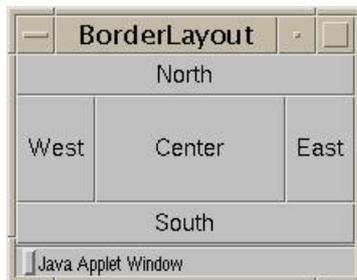
The constructor (shown below) creates the user interface components and `JPanel` object, adds the components to the `JPanel` object, adds the panel to the frame, and makes the `JButton` components event listeners. The `JFrame` object is created in the main method when the program starts.

```
SwingUI(){
    text = new JLabel("I'm a Simple Program");
    clicked = new JLabel("Button Clicked");

    button = new JButton("Click Me");
    //Add button as an event listener
    button.addActionListener(this);

    clickButton = new JButton("Click Again");
    //Add button as an event listener
    clickButton.addActionListener(this);

    //Create panel
    panel = new JPanel();
    //Specify layout manager and background color
    panel.setLayout(new BorderLayout(1,1));
    panel.setBackground(Color.white);
    //Add label and button to panel
    getContentPane().add(panel);
    panel.add(BorderLayout.CENTER, text);
    panel.add(BorderLayout.SOUTH, button);
}
```



When the `JPanel` object is created, the layout manager and background color are specified. The layout manager in use determines how user interface components are arranged on the display area.

The code uses the `BorderLayout` layout manager, which arranges user interface components in the five areas shown at left. To add a component, specify the area (north, south, east, west, or center).

```
//Create panel
panel = new JPanel();
//Specify layout manager and background color
panel.setLayout(new BorderLayout(1,1));
panel.setBackground(Color.white);
```

```
//Add label and button to panel
    getContentPane().add(panel);
    panel.add(BorderLayout.CENTER, text);
    panel.add(BorderLayout.SOUTH, button);
}
```

To find out about some of the other available layout managers and how to use them, see the JDC article [Exploring the AWT Layout Managers](#).

The call to the `getContentPane` method of the `JFrame` class is for adding the `Panel` to the `JFrame`. Components are not added directly to a `JFrame`, but to its content pane. Because the layout manager controls the layout of components, it is set on the content pane where the components reside. A content pane provides functionality that allows different types of components to work together in Project Swing.

## Action Listening

In addition to implementing the `ActionListener` interface, you have to add the event listener to the `JButton` components. An action listener is the `SwingUI` object because it implements the `ActionListener` interface. In this example, when the end user clicks the button, the underlying Java platform services pass the action (or event) to the `actionPerformed` method. In your code, you implement the `actionPerformed` method to take the appropriate action based on which button is clicked.

The component classes have the appropriate add methods to add action listeners to them. In the code the `JButton` class has an `addActionListener` method. The parameter passed to `addActionListener` is `this`, which means the `SwingUI` action listener is added to the button so button-generated actions are passed to the `actionPerformed` method in the `SwingUI` object.

```
        button = new JButton("Click Me");
//Add button as an event listener
        button.addActionListener(this);
```

## Event Handling

The `actionPerformed` method is passed an event object that represents the action event that occurred. Next, it uses an `if` statement to find out which component had the event, and takes action according to its findings.

```
public void actionPerformed(ActionEvent event){
    Object source = event.getSource();
    if (_clickMeMode) {
        text.setText("Button Clicked");
        button.setText("Click Again");
        _clickMeMode = false;
    } else {
        text.setText("I'm a Simple Program");
        button.setText("Click Me");
        _clickMeMode = true;
    }
}
```

You can find information on event handling for the different components in

[The Java Tutorial](#) section on [Event Handling](#).

## Main Method

The `main` method creates the top-level `frame`, sets the title, and includes code that lets the end user close the window using the frame menu.

```
public static void main(String[] args){
//Create top-level frame
    SwingUI frame = new SwingUI();
    frame.setTitle("Example");
//This code lets you close the window
    WindowListener l = new WindowAdapter() {
        public void windowClosing(WindowEvent e) {
            System.exit(0);
        }
    };
    frame.addWindowListener(l);
//This code lets you see the frame
    frame.pack();
    frame.setVisible(true);
}
}
```

The code for closing the window shows an easy way to add event handling functionality to a program. If the event listener interface you need provides more functionality than the program actually uses, use an adapter class. The Java APIs provide adapter classes for all listener interfaces with more than one method. This way, you can use the adapter class instead of the listener interface and implement only the methods you need. In the example, the `WindowListener` interface has 7 methods and this program needs only the `windowClosing` method so it makes sense to use the `WindowAdapter` class instead.

This code extends the `WindowAdapter` class and overrides the `windowClosing` method. The `new` keyword creates an anonymous instance of the extended inner class. It is anonymous because you are not assigning a name to the class and you cannot create another instance of the class without executing the code again. It is an inner class because the extended class definition is nested within the `SwingUI` class.

This approach takes only a few lines of code, while implementing the `WindowListener` interface would require 6 empty method implementations. Be sure to add the `WindowAdapter` object to the `frame` object so the `frame` object will listen for window events.

```
    WindowListener l = new WindowAdapter() {
//The instantiation of object l is extended to
//include this code:
        public void windowClosing(WindowEvent e){
            System.exit(0);
        }
    };
    frame.addWindowListener(l);
```

## Applets Revisited

Using what you learned in [Lesson 3: Building Applets](#) and this lesson, convert the example for [this lesson](#) into an applet. Give it a try before looking at the [solution](#).



In short, the differences between the applet and application versions are the following:

- The applet class is declared `public` so `appletviewer` can access it.
- The applet class descends from `Applet` and the application class descends from `JFrame`.
- The applet version has no `main` method.
- The application constructor is replaced in the applet by `start` and `init` methods.
- GUI components are added directly to the `Applet`; whereas, in the case of an application, GUI components are added to the content pane of its `JFrame` object.

## More Information

For more information on Project Swing, see the [Swing Connection](#), and [Fundamentals of Swing, Part 1](#).

Also see [The JFC Project Swing Tutorial: A Guide to Constructing GUIs](#).

To find out about some of the other available layout managers and how to use them, see the JDC article [Exploring the AWT Layout Managers](#).

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# Java™ Programming Language Basics, Part 1

## Lesson 5: Writing Servlets

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A servlet is an extension to a server that enhances the server's functionality. The most common use for a servlet is to extend a web server by providing dynamic web content. Web servers display documents written in HyperText Markup Language (HTML) and respond to user requests using the HyperText Transfer Protocol (HTTP). HTTP is the protocol for moving hypertext files across the internet. HTML documents contain text that has been marked up for interpretation by an HTML browser such as Netscape.

Servlets are easy to write. All you need is the Java® 2 Platform software, and JavaServer™ Web Development Kit (JWSDK). You can download a free copy of the [JWSDK](#).

This lesson shows you how to create a very simple form that invokes a basic servlet to process end user data entered on the form.

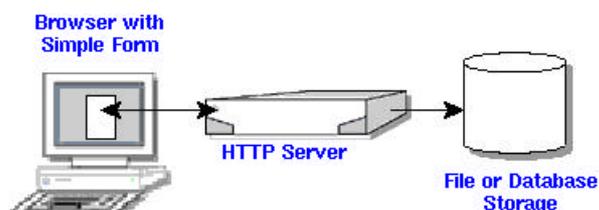
- [About the Example](#)
- [HTML Form](#)
- [Servlet Backend](#)
- [More Information](#)

---

## About the Example

A browser accepts end user input through an HTML form. The simple form used in this lesson has one text input field for the end user to enter text and a Submit button. When the end user clicks the Submit button, the simple servlet is invoked to process the end user input.

In this example, the simple servlet returns an HTML page that displays the text entered by the end user.



## HTML Form

The HTML form is embedded in this [HTML file](#). The diagram shows how the HTML page looks when it is opened in a browser.



The HTML file and form are similar to the simple application and applet examples in [Lesson 4](#) so you can compare the code and learn how servlets, applets, and applications handle end user inputs.

When the user clicks the `Click Me` button, the servlet gets the entered text, and returns an HTML page with the text.

The HTML page returned to the browser by the [ExampServlet.java](#) servlet is shown below. The servlet code to retrieve the user's input and generate the HTML page follows with a discussion.



---

**Note:** To run the example, you have to put the servlet and HTML files in the correct directories for the Web server you are using. For example, with Java WebServer 1.1.1, you place the servlet in the `~/JavaWebServer1.1.1/servlets` and the HTML file in the `~/JavaWebServer1.1.1/public_html` directory.

---

## Servlet Backend

[ExampServlet.java](#) builds an HTML page to return to the end user. This means the servlet code does not use any Project Swing or Abstract Window Toolkit (AWT) components or have event handling code. For this simple servlet, you only need to import these packages:

- `java.io` for system input and output. The `HttpServlet` class uses the `IOException` class in this package to signal that an input or output exception of some kind has occurred.
- `javax.servlet`, which contains generic (protocol-independent) servlet classes. The `HttpServlet` class uses the `ServletException` class in this package to indicate a servlet problem.
- `javax.servlet.http`, which contains HTTP servlet classes. The `HttpServlet` class is in this package.

```
import java.io.*;
import javax.servlet.*;
```

```
import javax.servlet.http.*;

public class ExampServlet extends HttpServlet {
    public void doPost(HttpServletRequest request,
        HttpServletResponse response)
        throws ServletException, IOException
    {
        response.setContentType("text/html");
        PrintWriter out = response.getWriter();

        out.println("<title>Example</title>" +
            "<body bgcolor=FFFFFF>");

        out.println("<h2>Button Clicked</h2>");

        String DATA = request.getParameter("DATA");

        if(DATA != null){
            out.println(DATA);
        } else {
            out.println("No text entered.");
        }

        out.println("<P>Return to
            <A HREF=\"../simpleHTML.html\">Form</A>");
        out.close();
    }
}
```

## Class and Method Declarations

All servlet classes extend the `HttpServlet` abstract class. `HttpServlet` simplifies writing HTTP servlets by providing a framework for handling the HTTP protocol. Because `HttpServlet` is abstract, your servlet class must extend it and override at least one of its methods. An abstract class is a class that contains unimplemented methods and cannot be instantiated itself.

```
public class ExampServlet extends HttpServlet {
    public void doPost(HttpServletRequest request,
        HttpServletResponse response)
        throws ServletException, IOException
    {
```

The `ExampServlet` class is declared `public` so the web server that runs the servlet, which is not local to the servlet, can access it.

The `ExampServlet` class defines a `doPost` method with the same name, return type, and parameter list as the `doPost` method in the `HttpServlet` class. By doing this, the `ExampServlet` class overrides and implements the `doPost` method in the `HttpServlet` class.

The `doPost` method performs the HTTP POST operation, which is the type of operation specified in the HTML form used for this example. The other possibility is the HTTP GET operation, in which case you would implement the `doGet` method instead.

In short, `POST` requests are for sending any amount of data directly over the connection without changing the URL, and `GET` requests are for getting limited amounts of information appended to the URL. `POST` requests cannot be bookmarked or emailed and do not change the Uniform Resource Locators (URL) of the response. `GET` requests can be bookmarked and emailed and add information to the URL of the response.

The parameter list for the `doPost` method takes a `request` and a `response` object. The browser sends a request to the servlet and the servlet sends a response back to the browser.

The `doPost` method implementation accesses information in the `request` object to find out who made the request, what form the request data is in, and which HTTP headers were sent, and uses the `response` object to create an HTML page in response to the browser's request. The `doPost` method throws an `IOException` if there is an input or output problem when it handles the request, and a `ServletException` if the request could not be handled. These exceptions are handled in the `HttpServlet` class.

## Method Implementation

The first part of the `doPost` method uses the `response` object to create an HTML page. It first sets the response content type to be `text/html`, then gets a `PrintWriter` object for formatted text output.

```
response.setContentType("text/html");
PrintWriter out = response.getWriter();

out.println("<title>Example</title>" +
    "<body bgcolor=#FFFFFF>");

out.println("<h2>Button Clicked</h2>");
```

The next line uses the `request` object to get the data from the text field on the form and store it in the `DATA` variable. The `getParameter` method gets the named parameter, returns `null` if the parameter was not set, and an empty string if the parameter was sent without a value.

```
String DATA = request.getParameter("DATA");
```

The next part of the `doPost` method gets the data out of the `DATA` parameter and passes it to the `response` object to add to the HTML response page.

```
if(DATA != null){
    out.println(DATA);
} else {
    out.println("No text entered.");
}
```

The last part of the `doPost` method creates a link to take the end user from the HTML response page back to the original form, and closes the response.

```
out.println("<P>Return to  
  <A HREF=\"../simpleHTML.html\">Form</A>");  
out.close();  
}
```

---

**Note:** To learn how to use the other methods available in the `HttpServlet`, `HttpServletRequest`, and `HttpServletResponse` classes, see [The Java Tutorial](#) trail on [Servlets](#).

---

## More Information

You can find more information on servlets in the [Servlets](#) trail in [The Java Tutorial](#).

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# Java™ Programming Language Basics, Part 1

## Lesson 6: File Access and Permissions

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So far, you have learned how to retrieve and handle a short text string entered from the keyboard into a simple graphical user interface (GUI). But programs also retrieve, handle, and store data in files and databases.

This lesson expands the examples from previous lessons to perform basic file access using the application programming interfaces (APIs) in the `java.io` package. It also shows you how to grant applets permission to access specific files, and how to restrict an application so it has access to specific files only.

- [File Access by Applications](#)
- [System Properties](#)
- [File.separatorChar](#)
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## File Access by Applications

The Java® 2 Platform software provides a rich range of classes for reading character or byte data into a program, and writing character or byte data out to an external file, storage device, or program. The source or destination might be on the local computer system where the program is running or anywhere on the network.

This section shows you how to read data from and write data to a file on the local computer system. See [The Java™ Tutorial](#) trail on [Reading and Writing](#) for information on transferring data between programs, between a program and memory, and performing operations such as buffering or character encoding on data as it is read or written.

- **Reading:** A program opens an input *stream* on the file and reads the data in serially (in the order it was written to the file).
- **Writing:** A program opens an output stream on the file and writes the

data out serially.

This first example converts the [SwingUI.java](#) example from Lesson 4 to accept user input through a text field. The window on the left appears when you start the [FileIO](#) application, and the window on the right appears when you click the button. When you click the button, whatever is entered into the text field is saved to a file. After that, another file is opened and read and its text is displayed in the window on the right. Click again and you are back to the original window with a blank text field ready for more input.



When Application Starts    When Button Clicked

The conversion from the [SwingUI.java](#) program for Lesson 4 to the [FileIO.java](#) program for this lesson primarily involves the `constructor` and the `actionPerformed` method as described here.

### Constructor and Instance Variable Changes

A `JTextField` instance variable is added to the class so the `constructor` can instantiate the object and the `actionPerformed` method can access the text the end user types into it.

The `constructor` instantiates the `JTextField` with a value of 20. This value tells the Java platform the number of columns to use to calculate the preferred width of the field. Lower values result in a narrower display, and likewise, higher values result in a wider display.

The `text` label is added to the `North` section of the `BorderLayout` so the `JTextField` can be added to the `Center` section.

---

**Note:** You can learn more about component sizing in [The Java Tutorial](#) sections on [Solving Common Layout Problems](#) and [Layout Management](#).

---

```
//Instance variable for text field
JTextField textField;

FileIO(){
    text = new JLabel("Text to save to file:");
    clicked = new
        JLabel("Text retrieved from file:");

    button = new JButton("Click Me");
    button.addActionListener(this);
```

```
clickButton = new JButton("Click Again");
clickButton.addActionListener(this);

//Text field instantiation
textField = new JTextField(20);

panel = new JPanel();
panel.setLayout(new BorderLayout());
panel.setBackground(Color.white);
getContentPane().add(panel);

//Adjustments to layout to add text field
panel.add("North", text);
panel.add("Center", textField);
panel.add("South", button);
}
```

## Method Changes

The `actionPerformed` method uses the `FileInputStream` and `FileOutputStream` classes to read data from and write data to a file. These classes handle data in byte streams, as opposed to character streams, which are shown in the applet example. A more detailed explanation of the changes to the method implementation follows the code.

```
public void actionPerformed(
   (ActionEvent event){
    Object source = event.getSource();
    if(source == button){
    //Variable to display text read from file
    String s = null;
    if(_clickMeMode){
    try{
    //Code to write to file
    String text = textField.getText();
    byte b[] = text.getBytes();

    String outputFileName =
        System.getProperty("user.home",
        File.separatorChar + "home" +
        File.separatorChar + "monicap") +
        File.separatorChar + "text.txt";
    File outputFile = new File(outputFileName);
    FileOutputStream out = new
        FileOutputStream(outputFile);
    out.write(b);
    out.close();

    //Code to read from file
    String inputFileName =
        System.getProperty("user.home",
        File.separatorChar + "home" +
        File.separatorChar + "monicap") +
        File.separatorChar + "text.txt";
    File inputFile = new File(inputFileName);
    FileInputStream in = new
        FileInputStream(inputFile);

    byte bt[] = new
        byte[(int)inputFile.length()];
```

```
        in.read(bt);
        s = new String(bt);
        in.close();
    } catch (java.io.IOException e) {
        System.out.println("Cannot access text.txt");
    }
}
//Clear text field
textField.setText("");
//Display text read from file
text.setText("Text retrieved from file:");
textField.setText(s);
button.setText("Click Again");
_clickMeMode = false;
} else {
//Save text to file
text.setText("Text to save to file:");
textField.setText("");
button.setText("Click Me");
_clickMeMode = true;
}
}
}
```

To write the end user text to a file, the text is retrieved from the `textField` and converted to a byte array.

```
String text = textField.getText();
byte b[] = text.getBytes();
```

Next, a `File` object is created for the file to be written to and used to create a `FileOutputStream` object.

```
String outputFileName =
    System.getProperty("user.home",
        File.separatorChar + "home" +
        File.separatorChar + "monicap") +
    File.separatorChar + "text.txt";
File outputFile = new File(outputFileName);
FileOutputStream out = new
    FileOutputStream(outputFile);
```

Finally, the `FileOutputStream` object writes the byte array to the `File` object and closes the output stream when the operation completes.

```
out.write(b);
out.close();
```

The code to open a file for reading is similar. To read text from a file, a `File` object is created and used to create a `FileInputStream` object.

```
String inputFileName =
    System.getProperty("user.home",
        File.separatorChar + "home" +
        File.separatorChar + "monicap") +
    File.separatorChar + "text.txt";
File inputFile = new File(inputFileName);
FileInputStream out = new
    FileInputStream(inputFile);
```

Next, a `byte` array is created the same size as the file into which the file contents are read.

```
byte bt[] = new byte[(int)inputFile.length()];
in.read(bt);
```

Finally, the byte array is used to construct a `String` object, which is used to create the text for the `label` component. The `FileInputStream` is closed when the operation completes.

```
String s = new String(bt);
label.setText(s);
in.close();
```

## System Properties

The above code used a call to `System.getProperty` to create the pathname to the file in the user's home directory. The `System` class maintains a set of properties that define attributes of the current working environment. When the Java platform starts, system properties are initialized with information about the runtime environment including the current user, Java platform version, and the character used to separate components of a file name (`File.separatorChar`).

The call to `System.getProperty` uses the keyword `user.home` to get the user's home directory and supplies the default value `File.separatorChar + "home" + File.separatorChar + "monicap"` in case no value is found for this key.

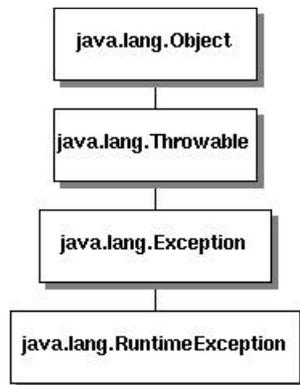
## File.separatorChar

The above code used the `java.io.File.separatorChar` variable to construct the directory pathname. This variable is initialized to contain the file separator value stored in the `file.separator` system property and gives you a way to construct platform-independent pathnames.

For example, the pathname `/home/monicap/text.txt` for Unix and `\home\monicap\text.txt` for Windows are both represented as `File.separatorChar + "home" + File.separatorChar + "monicap" + File.separatorChar + "text.txt"` in a platform-independent construction.

