



GLG Programming Tutorial for Java

*GLG Toolkit
Version 3.2*

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GLG Programming Tutorial for Java



Overview

The GLG Toolkit provides a 100% pure Java class library that allows the user to load, display and animate GLG drawings in a Java application. A GLG drawing can be created in the GLG Graphics Builder or programmatically. It may contain predefined GLG components from the GLG Widgets catalog, such as graphs, gauges, meters, or custom graphics created by the user.

A GLG Java application can be written as a stand-alone Java program or as an applet. To display GLG graphics, an application creates a GLG bean that can be used either as a top level applet or as a Java bean inside another Java component. Examples of using the GLG bean in both cases appear later in this tutorial, as well as in the examples directory `<glg_dir>/examples_java`.

The GLG Toolkit for Java supports Swing and Java2D.

Types of Glg beans

There are several types of the GLG Bean class provided.

GlgJBean

Heavyweight Swing-based Java bean and applet, subclassed from *JApplet*.

GlgJLWBean

Lightweight Swing-based Java bean for use with *JDesktopPane* and *JInternalFrame*.

GlgBean

An AWT-based Java bean and applet, subclassed from *Applet*.

All GLG Bean classes have the same GLG-inherited interface and differ only in the methods inherited from their respective Swing or AWT superclasses. The Swing and AWT-based GLG beans should not be intermixed in one application.

All GLG Bean components are recognized by Java IDEs. They may be directly inserted into an application or subclassed (as seen in our demos and examples of this tutorial) to create custom components with additional functionality.

Since all GLG Bean classes have the same functionality, this tutorial uses the generic term *GlgBean* for all of them, regardless of the actual flavor of the bean used.

Classes and Packages

The Toolkit provides GLG jar files containing the **com.genlogic** package which includes the entire GLG programming API for GLG Java classes. The main GLG classes are the ***GlgObject*** class and the **GLG Bean** classes (*GlgJBean*, *GlgJLWBean* or *GlgBean*). Both classes provide GLG API and

GLG Extended API methods. A few utility classes, such as *GlgPoint*, *GlgCube*, *GlgTraceData*, provide some convenient functionality. The rest of the classes (*GlgArc*, *GlgPolygon*, etc.) extend the generic *GlgObject* class, providing constructors for creating GLG objects of different types.

The *GlgObject* class is a generic GLG superclass that provides API methods for all GLG objects. The GLG bean classes (*GlgJBean*, *GlgJLWBean*, *GlgBean*) provide the same set of methods as those for the *GlgObject* class. While the *GlgObject* methods have to be invoked for individual objects, the bean provides a central location for invoking methods involving any object or resource.

The standard API provides methods for loading, displaying and animating the drawing, handling user interaction, and setting and querying resource values. The Extended API provides methods for creating and adding objects to the drawing programmatically, as well as programmatic access to object manipulation.

Jar File Usage

The GLG API package must be included in all GLG Java programs as follows:

```
import com.genlogic.*;
```

To compile GLG Java programs, the **CLASSPATH** environment variable should include one of the following GLG jar files:

For the evaluation version of the Toolkit

GlgCE.jar Standard and Extended API for the GLG Bean

GlgServerCE.jar Standard and Extended API for the JSP Servlet

For the production version of the Toolkit

Glg2.jar Standard API for the GLG Bean

GlgExt2.jar Standard and Extended API for the GLG Bean

GlgServer.jar Standard and Extended API for the JSP Servlet

The GLG jar files for the evaluation version are located in the `<glg_dir>/eval/lib` directory, and for the production version in the `<glg_dir>/lib` directory.

For example, to use the evaluation version of the Toolkit, the **CLASSPATH** environment variable should be set as follows:

on Windows in the MSDOS prompt,

```
set CLASSPATH=.;<glg_dir>\eval\lib\GlgCE.jar
```

on Unix,

```
export CLASSPATH=.:<glg_dir>/eval/lib/GlgCE.jar
```

To run GLG Java demos, the **GlgDemo.jar** file should also be added to the CLASSPATH environment variable. GlgDemo.jar contains the classes for all GLG Java demos and is located in the `<glg_dir>/DEMOS/java_demos/java2` directory. This directory also contains the GlgCE.jar file and the demo drawings.

