Chapter 14: Applets and More

Starting Out with Java: From Control Structures through Objects

Fifth Edition

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Chapter Topics

Chapter 14 discusses the following main topics:

- Introduction to Applets
- A Brief Introduction to HTML
- Creating Applets with Swing
- Using AWT for Portability
- Drawing Shapes
- Handling Mouse and Key Events
- `Timer` Objects
- Playing Audio

Introduction to Applets

- There are two types of programs you can create with Java:
  - applications
  - applets.
- An *application* is a stand-alone program that runs on your computer.
- *Applets* are Java programs that are usually part of a Web site.
- If a user opens the Web site with a Java-enabled browser, the applet is executed inside the browser window.

Introduction to Applets

- It appears to the user that the applet is part of the Web site.
- Applets are stored on a Web server along with the site's Web pages.
- Applets associated with a viewed web page are transmitted to the user's system.
- Once the applets are transmitted, the user's system executes them.
- Applets can be used to extend the capabilities of a Web page.

Introduction to Applets

- Web pages are normally written in Hypertext Markup Language (HTML).
- HTML is static content; whereas, applets are dynamic.
- An applet does not have to be on a web server in order to be executed.
  - They can be stored on the local computer.

Applet Limitations

- Applets run on the user's system, not the server.
- For security purposes, applets can not:
  - access the local computer file system,
  - run any other program on the user's system.
  - execute operating system procedures.
  - retrieve information about the user or their system.
  - make network connections with any system except the server from which the applet was transmitted.
  - run anonymously.
    - If an applet displays a window, it will automatically have a message such as "Warning: Applet Window" displayed in it.

Introduction to HTML

- Hypertext Markup Language (HTML) is the language that Web pages are written in.
  - *Hypertext* can contain a link to other content on the web page, or another web page.
  - A *Markup Language* allows you to "mark up" a text file by inserting special instructions.
    - These instructions tell the browser how to format the text and create any hypertext links.
- To make a web page, create a text file:
  - that contains HTML instructions (known as *tags)*,
  - the text that should be displayed on the Web page, and
  - typically has a .html file extension.

Introduction to HTML

- This document is called an *HTML document*.
- The tags instruct the browser:
  - how to format the text,
  - where to place images,
  - what to do when the user clicks on a link, etc.
- Most HTML tags have an opening tag and a closing tag.
  - `<tag_name>Text</tag_name>`
- The tags are enclosed in angle brackets (< >).
- The closing tag is preceded by a forward slash (/).

Document Structure Tags

- The `<html></html>` tag marks the beginning and ending of an HTML document.
- The tag `<head></head>` marks the *document head*, a section containing information about the document.
- The document head contains the `<title> </title>` tag, which is contains the title of the document.
- Example: BasicWebPage1.html

Document Structure Tags

- After the document head comes the `<body></body>` tag.
- The *document body* contains all of the tags and text that produce output in the browser.
- Example: BasicWebPage2.html

Text Formatting Tags

- There are many HTML tags that you can use to change the appearance of text.
- For example, there are six different header tags.
  - `<h1></h1>` through `<h6></h6>`
- A level one header appears in boldface, and is much larger than regular text.
- A level two header also appears in boldface, but is smaller than a level one header.
- This pattern continues with the other header tags.

Text Formatting Tags

- Many tags allow an *align* attribute to be used to modify where the text shows on the web page:
  - `<h1 align="center">Text</h1>`
  - `<h1 align="left">Text</h1>`
  - `<h1 align="right">Text</h1>`
- An old way of centering text is to use the `<center></center>` tag to center a line of text.
- You can display text:
  - in boldface `<b></b>`, and italics `<i></i>` .
- Example: BasicWebPage3.html

Breaks in Text

- The `<br />` tag causes a line break to appear at the point in the text where it is inserted.
- Browsers usually ignore the newline characters that are created when you press the Enter key.
- The `<p />` tag causes a paragraph break.
  - A paragraph break typically inserts more space into the text than a line break.