## Exception Handling

An exception is a class that descends from either `java.lang.Exception` or `java.lang.RuntimeException` that defines mild error conditions your program might encounter. Rather than letting the program terminate, you can write code to handle exceptions and continue program execution.



The file input and output code in the `actionPerformed` method is enclosed in a `try` and `catch` block to handle the `java.lang.IOException` that might be thrown by code within the block.

`java.lang.IOException` is what is called a checked exception. The Java platform requires that a method catch or specify all checked exceptions that can be thrown within the scope of a method.

Checked exceptions descend from `java.lang.Throwable`. If a checked exception is not either caught or specified, the compiler throws an error.

In the example, the `try` and `catch` block catches and handles the `java.io.IOException` checked exception. If a method does not catch a checked exception, the method must specify that it can throw the exception because an exception that can be thrown by a method is really part of the method's public interface. Callers of the method must know about the exceptions that a method can throw so they can take appropriate actions.

However, the `actionPerformed` method already has a public interface definition that cannot be changed to specify the `java.io.IOException`, so in this case, the only thing to do is catch and handle the checked exception. Methods you define yourself can either specify exceptions or catch and handle them, while methods you override must catch and handle checked exceptions. Here is an example of a user-defined method that specifies an exception so callers of this method can catch and handle it:

```
public int aComputationMethod(int number1,
    int number2)
    throws IllegalArgumentException{
    //Body of method
}
```

---

**Note:** You can find more information on this topic in [The Java Tutorial](#) trail on [Handling Errors with Exceptions](#).

---

When you catch exceptions in your code, you should handle them in a way that is friendly to your end users. The exception and error classes have a `toString` method to print system error text and a `printStackTrace` method to print a stack trace, which can be very useful for debugging your application during development. But, it is probably better to deploy the program with a more user-friendly approach to handling errors.

You can provide your own application-specific error text to print to the command line, or display a dialog box with application-specific error text. Using application-specific error text that you provide will also make it much easier to internationalize the application later on because you will have access to the text.

For the example programs in this lesson, the error message for the file input and output is handled with application-specific error text that prints at the command line as follows:

```
//Do this during development
    }catch(java.io.IOException e){
        System.out.println(e.toString());
        System.out.println(e.printStackTrace());
    }

//But deploy it like this
    }catch(java.io.IOException e){
        System.out.println("Cannot access text.txt");
    }
```

If you want to make your code even more user friendly, you could separate the write and read operations and provide two `try` and `catch` blocks. The error text for the read operation could be *Cannot read text.txt*, and the error text for the write operation could be *Cannot write text.txt*.

As an exercise, change the code to handle the read and write operations separately. Give it a try before peeking at the [solution](#).

## File Access by Applets

The file access code for the [FileIOAppl.java](#) code is equivalent to the `FileIO.java` application, but shows how to use the APIs for handling data in character streams instead of byte streams. You can use either approach in applets or applications. In this lesson, the choice to handle data in bytes streams in the application and in character streams in the applet is purely random. In real-life programs, you would base the decision on your specific application requirements.

The changes to instance variables and the `constructor` are identical to the application code, and the changes to the `actionPerformed` method are nearly identical with these two exceptions:

- **Writing:** When the `textField` text is retrieved, it is passed directly to the `out.write` call.
- **Reading:** A character array is created to store the data read in from the input stream.

```
public void actionPerformed(ActionEvent event){
    Object source = event.getSource();
    if(source == button){
        //Variable to display text read from file
        String s = null;
        if(_clickMeMode){
            try{
                //Code to write to file
                String text = textField.getText();
                String outputFileName =
                    System.getProperty("user.home",
                        File.separatorChar + "home" +
```

```
        File.separatorChar + "monicap") +
        File.separatorChar + "text.txt";
        File outputFile = new File(outputFileName);
        FileWriter out = new
            FileWriter(outputFile);
        out.write(text);
        out.close();
//Code to read from file
        String inputFileName =
            System.getProperty("user.home",
                File.separatorChar + "home" +
                File.separatorChar + "monicap") +
                File.separatorChar + "text.txt";
        File inputFile = new File(inputFileName);
        FileReader in = new FileReader(inputFile);
        char c[] = new
            char[(char)inputFile.length()];
        in.read(c);
        s = new String(c);
        in.close();
    } catch (java.io.IOException e) {
        System.out.println("Cannot access text.txt");
    }
//Clear text field
        textField.setText("");
//Display text read from file
        text.setText("Text retrieved from file:");
        textField.setText(s);
        button.setText("Click Again");
        _clickMeMode = false;
    } else {
//Save text to file
        text.setText("Text to save to file:");
        textField.setText("");
        button.setText("Click Me");
        _clickMeMode = true;
    }
}
}
```

## Granting Applets Permission

If you tried to run the applet example, you undoubtedly saw errors when you clicked the `Click Me` button. This is because the Java 2 Platform security does not permit an applet to write to and read from files without explicit permission.

An applet has no access to local system resources unless it is specifically granted the access. So for the `FileUIApp1` program to read from `text.txt` and write to `text.txt`, the applet has to be given the appropriate read or write access permission for each file.

Access permission is granted with a policy file, and `appletviewer` is launched with the policy file to be used for the applet being viewed.

## Creating a Policy File

Policy tool is a Java 2 Platform security tool for creating policy files. [The](#)

[Java Tutorial](#) trail on [Controlling Applets](#) explains how to use Policy Tool in good detail. Here is the policy file you need to run the applet. You can use Policy tool to create it or copy the text below into an ASCII file.

```
grant {
    permission java.util.PropertyPermission
        "user.home", "read";
    permission java.io.FilePermission
        "${user.home}/text.txt", "read,write";
};
```

## Running an Applet with a Policy File

Assuming the policy file is named `polfile` and is in the same directory with an HTML file named `fileIO.html` that contains the HTML to run the `FileIOApp1` applet, you would run the application in `appletviewer` like this:

```
appletviewer -J-Djava.security.policy=polfile fileIO.html
```

---

**Note:** If your browser is enabled for the Java 2 Platform or if you have [Java Plug-in](#) installed, you can run the applet from the browser if you put the policy file in your local home directory.

---

Here is the `fileIO.html` file for running the `FileIOApp1` applet:

```
<HTML>
<BODY>

<APPLET CODE=FileIOApp1.class WIDTH=200 HEIGHT=100>
</APPLET>

</BODY>
</HTML>
```

## Restricting Applications

You can use the default security manager and a policy file to restrict the application's access as follows.

```
java -Djava.security.manager
    -Djava.security.policy=apppolfile FileIO
```

Because the application runs within the security manager, which disallows all access, the policy file needs two additional permissions. One so the security manager can access the event queue and load the user interface components, and another so the application does not display the banner warning that its window was created by another program (the security manager).

```
grant {
    permission java.awt.AWTPermission
        "accessEventQueue";
    permission java.awt.AWTPermission
```

```

        "showWindowWithoutWarningBanner";

    permission java.util.PropertyPermission
        "user.home", "read";
    permission java.io.FilePermission
        "${user.home}/text.txt", "read,write";
};

```

## File Access by Servlets

Although servlets are invoked from a browser, they are under the security policy in force for the web server under which they run. When file input and output code is added to `ExampServlet.java` from Lesson 5, [FileIOServlet](#) for this lesson executes without restriction under Java WebServer™ 1.1.1.

**I'm a Simple Form**

Enter some text and click the Submit button. Clicking Submit invokes [FileIOServlet.java](#), which returns an HTML page to the browser.

**Button Clicked**

**Text from form:** Four score and seven years ago

**Text from file:** Here is some text.

Return to [Form](#)

```

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class FileIOServlet extends HttpServlet {

    public void doPost(HttpServletRequest request,
        HttpServletResponse response)
        throws ServletException, IOException
    {
        response.setContentType("text/html");
        PrintWriter out = response.getWriter();
        out.println("<title>Example<title>" +
            "<body bgcolor=FFFFFF>");

        out.println("<h2>Button Clicked</h2>");

        String DATA = request.getParameter("DATA");

        if(DATA != null){
            out.println("<STRONG>Text from
                form:</STRONG>");
            out.println(DATA);
        } else {
            out.println("No text entered.");
        }
    }
}

```

```
    }

    try{
//Code to write to file
        String outputFileName=
            System.getProperty("user.home",
                File.separatorChar + "home" +
                File.separatorChar + "monicap") +
                File.separatorChar + "text.txt";
        File outputFile = new File(outputFileName);
        FileWriter fout = new FileWriter(outputFile);
        fout.write(DATA);
        fout.close();

//Code to read from file
        String inputFileName =
            System.getProperty("user.home",
                File.separatorChar + "home" +
                File.separatorChar + "monicap") +
                File.separatorChar + "text.txt";
        File inputFile = new File(inputFileName);
        FileReader fin = new
            FileReader(inputFile);
        char c[] = new
            char[(char)inputFile.length()];
        int i;
        i = fin.read(c);
        String s = new String(c);
        out.println("<P>
            <STRONG>Text from file:</STRONG>");
        out.println(s);
        fin.close();
    }catch(java.io.IOException e){
        System.out.println("Cannot access text.txt");
    }

    out.println("<P>Return to
        <A HREF=\"../simpleHTML.html\">Form</A>");
    out.close();
}
}
```

## Appending

So far the examples have shown you how to read in and write out streams of data in their entirety. But often, you want to append data to an existing file or read in only certain amounts. Using the [RandomAccessFile](#) class, alter the [FileIO.java](#) class to append to the file.

Give it a try before taking a peek at the [Solution](#).

## More Information

For more information on file input and output, see the [Reading and Writing](#) trail in [The Java Tutorial](#).

You can learn more about component sizing in [The Java Tutorial](#) sections on [Solving Common Layout Problems](#) and [Layout Management](#).

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# Java™ Programming Language Basics, Part 1

## Lesson 7: Database Access and Permissions

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This lesson converts the application, applet, and servlet examples from Lesson 6 to write to and read from a database using JDBC™. JDBC is the Java™ database connectivity application programming interface (API) available in the Java® 2 Platform software.

The code for this lesson is very similar to the code you saw in Lesson 6, but additional steps (beyond converting the file access code to database access code) include setting up the environment, creating a database table, and connecting to the database. Creating a database table is a database administration task that is not part of your program code. However, establishing a database connection and the resulting database access are.

As in Lesson 6, the applet needs appropriate permissions to connect to the database. Which permissions it needs varies with the type of driver used to make the database connection.

- [Database Setup](#)
- [Create Database Table](#)
- [Database Access by Applications](#)
  - [Establishing a Connection](#)
  - [Final and Private Variables](#)
  - [Writing and Reading Data](#)
- [Database Access by Applets](#)
  - [JDBC Driver](#)
  - [JDBC-ODBC Bridge with ODBC Driver](#)
- [Database Access by Servlets](#)
- [More Information](#)

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## Database Setup

You need access to a database if you want to run the examples in this lesson. You can install a database on your machine or perhaps you have access to a database at work. Either way, you need a database driver and any relevant environment settings so your program can load the driver and locate the database. The program will also need database login information in the form of a user name and password.

A database driver is software that lets a program establish a connection

with a database. If you do not have the right driver for the database to which you want to connect, your program will be unable to establish the connection.

Drivers either come with the database or are available from the Web. If you install your own database, consult the documentation for the driver for information on installation and any other environment settings you need for your platform. If you are using a database at work, consult your database administrator for this information.

To show you two ways to do it, the application example uses the `jdbc` driver, the applet examples use the `jdbc` and `jdbc.odbc` drivers, and the servlet example uses the `jdbc.odbc` driver. All examples connect to an `OracleOCI7.3.4` database.

Connections to other databases will involve similar steps and code. Be sure to consult your documentation or system administrator if you need help connecting to the database.

## Create Database Table

Once you have access to a database, create a table in it for the examples in this lesson. You need a table with one text field for storing character data.

```
TABLE DBA (  
    TEXT          varchar2(100) ,  
    primary key (TEXT)  
)
```

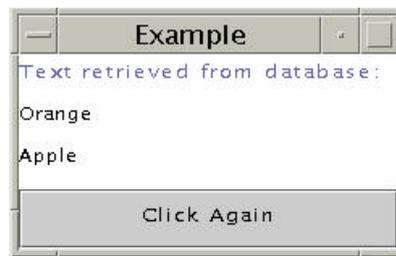
## Database Access by Applications

This example converts the [FileIO](#) program from Lesson 6 to write data to and read data from a database. The top window below appears when you start the [Db](#) application, and the window beneath it appears when you click the `Click Me` button.

When you click the `Click Me` button, whatever is entered into the text field is saved to the database. After that, the data is retrieved from the database and displayed in the window shown on the bottom. If you write data to the table more than once, everything written is read and displayed in the window shown on the bottom, so you might have to enlarge the window to see the entire list of table items.



When Application Starts



### After Writing Orange and Apple to Database

The database access application needs code to establish the database connection and do the database read and write operations.

### Establishing a Database Connection

The JDBC `DriverManager` class can handle multiple database drivers, and initiates all database communication. To load the driver and connect to the database, the application needs a `Connection` object and `Strings` that represent the `_driver` and `_url`.

The `_url` string is in the form of a Uniform Resource Locator (URL). It consists of the URL, Oracle subprotocol, and Oracle data source in the form `jdbc:oracle:thin:`, the database login username, the password, plus machine, port, and protocol information.

```
private Connection c;

final static private String _driver =
    "oracle.jdbc.driver.OracleDriver";

final static private String _url =
    "jdbc:oracle:thin:username/password@(description=(
    address_list=(address=(protocol=tcp)
    (host=developer)(port=1521)))
    (source_route=yes)(connect_data=(sid=jdcsid)))";
```

The `actionPerformed` method calls the `Class.forName(_driver)` method to load the driver, and the `DriverManager.getConnection` method to establish the connection. The [Exception Handling](#) section in Lesson 6 describes `try` and `catch` blocks. The only thing different here is that this block uses two `catch` statements because two different errors are possible.

The call to `Class.forName(_driver);` throws `java.lang.ClassNotFoundException`, and the call to `c = DriverManager.getConnection(_url);` throws `java.sql.SQLException`. In the case of either error, the application tells the user what is wrong and exits because the program cannot operate in any meaningful way without a database driver or connection.

```
public void actionPerformed(ActionEvent event){
    try{
    //Load the driver
        Class.forName(_driver);
```

```
//Establish database connection
    c = DriverManager.getConnection(_url);
}catch (java.lang.ClassNotFoundException e){
    System.out.println("Cannot find driver class");
    System.exit(1);
}catch (java.sql.SQLException e){
    System.out.println("Cannot get connection");
    System.exit(1);
}
```

## Final and Private Variables

The member variables used to establish the database connection above are declared `private`, and two of those variables are also declared `final`.

**final:** A `final` variable contains a constant value that can never change once it is initialized. In the example, the user name, and password are `final` variables because you would not want to allow an instance of this or any other class to change this information.

**private:** A `private` variable can only be used (accessed) by the class in which it is declared. No other class can read or change `private` variables. In the example, the database driver, user name, and password variables are `private` to prevent an outside class from accessing them and jeopardizing the database connection, or compromising the secret user name and password information. You can find more information on this in the [Objects and Class](#) lesson in [The Java Tutorial](#)

## Writing and Reading Data

In the write operation, a `Statement` object is created from the `Connection`. The `Statement` object has methods for executing SQL queries and updates. Next, a `String` object that contains the SQL update for the write operation is constructed and passed to the `executeUpdate` method of the `Statement` object.

```
Object source = event.getSource();
if(source == button){
    JTextArea displayText = new JTextArea();

    try{
//Code to write to database
        String theText = textField.getText();
        Statement stmt = c.createStatement();
        String updateString = "INSERT INTO dba VALUES
                               ('" + theText + "')";
        int count = stmt.executeUpdate(updateString);
```

SQL commands are `String` objects, and therefore, follow the rules of `String` construction where the string is enclosed in double quotes (" ") and variable data is appended with a plus (+). The variable `theText` is a text variable. Single quotes are prepended and appended to comply with SQL syntax.

In the read operation, a `ResultSet` object is created from the `executeQuery` method of the `Statement` object. The `ResultSet` contains the data returned by the query. To retrieve the data returned, the code iterates through the `ResultSet`, retrieves the data, and appends the data to the text area, `displayText`.

```
//Code to read from database
    ResultSet results = stmt.executeQuery(
        "SELECT TEXT FROM dba ");
    while(results.next()){
        String s = results.getString("TEXT");
        displayText.append(s + "\n");
    }
    stmt.close();
} catch (java.sql.SQLException e){
    System.out.println(e.toString());
}
}
//Display text read from database
panel.removeAll();
panel.add("North", clicked);
panel.add("Center", displayText);
panel.add("South", clickButton);
panel.validate();
panel.repaint();
}
```

## Database Access by Applets

The applet version of the example is like the application code described above except for the standard differences between applications and applets described in the [Structure and Elements](#) section of Lesson 3.

However, if you run the applet without a policy file, you get a stack trace indicating permission errors. The [Granting Applets Permission](#) section in Lesson 6 introduced you to policy files and how to launch an applet with the permission it needs. The Lesson 6 applet example provided the policy file and told you how to launch the applet with it. This lesson shows you how to read the stack trace to determine the permissions you need in a policy file.

To keep things interesting, this lesson has two versions of the database access applet: one uses the JDBC driver, and the other uses the the JDBC-ODBC bridge with an Open DataBase Connectivity (ODBC) driver.

Both applets do the same operations to the same database table using different drivers. Each applet has its own policy file with different permission lists and has different requirements for locating the database driver

### JDBC Driver

The JDBC driver is used from a program written exclusively in the Java language (Java program). It converts JDBC calls directly into the protocol used by the DBMS. This type of driver is available from the DBMS vendor and is usually packaged with the DBMS software.

**Starting the Applet:** To successfully run, the [DbApp1.java](#) applet needs an available database driver and a policy file. This section walks through the steps to get everything set up. Here is the `DbApp1.html` file for running the `DbApp1` applet:

```
<HTML>
<BODY>

<APPLET CODE=DbApp1.class
        WIDTH=200
        HEIGHT=100>
</APPLET>

</BODY>
</HTML>
```

And here is how to start the applet with `appletviewer`:

```
appletviewer DbApp1.html
```

**Locating the Database Driver:** Assuming the driver is not available to the `DriverManager` for some reason, the following error generates when you click the `Click Me` button.

```
cannot find driver
```

This error means the `DriverManager` looked for the JDBC driver in the directory where the applet HTML and class files are and could not find it. To correct this error, copy the driver to the directory where the applet files are, and if the driver is bundled in a zip file, unzip the zip file so the applet can access the driver.

Once you have the driver in place, launch the applet again.

```
appletviewer DbApp1.html
```

**Reading a Stack Trace:** Assuming the driver is locally available to the applet, if the [DbApp1.java](#) applet is launched without a policy file, the following stack trace is generated when the end user clicks the `Click Me` button.

```
java.security.AccessControlException: access denied
(java.net.SocketPermission developer resolve)
```

The first line in the above stack trace tells you access is denied. This means this stack trace was generated because the applet tried to access a system resource without the proper permission. The second line means to correct this condition you need a `SocketPermission` that gives the applet access to the machine (`developer`) where the database is located.

You can use `Policy` tool to create the policy file you need, or you can create it with an ASCII editor. Here is the policy file with the permission indicated by the stack trace:

```
grant {
    permission java.net.SocketPermission "developer",
        "resolve";
    "accessClassInPackage.sun.jdbc.odbc";
};
```

Run the applet again, this time with a policy file named `DbApp1Pol` that has the above permission in it:

```
appletviewer -J-Djava.security.policy=DbApp1Pol
                DbApp1.html
```

You get a stack trace again, but this time it is a different error condition.

```
java.security.AccessControlException: access denied
(java.net.SocketPermission
129.144.176.176:1521 connect,resolve)
```

Now you need a `SocketPermission` that allows access to the Internet Protocol (IP) address and port on the `developer` machine where the database is located.