For example, to run the GLG Java demos on Windows, set the CLASSPATH environment variable as follows:

```
cd <glg_dir>\DEMOS\java_demos\java2
set CLASSPATH=.;.\GlgDemo.jar;.\GlgCE.jar
```

To run the demos on Unix/Linux:

```
cd <glg_dir>/DEMOS/java_demos/java2
set CLASSPATH=../GlgDemo.jar:../GlgCE.jar
```

Another example:

If the production version of the Toolkit is being used with the GLG Standard API, set the CLASSPATH environment variable as follows.

on Windows in the MSDOS prompt,

```
set CLASSPATH=.;<glg_dir>\lib\Glg2.jar
```

on Unix,

```
export CLASSPATH=../<glg_dir>/lib/Glg2.jar
```

1. Structure of Typical GLG Java Application

The structure of a typical GLG Java application proceeds as follows.

- Adding the *GlgBean* to an application interface.
- Loading and displaying a drawing in the *GlgBean*.
- Initializing the drawing.
- Handling dynamic updates.
- Handling user interaction, including the selection of objects and interacting with GLG control widgets.

Each of these steps, including code samples and detailed explanation, is described in detail later in this tutorial.

Before plunging into the technical details of these steps, let us examine the general model of a GLG application. A typical GLG application loads and displays one or more GLG drawings, animates the drawings with dynamic data and responds to user interaction. The Java version of the GLG Toolkit is both data and event driven.

When the application's data changes, the Toolkit's resource mechanism is used to set new values for the drawing's resources. New data values may be used to control the attributes or dynamics of the drawing's objects, or the values may be displayed in a GLG graph widget. The Toolkit automatically updates the drawing to reflect the new data values, handling all aspects of attribute changes, dynamics recalculation, damage repair and double buffering.

The Toolkit automatically handles most low-level Java events. When a user interacts with a GLG drawing, the low-level events are converted into high-level GLG events, such as input or selection events, and then passed to the application for processing.

There are several types of user input events. The *Input* event is generated when the user interacts with input widgets, such as buttons, toggles, knobs and sliders. The *Object Selection* and *Custom* events are generated when the user selects objects with mouse button or moves the mouse over them. All events are passed to the application's listeners, which are responsible for processing them.

Adding GlgBean to an Application Interface

A *GlgBean* may be used in various ways in a Java application.

- as a Java bean component in a stand-alone Java application.
- as a top level applet;
- as a Java bean component inside another applet;

Using GlgBean in a Stand-alone Java Program

To use a GlgBean in a stand-alone Java program, the GlgBean should be created and added to the application interface. Once a GlgBean object has been created, the *SetDrawingName* method can be used to specify a drawing filename to be displayed in the GlgBean.

Below is an example of a GlgBean being added to a *Frame* and a drawing name, “bar1.g,” set to be displayed in the GlgBean:

```
public static void main( String arg[] )
{
    // Use invokeLater to create all interface components synchronously
    // with the event thread.
    SwingUtilities.invokeLater( new Runnable()
        { public void run() { Main( arg ); } } );
}

public static void Main( final String arg[] )
{
    ....
    JFrame frame = new JFrame();
    frame.setResizable( true );
    frame.setSize( 600, 400 );

    // Create a GlgBean component
    GlgJBean glg_bean = new GlgJBean();

    // Set a GLG drawing name to be displayed in a GLG bean
    glg_bean.SetDrawingName( "bar1.g" );

    // Add glg_bean component to a frame
    frame.getContentPane().add( glg_bean );
    frame.show();
}
```

The path to the drawing filename is relative to the current directory. The details of specifying a drawing to be displayed in a GlgBean are described in the *Loading and Displaying a Drawing* section on page 13.

Examples of using a GlgBean in a stand-alone Java program may be found in the `<glg_dir>/examples_java` directory. Please refer to the README file in that directory for a description of each example.

Using GlgBean as an Applet

To use a GlgBean as a top level applet, an application should subclass a GlgBean class as follows.

```
public class GlgGraphApplet extends GlgJBean implements ActionListener
{
    //...
}
```

The *ActionListener* interfaces is optional and is used to implement an update timer for animating the bean with dynamic data.

A GLG drawing displayed in the applet can be specified either as a **DrawingURL** parameter in the *.html* file or set directly in the code.

The following example shows the use of the DrawingURL parameter in the *.html* file:

```
<param NAME=DrawingURL VALUE=bar1.g>
```

Unless an absolute path is used, the name of the drawing URL is relative to the applet's document base directory.