Breaks in Text

- The `<hr />` tag causes a horizontal rule to appear at the point in the text where it is inserted.
- A horizontal rule is a thin, horizontal line that is drawn across the web page.
- Example: BasicWebPage4.html

HTML Links

- A link is some element in a Web page that can be clicked on by the user.
- The tag that is used to insert a link has the following general format:
  - `<a href="Address">Text</a>`
- The *Text* that appears between the opening and closing tags is the text that will be displayed in the web page.
- The web resource that is located at *Address* will be displayed in the browser.

HTML Links

- This address is a *uniform resource locator* (*URL*).
- The address is enclosed in quotation marks.
- Example:
  - `<a href="http://www.gaddisbooks.com">Click here to go to the textbook's web site.</a>`
- Example: LinkDemo.html

Creating Applets With Swing

- Applets are very similar to the GUI applications.
- Instead of displaying its own window, an applet appears in the browser's window.
- The differences between GUI application code and applet code are:
  - A GUI application class is derived from `JFrame`.
  - An applet class is derived from `JApplet`.
    - The `JApplet` class is part of the `javax.swing` package.
  - A GUI application class has a constructor that creates other components and sets up the GUI.
  - An applet class does not normally have a constructor.
    - Instead, it has a method named `init` that performs the same operations as a constructor.

Creating Applets With Swing

- The differences are (continued):
  - The following methods are not called in an applet:
    - `super`
    - `setSize`
    - `setDefaultCloseOperation`
    - `pack`
    - `setVisible`
  - No `main` method is needed to create an `Applet` object.
    - The browser creates an instance of the class automatically.
- Example:
  - SimpleApplet.java
  - SimpleApplet.html

Running an Applet

- The process of running an applet is different from that of running an application.
- To run an applet, create an HTML document with an `APPLET` tag, which has the following general format:

```
<applet
  code="Filename.class"
  width="width_value"
  height="height_value"></applet>
```

- Don't forget the closing angle bracket.
- Attributes should be enclosed in quotes.

Running an Applet

- *Filename.class* is the compiled bytecode of the applet, not the `.java` file.
- You can optionally specify a path along with the file name.
- If you specify only the file name, it is assumed that the file is in the same directory as the HTML
- The browser:
  - loads specified byte code, and
  - executes it in an area that is the size specified by the *width_value* and *height_value*.

Using `appletviewer`

- The `appletviewer` program loads and executes an applet without the need for a Web browser.
- When running the program, specify the name of an HTML document as a command line argument.

```
appletviewer SimpleApplet.html
```

- This command executes any applet referenced by an `APPLET` tag in the file *SimpleApplet.html*.
- If the document has more than one `APPLET` tag, it will execute each applet in a separate window.

Applet Event Handling

- Events in applets are handled with event listeners exactly as they are in GUI applications.
- Example:
  - TempConverter.java
  - TempConverter.html

Using AWT for Portability

- AWT is the original library that has been part of Java since its earliest version.
- Swing is an improved library that was introduced with Java 2.
- Some browsers do not directly support the Swing classes in applets.
- These browsers require a *plug-in* to run swing applets.
- This plug-in is automatically installed on a computer when the Java SDK is installed.

Using AWT for Portability

- Other people running applets might not have the required plug-in.
- The AWT classes can be used instead of the Swing classes for the components in the applet.
- The AWT component classes:
  - there is a corresponding AWT class for each of the Swing classes covered so far.
  - The names of the AWT classes names do not start with the letter J.
- Example:
  - AWTTempConverter.java, TempConverter.html

Drawing Shapes

- Components have an associated `Graphics` object that may be used to draw lines and shapes.
- Java allows drawing of lines and graphical shapes such as rectangles, ovals, and arcs.
- Frame or panels can become a canvas for your drawings.