Here is the `DbApp1Pol` policy file with the permission indicated by the stack trace added to it:

```
grant {
    permission java.net.SocketPermission "developer",
        "resolve";
    permission java.net.SocketPermission
        "129.144.176.176:1521", "connect,resolve";
};
```

Run the applet again. If you use the above policy file with the `Socket` permissions indicated, it works just fine.

```
appletviewer -J-Djava.security.policy=DbApp1Pol
                DbApp1.html
```

## JDBC-ODBC Bridge with ODBC Driver

Open Data Base Connectivity (ODBC) is Microsoft's programming interface for accessing a large number of relational databases on numerous platforms. The JDBC-ODBC bridge is built into the Solaris and Windows versions of the Java platform so you can do two things:

1. Use ODBC from a Java program
2. Load ODBC drivers as JDBC drivers. This example uses the JDBC-ODBC bridge to load an ODBC driver to connect to the database. The applet has no ODBC code, however.

The `DriverManager` uses environment settings to locate and load the database driver. For this example, the driver file does not need to be locally accessible.

**Start the Applet:** Here is the `DbasOdb.html` file for running the `DbasOdbApplet` applet:

```
<HTML>
<BODY>

<APPLET CODE=DbasOdbApplet.class
        WIDTH=200
        HEIGHT=100>
</APPLET>

</BODY>
</HTML>
```

And here is how to start the applet:

```
appletviewer DbasOdb.html
```

**Reading a Stack Trace:** If the [DbasOdbApplet.java](#) applet is launched without a policy file, the following stack trace is generated when the end user clicks the `Click Me` button.

```
java.security.AccessControlException: access denied
 (java.lang.RuntimePermission
 accessClassInPackage.sun.jdbc.odbc )
```

The first line in the above stack trace tells you access is denied. This means this stack trace was generated because the applet tried to access a system resource without the proper permission. The second line means you need a `RuntimePermission` that gives the applet access to the `sun.jdbc.odbc` package. This package provides the JDBC-ODBC bridge functionality to the Java<sup>1</sup> virtual machine (VM).

You can use Policy tool to create the policy file you need, or you can create it with an ASCII editor. Here is the policy file with the permission indicated by the stack trace:

```
grant {
    permission java.lang.RuntimePermission
        "accessClassInPackage.sun.jdbc.odbc";
};
```

Run the applet again, this time with a policy file named `DbasOdbPol` that has the above permission in it:

```
appletviewer -J-Djava.security.policy=DbasOdbPol
                                                    DbasOdb.html
```

You get a stack trace again, but this time it is a different error condition.

```
java.security.AccessControlException:
access denied (java.lang.RuntimePermission
file.encoding read)
```

The stack trace means the applet needs read permission to the encoded

(binary) file. Here is the `DbasOdbPol` policy file with the permission indicated by the stack trace added to it:

```
grant {
    permission java.lang.RuntimePermission
        "accessClassInPackage.sun.jdbc.odbc";
    permission java.util.PropertyPermission
        "file.encoding", "read";
};
```

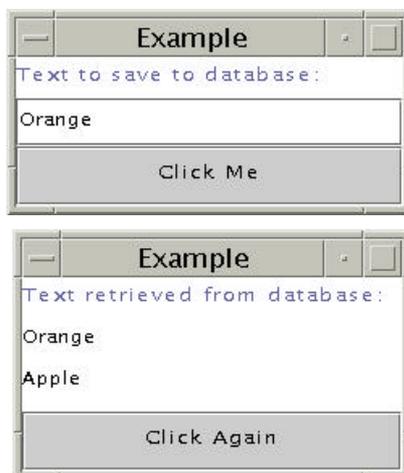
Run the applet again. If you use the above policy file with the Runtime and Property permissions indicated, it works just fine.

```
appletviewer -J-Djava.security.policy=DbasOdbPol
                DbasOdb.html
```

## Database Access by Servlets

As you learned in Lesson 6, servlets are under the security policy in force for the web server under which they run. When the database read and write code is added to the `FileIOServlet` from Lesson 6, the [DbasServlet.java](#) servlet for this lesson executes without restriction under Java WebServer™ 1.1.1.

The web server has to be configured to locate the database. Consult your web server documentation or database administrator for help. With Java WebServer 1.1.1, the configuration setup involves editing the startup scripts with such things as environment settings for loading the ODBC driver, and locating and connecting to the database.



```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

import java.sql.*;
import java.net.*;
import java.io.*;

public class DbasServlet extends HttpServlet {

    private Connection c;
```

```

final static private String _driver =
    "sun.jdbc.odbc.JdbcOdbcDriver";
final static private String _user = "username";
final static private String _pass = "password";
final static private String
    _url = "jdbc:odbc:jdc";

public void doPost(HttpServletRequest request,
    HttpServletResponse response)
    throws ServletException, IOException{
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    out.println("<title>Example<title>" +
        "<body bgcolor=FFFFFF>");

    out.println("<h2>Button Clicked</h2>");

    String DATA = request.getParameter("DATA");

    if(DATA != null){
        out.println("<STRONG>Text from
            form:</STRONG>");
        out.println(DATA);
    } else {
        out.println("No text entered.");
    }

    //Establish database connection
    try{
        Class.forName (_driver);
        c = DriverManager.getConnection(_url,
            _user,
            _pass);

    } catch (Exception e) {
        e.printStackTrace();
        System.exit(1);
    }

    try{
    //Code to write to database
        Statement stmt = c.createStatement();
        String updateString = "INSERT INTO dba " +
            "VALUES ('" + DATA + "')";
        int count = stmt.executeUpdate(updateString);

    //Code to read from database
        ResultSet results = stmt.executeQuery(
            "SELECT TEXT FROM dba ");
        while(results.next()){
            String s = results.getString("TEXT");
            out.println("<BR>
                <STRONG>Text from database:</STRONG>");
            out.println(s);
        }
        stmt.close();
    }catch(java.sql.SQLException e){
        System.out.println(e.toString());
    }

    out.println("<P>Return to
        <A HREF=\"../dbaHTML.html\">Form</A>");

```

```
        out.close();  
    }  
}
```

## More Information

You can find more information on variable access settings in the [Objects and Classes](#) trail in [The Java Tutorial](#)

<sup>1</sup> As used on this web site, the terms "Java virtual machine" or "JVM" mean a virtual machine for the Java platform.

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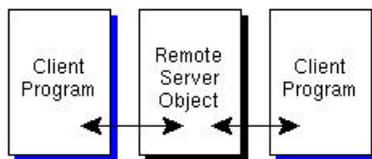
# Java™ Programming Language Basics, Part 1

## Lesson 8: Remote Method Invocation

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The Java™ Remote Method Invocation (RMI) application programming interface (API) enables client and server communications over the net. Typically, client programs send requests to a server program, and the server program responds to those requests.

A common example is sharing a word processing program over a network. The word processor is installed on a server, and anyone who wants to use it starts it from his or her machine by double clicking an icon on the desktop or typing at the command line. The invocation sends a request to a server program for access to the software, and the server program responds by making the software available to the requestor.



The RMI API lets you create a publicly accessible remote server object that enables client and server communications through simple method calls on the server object. Clients can easily communicate directly with the server object and indirectly with each other through the server object using Uniform Resource Locators (URLs) and HyperText Transfer Protocol (HTTP).

This lesson explains how to use the RMI API to establish client and server communications.

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  - [File Summary](#)
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  - [Run the RemoteServer Server Object](#)
  - [Run the RMIClient1 Program](#)
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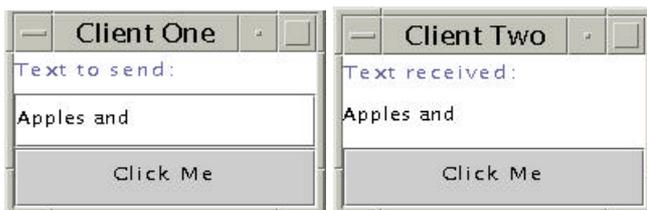
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### About the Example

This lesson converts the [File Input and Output](#) application from [Lesson 6: File Access and Permissions](#) to the RMI API.

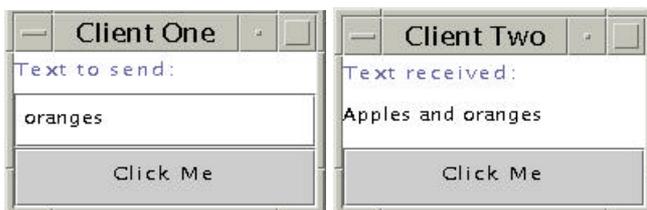
### Program Behavior

The [RMIClient1](#) program presents a simple user interface and prompts for text input. When you click the `Click Me` button, the text is sent to the [RMIClient2](#) program by way of the remote server object. When you click the `Click Me` button on the [RMIClient2](#) program, the text sent from [RMIClient1](#) appears.



#### First Instance of Client 1

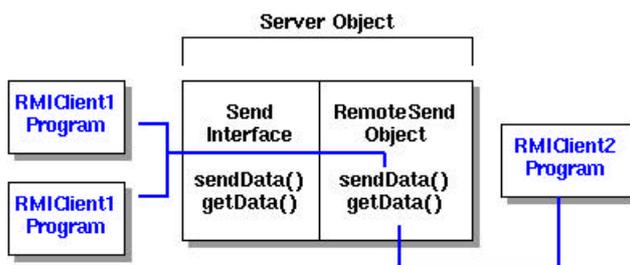
If you start a second instance of [RMIClient1](#) and type in some text, that text is sent to [RMIClient2](#) when you click the `Click Me` button. To see the text received by [RMIClient2](#), click its `Click Me` button.



#### Second Instance of Client 1

### File Summary

The example program consists of the [RMIClient1](#) program, remote object and interface, and the [RMIClient2](#) program as illustrated in the diagram. The corresponding source code files for these executables are described in the bullet list below.



- [RMIClient1.java](#): Client program that calls the `sendData` method on the `RemoteServer` server object.
- [RMIClient2.java](#): Client program that calls the `getData` method on

the `RemoteServer` server object.

- [RemoteServer.java](#): Remote server object that implements `Send.java` and the `sendData` and `getData` remote methods.
- [Send.java](#): Remote interface that declares the `sendData` and `getData` remote server methods.

In addition, the following [java.policy](#) security policy file grants the permissions needed to run the example.

```
grant {
    permission java.net.SocketPermission
        "*:1024-65535",
        "connect,accept,resolve";
    permission java.net.SocketPermission
        "*:80", "connect";
    permission java.awt.AWTPermission
        "accessEventQueue";
    permission java.awt.AWTPermission
        "showWindowWithoutWarningBanner";
};
```

### Compile the Example

These instructions assume development is in the `zelda` home directory. The server program is compiled in the home directory for user `zelda`, but copied to the `public_html` directory for user `zelda` where it runs.

Here is the command sequence for the Unix and Win32 platforms; an explanation follows.

#### Unix:

```
cd /home/zelda/classes
javac Send.java
javac RemoteServer.java
javac RMIClient2.java
javac RMIClient1.java
rmic -d . RemoteServer
cp RemoteServer*.class /home/zelda/public_html/classes
cp Send.class /home/zelda/public_html/classes
```

#### Win32:

```
cd \home\zelda\classes
javac Send.java
javac RemoteServer.java
javac RMIClient2.java
javac RMIClient1.java
rmic -d . RemoteServer
copy RemoteServer*.class \home\zelda\public_html\classes
copy Send.class \home\zelda\public_html\classes
```

The first two `javac` commands compile the `RemoteServer` and `Send` class and interface. The third `javac` command compiles the `RMIClient2` class. The last `javac` command compiles the `RMIClient1` class.

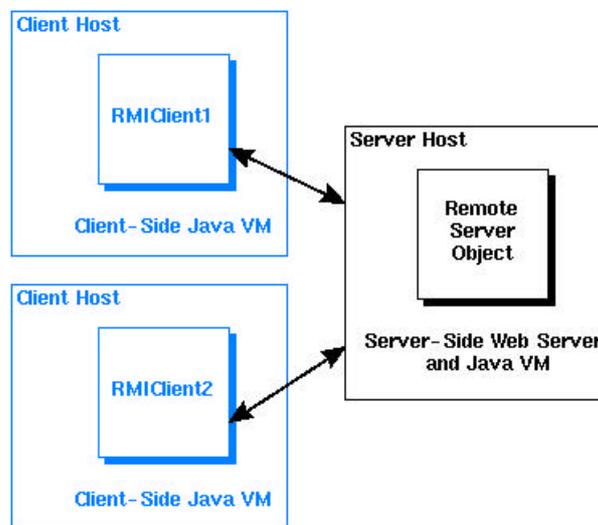
The next line runs the `rmic` command on the `RemoteServer` server

class. This command produces output class files of the form `ClassName_Stub.class` and `ClassName_Skel.class`. These output classes let clients invoke methods on the `RemoteServer` server object.

The first copy command moves the `RemoteServer` class file with its associated `skel` and `stub` class files to a publicly accessible location in the `/home/zelda/public_html/classes` directory, which is on the server machine, so they can be publicly accessed and downloaded. They are placed in the `public_html` directory to be under the web server running on the server machine because these files are accessed by client programs using URLs.

The second copy command moves the `Send` class file to the same location for the same reason. The `RMIClient1` and `RMIClient2` class files are not made publicly accessible; they communicate from their client machines using URLs to access and download the remote object files in the `public_html` directory.

- `RMIClient1` is invoked from a client-side directory and uses the server-side web server and client-side Java VM to download the publicly accessible files.
- `RMIClient2` is invoked from a client-side directory and uses the server-side web server and client-side Java VM to download the publicly accessible files.



## Start the RMI Registry

Before you start the client programs, you must start the RMI Registry, which is a server-side naming repository that allows remote clients to get a reference to the remote server object.

Before you start the RMI Registry, make sure the shell or window in which you run the `rmiregistry` command does not have a `CLASSPATH` environment variable that points to the remote object classes, including the `stub` and `skel` classes, anywhere on your system. If the RMI Registry finds these classes when it starts, it will not load them from the server-side

Java VM, which will create problems when clients try to download the remote server classes.

The following commands unset the `CLASSPATH` and start the RMI Registry on the default 1099 port. You can specify a different port by adding the port number as follows: `rmiregistry 4444 &`. If you specify a different port number, you must specify the same port number in your [server-side](#) code as well.

**Unix:**

```
cd /home/zelda/public_html/classes
unsetenv CLASSPATH
rmiregistry &
```

**Win32:**

```
cd \home\zelda\public_html\classes
set CLASSPATH=
start rmiregistry
```

---

**Note:** You might want to set the `CLASSPATH` back to its original setting at this point.

---

## Run the RemoteServer Server Object

To run the example programs, start `RemoteServer` first. If you start either `RMIClient1` or `RMIClient2` first, they will not be able to establish a connection because the remote server object is not running.

In this example, `RemoteServer` is started from the `/home/zelda/public_html/classes` directory.

The lines beginning at `java` should be all on one line with spaces where the lines break. The properties specified with the `-D` option to the `java` interpreter command are program attributes that manage the behavior of the program for this invocation.

**Unix:**

```
cd /home/zelda/public_html/classes
java
-Djava.rmi.server.codebase=http://kq6py/~zelda/classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RemoteServer
```

**Win32:**

```
cd \home\zelda\public_html\classes
java -Djava.rmi.server.codebase=file:
      c:\home\zelda\public_html\classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RemoteServer
```

- The `java.rmi.server.codebase` property specifies where the publicly accessible classes are located.
- The `java.rmi.server.hostname` property is the complete host

name of the server where the publicly accessible classes reside.

- The `java.rmi.security.policy` property specifies the [policy file](#) with the permissions needed to run the remote server object and access the remote server classes for download.
- The class to execute (`RemoteServer`).

### Run the RMIclient1 Program

Here is the command sequence for the Unix and Win32 platforms; an explanation follows.

In this example, `RMIclient1` is started from the `/home/zelda/classes` directory.

The lines beginning at `java` should be all on one line with spaces where the lines break. Properties specified with the `-D` option to the `java` interpreter command are program attributes that manage the behavior of the program for this invocation.

#### Unix:

```
cd /home/zelda/classes

java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes/
-Djava.security.policy=java.policy
      RMIclient1 kq6py.eng.sun.com
```

#### Win32:

```
cd \home\zelda\classes

java -Djava.rmi.server.codebase=
      file:c:\home\zelda\classes\
-Djava.security.policy=java.policy
      RMIclient1 kq6py.eng.sun.com
```

- The `java.rmi.server.codebase` property specifies where the publicly accessible classes for downloading are located.
- The `java.security.policy` property specifies the [policy file](#) with the permissions needed to run the client program and access the remote server classes.
- The client program class to execute (`RMIclient1`), and the host name of the server (`kq6py`) where the remote server classes are.

### Run RMIclient2

Here is the command sequence for the Unix and Win32 platforms; an explanation follows.

In this example, `RMIclient2` is started from the `/home/zelda/classes` directory.

The lines beginning at `java` should be all on one line with spaces where the lines break. The properties specified with the `-D` option to the `java` interpreter command are program attributes that manage the behavior of the program for this invocation.

**Unix:**

```
cd /home/zelda/classes
java -Djava.rmi.server.codebase=
        http://kq6py/~zelda/classes
-Djava.security.policy=java.policy
        RMIClient2 kq6py.eng.sun.com
```

**Win32:**

```
cd \home\zelda\classes
java -Djava.rmi.server.codebase=
        file:c:\home\zelda\public_html\classes
-Djava.security.policy=java.policy
        RMIClient2 kq6py.eng.sun.com
```

- The `java.rmi.server.codebase` property specifies where the publicly accessible classes are located.
- The `java.rmi.server.hostname` property is the complete host name of the server where the publicly accessible classes reside.
- The `java.rmi.security.policy` property specifies the [policy file](#) with the permissions needed to run the remote server object and access the remote server classes for download.
- The class to execute (`RMIClient2`).

## RemoteServer Class

The [RemoteServer](#) class extends `UnicastRemoteObject` and implements the `sendData` and `getData` methods declared in the `Send` interface. These are the remotely accessible methods.

`UnicastRemoteObject` implements a number of `java.lang.Object` methods for remote objects and includes constructors and static methods to make a remote object available to receive method calls from client programs.

```
class RemoteServer extends UnicastRemoteObject
    implements Send {

    String text;

    public RemoteServer() throws RemoteException {
        super();
    }

    public void sendData(String gotText){
        text = gotText;
    }

    public String getData(){
```

```
        return text;
    }
```

The `main` method installs the `RMISecurityManager` and opens a connection with a port on the machine where the server program runs. The security manager determines whether there is a policy file that lets downloaded code perform tasks that require permissions. The `main` method creates a name for the the `RemoteServer` object that includes the server name (`kq6py`) where the RMI Registry and remote object run, and the name, `Send`.

By default the server name uses port 1099. If you want to use a different port number, you can add it with a colon as follows: `kq6py:4444`. If you change the port here, you must start the [RMI Registry](#) with the same port number.

The `try` block creates an instance of the `RemoteServer` class and binds the name to the remote object to the RMI Registry with the `Naming.rebind(name, remoteServer);` statement.

```
public static void main(String[] args){
    if(System.getSecurityManager() == null) {
        System.setSecurityManager(new
            RMISecurityManager());
    }
    String name = "//kq6py.eng.sun.com/Send";
    try {
        Send remoteServer = new RemoteServer();
        Naming.rebind(name, remoteServer);
        System.out.println("RemoteServer bound");
    } catch (java.rmi.RemoteException e) {
        System.out.println("Cannot create
            remote server object");
    } catch (java.net.MalformedURLException e) {
        System.out.println("Cannot look up
            server object");
    }
}
}
```

---

**Note:** The `remoteServer` object is type `Send` (see instance declaration at top of class) because the interface available to clients is the `Send` interface and its methods; not the `RemoteServer` class and its methods.

---

## Send Interface

The [Send](#) interface declares the methods implemented in the `RemoteServer` class. These are the remotely accessible methods.

```
public interface Send extends Remote {

    public void sendData(String text)
        throws RemoteException;
}
```

```
    public String getData() throws RemoteException;
}
```

## RMIClient1 Class

The [RMIClient1](#) class establishes a connection to the remote server program and sends data to the remote server object. The code to do these things is in the `actionPerformed` and `main` methods.

### actionPerformed Method

The `actionPerformed` method calls the `RemoteServer.sendData` method to send text to the remote server object.

```
public void actionPerformed(ActionEvent event){
    Object source = event.getSource();

    if(source == button){
//Send data over socket
        String text = textField.getText();
        try{
            send.sendData(text);
        } catch (java.rmi.RemoteException e) {
            System.out.println("Cannot send data to server");
        }
        textField.setText(new String(""));
    }
}
```

### main Method

The `main` method installs the `RMISecurityManager` and creates a name to use to look up the `RemoteServer` server object. The client uses the `Naming.lookup` method to look up the `RemoteServer` object in the RMI Registry running on the server.