Alternatively, to specify the drawing to be displayed in the Java code, the GlgBean's **SetDrawingURL** method can be used. The following example shows how to invoke SetDrawingURL from the applet's *start* method:

```
public class GlgGraphApplet extends GlgJBean implements ActionListener
{
    ...
    // Invoked by the browser to start the applet
    public void start()
    {
        SetDrawingURL( "bar1.g" );
        //...
    }
}
```

In both cases, unless an absolute path is used, the drawing URL is relative to the applet's document base directory.

For details, refer to the *Loading and Displaying a Drawing* section on page 13.

The GlgGraphApplet.java example, located in the `<glg_dir>/examples_java` directory, demonstrates the usage of a GlgBean as a top level applet.

Using GlgBean as a Component of an Applet

The following code sample demonstrates how to add a GlgBean as a component to another applet.

```
public class GlgGraphComponent extends JApplet
{
    GlgJBean glg_bean;

    //Constructor
    public GlgGraphComponent()
    {
        setLayout( new GridLayout( 1, 1 ) );
        glg_bean = new GlgJBean();
        add( glg_bean );
    }

    // Invoked by the browser to start the applet
    public void start()
    {
        super.start();
        glg_bean.SetParentApplet( this );
        glg_bean.SetDrawingName( "bar1.g" );
    }
    //...
}
```

In the above code, the *SetDrawingName* method is used to specify the drawing to be displayed in the GlgBean. In this case, the *SetDrawingURL* method could have been used as well, since the GlgBean is used inside an applet, where the drawing is specified as a URL. *SetDrawingName* is a generic method which can be used in a stand-alone program as well as in a web environment. If *SetDrawingURL* is used to set the drawing, an absolute URL path can be specified instead of a local one.

If a relative path is used to set the drawing name, the GlgBean must know what its parent applet is in order to retrieve information about the applet's *DocumentBase* directory, which is used by the GlgBean to load the drawing. As shown in the code sample above, GlgBean's *SetParentApplet* method should be used to set a parent applet for the GlgBean.

For details, refer to the *Loading and Displaying a Drawing* section on page 13.

Subclassing GlgBean

In addition to the standard GlgBean methods, the GlgBean class may be subclassed to provide additional custom functionality. Subclassing the GlgBean may be very convenient for creating custom beans that display graphics and encapsulate graphical and user interaction functionality. Such beans may be used as custom components in the application.

There are two GLG beans available for Swing applications: a *heavyweight GlgJBean*, or a *lightweight GlgJLWBean*. The advantages and disadvantages of using a heavyweight GLG bean as opposed to a lightweight bean is described in the *Using GLG Components in Java2* chapter. For AWT applications, *GlgBean* class is provided. The technique of subclassing the *GlgJBean*, *GlgJLWBean* and *GlgBean* is identical. Therefore all examples in this chapter refer only to the GlgJBean class, regardless of the GLG bean flavor actually used.

The following sample code illustrates how to subclass a `GlgBean` and add a new `GlgGraphClass` component to an applet.

```
public class GlgSubclassExample extends JApplet
{
    // Custom component to display and update a GLG graph
    GlgGraphClass graph_component;

    // Constructor
    public GlgSubclassExample()
    {
        ...
        // Create a custom component and add it to the applet
        graph_component = new GlgGraphClass();
        add( graph_component );
    }

    // Invoked by the browser to start the applet
    public void start()
    {
        // Define parent applet for the custom graph component
        graph_component.SetParentApplet( this );
    }

    // Class definition for a custom component.
    class GlgGraphClass extends GlgJBean implements ActionListener
    {
        // Constructor
        public GlgGraphClass()
        {
            // Set the drawing by specifying its name.
            SetDrawingName( "bar1.g" );
        }

        // Ready callback to place initialization code
        public void ReadyCallback( GlgObject viewport )
        {
            // Start periodic dynamic updates
            StartUpdates();
            //...
        }

        // Input callback to handle user interaction
        public void InputCallback( GlgObject viewport,
                                   GlgObject message_obj )
        {
            //...
        }
    }
}
```

```
// Update procedure to update the graph with random data.
// Invoked by a timer.
void UpdateGraphProc()
{
    // Push next data value into a graph
    SetDResource( "DataGroup/EntryPoint", GetData() );
    Update();
    //...
}
}
```

The name of the drawing may be specified in the constructor of the inherited class, as shown in the above code sample. The drawing name is relative to the current directory, if running a stand-alone Java program, or to the document base directory if a custom GLG component is being used inside an applet. The document base directory of a parent applet must be passed to the custom component using `GlgBean`'s ***SetParentApplet*** method. As shown in the above sample code, this can be done in the start method of the parent applet.