XY Coordinates

- The location of each pixel in a component is identified with an *X* coordinate and a *Y* coordinate.
- The coordinates are usually written in the form (*X*, *Y*).
- Unlike Cartesian coordinates, the upper-left corner of a drawing area (0, 0).
- The *X* coordinates increase from left to right, and the *Y* coordinates increase from top to bottom.
- When drawing a line or shape on a component, you must indicate its position using *X* and *Y* coordinates.

`Graphics` Objects

- Each component has an internal object that is derived from the `Graphics` class, which is part of the `java.awt` package.
- This object has numerous methods for drawing graphical shapes on the surface of the component.

`Graphics` Objects

- Some of the methods of the `Graphics` class:
  - `setColor(Color c)` – Sets the drawing color for this object.
  - `getColor()` – Returns the current drawing color for this object.
  - `drawLine(int x1, int y1, int x2, int y2)` – Draws a line on the component
  - `drawRect(int x, int y, int width, int height)` – Draws the outline of a rectangle on the component.
  - `fillOval(int x, int y, int width, int height)` – Draws a filled oval.
  - `drawString(String str, int x, int y)` – Draws the string passed into *str* using the current font.

`Graphics` Objects

- In order to call these methods, you must get a reference to a component's `Graphics` object.
- One way to do this is to override the `paint` method.
- You can override the `paint` method in any class that is derived from:
  - `JApplet`
  - `JFrame`
  - Any AWT class
- The `paint` method is responsible for displaying, or "painting," a component on the screen.

`Graphics` Objects

- The `paint` method is automatically called
  - when the component is first displayed and
  - any time the component needs to be redisplayed.
- The header for the `paint` method is:

```
public void paint(Graphics g)
```

- The method's argument is a `Graphics` object, which is automatically passed by the calling component.
- Overriding the `paint` method, allows drawing of graphics on the `Graphics` object argument.
  Example: LineDemo.java, LineDemo.html

`Graphics` Objects

- The `Graphics` object argument is responsible for drawing the entire applet window.
- It is advisable to call the base class paint method passing the `Graphics` object, `g`, as an argument:

```
super.paint(g);
g.setColor(Color.red);
g.drawLine(20, 20, 280, 280);
```

- This is a red diagonal line drawn from the top-left area of the applet window to the bottom-right area.

Rectangles

- Rectangles can be drawn or filled.

```
g.drawRect(10, 10, 50, 50);
g.fillRect(10, 10, 50, 50);
```

- The `fillRect` and `drawRect` take four integers as parameters:

```
drawRect(int x, int y, int width, int height)
```

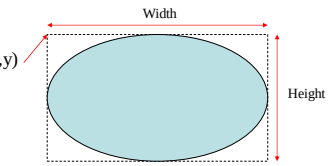
- Example:
  - RectangleDemo.java
  - RectangleDemo.html

Ovals and Bounding Rectangles

- Ovals are created by drawing the oval inside of a "bounding rectangle".
- This rectangle is invisible to the viewer of the `Graphics` object.

```
g.fillOval(x, y, width, height);
```

Example:
OvalDemo.java
OvalDemo.html



Arcs

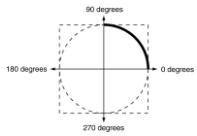
- Arcs are drawn from the 90 degree position counterclockwise and can be filled or unfilled

```
g.drawArc(0, 20, 120, 120, 0, 90);
g.fillArc(0, 20, 120, 120, 0, 90);
```

- The `fillArc` and `drawArc` take six integers as parameters:

```
drawArc(int x, int y, int width, int height, int
  start, int end)
```

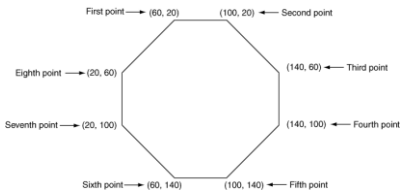
- Example:
  - ArcDemo.java
  - ArcDemo.html