The security manager determines whether there is a policy file that lets downloaded code perform tasks that require permissions.

```
RMIClient1 frame = new RMIClient1();

if(System.getSecurityManager() == null) {
    System.setSecurityManager(new RMISecurityManager());
}

try {
//args[0] contains name of server where Send runs
    String name = "//" + args[0] + "/Send";
    send = ((Send) Naming.lookup(name));
} catch (java.rmi.NotBoundException e) {
    System.out.println("Cannot look up
        remote server object");
} catch (java.rmi.RemoteException e){
    System.out.println("Cannot look up
        remote server object");
} catch (java.net.MalformedURLException e) {
    System.out.println("Cannot look up
```

```
        remote server object");  
    }
```

## RMIClient2 Class

The [RMIClient2](#) class establishes a connection with the remote server program and gets the data from the remote server object and displays it. The code to do this is in the `actionPerformed` and `main` methods.

### actionPerformed Method

The `actionPerformed` method calls the `RemoteServer.getData` method to retrieve the data sent by the client program. This data is appended to the `TextArea` object for display to the end user on the server side.

```
public void actionPerformed(ActionEvent event) {  
    Object source = event.getSource();  
  
    if(source == button){  
        try{  
            String text = send.getData();  
            textArea.append(text);  
        } catch (java.rmi.RemoteException e) {  
            System.out.println("Cannot send data  
                to server");  
        }  
    }  
}
```

### main Method

The `main` method installs the `RMI SecurityManager` and creates a name to use to look up the `RemoteServer` server object. The `args[0]` parameter provides the name of the server host. The client uses the `Naming.lookup` method to look up the `RemoteServer` object in the RMI Registry running on the server.

The security manager determines whether there is a policy file that lets downloaded code perform tasks that require permissions.

```
RMIClient2 frame = new RMIClient2();  
  
if(System.getSecurityManager() == null) {  
    System.setSecurityManager(new RMI SecurityManager());  
}  
  
try {  
    String name = "//" + args[0] + "/Send";  
    send = ((Send) Naming.lookup(name));  
} catch (java.rmi.NotBoundException e) {  
    System.out.println("Cannot look up remote  
        server object");  
} catch (java.rmi.RemoteException e){  
    System.out.println("Cannot look up remote  
        server object");  
}
```

```
    } catch(java.net.MalformedURLException e) {  
        System.out.println("Cannot look up remote  
            server object");  
    }  
}
```

## More Information

You can find more information on the RMI API in the [RMI](#) trail of [The Java Tutorial](#).

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# Essentials of the Java™ Programming Language: A Hands-On Guide, Part 2

by *Monica Pawla*

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This series of lessons builds on the material presented in [Java™ Programming Language Basics, Part 1](#), which introduced applications, applets, and servlets; simple file and database access operations; and remote method invocation (RMI).

The lessons and code examples for Part 2 are somewhat more complex. They walk you through network communications, building a user interface using more components, data encryption and decryption (pseudo code only grouping multiple data elements into one object (collections), and internationalizing a program. Part 2 concludes with some object-oriented programming concepts.

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## Java™ Programming Language Basics, Part 2

### Lesson 1: Socket Communications

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[Java™ Programming Language Basics, Part 1](#), finished with a simple network communications example using the Remote Method Invocation (RMI) application programming interface (API). The RMI example allows multiple client programs to communicate with the same server program without any explicit code to do this because the RMI API is built on sockets and threads.

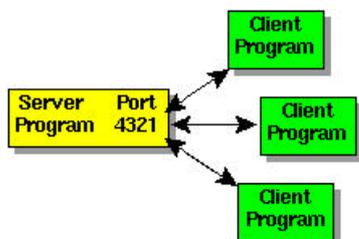
This lesson presents a simple sockets-based program to introduce the concepts of sockets and multi-threaded programming. A multi-threaded program performs multiple tasks at one time such as fielding simultaneous requests from many client programs.

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## What are Sockets and Threads?

A socket is a software endpoint that establishes bidirectional communication between a server program and one or more client programs. The socket associates the server program with a specific hardware port on the machine where it runs so any client program anywhere in the network with a socket associated with that same port can communicate with the server program.



A server program typically provides resources to a network of client programs. Client programs send requests to the server program, and the server program responds to the request.

One way to handle requests from more than one client is to make the server program multi-threaded. A multi-threaded server creates a thread for each communication it accepts from a client. A thread is a sequence of instructions that run independently of the program and of any other threads.

Using threads, a multi-threaded server program can accept a connection

from a client, start a thread for that communication, and continue listening for requests from other clients.

## About the Examples

The examples for this lesson consist of two versions of the client and server program pair adapted from the [FileIO.java](#) application presented in [Part 1, Lesson 6: File Access and Permissions](#).

Example 1 sets up a client and server communication between one server program and one client program. The server program is not multi-threaded and cannot handle requests from more than one client.

Example 2 converts the server program to a multi-threaded version so it can handle requests from more than one client.

### Example 1: Client-Side Behavior

The [client program](#) presents a simple user interface and prompts for text input. When you click the `Click Me` button, the text is sent to the server program. The client program expects an echo from the server and prints the echo it receives on its standard output.



### Example 1: Server-Side Behavior

The [server program](#) presents a simple user interface, and when you click the `Click Me` button, the text received from the client is displayed. The server echoes the text it receives whether or not you click the `Click Me` button.



### Example 1: Compile and Run

To run the example programs, start the server program first. If you do not, the client program cannot establish the socket connection. Here are the compiler and interpreter commands to compile and run the example.

```
javac SocketServer.java
javac SocketClient.java

java SocketServer
```

```
java SocketClient
```

## Example 1: Server-Side Program

The [server program](#) establishes a socket connection on Port 4321 in its `listenSocket` method. It reads data sent to it and sends that same data back to the server in its `actionPerformed` method.

### listenSocket Method

The `listenSocket` method creates a `ServerSocket` object with the port number on which the server program is going to listen for client communications. The port number must be an available port, which means the number cannot be reserved or already in use. For example, Unix systems reserve ports 1 through 1023 for administrative functions leaving port numbers greater than 1024 available for use.

```
public void listenSocket(){
    try{
        server = new ServerSocket(4321);
    } catch (IOException e) {
        System.out.println("Could not listen on port 4321");
        System.exit(-1);
    }
}
```

Next, the `listenSocket` method creates a `Socket` connection for the requesting client. This code executes when a client starts up and requests the connection on the host and port where this server program is running. When the connection is successfully established, the `server.accept` method returns a new `Socket` object.

```
    try{
        client = server.accept();
    } catch (IOException e) {
        System.out.println("Accept failed: 4321");
        System.exit(-1);
    }
}
```

Then, the `listenSocket` method creates a `BufferedReader` object to read the data sent over the socket connection from the `client` program. It also creates a `PrintWriter` object to send the data received from the client back to the server.

```
    try{
        in = new BufferedReader(new InputStreamReader(
                                client.getInputStream()));
        out = new PrintWriter(client.getOutputStream(),
                              true);
    } catch (IOException e) {
        System.out.println("Read failed");
        System.exit(-1);
    }
}
```

Lastly, the `listenSocket` method loops on the input stream to read data as it comes in from the client and writes to the output stream to send the

data back.

```
while(true){
    try{
        line = in.readLine();
//Send data back to client
        out.println(line);
    } catch (IOException e) {
        System.out.println("Read failed");
        System.exit(-1);
    }
}
```

### actionPerformed Method

The `actionPerformed` method is called by the Java platform for action events such as button clicks. This `actionPerformed` method uses the text stored in the `line` object to initialize the `textArea` object so the retrieved text can be displayed to the end user.

```
public void actionPerformed(ActionEvent event) {
    Object source = event.getSource();

    if(source == button){
        textArea.setText(line);
    }
}
```

### Example 1: Client-Side Program

The [client program](#) establishes a connection to the server program on a particular host and port number in its `listenSocket` method, and sends the data entered by the end user to the server program in its `actionPerformed` method. The `actionPerformed` method also receives the data back from the server and prints it to the command line.

### listenSocket Method

The `listenSocket` method first creates a `Socket` object with the computer name (`kq6py`) and port number (4321) where the server program is listening for client connection requests. Next, it creates a `PrintWriter` object to send data over the socket connection to the server program. It also creates a `BufferedReader` object to read the text sent by the server back to the client.

```
public void listenSocket(){
//Create socket connection
    try{
        socket = new Socket("kq6py", 4321);
        out = new PrintWriter(socket.getOutputStream(),
            true);
        in = new BufferedReader(new InputStreamReader(
            socket.getInputStream()));
    } catch (UnknownHostException e) {
        System.out.println("Unknown host: kq6py");
        System.exit(1);
    } catch (IOException e) {
```

```
        System.out.println("No I/O");
        System.exit(1);
    }
}
```

### actionPerformed Method

The `actionPerformed` method is called by the Java platform for action events such as button clicks. This `actionPerformed` method code gets the text in the `Textfield` object and passes it to the `PrintWriter` object, which then sends it over the socket connection to the server program.

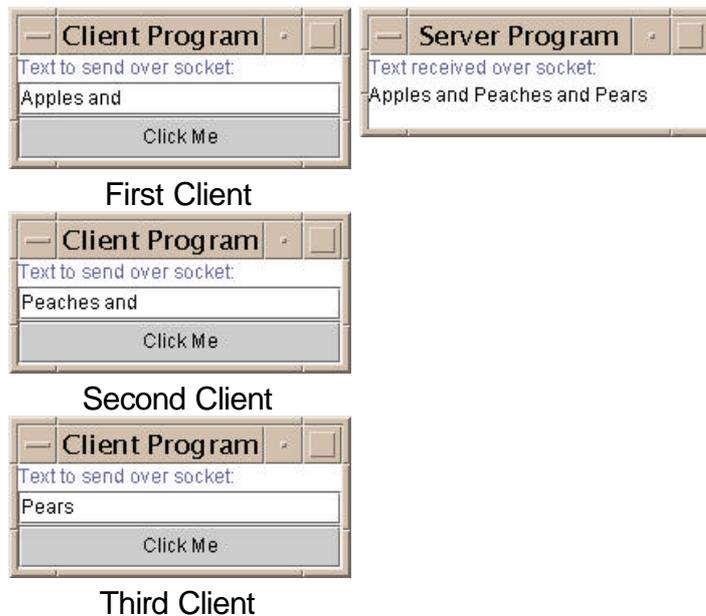
The `actionPerformed` method then makes the `Textfield` object blank so it is ready for more end user input. Lastly, it receives the text sent back to it by the server and prints the text out.

```
public void actionPerformed(ActionEvent event){
    Object source = event.getSource();

    if(source == button){
//Send data over socket
        String text = textField.getText();
        out.println(text);
        textField.setText(new String(""));
        out.println(text);
    }
//Receive text from server
    try{
        String line = in.readLine();
        System.out.println("Text received: " + line);
    } catch (IOException e){
        System.out.println("Read failed");
        System.exit(1);
    }
}
```

### Example 2: Multithreaded Server Example

The example in its current state works between the server program and one client program only. To allow multiple client connections, the server program has to be converted to a [multithreaded server](#) program.



The multithreaded server program creates a new thread for every client request. This way each client has its own connection to the server for passing data back and forth. When running multiple threads, you have to be sure that one thread cannot interfere with the data in another thread.

In this example the `listenSocket` method loops on the `server.accept` call waiting for client connections and creates an instance of the `ClientWorker` class for each client connection it accepts. The `textArea` component that displays the text received from the client connection is passed to the `ClientWorker` instance with the accepted client connection.

```
public void listenSocket(){
    try{
        server = new ServerSocket(4444);
    } catch (IOException e) {
        System.out.println("Could not listen on port 4444");
        System.exit(-1);
    }
    while(true){
        ClientWorker w;
        try{
            //server.accept returns a client connection
            w = new ClientWorker(server.accept(), textArea);
            Thread t = new Thread(w);
            t.start();
        } catch (IOException e) {
            System.out.println("Accept failed: 4444");
            System.exit(-1);
        }
    }
}
```

The important changes in this version of the server program over the non-threaded server program are the `line` and `client` variables are no longer instance variables of the server class, but are handled inside the `ClientWorker` class.

The `ClientWorker` class implements the `Runnable` interface, which has one method, `run`. The `run` method executes independently in each thread. If three clients request connections, three `ClientWorker` instances are created, a thread is started for each `ClientWorker` instance, and the `run` method executes for each thread.

In this example, the `run` method creates the input buffer and output writer, loops on the input stream waiting for input from the client, sends the data it receives back to the client, and sets the text in the text area.

```
class ClientWorker implements Runnable {
    private Socket client;
    private JTextArea textArea;

    //Constructor
    ClientWorker(Socket client, JTextArea textArea) {
        this.client = client;
        this.textArea = textArea;
    }

    public void run(){
        String line;
        BufferedReader in = null;
        PrintWriter out = null;
        try{
            in = new BufferedReader(new
                InputStreamReader(client.getInputStream()));
            out = new
                PrintWriter(client.getOutputStream(), true);
        } catch (IOException e) {
            System.out.println("in or out failed");
            System.exit(-1);
        }

        while(true){
            try{
                line = in.readLine();
                //Send data back to client
                out.println(line);
                //Append data to text area
                textArea.append(line);
            }catch (IOException e) {
                System.out.println("Read failed");
                System.exit(-1);
            }
        }
    }
}
```

The `JTextArea.append` method is thread safe, which means its implementation includes code that allows one thread to finish its append operation before another thread can start an append operation. This prevents one thread from overwriting all or part of a string of appended text and corrupting the output. If the `JTextArea.append` method were not thread safe, you would need to wrap the call to `textArea.append(line)` in a synchronized method and replace the `run` method call to `textArea.append(line)` with a call to `appendText(line)`:

```
public synchronized void appendText(line){
    textArea.append(line);
}
```

The `synchronized` keyword means this thread has a lock on the `textArea` and no other thread can change the `textArea` until this thread finishes its append operation.

The `finalize()` method is called by the Java virtual machine (JVM)\* before the program exits to give the program a chance to clean up and release resources. Multi-threaded programs should close all `Files` and `Sockets` they use before exiting so they do not face resource starvation. The call to `server.close()` in the `finalize()` method closes the `Socket` connection used by each thread in this program.

```
protected void finalize(){
//Objects created in run method are finalized when
//program terminates and thread exits
    try{
        server.close();
    } catch (IOException e) {
        System.out.println("Could not close socket");
        System.exit(-1);
    }
}
```

## More Information

You can find more information on sockets in the [All About Sockets](#) section in [The Java Tutorial](#).

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## Java™ Programming Language Basics, Part 2

### Lesson 2: User Interfaces Revisited

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In [Java™ Programming Language Basics, Part 1](#), you learned how to use Java Foundation Classes (JFC) Project Swing (Project Swing) components to build a simple user interface with very basic backend functionality. You also learned how to use the Remote Method Invocation (RMI) application programming interface (API) to send data from a client program to a server program on the net where the data can be accessed by other client programs.

This lesson takes the RMI application from [Part 1, Lesson 8: Remote Method Invocation](#), creates a more involved user interface, and uses a different layout manager. These changes give you the beginnings of a very simple electronic-commerce application that consists of two types of client programs: one lets end users place purchase orders and the other lets order processors view the orders.

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## About the Example

This is a very simple electronic commerce example for instructional purposes only. It consists of three programs: two client programs, one for ordering fruit and another for viewing the order, and one server program that makes order information available to clients that view the orders.

### Fruit Order Client

The [FruitClient](#) program presents a user interface and prompts the end user to order apples, peaches, and pears at \$1.25 each.

After the end user enters the number of each item to order, he or she presses the Return key to commit the order and update the running total.

The Tab key or mouse moves the cursor to the next field. At the bottom, the end user provides a credit card number and customer ID.

When the end user clicks `Purchase`, all values entered into the form are sent to the server program.

The end user must press the Return key for the total to update. If the Return key is not pressed, an incorrect total is sent across the net with the order. The end of this lesson asks you to change the code so there is no danger incorrect totals are sent across the net because the end user did not press the Return key.

## Server Program

The [RemoteServer](#) program provides remotely accessible `send` and `get` methods. Fruit order clients call `send` methods to send data to the server, and view order clients call the `get` methods to retrieve the data. In this example, the server program has no user interface.

## View Order Client

The [OrderClient](#) program presents a user interface, and when the end user clicks `View Order`, the program gets the order data from the server program and puts it on the screen.

## Compile and Run the Example

See [Part 1, Lesson 8: Remote Method Invocation](#), for information on how to run the example. Use the Part 1, Lesson 8 instructions, but use the source code provided in this lesson. Here is a summarized version of those steps:

**Compile:** These instructions assume development is in the `zelda` home directory.

**Unix:**

```
cd /home/zelda/classes
javac Send.java
javac RemoteServer.java
javac RMIClient2.java
javac RMIClient1.java
rmic -d . RemoteServer
cp RemoteServer*.class /home/zelda/public_html/classes
cp Send.class /home/zelda/public_html/classes
```

**Win32:**

```
cd \home\zelda\classes
javac Send.java
javac RemoteServer.java
javac RMIClient2.java
javac RMIClient1.java
rmic -d . RemoteServer
copy RemoteServer*.class \home\zelda\public_html\classes
copy Send.class \home\zelda\public_html\classes
```

**Start rmi Registry:**

**Unix:**

```
cd /home/zelda/public_html/classes
unsetenv CLASSPATH
rmiregistry &
```

**Win32:**

```
cd \home\zelda\public_html\classes
set CLASSPATH=
start rmiregistry
```

**Start Remote Server:**

**Unix:**

```
cd /home/zelda/public_html/classes
java
-Djava.rmi.server.codebase=http://kq6py/~zelda/classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RemoteServer
```

**Win32:**

```
cd \home\zelda\public_html\classes
java -Djava.rmi.server.codebase=
    file:c:\home\zelda\public_html\classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RemoteServer
```

**Start RMIClient1:**

**Unix:**

```
cd /home/zelda/classes

java -Djava.rmi.server.codebase=
    http://kq6py/~zelda/classes/
-Djava.security.policy=java.policy RMIClient1
```

```
kq6py.eng.sun.com/~zelda
```

**Win32:**

```
cd \home\zeldzeldaa\classes
```

```
java -Djava.rmi.server.codebase=
      file:c:\home\zelda\classes\
-Djava.security.policy=java.policy RMIClient1
kq6py.eng.sun.com\home\zelda\public\html
```

**Start RMIClient2:****Unix:**

```
cd /home/zelda/classes
java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RMIClient2
kq6py.eng.sun.com
```

**Win32:**

```
cd \home\zelda\classes
java -Djava.rmi.server.codebase=
      file:c:\home\zelda\public_html\classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RMIClient2
kq6py.eng.sun.com
```

**Fruit Order Client Code**

The [RMIClient1.java](#) code uses label, text field, text area, and button components to create the user interface for ordering fruit.

Select Items	Specify Quantity
Apples	2
Peaches	1
Pears	4
Total Items:	7
Total Cost:	8.75
Credit Card:	1234-4321-1234-3
Customer ID:	munchkin

Reset Purchase

On the display, user interface components are arranged in a 2-column grid with labels in the left column, and the input and output data fields (text fields and text areas) aligned in the right column.

The end user enters his or her apples, peaches, and pears order into the text fields and presses the Return key after each fruit entry. When the Return key is pressed, the text field behavior updates the item and cost totals displayed in the text areas.

The `Reset` button behavior clears the display, and the underlying total cost and items variables. The `Purchase` button behavior sends the order data to the server program. If the `Reset` button is clicked before the `Purchase` button, null values are sent over the network.

**Instance Variables**

These next lines declare the Project Swing component classes the `SwingUI` class uses. These are instance variables that can be accessed

by any method in the instantiated class. In this example, they are built in the `SwingUI` constructor and accessed in the `actionPerformed` method implementation.

```
JLabel col1, col2;
JLabel totalItems, totalCost;
JLabel cardNum, custID;
JLabel applechk, pearchk, peachchk;

JButton purchase, reset;
JPanel panel;

JTextField appleqnt, pearqnt, peachqnt;
JTextField creditCard, customer;
JTextArea items, cost;

static Send send;
int itotal=0;
double icost=0;
```

## Constructor

The constructor is fairly long because it creates all the components, sets the layout to a 2-column grid, and places the components in the grid on a panel. A panel is a container component that holds other components.