A custom GLG component may also handle the dynamic updates occurring in the GLG drawing so that all graphical functionality is encapsulated in one class. As shown in the above code sample, periodic dynamic updates may be started in the *Ready* callback using a *timer*. In this code sample, *StartUpdates* is a generic method used to accomplish this. Dynamic updates are handled in the *UpdateGraphProc* method.

An example of subclassing a GLG bean may be found in `GlgSubclassExample` located in the `<glg_dir>/examples_java` directory.

Loading and Displaying a Drawing

A GLG drawing to be displayed in the `GlgBean` may be created in the `GlgBuilder` or programmatically using the GLG Extended API.

A GLG viewport object, which is an encapsulation of a native window object, is used as a drawing surface for drawing graphics. The viewport is a composite object that contains other GLG graphical objects, such as polygons, arcs, text and others, including embedded viewports.

To display a GLG drawing in the `GlgBean`, the drawing must contain a viewport at the top of the hierarchy named **\$Widget**, which is used by the `GlgBean` as a top level viewport. Most predefined GLG components, such as graphs and controls, contain a *\$Widget* viewport, allowing them to be displayed in the `GlgBean` without modification. However, if these components are inserted into other GLG drawings to create custom panels, the *\$Widget* viewport of each component should be renamed so that there is only one top level viewport in the drawing named "\$Widget". For example, if the drawing contains two controls, their viewports could be named "Control1" and "Control2", whereas the drawing's top level viewport should be named *\$Widget*.

For details on using a viewport object and creating nested viewports and custom panels, refer to the "GLG Builder and Animation Tutorial".

A GLG Java application may need to display multiple GLG components, which can vary from individual widgets, such as graphs and controls, to complex graphical displays. An application may use two approaches.

1. An application can contain one GlgBean that displays a GLG drawing composed of multiple GLG components (graphs, controls, dynamic graphical objects, etc.). Such a GLG drawing may be created in the GlgBuilder and then loaded in the program to be displayed in the GlgBean. An example may be found in the GlgControlPanel example located in the `<glg_dir>/examples_java` directory.
2. An application can create multiple GLG beans, each displaying a separate GLG drawing or component. For example, each control or graph is displayed in a separate GlgBean. An example of creating multiple GLG beans may be found in the GlgControlBean example located in the `<glg_dir>/examples_java` directory.

Certainly, an application may also use a combination of the above approaches.

To define a GLG drawing to be displayed in the GlgBean, an application may use the following methods:

- use the **DrawingURL** parameter in the `.html` file if the GlgBean is used as a top level applet;
- set the drawing name in the application code.

If the GlgBean is used as a top level applet, GlgBean's *DrawingURL* parameter may be used in the `.html` file to specify a GLG drawing:

```
<param NAME=DrawingURL VALUE=bar1.g>
```

If a full path is not specified, the drawing URL is assumed to be relative to the applet's document base directory.

To specify the drawing to be displayed in the Java code, one of the following GlgBean methods can be used:

SetDrawingURL(drawing_url)

SetDrawingFile(filename)

SetDrawingName(drawing_name)

The **SetDrawingURL** method takes a URL as an argument, which can be either a full URL path or a URL relative to the current document base. This method can be used if GlgBean is a top level applet or a component inside another applet.

The **SetDrawingFile** method assumes filename, the argument it is passed, is the name of the drawing file on the local system. The filename can be specified using an absolute or pathname relative to the current directory. The "file://..." notation may be used to specify the drawing, but in this case, the **SetDrawingURL** method should be used instead of **SetDrawingFile**. The **SetDrawingFile** method can be used only in a stand-alone Java program.

Regardless of how the `GlgBean` is used, ***SetDrawingName*** may be used as a generic method for setting the drawing to be displayed in the bean. The Toolkit determines how to interpret the passed drawing name depending on its usage. Unless a full URL path or filename is specified, the name is assumed to be relative to the applet's document base directory or the current directory on the local system.

For example, to set the drawing name to be displayed in the Java code, regardless of whether the `GlgBean` is used on the web or in a stand-alone program, the ***SetDrawingName*** method can be used, as shown in the code sample below.