Polygons

- Polygons are drawn using arrays of integers representing x, y coordinates

```
int[]xCoords={60,100,140,140,100,60,20,20};
int[]yCoords={20,20,60,100,140,140,100,60};
```



Polygons

- The `fillPolygon` and `drawPolygon` use the arrays as parameters:
- Example:
  - PolygonDemo.java
  - PolygonDemo.html

The `repaint` Method

- We do not call a component's `paint` method.
- It is automatically called when the component must be redisplayed.
- We can force the application or applet to call the `paint` method.

```
repaint();
```

- The `repaint` method clears the surface of the component and then calls the `paint` method.

Drawing on Panels

- To draw on a panel, get a reference to the panel's `Graphics` object and use that object's methods.
- The resulting graphics are drawn only on the panel.
- Getting a reference to a `JPanel` component's `Graphics` object is similar to previous examples.
- Instead of overriding the `JPanel` object's `paint` method, override its `paintComponent` method.
- This is true for all Swing components except `JApplet` and `JFrame`.

Drawing on Panels

- The `paintComponent` method serves the same purpose as the `paint` method.
- When it is called, the component's `Graphics` object is passed as an argument.

```
public void paintComponent(Graphics g)
```

- When overriding this method, first call the base class's `paintComponent` method.

```
super.paintComponent(g);
```


Drawing on Panels

- After this you can call any of the `Graphics` object's methods to draw on the component.
- Example:
  - GraphicsWindow.java,
  - DrawingPanel.java,
  - GraphicsWindow.html

Handling Mouse Events

- The mouse generates two types of events:
  - mouse events and mouse motion events.
- Any component derived from the `Component` class can handle events generated by the mouse.
- To handle mouse events you create:
  - a *mouse listener* class and/or
  - a *mouse motion listener* class.

Handling Mouse Events

- A mouse listener class can respond to any of the follow events:
  - The mouse button is pressed.
  - The mouse button is released.
  - The mouse button is clicked on (pressed, then released without moving the mouse).
  - The mouse cursor enters a component's screen space.
  - The mouse cursor exits a component's screen space.
- A mouse listener class must implement the `MouseListener` interface.

Mouse Listener Methods

- `public void mousePressed(MouseEvent e)`
  - called if the mouse button is pressed over the component.
- `public void mouseClicked(MouseEvent e)`
  - called if the mouse is pressed and released over the component without moving the mouse.
- `public void mouseReleased(MouseEvent e)`
  - called when the mouse button is released.
- `public void mouseEntered(MouseEvent e)`
  - called when the mouse cursor enters the screen area of the component.
- `public void mouseExited(MouseEvent e)`
  - This method is called when the mouse cursor leaves the screen area of the component.

Mouse Events

- The `MouseEvent` object contains data about the mouse event.
- `getX` and `getY` are two common methods of the `MouseEvent` class.
- They return the *X* and *Y* coordinates of the mouse cursor when the event occurs.
- Once a mouse listener class is created, it can be registered with a component using the `addMouseListener` method

Mouse Motion Events

- The appropriate methods in the mouse listener class are automatically called when their corresponding mouse events occur.
- A mouse motion listener class can respond to the following events:
  - The mouse is dragged
  - The mouse moved.
- A mouse motion listener class must implement the `MouseMotionListener` interface and it's methods.