The `Reset` and `Purchase` buttons and the `appleQnt`, `pearQnt`, and `peachQnt` text fields are added as action listeners. This means when the end user clicks one of the buttons or presses Return in one of the text fields, an action event occurs that causes the platform to call the `FruitClient.actionPerformed` method where the behaviors for these components are defined.

As explained in [Part1, Lesson 4: Building a User Interface](#), a class declares the `ActionListener` interface and implements the `actionPerformed` method if it needs to handle action events such as button clicks and text field Returns. Other user interface components generate some different action events, and as a result, require you to implement different interfaces and methods.

```
//Create left and right column labels
col1 = new JLabel("Select Items");
col2 = new JLabel("Specify Quantity");

//Create labels and text field components
applechk = new JLabel(" Apples");
appleqnt = new JTextField();
appleqnt.addActionListener(this);

pearchk = new JLabel(" Pears");
pearqnt = new JTextField();
pearqnt.addActionListener(this);

peachchk = new JLabel(" Peaches");
peachqnt = new JTextField();
peachqnt.addActionListener(this);
```

```
cardNum = new JLabel("    Credit Card:");
creditCard = new JTextField();

customer = new JTextField();
custID = new JLabel("    Customer ID:");

//Create labels and text area components
totalItems = new JLabel("Total Items:");
totalCost = new JLabel("Total Cost:");
items = new JTextArea();
cost = new JTextArea();

//Create buttons and make action listeners
purchase = new JButton("Purchase");
purchase.addActionListener(this);

reset = new JButton("Reset");
reset.addActionListener(this);
```

In the next lines, a `JPanel` component is created and added to the top-level frame, and the layout manager and background color for the panel are specified. The layout manager determines how user interface components are arranged on the panel.

The example in [Part 1, Lesson 4: Building a User Interface](#), used the `BorderLayout` layout manager. This example uses the `GridLayout` layout manager, which arranges components in a grid or the number of rows and columns you specify. The example uses a 2-column grid with an unlimited number of rows as indicated by the zero (unlimited rows) and two (two columns) in the statement `panel.setLayout(new GridLayout(0,2));`.

The layout manager and color are set on the panel, and the panel is added to the content pane with a call to the `getContentPane` method of the `JFrame` class. A content pane lets different types of components work together in Project Swing.

```
//Create a panel for the components
panel = new JPanel();

//Set panel layout to 2-column grid
//on a white background
panel.setLayout(new GridLayout(0,2));
panel.setBackground(Color.white);

//Add components to panel columns
//going left to right and top to bottom
getContentPane().add(panel);
panel.add(col1);
panel.add(col2);

panel.add(applechk);
panel.add(appleqnt);

panel.add(peachchk);
panel.add(peachqnt);

panel.add(pearchk);
```

```
panel.add(pearQnt);

panel.add(totalItems);
panel.add(items);

panel.add(totalCost);
panel.add(cost);

panel.add(cardNum);
panel.add(creditCard);

panel.add(custID);
panel.add(customer);

panel.add(reset);
panel.add(purchase);
```

## Event Handling

The `actionPerformed` method provides behavior for each of the following possible application events:

- The mouse is clicked on the `Purchase` or `Reset` button.
- The `Return` key is pressed inside the `appleQnt`, `peachQnt`, or `pearQnt` field.

Rather than show the entire `actionPerformed` method here, this section describes the `purchase` button and `pearQnt` text field behaviors only. The `Reset` button is similar to the `purchase` button, and the other text fields are similar to `pearQnt`.

**Purchase Button:** The `Purchase` button behavior involves retrieving data from the text fields and text areas, and sending that data to the server program. The server program is available to the `FruitClient` program through its `Send` interface, which declares the remote server methods for sending and getting data.

The `send` variable is an instance of the `Send` interface. This instance is created in the `FruitClient` program's main method. The `send` variable is declared `static` and `global` in the `FruitClient` program so the `static` main method can instantiate it, and to make it accessible to the `actionPerformed` method.

```
if(source == purchase){
    cardnum = creditCard.getText();
    custID = customer.getText();
    apples = appleQnt.getText();
    peaches = peachQnt.getText();
    pears = pearQnt.getText();
    try{
        send.sendCreditCard(cardnum);
        send.sendCustID(custID);
        send.sendAppleQnt(apples);
        send.sendPeachQnt(peaches);
        send.sendPearQnt(pears);
    }
```

```

        send.sendTotalCost(icost);
        send.sendTotalItems(itotal);
    } catch (Exception e) {
        System.out.println("Cannot send data to server");
    }
}

```

**pearQnt Text Field:** The `pearQnt` text field behavior involves retrieving the number of pears the end user wants to order, adding the number to the items total, using the number to calculate the cost, and adding the cost for pears to the total cost. Two interesting things in this code involve managing the cursor focus and converting strings to numbers for the calculations. Both topics are covered below.

```

if(source == pearqnt){
    number = pearqnt.getText();
    if(number.length() > 0){
        pearsNo = Integer.valueOf(number);
        itotal += pearsNo.intValue();
        pearqnt.setNextFocusableComponent(creditCard);
    } else {
        itotal += 0;
        pearqnt.setNextFocusableComponent(creditCard);
    }
}
}

```

## Cursor Focus

End users can use the Tab key to move the cursor from one component to another within the user interface. The default Tab key movement steps through all user interface components including the text areas.

Because the end user does not interact with the text areas, there is no reason for the cursor to go there. The example program includes a call in its constructor to `pearqnt.setNextFocusableComponent` to make the cursor move from the `pearqnt` text field to the `creditcard` text field bypassing the total cost and total items text areas when the Tab key is pressed.

```

applechk = new JLabel(" Apples");
appleqnt = new JTextField();
appleqnt.addActionListener(this);

pearchk = new JLabel(" Pears");
pearqnt = new JTextField();
pearqnt.addActionListener(this);

peachchk = new JLabel(" Peaches");
peachqnt = new JTextField();
peachqnt.addActionListener(this);

cardNum = new JLabel(" Credit Card:");
creditCard = new JTextField();
//Make cursor go to creditCard component
pearqnt.setNextFocusableComponent(creditCard);

customer = new JTextField();
custID = new JLabel(" Customer ID:");

```

## Converting Strings to Numbers and Back

To calculate the items ordered and their cost, the string values retrieved from the `appleQnt`, `peachQnt`, and `pearQnt` text fields have to be converted to their number equivalents.

The string value is returned in the `number` variable. To be sure the user actually entered a value, the string length is checked. If the length is not greater than zero, the end user pressed Return without entering a value. In this case, the `else` statement adds zero to the running total and the cursor focus is set for the `creditCard` text field. Adding zero is not really necessary, but does make the code more understandable for someone reading it.

If the length is greater than zero, an instance of the `java.lang.Integer` class is created from the string. Next, the `Integer.intValue()` method is called to produce the integer (`int`) equivalent of the string value so it can be added to the items total kept in the `itotal` integer variable.

```
if(number.length() > 0){
    pearsNo = Integer.valueOf(number);
    itotal += pearsNo.intValue();
} else {
    itotal += 0;
}
```

To display the running item and cost totals in their respective text areas, the totals have to be converted back to strings. The code at the end of the `actionPerformed` method shown below does this.

To display the total items, a `java.lang.Integer` object is created from the `itotal` integer variable. The `Integer.toString` method is called to produce the `String` equivalent of the integer (`int`). This string is passed to the call to `this.cost.setText(text2)` to update the Total Cost field in the display.

---

**Note:** The `cost` text area variable is referenced as `this.cost` because the `actionPerformed` method also has a `cost` variable of type `Double`. To reference the global text area and not the local `Double` by the same name, you have to reference it as `this.cost`.

---

```
num = new Integer(itotal);
text = num.toString();
this.items.setText(text);

icost = (itotal * 1.25);
cost = new Double(icost);
text2 = cost.toString();
this.cost.setText(text2);
```

Until now, all data types used in the examples have been classes. But, the `int` and `double` data types are not classes. They are primitive data types.

The `int` data type contains a single whole 32-bit integer value that can be positive or negative. You can use the standard arithmetic operators (+, -, \*, and /) to perform arithmetic operations on the integer.

The `Integer` class, not only contains a whole 32-bit integer value that can be positive or negative, but provides methods for working on the value. For example, the `Integer.intValue` method lets you convert an `Integer` to an `int` to perform arithmetic operations.

The `double` data type contains a 64-bit double-precision floating point value. The `Double` class not only contains a 64-bit double-precision floating point value, but provides methods for working on the value. for example, the `Double.doubleValue` method lets you convert a `Double` to a `double` to perform arithmetic operations.

## Server Program Code

The server program consists of the [RemoteServer.java](#) class that implements the methods declared in the [Send.java](#) interface. These classes are described in [Part 1, Lesson 8: Remote Method Invocation](#) with the only difference being in this lesson there are many more `sendXXX` and `getXXX` methods to declare and implement. Here is the list:

- `public void sendCreditCard(String creditcard){cardnum = creditcard;}`
- `public String getCreditCard(){return cardnum;}`
- `public void sendCustID(String cust){custID = cust;}`
- `public String getCustID(){return custID;}`
- `public void sendAppleQnt(String apps){apples = apps;}`
- `public String getAppleQnt(){return apples;}`
- `public void sendPeachQnt(String pchs){ peaches = pchs;}`
- `public String getPeachQnt(){return peaches;}`
- `public void sendPearQnt(String prs){pears = prs;}`
- `public String getPearQnt(){return pears;}`
- `public void sendTotalCost(double cst){cost = cst;}`
- `public double getTotalCost(){return cost; }`
- `public void sendTotalItems(int itm){items = itm;}`
- `public int getTotalItems(){return items;}`

The important thing to note is data of any type and size can be easily passed from one client through the server to another client using the RMI API. No special handling is needed for large amounts of data or special considerations for different data types, which can sometimes be issues when using socket communications.

## View Order Client Code

The [OrderClient.java](#) class uses text areas and buttons to display the order information.

Field	Value
Credit Card:	1234-4321-1234-31
Customer ID:	munchkin
Apples:	2
Peaches:	1
Pears:	4
Total Items:	7
Total Cost:	8.75

The code is very similar to the `FruitOrder.java` class so rather than repeat much of what you have read above, this section highlights two parts of the `actionPerformed` method behavior for viewing an order.

The first part retrieves the credit card number, and the number of apples, peaches, and pears ordered from the server and sets those values in the corresponding text areas.

The second part retrieves the cost and item totals, which are `double` and `integer`, respectively. It then converts the total cost to a `java.lang.Double` object, and the total items to a `java.lang.Integer` object, and calls the `toString` method on each to get the string equivalents. Finally, the strings can be used to set the values for the corresponding text areas.

```

if(source == view){
    try{
//Retrieve and display text
        text = send.getCreditCard();
        creditNo.setText(text);

        text = send.getCustID();
        customerNo.setText(text);

        text = send.getAppleQnt();
        applesNo.setText(text);

        text = send.getPeachQnt();
        peachesNo.setText(text);

        text = send.getPearQnt();
        pearsNo.setText(text);

//Convert Numbers to Strings
        cost = send.getTotalCost();
        price = new Double(cost);
        unit = price.toString();
        icost.setText(unit);

        items = send.getTotalItems();
        itms = new Integer(items);
        i = itms.toString();
        itotal.setText(i);

    } catch (Exception e) {
        System.out.println("Cannot send data to server");
    }
}

```

## Program Improvements

The example program as it is currently written has two major design flaws

in the fruit order client. The first one involves the need to press the Return key for calculations to happen, and the second involves handling the error condition if the end user enters a character that is not a number when ordering apples, peaches, and pears.

**Calculations and Pressing Return:** If the end user enters a value for apples, peaches, or pears and moves to the next field without pressing the Return key, no calculation is made. This means when the end user clicks the Purchase key, the order is sent, but the item and cost totals will be incorrect. So, in this particular application relying on the Return key action event is not good design.

Modify the `actionPerformed` method so this does not happen. Here is one possible [solution](#). Give it a try before taking a look.

**Non-Number Errors:** If the end user enters a non-number value for apples, peaches, or pears the program will present a stack trace indicating an illegal number format. A good program will catch and handle the error, rather than produce a stack trace.

**Hint:** You need to figure out which part of the code throws the error and enclose it in a `try` and `catch` block. `try` and `catch` blocks were first introduced in [Part 1, Lesson 6: File Access and Permissions](#). The error you need to catch is `java.lang.NumberFormatException`.

Give it a try before taking a look at the [solution](#).

## More Information

You can find more information on event listening in the [Writing Event Listeners](#) lesson in [The Java Tutorial](#).

The [Variables and Data Types](#) trail in [The Java Tutorial](#) provides more information on primitive data types.

See [The JFC Swing Tutorial: A Guide to Constructing GUIs](#) for more information on Project Swing.

**\*As used on this web site, the terms "Java virtual machine" or "JVM" mean a virtual machine for the Java platform.**

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## Java™ Programming Language Basics, Part 2

### Lesson 3: Cryptography

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Many people are protective of their credit card numbers, and for good reason. A stolen credit card number with other personal information can give a thief all he or she needs to create serious mayhem in someone's life. One way to keep credit card and other proprietary information secure when sending it over the net is to encrypt it.

Encryption is the process of applying a key to plain text that transforms that plain text into unintelligible (cipher) text. Only programs with the key to turn the cipher text back to original text can decrypt the protected information.

This lesson adapts the [Part 2, Lesson 2: User Interfaces Revisited](#) example to encrypt the credit card number before sending it over the net, and decrypt it on the other side.

---

**Note:** Because cryptography software is not exportable outside the United States and Canada, the example in this lesson is in pseudo code rather than source code.

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  - [Encrypting the Symmetric Key with the RSA Algorithm](#)
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---

### About the Example

To safely send the credit card number over the net, the example program gets the plain text credit card number entered by the end user and passes the credit card number to its `encrypt` method.

Fruit \$1.25 Each	
Select Items	Specify Quantity
Apples	<input type="text" value="2"/>
Peaches	<input type="text" value="1"/>
Pears	<input type="text" value="4"/>
Total Items:	7
Total Cost:	8.75
Credit Card:	<input type="text" value="1234-4321-1234-31"/>
Customer ID:	<input type="text" value="munchkin"/>
<input type="button" value="Reset"/> <input type="button" value="Purchase"/>	

The `encrypt` method creates a cipher and session key, and uses the session key with the cipher to encrypt the credit card number.

A session key is a secret key that is generated new each time the `Purchase` button is clicked. Changing the session key protects against an unauthorized program getting the key and decrypting hundreds and thousands of credit card numbers with it.

The credit card number is encrypted and decrypted with the same session key. This type of cryptography is called symmetric key

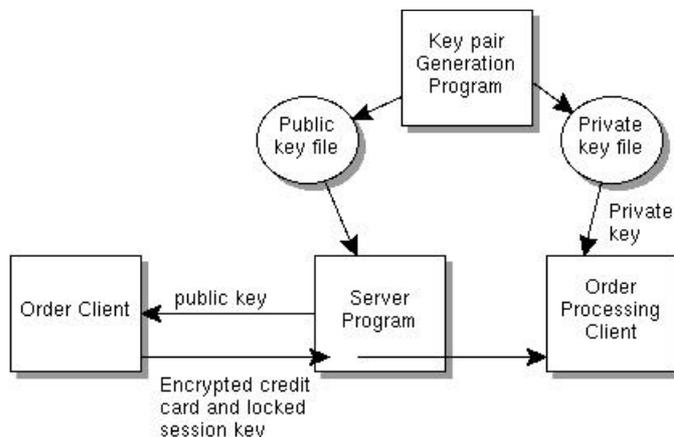
encryption, and in our example, requires the session key and encrypted credit card number be sent over the net to the receiving program. Because the session key is sent over the net, it too should be protected against unauthorized access.

To protect the session key, it is encrypted with or wrapped under the public key of the recipient. Even if an unauthorized program gets the wrapped session key and credit card number, he or she would have to recover the session key with the intended recipient's private key to be able to decrypt the credit card number with the session key.

Anything encrypted with a public key, can only be decrypted with the private key corresponding to the public key that originally encrypted it. This type of cryptography is called asymmetric key encryption. In the example, the public key is made readily available to any client program that requests it, and the private key is kept secret and made available to specific, trusted clients only.

As shown in the diagram, this example uses a separate program to generate the public and private key pair. The public key is stored in one file, and the private key is stored in another. The file with the private key must be kept in a very secure place. Many companies keep the private key file on an external storage medium such as tape or disk to prevent an unauthorized person or program from breaking into the system and getting the private key.

The server program loads the public key from the public key file, and makes it available to order clients for encrypting the session key. Order processing clients get the encrypted session key and credit card number, load the private key, use the private key to decrypt the session key, and use the session key to decrypt the credit card number.



## Running the Example

If you are within the United States or Canada, you can download the `javax.crypto` package from the [Products & APIs](#) page. It contains documentation and a Java™ Archive (JAR) file with the cryptographic APIs and a cryptographic service provider. A cryptographic service provider is a package or set of packages that supplies a concrete implementation of a cryptographic algorithm.

Copy the JAR file to the `jdk1.2/jre/lib/ext` directory of your Java 2 SDK, Standard Edition, installation or to the `jre1.2/lib/security` directory of your Java Runtime Environment (JRE) 1.2 installation.

Make sure you have the following entries in the `jdk1.2/jre/lib/security/java.security` or `jre1.2/lib/security/java.security` file:

```
security.provider.1=sun.security.provider.Sun
security.provider.2=com.sun.crypto.provider.SunJCE
```

You also need to install a package with an asymmetric algorithm such as the Rivest, Shamir, and Adleman (RSA) Asymmetric-Cipher algorithm.

The asymmetric algorithm is needed to create the asymmetric cipher for the public and private key encryption. Add the asymmetric algorithm package to `jdk1.2/jre/lib/security/java.security` or `jre1.2/lib/security/java.security` as `security.provider.3=` and put it in the `jdk1.2/jre/lib/ext` or `jre1.2/lib/ext` directory with the other JAR files.

Using the documentation in the download, convert the pseudo code to source code.

Compile and run the example as usual.

## Pseudo Code

A cipher object is used in the encryption and decryption process. The cipher object is created with a specific cryptographic algorithm depending on the type of encryption in use. In this example, two types of encryption

are used: symmetric and asymmetric.

Symmetric key encryption uses a symmetric algorithm such as Data Encryption Standard (DES). The asymmetric key encryption uses an asymmetric algorithm such as Rives, Shamir, and Adleman (RSA) Asymmetric-Cipher algorithm.

The `javax.crypto` package defines the framework for both symmetric and asymmetric encryption into which concrete cipher implementations can be plugged. The SunJCE provider that comes standard with JCE 1.2 supplies only implementations of symmetric encryption algorithms such as DES. For an implementation of an asymmetric encryption algorithm such as RSA, you need to install a different provider.

The pseudo code shows two ways to do the asymmetric encryption of the session key. One way uses an RSA key to encrypt the symmetric key. The other way uses another asymmetric algorithm to seal (encrypt) the symmetric key. Sealing is the preferred way, but presents a problem when you use the RSA key because the RSA algorithm imposes a size restriction (discussed below) on the object being encrypted and sealing makes the object too large for RSA encryption.

After the cipher is created with the correct symmetric or asymmetric algorithm, it is initialized for encryption or decryption with a key. In the case of symmetric encryption, the key is a secret key, and in the case of asymmetric encryption, the key is either the public or private key.

## Server

The `Send` interface declares and the `RemoteServer` class implements methods to handle the encrypted credit card number and the encrypted secret key. It also defines a method to return the public key when a client requests it. In pseudo code, this is what the server interface and class need to declare and implement:

```
A method to get the public key
A method to send the encryped credit card number
A method to get the encrypted credit card number
A method to send the encrypted symmetric key
A method to get the encrypted symmetric key
```

## Generating the Public and Private Key Pair

You need a program to generate a public and private key pair and store them to separate files. The public key is read from its file when a client calls the method to get the public key. The private key is read from its file when `RMIClient2` needs it to decrypt the secret key.

```
Generate public and private key pair
    using asymmetric algorithm
Store private Key in very safe place
Store public key in accessible place
```

## Sealing the Symmetric Key

Sealing the symmetric key involves creating a sealed object that uses an asymmetric cipher to seal (encrypt) the session key. The RSA asymmetric algorithm cannot be used because it has the size restrictions described in the next section, and the sealing process makes the session key too large to use with the RSA algorithm.