If the `GlgBean` is used as a Java Bean component within another applet, the `GlgBean` has to know what the current document base is to determine a full path for the drawing name. To retrieve the document base, the `GlgBean` provides the ***SetParentApplet*** method to pass the parent applet to the `GlgBean`.

These methods may be placed in the applet's *start* method which is invoked by the browser when the applet is started. The drawing name should be unset in the applet's *stop* method to perform a cleanup and destroy the drawing.

```
public class GlgGraphComponent extends JApplet implements
        ActionListener
{
    GlgJBean glg_bean;
    //...
    // Invoked by the browser to start the applet
    public void start()
    {
        super.start();
        glg_bean.SetParentApplet( this );
        glg_bean.SetDrawingName( "bar1.g" );
    }

    // Invoked by the browser to stop the applet.
    public void stop()
    {
        // Unset the drawing
        glg_bean.SetDrawingName( null );
        super.stop();
    }
}
```

If the `GlgBean` is used in a stand-alone Java program, the drawing name may be set in the `main()` method. Please refer to the Java examples located in the `<glg_dir>/examples_java` directory for complete source code.

When the drawing name is set using any of the above methods, a few steps take place internally in the Toolkit:

- the drawing is loaded from a URL or file and the *\$Widget* viewport is extracted;
- the hierarchy, including the creation of graphs' *DataSamples*, is set up for the GLG objects in the drawing,
- the drawing is drawn the first time upon receiving a paint event.

A GLG Java application, like any other Java application, is event driven, which means the above steps are completed when certain events are processed. When calling the *SetDrawingName* method, the drawing name is set for the *GlgBean*, but the drawing may not be loaded right away. Instead, it may wait for particular events to occur. An application should wait for certain events and not expect a drawing and its contents to be set up and available immediately after the call to *SetDrawingName*. To be notified when these events occur, the *GlgBean* provides various interfaces for event listeners. For example, to set its initial drawing parameters, an application may add a listener to be invoked after the drawing is loaded but before it gets drawn for the first time.

Various *GlgBean* listeners are discussed in the *Initializing the Drawing* section and the *Handling User Interaction* section.

The methods described above rely on event processing. If complete control of loading is required, for accessibility without waiting for events to be processed, the drawing can be loaded directly using the *GlgObject.LoadWidget* method. This method returns the drawing's top level viewport which can be attached to the *GlgBean* using the *SetDrawingObject* method, which can also be used if the drawing is to be created programmatically.

The following code sample illustrates the usage of these methods:

```
public class GlgGraphComponent extends JApplet implements
        ActionListener
{
    GlgJBean glg_bean;
    GlgObject viewport;
    //...
    // Invoked by the browser to start the applet
    public void start()
    {
        super.start();

        // Load GLG drawing from a URL and attach its viewport to the
        // glg_bean.
        viewport = GlgObject.LoadWidget( drawing_url, GlgObject.URL);
        glg_bean.SetDrawingObject( viewport );
    }

    public void stop()
    {
        // Unset the drawing.
        glg_bean.SetDrawingObject( null );
        super.stop();
    }
}
```

The *GlgObject.LoadWidget* method loads a GLG drawing and returns the object ID of the viewport named *\$Widget*. The *SetDrawingObject* method attaches the viewport to the *GlgBean*. Upon execution of these methods, the drawing is loaded and the hierarchy setup is complete. Its contents become accessible and it will be painted upon the reception of a paint event.

Initializing the Drawing

Often, an application needs to set or modify its objects' attributes before the drawing is drawn for the first time. The initial attributes of a drawing may be set after the drawing has been painted for the first time, but it would cause flickering since the drawing has to be repainted to reflect the new settings. To avoid this, the initial parameters may be set after the drawing is loaded but before it is initially drawn.

When a GLG drawing is loaded, the hierarchy of the GLG objects is set up before the drawing is displayed. GLG objects can contain any number of subobjects. For example, a GLG graph object has a particular number of datasamples and labels, as defined by the corresponding graph object's parameters. A hierarchy setup of a drawing containing a graph causes the graph's datasample and label instances to be created.

If the initial number of datasamples and labels needs to be set at run time, it must be done *before* the datasample and label instances are created, to avoid destruction and recreation of the new number of instances. On the other hand, filling the graph with initial data values and labels must be done *after* the hierarchy setup, when the datasample and label instances have already been created.