Mouse Motion Listener Methods

- `public void mouseDragged(MouseEvent e)`
  - called when a dragging operation begins over the component.
    - The `mousePressed` method is always called just before this method.
- `public void mouseMoved(MouseEvent e)`
  - called when the mouse cursor is over the component and it is moved.
- Example:
  - MouseEvents.java
  - MouseEvents.html

Using Adapter Classes

- The mouse listener class must implement ***all*** of the methods required by the interfaces they implement.
- If any of the methods are omitted, a compiler error results.
- The `MouseAdapter` and `MouseMotionAdapter` classes provide empty implementations of the methods.
- They can serve as base classes for mouse listener and mouse motion listener classes.
- Examples: DrawBoxes.java, DrawBoxes.html, DrawBoxes2.java, DrawBoxes2.html

`Timer` Objects

- `Timer` objects automatically generate action events at regular time intervals.
- This is useful when you want a program to:
  - perform an operation at certain times or
  - after an amount of time has passed.
- `Timer` objects are created from the `Timer` class.
- The general format of the `Timer` class's constructor:

```
Timer(int delay, ActionListener listener)
```


`Timer` Objects

- The *`delay`* parameter is the amount of time between action events in milliseconds.
- The the *`listener`* parameter is a reference to an action listener to be registered with the `Timer` object.
  - Passing `null` will cause no action listener to be registered.
  - the `Timer` object's `addActionListener` method can register an action listener after the object's creation.

`Timer` Object Methods

- `void addActionListener (ActionListener listener)`
  - Registers the object referenced by *`listener`* as an action listener.
- `int getDelay()`
  - Returns the current time delay in milliseconds.
- `boolean isRunning()`
  - Returns true if the `Timer` object is running.
- `void setDelay(int delay)`
  - Sets the time delay in milliseconds.
- `void start()`
  - Starts the `Timer` object.
- `void stop()`
  - Stops the `Timer` object.

`Timer` Object Methods

- An application can use a `Timer` object to automatically execute code at regular time intervals.
- Example:
  - BouncingBall.java
  - BouncingBall.html

Playing Audio

- Java programs can play audio that is stored in a variety sound file formats.
  - .aif or .aiff (Macintosh Audio File)
  - .au (Sun Audio File)
  - .mid or .rmi (MIDI File)
  - .wav (Windows Wave File)
- One way to play an audio file is to use the `Applet` class's `play` method.
- One version of this method is:
  - **`void play(URL baseLocation, String fileName)`**

Playing Audio

- The argument passed to *`baseLocation`* is a `URL` object that specifies the location of the file.
- The argument passed to *`fileName`* is and name of the file.
- The sound that is recorded in the file is played one time.
- The `getDocumentBase` or `getCodeBase` methods can get a `URL` object for the first argument.

Playing Audio

- The `getDocumentBase` method returns a `URL` object containing the location of the HTML file that invoked the applet.

```
play(getDocumentBase(), "mysound.wav");
```

- The `getCodeBase` method returns a `URL` object containing the location of the applet's .class file.

```
play(getCodeBase(), "mysound.wav");
```

- If the sound file specified by the arguments to the play method cannot be found, no sound will be played.

Using an `AudioClip` Object

- The `Applet` class's play method:
  - loads a sound file,
  - plays it one time, and
  - releases it for garbage collection.
- If you need to load a sound file to be played multiple times, use an `AudioClip` object.
- An `AudioClip` object is an object that implements the `AuidoClip` interface.

Using an `AudioClip` Object

- The `AudioClip` interface specifies the following three methods:
  - `play` – plays a sound one time.
  - `loop` – repeatedly plays a sound.
  - `stop` – causes a sound to stop playing.
- The `Applet` class's `getAudioClip` method can be used to create an `AudioClip` object:

```
AudioClip getAudioClip(URL baseLocation,
                       String fileName)
```

- The method returns an `AudioClip` object that can be used to play the sound file.
- Example: AudioDemo2.java, AudioDemo2.html

Playing Audio in an Application

- Playing audio in from a `JFrame` is slightly different than playing audio from an applet.

```
// Create a file object for the step.wav file.
File file = new File("step.wav");

// Get a URI object for the audio file.
URI uri = file.toURI();

// Get a URL for the audio file.
URL url = uri.toURL();

// Get an AudioClip object for the sound
// file using the Applet class's static
// newAudioClip method.
sound = Applet.newAudioClip(url);
```

Example: AudioFrame.java