**RMIClient1Sealed.java:** The [RMIClient1.java](#) code has an `encrypt` method to encrypt the credit card number, seal the symmetric key, and send the encrypted credit card number and sealed key to the server. Here is the pseudo code to do it:

```
private void encrypt(credit card number){
    Create cipher for symmetric key encryption (DES)
    Create a key generator
    Create a secret (session) key with key generator
    Initialize cipher for encryption with session key
    Encrypt credit card number with cipher
    Get public key from server
    Create cipher for asymmetric encryption
                                (do not use RSA)
    Initialize cipher for encryption with public key
    Seal session key using asymmetric Cipher
    Send encrypted credit card number and sealed
    session key to server
}
```

**RMIClient2Sealed.java:** The [RMIClient2.java](#) code has a `decrypt` method to unseal the symmetric key and decrypt the credit card number. Here is the pseudo code to do it:

```
public byte[] decrypt(encrypted key,
                    encrypted credit card number){
    Get private key from file
    Create asymmetric cipher (do not use RSA)
    Initialize cipher for decryption with private key
    Unseal wrapped session key using asymmetric cipher
    Create symmetric cipher
    Initialize cipher for decryption with session key
    Decrypt credit card number with symmetric cipher
}
```

### Encrypting the Symmetric Key with the RSA Algorithm

The RSA algorithm imposes size restrictions on the object being encrypted. RSA encryption uses the PKCS#1 standard with PKCS#1 block type 2 padding. The PKCS RSA encryption padding scheme needs 11 spare bytes to work. So, if you generate an RSA key pair with a key size of 512 bits, you cannot use the keys to encrypt more than 53 bytes ( $53 = 64 - 11$ ).

So, if you have a session key that is only 8 bytes long, sealing expands it to 3644 bytes, which is way over the size restriction imposed by the RSA algorithm. In the process of sealing, the object to be sealed (the session key, in this case) is first serialized, and then the serialized contents are encrypted. Serialization adds more information to the session key such as

the class of the session key, the class signature, and any objects referenced by the session key. The additional information makes the session key too large to be encrypted with an RSA key, and the result is a `javax.crypto.IllegalBlockSizeException` run time error.

**RMIClient1.java:** The [RMIClient1.java](#) code has an `encrypt` method to encrypt the credit card number, seal (encrypt) the session key, and send the encrypted credit card number and sealed session key to the server. Here is the pseudo code to do it:

```
private void encrypt(credit card number){
    Create cipher for symmetric key encryption (DES)
    Create a key generator
    Create a secret (session) key with key generator
    Initialize cipher for encryption with session key
    Encrypt credit card number with cipher
    Get public key from server
    Create cipher for asymmetric encryption (RSA)
    Initialize cipher for encryption with public key
    Encrypt session key
    Send encrypted credit card number and session
                                     key to server
}
```

**RMIClient2.java:** The [RMIClient2.java](#) code has a `decrypt` method to unseal (decrypt) the symmetric key and decrypt the credit card number. Here is the pseudo code to do it:

```
public String decrypt(encrypted key,
                     encrypted credit card number){
    Decrypt credit card number
    Get private key from file
    Create asymmetric cipher (RSA)
    Initialize cipher for decryption with private key
    Decrypt symmetric key
    Instantiate symmetric key
    Create symmetric cipher
    Initialize Cipher for decryption with session key
    Decrypt credit card number with symmetric Cipher
}
```

## More Information

You can find more information on key encryption on the [Security Dynamics](#) Web site (for RSA encryption), or by using a search engine and searching on RSA Cryptography, asymmetric key encryption, or symmetric key encryption.

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## Java™ Programming Language Basics, Part 2

### Lesson 4: Serialization

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One big problem with the example program in its current form is the fact that sending clients can overwrite each other's data before receiving clients have a chance to get and process it. This lesson adapts the server code to ensure all orders are processed (nothing is overwritten), and all orders are processed in the order they are received by the server.

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---

### About the Example

The example adapts the [Part 2, Lesson 2: User Interfaces Revisited](#) example to wrap the fruit order data into a single data object and send the data object over the network to the server. This is more efficient than sending each unit of data separately.

### Wrapping the Data

The [DataOrder.java](#) class is very simple. It defines the fields that wrap and store the fruit order data. It has no methods. It implements the `Serializable` interface so its data can be serialized, and written to and read from a file as a single unit.

Object serialization transforms an object's data to a bytestream that represents the state of the data. The serialized form of the data contains enough information to recreate the object with its data in a similar state to what it was when saved.

```
import java.io.*;

class DataOrder implements Serializable{
    String apples, peaches, pears, cardnum, custID;
    double icost;
    int itotal;
}
```

### Sending Data

The [RMIClient1.java](#) program is modified to use the `DataOrder` class to send the order data over the net. The `RMIClient1.actionPerformed` method creates an instance of the `DataOrder` class and initializes its fields with order data retrieved from the user interface text fields and areas.

```
public void actionPerformed(ActionEvent event){
    Object source = event.getSource();
    Integer applesNo, peachesNo, pearsNo, num;
    Double cost;
    String number, text, text2;
    DataOrder order = new DataOrder();

    if(source == purchase){
        order.cardnum = creditCard.getText();
        order.custID = customer.getText();
        order.apples = appleqnt.getText();
        order.peaches = peachqnt.getText();
        order.pears = pearqnt.getText();
```

The total number of items is calculated using the `order.icost` field.

```
if(order.apples.length() > 0){
    try{
        applesNo = Integer.valueOf(order.apples);
        order.itotal += applesNo.intValue();
    } catch (java.lang.NumberFormatException e) {
        appleqnt.setText("Invalid Value");
    }
} else {
    order.itotal += 0;
}
```

The total number of items is retrieved from the `order.itotal` field and displayed in the user interface.

```
num = new Integer(order.itotal);
text = num.toString();
this.items.setText(text);
```

Similarly, the total cost is calculated and displayed in the user interface using the `order.icost` field.

```
order.icost = (order.itotal * 1.25);
cost = new Double(order.icost);
text2 = cost.toString();
this.cost.setText(text2);

try{
    send.sendOrder(order);
} catch (Exception e) {
    System.out.println("Cannot send data to server");
}
```

After the totals are calculated, the `order` object is sent over the net to the server program.

## Server Program

The [Send.java](#) and [RemoteServer.java](#) classes are much simpler in this lesson. They have one `getXXX` method that returns an instance of `DataOrder`, and one `setXXX` method that accepts an instance of `DataOrder`.

### Send.java

```
import java.rmi.Remote;
import java.rmi.RemoteException;

public interface Send extends Remote {
    public void sendOrder(DataOrder order)
        throws RemoteException;
    public DataOrder getOrder() throws RemoteException;
}
```

### RemoteServer.java

The `RemoteServer.sendOrder` method accepts a `DataOrder` instance as input, and stores each order in a separate file where the file name is a number. The first order received is stored in a file named `1`, the second order is stored in a file named `2`, and so forth.

To keep track of the file names, the `value` variable is incremented by `1` each time the `sendOrder` method is called, converted to a `String`, and used for the file name in the serialization process.

Objects are serialized by creating a serialized output stream and writing the object to the output stream. In the code, the first line in the `try` block creates a `FileOutputStream` with the file name to which the serialized object is to be written.

The next line creates an `ObjectOutputStream` from the file output stream. This is the serialized output stream to which the `order` object is written in the last line of the `try` block.

### RemoteServer.java

```
public void sendOrder(DataOrder order){

    value += 1;
    num = new Integer(value);
    orders = num.toString();
    try{
        FileOutputStream fos =
            new FileOutputStream(orders);
        ObjectOutputStream oos =
            new ObjectOutputStream(fos);
        oos.writeObject(order);
    }catch (java.io.FileNotFoundException e){
        System.out.println(e.toString());
    }catch (java.io.IOException e){
        System.out.println(e.toString());
    }
}
```

The `RemoteServer.getOrder` method does what the `sendOrder` method does in reverse using the `get` variable to keep track of which orders have been viewed.

But first, this method checks the `value` variable. If it is equal to zero, there are no orders to get from a file and view, and if it is greater than the value in the `get` variable, there is at least one order to get from a file and view. As each order is viewed, the `get` variable is incremented by 1.

```
public DataOrder getOrder(){
    DataOrder order = null;

    if(value == 0){
        System.out.println("No Orders To Process");
    }

    if(value > get){
        get += 1;
        num = new Integer(get);
        orders = num.toString();
        try{
            FileInputStream fis =
                new FileInputStream(orders);
            ObjectInputStream ois =
                new ObjectInputStream(fis);
            order = (DataOrder)ois.readObject();
        }catch (java.io.FileNotFoundException e){
            System.out.println(e.toString());
        }catch (java.io.IOException e){
            System.out.println(e.toString());
        }catch (java.lang.ClassNotFoundException e){
            System.out.println(e.toString());
        }
    }else{
        System.out.println("No Orders To Process");
    }
    return order;
}
```

## Receiving Data

The [RMIClient2.actionPerformed](#) method gets an `order` object and references its fields to display data in the user interface.

```
if(source == view){
    try{
        order = send.getOrder();
        creditNo.setText(order.cardnum);
        customerNo.setText(order.custID);
        applesNo.setText(order.apples);
        peachesNo.setText(order.peaches);
        pearsNo.setText(order.pears);

        cost = order.icost;
        price = new Double(cost);
        unit = price.toString();
        icost.setText(unit);
    }
}
```

```
        items = order.itotal;
        itms = new Integer(items);
        i = itms.toString();
        itotal.setText(i);
    } catch (Exception e) {
        System.out.println("Cannot send data to server");
    }
}
```

## More Information

You can find more information on serialization in the [Reading and Writing \(but no 'rithmetic\)](#) lesson in [The Java™ Tutorial](#).

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# Java™ Programming Language Basics, Part 2

## Lesson 5: Collections

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A collection is an object that contains other objects and provides methods for working on the objects it contains. A collection can consist of the same types of objects, but can contain objects of different types too.

This lesson adapts the [RMIClient2](#) program from [Part 2, Lesson 2: User Interfaces Revisited](#) to use the Collections application programming interface (API) to maintain and print a list of unique customer IDs. The customer IDs are all objects of type `String` and represent the same type of information, a customer ID. You could, however, have a collection object that contains objects of type `String`, `Integer`, and `Double` if it makes sense in your application.

- [About Collections](#)
- [Creating a Set](#)
- [Printing](#)
- [More Information](#)

---

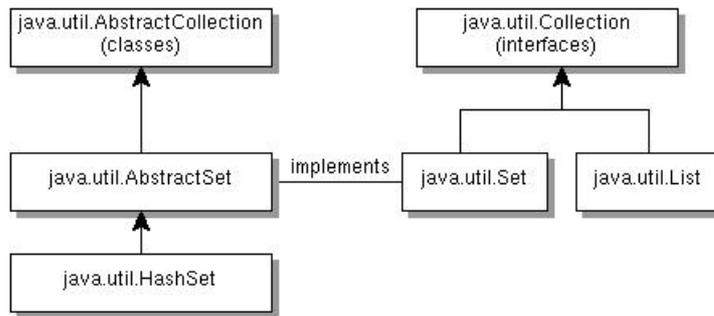
## About Collections

The Collection classes available to use in programs implement Collection interfaces. Interfaces are abstract data types that let collections be manipulated independently of their representation details. There are three primary types of collection interfaces: `List`, `Set`, and `Map`. This lesson focuses on the `List` and `Set` collections.

`Set` implementations do not permit duplicate elements, but `List` implementations do. Duplicate elements have the same data type and value. For example, two customer IDs of type `String` containing the value `Zelda` are duplicate; whereas, an element of type `String` containing the value `1` and an element of type `Integer` containing the value `1` are not duplicate.

The API provides two general-purpose `Set` implementations. `HashSet`, which stores its elements in a hash table, and `TreeSet`, which stores its elements in a balanced binary tree called a red-black tree. The example for this lesson uses the `HashSet` implementation because it currently has the best performance.

This diagram shows the Collection interfaces on the right and the class hierarchy for the `java.util.HashSet` on the left. You can see that the `HashSet` class implements the `Set` interface.



## Creating a Set

This example adapts the [RMIClient2.java](#) class to collect customer IDs in a `Set` and print the list of customer IDs whenever the `View` button is clicked.

The collection object is a `Set` so if the same customer enters multiple orders, there is only one element for that customer in the list of customer IDs. If the program tries to add an element that is the same as an element already in the set, the second element is simply not added. No error is thrown and there is nothing you have to do in your code.

The [RMIClient2.actionPerformed](#) method calls the `addCustomer` method to add a customer ID to the set when the order processor clicks the `View` button.

The `addCustomer` method shown below adds the customer ID to the set and prints a notice that the customer ID has been added.

```
//Create list of customer IDs
public void addCustomer(String custID){
    s.add(custID);
    System.out.println("Customer ID added");
}
```

## Printing

The `print` method is called from the [RMIClient2.actionPerformed](#) method when the order processor clicks the `View` button. The `print` method prints the elements currently in the set to the command line.

---

**Note:** A `HashSet` does not guarantee the order of the elements in the set. Elements are printed in the order they occur in the set, but that order is not necessarily the same as the order in which the elements were placed in the set.

---

To traverse the set, an object of type `Iterator` is returned from the set. The `Iterator` object has a `hasNext` method that lets you test if there is another element in the set, a `next` that lets you move over the elements in the set, and a `remove` method that lets you remove an element.

The example print method shows two ways to print the set. The first way uses an iterator and the second way simply calls `System.out.println` on the set. In the iterator approach, the element returned by the `next` method is printed to the command line until there are no more elements in the set.

```
//Print customer IDs
public void print(){
//Iterator approach
    if(s.size()!=0){
        Iterator it = s.iterator();
        while(it.hasNext()){
            System.out.println(it.next());
        }
//Call System.out.println on the set
        System.out.println(s);
    }else{
        System.out.println("No customer IDs available");
    }
}
```

## More Information

You can find more information on Collections in the [Collections](#) trail in [The Java™ Tutorial](#).

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## Java™ Programming Language Basics, Part 2

### Lesson 6: Internationalization

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More and more companies, large and small, are doing business around the world using many different languages. Effective communication is always good business, so it follows that adapting an application to a local language adds to profitability through better communication and increased satisfaction.

The Java™ 2 platform provides internationalization features that let you separate culturally dependent data from the application (internationalization) and adapt it to as many cultures as needed (localization).

This lesson takes the two client programs from [Part 2, Lesson 5: Collections](#), internationalizes them and adapts the text to France, Germany, and the United States.

- [Identify Culturally Dependent Data](#)
- [Create Keyword and Value Pair Files](#)
- [Internationalize Application Text](#)
- [Internationalize Numbers](#)
- [Compile and Run the Application](#)
- [Program Improvements](#)
- [More Information](#)

---

### Identify Culturally Dependent Data

The first thing you need to do is identify the culturally dependent data in your application. Culturally-dependent data is any data that varies from one culture or country to another. Text is the most obvious and pervasive example of culturally dependent data, but other things like number formats, sounds, times, and dates must be considered too.

The [RMIClient1.java](#) and [RMIClient2.java](#) classes have the following culturally-dependent data visible to the end user:

Select Items	Specify Quantity
Apples	2
Peaches	1
Pears	4
Total Items:	7
Total Cost:	8.75
Credit Card:	1234-4321-1234-3
Customer ID:	munchkin

Reset Purchase

- Titles and labels (window titles, column heads, and left column labels)
- Buttons (Purchase, Reset, View)
- Numbers (values for item and cost totals)
- Error messages

Although the application has a server program, the server program is not being internationalized and localized. The only visible culturally-dependent data in the server program is the error message text.

The server program runs in one place and the assumption is that it is not seen by anyone other than the system administrator who understands the language in which the error messages is hard coded. In this example, it is English.

All error messages in `RMIClient1` and `RMIClient2` are handled in `try` and `catch` blocks, as demonstrated by the `print` method below. This way you have access to the error text *No data available* for translation into another language.

```
public void print(){
    if(s!=null){
        Iterator it = s.iterator();
        while(it.hasNext()){
            try{
                String customer = (String)it.next();
                System.out.println(customer);
            }catch (java.util.NoSuchElementException e){
                System.out.println("No data available");
            }
        }
    }else{
        System.out.println("No customer IDs available");
    }
}
```

The `print` method could have been coded to declare the exception in its `throws` clause as shown below, but this way you cannot access the error message text thrown when the method tries to access unavailable data in the set.

In this case, the system-provided text for this error message is sent to the command line regardless of the locale in use for the application. The point here is it is always better to use `try` and `catch` blocks wherever possible if there is any chance the application will be internationalized so you can localize the error message text.

```
public void print()
    throws java.util.NoSuchElementException{
    if(s!=null){
```

```
        Iterator it = s.iterator();
        while(it.hasNext()){
            String customer = (String)it.next();
            System.out.println(customer);
        }
    }else{
        System.out.println("No customer IDs available");
    }
}
```

Here is a list of the title, label, button, number, and error text visible to the user, and therefore, subject to internationalization and localization. This data was taken from both [RMIClient1.java](#) and [RMIClient2.java](#).

- **Labels:** Apples, Peaches, Pears, Total Items, Total Cost, Credit Card, Customer ID
- **Titles:** Fruit \$1.25 Each, Select Items, Specify Quantity
- **Buttons:** Reset, View, Purchase
- **Number Values:** Value for total items, Value for total cost
- **Errors:** Invalid Value, Cannot send data to server, Cannot look up remote server object, No data available, No customer IDs available, Cannot access data in server

## Create Keyword and Value Pair Files

Because all text visible to the user will be moved out of the application and translated, your application needs a way to access the translated text during execution. This is done with keyword and value pair files, where this is a file for each language. The keywords are referenced from the application instead of the hard-coded text and used to load the appropriate text from the file for the language in use.

For example, you can map the keyword purchase to Kaufen in the German file, Achetez in the French file, and Purchase in the United States English file. In your application, you reference the keyword purchase and indicate the language to use.

Keyword and value pairs are stored in files called properties files because they store information about the programs properties or characteristics. Property files are plain-text format, and you need one file for each language you intend to use.

In this example, there are three properties files, one each for the English, French, and German translations. Because this application currently uses hard-coded English text, the easiest way to begin the internationalization process is to use the hard-coded text to set up the key and value pairs for the English properties file.

The properties files follow a naming convention so the application can locate and load the correct file at run time. The naming convention uses

language and country codes which you should make part of the file name. The language and country are both included because the same language can vary between countries. For example, United States English and Australian English are a little different, and Swiss German and Austrian German both differ from each other and from the German spoken in Germany.

These are the names of the properties files for the German (`de_DE`), French (`fr_FR`), and American English (`en_US`) translations where `de`, `fr`, and `en` indicate the German (Deutsche), French, and English languages; and `DE`, `FR`, and `US` indicate Germany (Deutschland), France, and the United States:

- `MessagesBundle_de_DE.properties`
- `MessagesBundle_en_US.properties`
- `MessagesBundle_fr_FR.properties`

Here is the English language properties file. Keywords appear to the left of the equals (=) sign, and text values appear to the right.

#### [MessagesBundle\\_en\\_US.properties](#)

```
apples=Apples:
peaches=Peaches:
pears=Pears:
items=Total Items:
cost=Total Cost:
card=Credit Card:
customer=Customer ID:

title=Fruit 1.25 Each
1col=Select Items
2col=Specify Quantity

reset=Reset
view=View
purchase=Purchase

invalid=Invalid Value
send=Cannot send data to server
nolookup=Cannot look up remote server object

nodata=No data available
noID=No customer IDs available
noserver=Cannot access data in server
```

With this file complete, you can hand it off to your French and German translators and ask them to provide the French and German equivalents for the text to the right of the equals (=) sign. Keep a copy for yourself because you will need the keywords to internationalize your application text.

The properties file with the [German](#) translations produces this user interface for the fruit order client:

Auswahl treffen	Menge angeben
Äpfel:	12
Birnen:	36
Pfirsiche:	10
Anzahl Früchte:	
Gesamtkosten:	72,50
Kreditkarte:	123-321-444-6962
Kundenidentifizierung:	heidi

Zurücksetzen      Kaufen

The properties file with the [French](#) translations produces this user interface for the fruit order client:

Choisissez les éléments	Indiquez la quantité
Pommes:	12
Pêches:	36
Poires:	10
Partia total:	72,50
Prx total:	72,50
Carte de Crédit:	123-321-444-6962
Numéro de client:	claire

Réinitialisez      Achetez

## Internationalize Application Text

This section walks through internationalizing the [RMIClient1.java](#) program. The [RMIClient2.java](#) code is almost identical so you can apply the same steps to that program on your own.

### Instance Variables

In addition to adding an import statement for the `java.util.*` package where the internationalization classes are, this program needs the following instance variable declarations for the internationalization process:

```
//Initialized in main method
static String language, country;
Locale currentLocale;
static ResourceBundle messages;

//Initialized in actionPerformed method
NumberFormat numFormat;
```

### main Method

The program is designed so the user specifies the language to use at the command line. So, the first change to the `main` method is to add the code

to check the command line parameters. Specifying the language at the command line means once the application is internationalized, you can easily change the language without any recompilation.

The `String[] args` parameter to the `main` method contains arguments passed to the program from the command line. This code expects 3 command line arguments when the end user wants a language other than English. The first argument is the name of the machine on which the program is running. This value is passed to the program when it starts and is needed because this is a networked program using the Remote Method Invocation (RMI) API.

The other two arguments specify the language and country codes. If the program is invoked with 1 command line argument (the machine name only), the country and language are assumed to be United States English.

As an example, here is how the program is started with command line arguments to specify the machine name and German language (de DE). Everything goes on one line.

```
java -Djava.rmi.server.codebase=  
    http://kq6py/~zelda/classes/  
    -Djava.security.policy=java.policy  
    RMIClient1 kq6py.eng.sun.com de DE
```

And here is the `main` method code. The `currentLocale` instance variable is initialized from the language and country information passed in at the command line, and the `messages` instance variable is initialized from the `currentLocale`.

The `messages` object provides access to the translated text for the language in use. It takes two parameters: the first parameter "MessagesBundle" is the prefix of the family of translation files this application uses, and the second parameter is the `Locale` object that tells the `ResourceBundle` which translation to use.

---

**Note:** This style of programming makes it possible for the same user to run the program in different languages, but in most cases, the program will use one language and not rely on command-line arguments to set the country and language.

---

If the application is invoked with `de DE` command line parameters, this code creates a `ResourceBundle` variable to access the `MessagesBundle_de_DE.properties` file.

```
public static void main(String[] args){  
    //Check for language and country codes  
    if(args.length != 3) {  
        language = new String("en");  
        country = new String ("US");  
        System.out.println("English");  
    }else{
```

```

        language = new String(args[1]);
        country = new String(args[2]);
        System.out.println(language + country);
    }

//Create locale and resource bundle
    currentLocale = new Locale(language, country);
    messages = ResourceBundle.getBundle("MessagesBundle",
        currentLocale);

    WindowListener l = new WindowAdapter() {
        public void windowClosing(WindowEvent e) {
            System.exit(0);
        }
    };

//Create the RMIclient1 object
    RMIclient1 frame = new RMIclient1();

    frame.addWindowListener(l);
    frame.pack();
    frame.setVisible(true);

    if(System.getSecurityManager() == null) {
        System.setSecurityManager(
            new RMISecurityManager());
    }

    try {
        String name = "//" + args[0] + "/Send";
        send = ((Send) Naming.lookup(name));
    } catch (java.rmi.NotBoundException e) {
        System.out.println(messages.getString(
            "nolookup"));
    } catch (java.rmi.RemoteException e){
        System.out.println(messages.getString(
            "nolookup"));
    } catch (java.net.MalformedURLException e) {
        System.out.println(messages.getString(
            "nolookup"));
    }
}

```

The applicable error text is accessed by calling the `getString` method on the `ResourceBundle`, and passing it the keyword that maps to the applicable error text.

```

    try {
        String name = "//" + args[0] + "/Send";
        send = ((Send) Naming.lookup(name));
    } catch (java.rmi.NotBoundException e) {
        System.out.println(messages.getString(
            "nolookup"));
    } catch (java.rmi.RemoteException e){
        System.out.println(messages.getString(
            "nolookup"));
    } catch (java.net.MalformedURLException e) {
        System.out.println(messages.getString(
            "nolookup"));
    }
}

```

## Constructor

The window title is set by calling the `getString` method on the `ResourceBundle`, and passing it the keyword that maps to the title text. You must pass the keyword exactly as it appears in the translation file, or you will get a runtime error indicating the resource is unavailable.

```
RMIClient1(){
//Set window title
    setTitle(messages.getString("title"));
}
```

The next thing the constructor does is use the `args` parameter to look up the remote server object. If there are any errors in this process, the `catch` statements get the applicable error text from the `ResourceBundle` and print it to the command line. User interface objects that display text, such as `JLabel` and `JButton`, are created in the same way:

```
//Create left and right column labels
    col1 = new JLabel(messages.getString("1col"));
    col2 = new JLabel(messages.getString("2col"));
...
//Create buttons and make action listeners
    purchase = new JButton(messages.getString(
        "purchase"));
    purchase.addActionListener(this);

    reset = new JButton(messages.getString("reset"));
    reset.addActionListener(this);
```

## actionPerformed Method

In the `actionPerformed` method, the `Invalid Value` error is caught and translated:

```
if(order.apples.length() > 0){
//Catch invalid number error
    try{
        applesNo = Integer.valueOf(order.apples);
        order.itotal += applesNo.intValue();
    }catch(java.lang.NumberFormatException e){
        appleqnt.setText(messages.getString("invalid"));
    }
} else {
    order.itotal += 0;
}
```

The `actionPerformed` method calculates item and cost totals, translates them to the correct format for the language currently in use, and displays them in the user interface.

## Internationalize Numbers

A `NumberFormat` object is used to translate numbers to the correct format for the language currently in use. To do this, a `NumberFormat`

object is created from the `currentLocale`. The information in the `currentLocale` tells the `NumberFormat` object what number format to use.

Once you have a `NumberFormat` object, all you do is pass in the value you want translated, and you receive a `String` that contains the number in the correct format. The value can be passed in as any data type used for numbers such as `int`, `Integer`, `double`, or `Double`. No code such as to convert an `Integer` to an `int` and back again is needed.

```
//Create number formatter
    numFormat = NumberFormat.getNumberInstance(
        currentLocale);

//Display running total
    text = numFormat.format(order.itotal);
    this.items.setText(text);

//Calculate and display running cost
    order.icost = (order.itotal * 1.25);
    text2 = numFormat.format(order.icost);
    this.cost.setText(text2);

    try{
        send.sendOrder(order);
    } catch (java.rmi.RemoteException e) {
        System.out.println(messages.getString("send"));
    }
}
```

## Compile and Run the Application

Here are the summarized steps for compiling and running the example program. The important thing to note is that when you start the client programs, you need to include language and country codes if you want a language other than United States English.

### Compile

These instructions assume development is in the `zelda` home directory.

#### Unix:

```
cd /home/zelda/classes
javac Send.java
javac RemoteServer.java
javac RMIClient2.java
javac RMIClient1.java
rmic -d . RemoteServer
cp RemoteServer*.class /home/zelda/public_html/classes
cp Send.class /home/zelda/public_html/classes
cp DataOrder.class /home/zelda/public_html/classes
```

#### Win32:

```
cd \home\zelda\classes
javac Send.java
javac RemoteServer.java
javac RMIClient2.java
javac RMIClient1.java
```

```
rmic -d . RemoteServer
copy RemoteServer*.class
           \home\zelda\public_html\classes
copy Send.class \home\zelda\public_html\classes
copy DataOrder.class \home\zelda\public_html\classes
```

## Start rmi Registry

### Unix:

```
cd /home/zelda/public_html/classes
unsetenv CLASSPATH
rmiregistry &
```

### Win32:

```
cd \home\zelda\public_html\classes
set CLASSPATH=
start rmiregistry
```

## Start the Server

### Unix:

```
cd /home/zelda/public_html/classes
java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes
      -Djava.rmi.server.hostname=kq6py.eng.sun.com
      -Djava.security.policy=java.policy RemoteServer
```

### Win32:

```
cd \home\zelda\public_html\classes
java -Djava.rmi.server.codebase=
      file:c:\home\zelda\public_html\classes
      -Djava.rmi.server.hostname=kq6py.eng.sun.com
      -Djava.security.policy=java.policy RemoteServer
```

## Start RMIClient1 in German

Note the addition of `de DE` for the German language and country at the end of the line.

### Unix:

```
cd /home/zelda/classes

java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes/
      -Djava.security.policy=java.policy
      RMIClient1 kq6py.eng.sun.com de DE
```

### Win32:

```
cd \home\zelda\classes

java -Djava.rmi.server.codebase=
      file:c:\home\zelda\classes\
      -Djava.security.policy=java.policy RMIClient1
      kq6py.eng.sun.com de DE
```

## Start RMIClient2 in French

Note the addition of `fr FR` for the French language and country at the end of the line.

### Unix:

```
cd /home/zelda/classes

java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy
      RMIClient2 kq6py.eng.sun.com fr FR
```

### Win32:

```
cd \home\zelda\classes

java -Djava.rmi.server.codebase=
      file:c:\home\zelda\public_html\classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=java.policy RMIClient2
      kq6py.eng.sun.com/home/zelda/public_html fr FR
```

## Program Improvements

A real-world scenario for an ordering application like this might be that [RMIClient1](#) is an applet embedded in a web page. When orders are submitted, order processing staff run [RMIClient2](#) as applications from their local machines.

So, an interesting exercise is to convert `RMIClient1.java` to its applet equivalent. The translation files would be loaded by the applet from the same directory from which the browser loads the applet class.

One way is to have a separate applet for each language with the language and country codes hard coded. Your web page can let them choose the language by clicking a link that launches the appropriate applet. Here are the source code files for the [English](#), [French](#), and [German](#) applets.

Here is the HTML code to load the French applet on a Web page.

```
<HTML>
<BODY>
<APPLET CODE=RMIFrenchApp.class WIDTH=300 HEIGHT=300>
</APPLET>
</BODY>
</HTML>
```

---

**Note:** To run an applet written with Java™ 2 APIs in a browser, the browser must be enabled for the Java 2 Platform. If your browser is not enabled for the Java 2 Platform, you have to use [appletviewer](#) to run the applet or install [Java Plug-in](#). Java Plug-in lets you run applets on web pages under the 1.2 version of the Java<sup>1</sup> virtual machine (VM) instead of the web browser's default Java VM.

---

To use applet viewer, type the following where `rmiFrench.html` is the HTML file for the French applet.

```
appletviewer rmiFrench.html
```

Another improvement to the program as it currently stands would be enhancing the error message text. You can locate the errors in the [Java API docs](#) and use the information there to make the error message text more user friendly by providing more specific information.

You might also want to adapt the client programs to catch and handle the error thrown when an incorrect keyword is used. Here are the error and stack trace provided by the system when this type of error occurs:

```
Exception in thread "main"
  java.util.MissingResourceException:
Can't find resource
  at java.util.ResourceBundle.getObject(Compiled Code)
  at java.util.ResourceBundle.getString(Compiled Code)
  at RMIClient1.<init>(Compiled Code)
  at RMIClient1.main(Compiled Code)
```

## More Information

You can find more information on Internationalization in the [Internationalization](#) trail in [The Java Tutorial](#).

You can find more information on applets in the [Writing Applets](#) trail in [The Java Tutorial](#).

---

<sup>1</sup> As used on this web site, the terms "Java virtual machine" or "JVM" mean a virtual machine for the Java platform

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## Java™ Programming Language Basics, Part Lesson 7: Packages and Java™ Archive File Form

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Until now, you have used classes from the Java API library by importing the package containing the class or classes you need. A package is a convenient way to organize groups of related classes, and in development, you should organize your application files into packages too. Packages make it easier to locate and use the class files and help you control access to class data at runtime.

When your application is fully tested, debugged, and ready for deployment, use the Java™ Archive file format to deploy the application. JAR file format is a compression and file packaging format and tool for bundling executable files with any other related application files so they can be deployed as one unit.

This lesson shows you how to organize the program files from [Part 2, Lesson 6: Internationalization](#) into packages and deploy the executable and other related files to production using JAR file format. Normally, you would use packages from the beginning of development.

- [Setting up Class Packages](#)
  - [Create the Directories](#)
  - [Declare the Packages](#)
  - [Make Classes and Fields Accessible](#)
  - [Change Client Code to Find the Properties File](#)
  - [Compile and Run the Example](#)
- [Using JAR Files to Deploy](#)
  - [Server Set of Files](#)
  - [Fruit Order Client Set of Files](#)
  - [View Order Client Set of Files](#)
  - [More Information](#)

---

### Setting up Class Packages

It is easy to organize class files into packages. All you do is put related class files in the same directory, give the directory a name that relates to the purpose of the classes, and add a line to the top of each class file that declares the package name, which is the same as the directory name where they reside.

For example, the class and other related files for the program files from [Part 2, Lesson 6: Internationalization](#) can be divided into three groups of files: fruit order client, view order client, and server files. Although these three sets of classes are related to each other, they have different functions and are to be

deployed separately.

## Create the Directories

To organize the internationalization program into three packages, you could create the following three directories and move the listed source files into them:

- client1
  - RMIEnglishApp.java
  - RMIFrenchApp.java
  - RMIGermanApp.java
  - MessagesBundle\_de\_DE.properties
  - MessagesBundle\_en\_US.properties
  - MessagesBundle\_fr\_FR.properties
  - index.html
  - rmiFapp.html
  - rmiGapp.html
  - rmiEapp.html
  - java.policy
- client2
  - RMIClient2.java
  - MessagesBundle\_de\_DE.properties
  - MessagesBundle\_en\_US.properties
  - MessagesBundle\_fr\_FR.properties
  - java.policy
- server
  - DataOrder.java
  - RemoteServer.java
  - Send.java
  - java.policy

## Declare the Packages

Each \*.java file needs a package declaration at the top that reflects the name of the directory. Also, the fruit order (client1 and view order (client2) client class files need an import statement for the server package because they have to access the remote server object at runtime.

As an example, the package declaration and import statements for the [RMIClient2.java](#) class file look like this:

```
//package declaration
package client2;

import java.awt.Color;
import java.awt.GridLayout;
import java.awt.event.*;
import javax.swing.*;

import java.io.*;
import java.net.*;

import java.rmi.*;
import java.rmi.server.*;
```

```
import java.util.*;
import java.text.*;

//Import server package
import server.*;
```

## Make Classes and Fields Accessible

With class files organized into packages, you have to declare the server classes in the `server` directory `public` so they can be instantiated by client programs, which are created from classes in the `client1` and `client2` directories. If you do not specify `public`, a class can only be instantiated to an object created from a class in the same package.

So client programs can access the fruit order data, the fields of the `DataOrder` class have to be `public` too. The [RemoteServer](#) class and [Send](#) interface need to be `public` classes, but their fields do not need to be `public` because they do not have public data.

Fields and methods without an access specifier such as `public` can only be accessed by objects created from classes in the same package.

Here is the new [DataOrder](#) class.

```
package server;

import java.io.*;

//Make class public
public class DataOrder implements Serializable{

//Make fields public
    public String apples, peaches, pears, cardnum, custID;
    public double icost;
    public int itotal;
}
```

## Change Client Code to Find the Properties Files

In the example, the properties files (`Messages_*`) are stored in the directories with the client source files. This makes it easier to package and deploy the files later. So the programs can find the properties files, you have to make one small change to the client source code.

The code that creates the `messages` variable needs to include the directory (package name) as follows:

```
messages = ResourceBundle.getBundle(
    "client2" +
    File.separatorChar +
    "MessagesBundle", currentLocale);
```

## Compile and Run the Example

Compiling and running the example organized into packages is a little different

from compiling and running the example in previous lessons. First, you have to execute the compiler and interpreter commands from one directory above the package directories, and second, you have to specify the package directory to the compiler and interpreter commands.

## Compile

These instructions assume development occurs in the `zelda` home directory

### Unix:

```
cd /home/zelda/classes

javac server/Send.java
javac server/RemoteServer.java
javac client2/RMIClient2.java
javac client1/RMIFrenchApp.java
javac client1/RMIGermanApp.java
javac client1/RMIEnglishApp.java
rmic -d . server.RemoteServer
cp server/RemoteServer*.class
    /home/zelda/public_html/classes
cp server/Send.class
    /home/zelda/public_html/classes
cp server/DataOrder.class
    /home/zelda/public_html/classes
```

### Win32:

```
cd \home\zelda\classes

javac server\Send.java
javac server\RemoteServer.java
javac client2\RMIClient2.java
javac client1\RMIFrenchApp.java
javac client1\RMIGermanApp.java
javac client1\RMIEnglishApp.java
rmic -d . server.RemoteServer
copy server\RemoteServer*.class
    \home\zelda\public_html\classes
copy server\Send.class
    \home\zelda\public_html\classes
copy server\DataOrder.class
    \home\zelda\public_html\classes
```

---

**Note:** The `rmic -d . server.RemoteServer` line uses `server.RemoteServer` instead of `server/RemoteServer` so the `_stub` and `_skel` classes are generated properly with the package.

---

## Start rmi Registry:

### Unix:

```
cd /home/zelda/public_html/classes
unsetenv CLASSPATH
rmiregistry &
```

### Win32:

```
cd \home\zelda\public_html\classes
set CLASSPATH=
start rmiregistry
```

## Start the Server

### Unix:

```
cd /home/zelda/public_html/classes

java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=
      server/java.policy server/RemoteServer
```

### Win32:

```
cd \home\zelda\public_html\classes

java -Djava.rmi.server.codebase=
      file:c:\home\zelda\public_html\classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=
      server\java.policy server\RemoteServer
```

**Start RMIGermanApp** Here is the HTML code to load the German applet, Note the directory/package name prefixed to the applet class name (client1/RMIGermanApp.class).

```
<HTML>
<BODY>
<APPLET CODE=client1/RMIGermanApp.class WIDTH=300 HEIGHT=30
</APPLET>
</BODY>
</HTML>
```

To run the applet with appletviewer, invoke the HTML file from the directory just above client1 as follows:

```
cd /home/zelda/classes

appletviewer rmiGapp.html
```

## Start RMIClient2 in French

### Unix:

```
cd /home/zelda/classes

java -Djava.rmi.server.codebase=
      http://kq6py/~zelda/classes
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=client2/java.policy
      client2/RMIClient2 kq6py.eng.sun.com fr FR
```

### Win32:

```
cd \home\zelda\classes

java -Djava.rmi.server.codebase=
      file:c:\home\zelda\public_html\classes
```

```
-Djava.rmi.server.hostname=kq6py.eng.sun.com
-Djava.security.policy=client2\java.policy
  client2\RMIClient2 kq6py.eng.sun.com fr FR
```

## Using JAR Files to Deploy

After testing and debugging, the best way to deploy the two client and serv files is to bundle the executables and other related application files into three separate JAR files, one JAR file for each client program, and one JAR file for the server program.

JAR files use the ZIP file format to compress and pack files into, and decompress and unpack files from, the JAR file. JAR files make it easy to deploy programs that consist of many files. Browsers can easily download applets bundled into JAR files, and the download goes much more quickly than if the applet and its related files were not bundled into a JAR file.

## Server Set of Files

Here are the server files:

- RemoteServer.class
- RemoteServer\_skel.class
- RemoteServer\_stub.class
- Send.class
- DataOrder.class
- java.policy

## Compress and Pack Server Files

To compress and pack the server files into one JAR file, type the following command on one line. This command is executed in the same directory with the files. If you execute the command from a directory other than where the files are, you have to specify the full pathname.

```
jar cf server.jar
  RemoteServer.class
  RemoteServer_skel.class
  RemoteServer_stub.class
  Send.class
  DataOrder.class
  java.policy
```

`jar` is the `jar` command. If you type `jar` with no options, you get the following help screen. You can see from the help screen that the `cf` options to the `jar` command mean create a new JAR file named `server.jar` and put the list of files that follows into it. The new JAR file is placed in the current directory.

```
kq6py% jar
Usage: jar {ctxu}[vfmOM] [jar-file] [manifest-file]
  [-C dir] files ...
Options:
  -c  create new archive
  -t  list table of contents for archive
```

```

-x  extract named (or all) files from archive
-u  update existing archive
-v  generate verbose output on standard output
-f  specify archive file name
-m  include manifest information from specified
    manifest file
-O  store only; use no ZIP compression
-M  Do not create a manifest file for the entries
-C  change to the specified directory and
    include the following file

```

If any file is a directory then it is processed recursively.

The manifest file name and the archive file name needs to be specified in the same order the 'm' and 'f' flags are specified.

Example 1: to archive two class files into an archive called classes.jar:

```
jar cvf classes.jar Foo.class Bar.class
```

Example 2: use an existing manifest file 'mymanifest' and archive all the files in the foo/ directory into 'classes.jar':

```
jar cvfm classes.jar mymanifest -C foo/ .
```

To deploy the server files, all you have to do is move the `server.jar` file a publicly accessible directory on the server where they are to execute.

## Decompress and Unpack Server Files

After moving the JAR file to its final location, the compressed and packed files need to be decompressed and unpacked so you can start the server. The following command means extract (x) all files from the `server.jar` file (f).

```
jar xf server.jar
```

## Fruit Order Set of Files

The fruit order set of files (below) consists of applet classes, web pages, translation files, and the policy file. Because they live on the web, they need to be in a directory accessible by the web server. The easiest way to deploy these files is to bundle them all into a JAR file and copy them to their location.

- RMIEnglishApp.class
- RMIFrenchApp.class
- RMIGermanApp.class
- index.html (top-level web page where user chooses language)
- rmiEapp.html (second-level web page for English)
- rmiFapp.html (second-level web page for French)
- rmiGapp.html (second-level web page for German)
- MessagesBundle\_de\_DE.properties
- MessagesBundle\_en\_US.properties
- MessagesBundle\_fr\_FR.properties
- java.policy

## Compress and Pack Files

```
jar cf applet.jar
    RMIEnglishApp.class
    RMIFrenchApp.class
    RMIGermanApp.class
    index.html
    rmiEapp.html
    rmiFapp.html
    rmiGapp.html
    MessagesBundle_de_DE.properties
    MessagesBundle_en_US.properties
    MessagesBundle_fr_FR.properties
    java.policy
```

To deploy the fruit order client files, copy the `applet.jar` file to its final location.

## Decompress and Unpack Files

An applet in a JAR file can be invoked from an HTML file without being unpacked. All you do is specify the `ARCHIVE` option to the `APPLET` tag in your web page, which tells `appletviewer` the name of the JAR file containing the class file. Be sure to include the package directory when you specify the applet class to the `CODE` option.

You can leave the translation files and policy file in the JAR file. When using `appletviewer`, the applet invoked from the JAR file will find them in the JAR file.

```
<HTML>
<BODY>
<APPLET CODE=client1/RMIFrenchApp.class
    ARCHIVE="applet.jar"
    WIDTH=300
    HEIGHT=300>
</APPLET>
</BODY>
</HTML>
```

However, you do need to unpack the web pages so you can move them to their final location. The following command does this. Everything goes on one line.

```
jar xv applet.jar index.html
    rmiEapp.html
    rmiFapp.html
    rmiGapp.html
```

---

**Note:** To run the HTML files from a browser, you need to unpack the JAR file, copy the `java.policy` file to your home directory and make sure it has the right name (`.java.policy` for Unix and `java.policy` for Windows), and install Java Plug-In.

---

## View Order Set of Files

The view order set of files (below) consists of the application class file and the policy file.

- RMIClient2.class
- java.policy

### Compress and Pack Files

```
jar cf vieworder.jar RMIClient2.class java.policy
```

To deploy the view order client files, copy the `vieworder.jar` file to its final location.

### Decompress and Unpack Files

```
jar xf vieworder.jar
```

### More Information

You can find more information on packages in the [Creating and Using Packages](#) lesson in [The Java Tutorial](#).

You can find more information on these and other JAR file format topics in the [JAR File Format](#) trail in [The Java Tutorial](#).

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# Java™ Programming Language Basics, Part 2

## Lesson 8: Object-Oriented Programming

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You have probably heard a lot of talk about object-oriented programming. And, if the Java™ programming language is your first experience with an object-oriented language, you are probably wondering what all the talk is about.

You already know a little about object-oriented programming because after working the example programs in [Java Programming Language Basics, Part 1](#) and [Part 2](#), you are somewhat familiar with the object-oriented concepts of class, object, instance, and inheritance plus the access levels `public` and `private`. But mostly, you have been doing object-oriented programming without really thinking about it.

And that is one of the great things about the Java programming language. It is inherently object oriented.

To help you gain a deeper understanding of object-oriented programming and its benefits, this lesson presents a very brief overview of object-oriented concepts and terminology as they relate to some of the example code presented in this tutorial.

- [Object-Oriented Programming Defined](#)
- [Classes](#)
- [Objects](#)
- [Well-Defined Boundaries and Cooperation](#)
- [Inheritance](#)
- [Polymorphism](#)
- [Data Access Levels](#)
- [Your Own Classes](#)
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---

## Object-Oriented Programming Defined

Object-oriented programming is a method of programming based on a hierarchy of classes, and well-defined and cooperating objects.

### Classes

A class is a structure that defines the data and the methods to work on that data. When you write programs in the Java language, all program data is wrapped in a class, whether it is a class you write or a class you

use from the Java platform API libraries.

The `ExampleProgram` class from the simple program in the first lesson of Part 1 is a programmer-written class that uses the `java.lang.System` class from the Java platform API libraries to print a character string to the command line.

```
class ExampleProgram {
    public static void main(String[] args){
        System.out.println("I'm a simple Program");
    }
}
```

Classes in the Java platform API libraries define a set of objects that share a common structure and behavior. The `java.lang.System` class used in the example defines such things as standard input, output, and error streams, and access to system properties. In contrast, the `java.lang.String` class defines character strings.

In the example, you do not see an explicit use of the `String` class, but in the Java language, a character string can be used anywhere a method expects to receive a `String` object. During execution, the Java platform creates a `String` object from the character string passed to the `System.out.println` call, but your program cannot call any of the `String` class methods because it did not instantiate the `String` object.

If you want access to the `String` methods, you can rewrite the example program to create a `String` object as follows. This way, you can call a method such as the `String.concat` method that adds text to the original string.

```
class ExampleProgram {
    public static void main(String[] args){
        String text = new String("I'm a simple Program ");
        System.out.println(text);
        String text2 = text.concat(
            "that uses classes and objects");
        System.out.println(text2);
    }
}
```

The output looks like this:

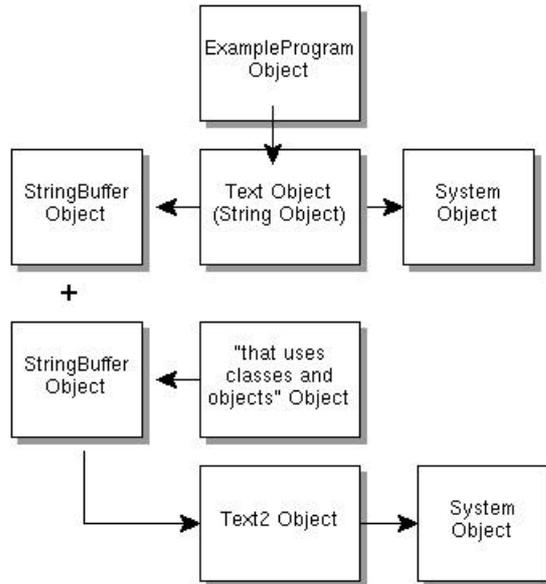
```
I'm a simple Program
I'm a simple Program that uses classes and objects
```

## Objects

An instance is an executable copy of a class. Another name for instance is object. There can be any number of objects of a given class in memory at any one time.

In the last example, four different `String` objects are created for the concatenation operation, `text` object, `text2` object, and a `String` object created *behind the scenes* from the " that uses classes and

objects" character string passed to the `String.concat` method.



Also, because `String` objects cannot be edited, the `java.lang.String.concat` method converts the `String` objects to `StringBuffer` (editable) string objects to do the concatenation.

Besides the `String` object, there is an instance of the `ExampleProgram.java` class in memory as well.

The `System` class is never instantiated by the `ExampleProgram` class because it contains only static variables and methods, and therefore, cannot be instantiated by a program, but it is instantiated *behind the scenes* by the Java™ virtual machine<sup>1</sup> (VM).

## Well-Defined Boundaries and Cooperation

Class definitions must allow objects to cooperate during execution. In the previous section, you saw how the `System`, `String`, and `StringBuffer` objects cooperated to print a concatenated character string to the command line.

This section changes the example program to display the concatenated character string in a `JLabel` component in a user interface to further illustrate the concepts of well-defined class boundaries and object cooperation.

The program code to place the text in a label to display it in a user interface uses a number of cooperating classes. Each class has its own function and purpose as summarized below, and where appropriate, the classes are defined to work with objects of another class.

- `ExampleProgram` defines the program data and methods to work on that data.
- `JFrame` defines the top-level window including the window title and frame menu.

- `WindowEvent` defines behavior for (works with) the Close option on the frame menu.
- `String` defines a character string to create the label.
- `JLabel` defines a user interface component to display static text.
- `JPanel` defines the background color, contains the label, and uses the default layout manager (`java.awt.FlowLayout`) to position the label on the display.

While each class has its own specific purpose, they all work together to create the simple user interface you see here.



```
import javax.swing.*;
import java.awt.Color;
import java.awt.event.*;

class ExampleProgram extends JFrame {

    public ExampleProgram(){
        String text = new String("I'm a simple Program ");
        String text2 = text.concat(
            "that uses classes and objects");

        JLabel label = new JLabel(text2);
        JPanel panel = new JPanel();
        panel.setBackground(Color.white);

        getContentPane().add(panel);
        panel.add(label);
    }

    public static void main(String[] args){
        ExampleProgram frame = new ExampleProgram();

        frame.setTitle("Fruit $1.25 Each");
        WindowListener l = new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        };

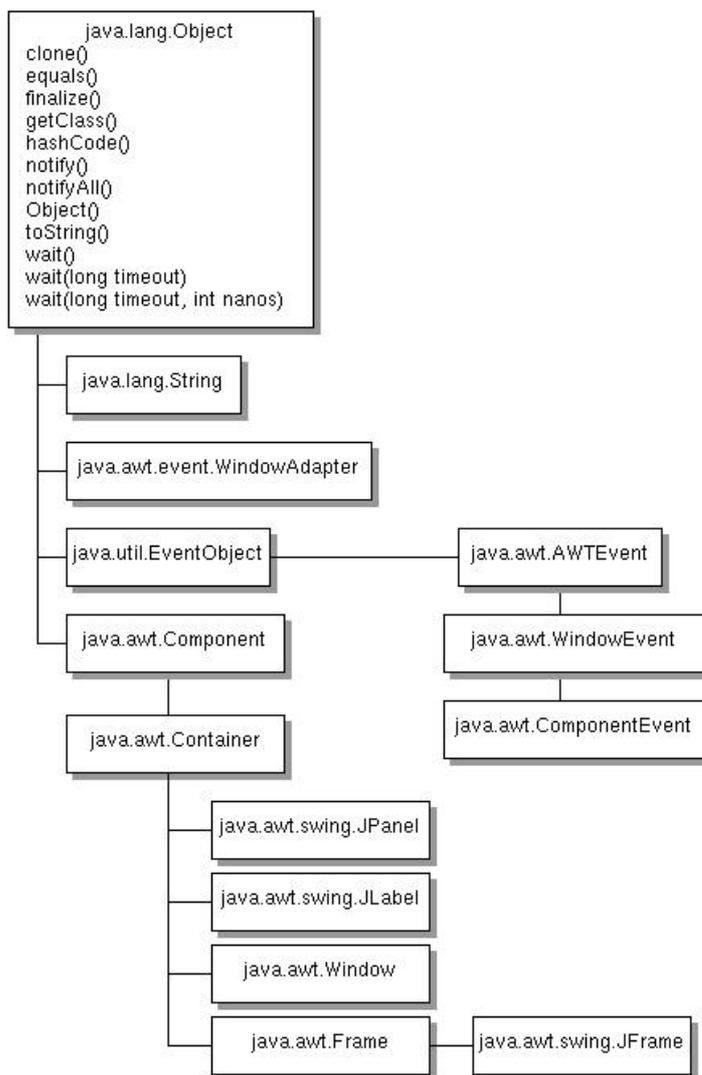
        frame.addWindowListener(l);
        frame.pack();
        frame.setVisible(true);
    }
}
```

## Inheritance

One object-oriented concept that helps objects work together is inheritance. Inheritance defines relationships among classes in an object-oriented language. In the Java programming language, all classes descend from `java.lang.Object` and implement its methods.

The following diagram shows the class hierarchy as it descends from `java.lang.Object` for the classes in the user interface example above. The `java.lang.Object` methods are also shown because they are inherited and implemented by all of its subclasses, which is every class in the Java API libraries. `java.lang.Object` defines the core set of behaviors that all classes have in common.

As you move down the hierarchy, each class adds its own set of class-specific fields and methods to what it inherits from its superclass or superclasses. The `java.awt.swing.JFrame` class inherits fields and methods from `java.awt.Frame`, which inherits fields and methods from `java.awt.Container`, which inherits fields and methods from `java.awt.Component`, which finally inherits from `java.lang.Object`, and each subclass adds its own fields and methods as needed.



## Polymorphism

Another way objects work together is to define methods that take other objects as parameters. You get even more cooperation and efficiency when the objects are united by a common superclass. All classes in the Java programming language have an inheritance relationship.

For example, if you define a method that takes a `java.lang.Object` as a parameter, it can accept any object in the entire Java platform. If you define a method that takes a `java.awt.Component` as a parameter, it can accept any component object. This form of cooperation is called *polymorphism*.

You saw an example of polymorphism in [Part 2, Lesson 5: Collections](#) where a collection object can contain any type of object as long as it descends from `java.lang.Object`. It is repeated here to show you that `Set` collection can add a `String` object and an `Integer` object to the `Set` because the `Set.add` method is defined to accept any class instance that traces back to the `java.lang.Object` class.

```
String custID = "munchkin";
Integer creditCard = new Integer(25);

Set s = new HashSet();
s.add(custID);
s.add(creditCard);
```

## Data Access Levels

Another way classes work together is through access level controls. Classes, and their fields and methods have access levels to specify how they can be used by other objects during execution. While cooperation among objects is desirable, there are times when you will want to explicitly control access, and specifying access levels is the way to gain that control. When you do not specify an access level, the default access level is in effect.

### Classes

By default, a class can be used only by instances of other classes in the same package. A class can be declared `public` to make it accessible to all class instances regardless of what package its class is in. You might recall that in Part 1, [Part 1, Lesson 3: Building Applets](#), the applet class had to be declared `public` so it could be accessed by the appletviewer tool because the appletviewer program is created from classes in another package.

Here is an applet class declared to have a `public` access level:

```
public class DbAppl extends Applet
    implements ActionListener {
```

Without the `public` access level (shown below), its access level is package by default. You get an error when you try to interpret a class with an access level of package with the appletviewer tool. The same is true if the access level is `protected` or `private`.

```
class DbAppl extends Applet
    implements ActionListener {
```

Also, in [Part 2, Lesson 6: Internationalization](#) the server classes are made

public so client classes can access them.

## Fields and Methods

Fields and methods can be declared `private`, `protected`, `public`, or `package`. If no access level is specified, the field or method access level is `package` by default.

`private`: A private field or method is accessible only to the class in which it is defined. In Part 1, [Lesson 7: Database Access and Permissions](#) the connection, user name, and password for establishing the database access are all private. This is to prevent an outside class from accessing them and jeopardizing the database connection, or compromising the secret user name and password information.

```
private Connection c;
```

`protected`: A protected field or method is accessible to the class itself, its subclasses, and classes in the same package.

`public`: A public field or method is accessible to any class of any parentage in any package. In [Part 2, Lesson 6: Internationalization](#) server data accessed by client programs is made public.

`package`: A package field or method is accessible to other classes in the same package.

## Your Own Classes

When you use the Java API library classes, they have already been designed with the above concepts in mind. They all descend from `java.lang.Object` giving them an inheritance relationship; they have well-defined boundaries; and they are designed to cooperate with each other where appropriate.

For example, you will not find a `String` class that takes an `Integer` object as input because that goes beyond the well-defined boundary for a `String`. You will, however, find the `Integer` class has a method for converting its integer value to a `String` so its value can be displayed in a user interface component, which only accepts `String` objects.

But what about when you write your own classes? How can you be sure your classes have well-defined boundaries, cooperate, and make use of inheritance? One way is to look at the functions you need a program to perform and separate them into distinct modules where each functional module is defined by its own class or group of classes.

## Well-Defined and Cooperating Classes

Looking at the [RMIClient2](#) class from the [Part 2, Lesson 5: Collections](#) lesson, you can see it performs the following functions: Get data, display data, store customer IDs, print customer IDs, and reset the display.

Getting data, displaying the data, and resetting the display are closely related and easily form a functional module. But in a larger program with more data processing, the storing and printing of customer IDs could be expanded to store and print a wider range of data. In such a case, it would make sense to have a separate class for storing data, and another class for printing it in various forms.

You could, for example, have a class that defines how to store customer IDs, and tracks the number of apples, peaches, and pears sold during the year. You could also have another class that defines report printing. It could access the stored data to print reports on apples, peaches, and pears sold by the month, per customer, or throughout a given season.

Making application code modular by separating out functional units makes it easier to update and maintain the source code. When you change a class, as long as you did not change any part of its public interface, you only have to recompile that one class.

## Inheritance

Deciding what classes your program needs means separating functions into modules, but making your code more efficient and easier to maintain means looking for common functions where you can use inheritance. If you need to write a class that has functionality similar to a class in the Java API libraries, it makes sense to extend that API library class and use its methods rather than write everything from scratch.

The [RMIClient2](#) class from the [Part 2, Lesson 5: Collections](#) lesson extends `JFrame` to leverage the ready-made functionality it provides for a program's top-level window including, frame menu closing behavior, background color setting, and a customized title.

Likewise, if you want to add customized behavior to an existing class, you can extend that class and add the functionality you want. For example, you might want to create your own `JButton` class with a different look. To do this, you can write your own class that extends `JButton` and implement it to appear the way you want. Then your program can instantiate your button class instead of the `JButton` class whenever you need a button with the new look you created.

## Access Levels

You should always keep access levels in mind when you declare classes, fields, and methods. Consider which objects really need access to the data, and use packages and access levels to protect your application data from all other objects executing in the system.

Most object-oriented applications do not allow other objects to access their fields directly by declaring them private. Then they make their methods protected, public, or package as needed and allow other objects to manipulate their private data by calling the methods only. This way, you can update your class by changing a field definition and the corresponding method implementation, but other objects that access that data do not

need to be changed because their interface to the data (the method signature) has not changed.

## Program Improvements

It is always best to restrict access as much as possible. Going back to [Part 2, Lesson 7: Packages and JAR Files](#), the server classes had to be made `public` and the `DataOrder` class fields also had to be made `public` so the client programs can access them.

At that time, no access level was specified for the other classes and fields so they are all `package` by default. All methods have an access level of `public`.

A good exercise would be to go back to the client classes and give the classes, fields, and methods an access level so they are not accessed inappropriately by other objects.

Here is one possible solution for the [RMIClient1.java](#) and [RMIClient2.java](#) client programs. Can you explain why the `actionPerformed` method cannot be made `private`? If not, make it `private`, run the `javac` command to compile, and see what the compiler has to say about it.

## More Information

You can find more information on Object-oriented programming concepts files in the [Object-Oriented Programming Concepts](#) trail in [The Java Tutorial](#).

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<sup>1</sup> As used on this web site, the terms "Java virtual machine" or "JVM" mean a virtual machine for the Java platform.

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[ This page was updated: 30-Mar-2000 ]

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