The number of datasamples and labels can also be changed dynamically at run time after the graph has been drawn. The Toolkit will automatically recreate the datasample and label instances to reflect the new settings.

To access GLG objects and their attributes at various stages of drawing initialization, an application may use the following **listeners** of the GlgBean:

H listener (*GlgHListener* interface), invoked upon hierarchy setup, *after* the drawing is loaded, but *before* the hierarchy setup has occurred;

V listener (*GlgVListener* interface), invoked *after* the drawing is loaded and *after* the hierarchy setup has occurred, but *before* the initial drawing;

Ready listener (*GlgReadyListener* interface), invoked *after* the drawing is ready, i.e. it is loaded, set up and painted for the first time;

The GlgBean also provides listeners for handling user interaction and system events:

Input listener (*GlgInputListener* interface), invoked upon user interaction, such as object selection and interaction with the GLG control widgets;

Select listener (*GlgSelectListener* interface), invoked when named objects in the drawing are selected with the mouse;

Trace listener (*GlgTraceListener* interface), invoked for all system events occurring in a GlgBean and commonly used as an escape mechanism for handling low-level events.

All listeners should be added to a GlgBean *before* a drawing name is set. **H**, **V** and **Ready** listeners are used to set the drawing's initial parameters and discussed in this chapter. The use of the **Input**, **Select** and **Trace** listeners is discussed in the *Handling User Interaction* chapter.

To add a listener to a GlgBean, the GlgBean's **AddListener** method should be used:

```
glg_bean.AddListener( listener_type, Object listener );
```

The second argument to the *AddListener* method is a class which implements the corresponding interface and overrides the interface's respective method to create custom application code. For example, the listener class *HListener* implements the *GlgHListener* interface and provides an implementation of the *H* callback method to set a drawing's initial attributes.

The following code sample illustrates the addition of *H*, *V* and *Ready* listeners to a GlgBean and definition of corresponding interfaces:

```
public class GlgGraphComponent extends JApplet implements
        ActionListener
{
    GlgJBean glg_bean;
    boolean IsReady = false;

    //Constructor
    public GlgGraphComponent()
    {
        setLayout( new GridLayout( 1, 1 ) );
        glg_bean = new GlgJBean();
        add( glg_bean );

        // Add Hierarchy Setup, Value and Ready Listeners.
        glg_bean.AddListener( GlgObject.H_CB, new HListener() );
        glg_bean.AddListener( GlgObject.V_CB, new VListener() );
        glg_bean.AddListener( GlgObject.READY_CB, new ReadyListener() );
    }

    // Invoked by the browser to start the applet
    public void start()
    {
        super.start();
        glg_bean.SetParentApplet( this );
        glg_bean.SetDrawingName( "bar1.g" );
        //...
    }

    // Invoked by the browser to stop the applet.
    public void stop()
    {
        // Unset the drawing
        glg_bean.SetDrawingName( null );
        IsReady = false;
        super.stop();
    }
}
```

```

// Define a class HListener which implements GlgHListener interface.
// This class should provide an implementation of the HCallback
// method.
class HListener implements GlgHListener
{
    public void HCallback( GlgObject viewport )
    {
        // Set initial graph parameters, including titles, datasample
        // and label parameters.

        viewport.SetSResource( "Title/String", "Bar Graph" );
        viewport.SetSResource( "XAxisLabel/String", "Sample" );
        viewport.SetSResource( "YAxisLabel/String", "Value" );

        // Set initial DataSample value
        viewport.SetDResource( "DataGroup/DataSample/Value", 0. );

        // Set number of data samples
        viewport.SetDResource( "DataGroup/Factor", 20. );
    }
}

// Define a class VListener which implements GlgVListener interface
// and its VCallback() method.
class VListener implements GlgVListener
{
    public void VCallback( GlgObject viewport )
    {
        // This callback may be used to fill graph with data for the
        // initial appearance.
    }
}

// Define a class ReadyListener which implements GlgReadyListener
// interface. This class should provide an implementation of the
// ReadyCallback method.
class ReadyListener implements GlgReadyListener
{
    public void ReadyCallback( GlgObject viewport )
    {
        // Enable dynamic updates
        IsReady = true;

        //Place custom initialization code here
    }
}
}

```

Please refer to the Java examples in `<glg_dir>/examples_java` directory for the complete source code which illustrates the usage of the GlgBean's listeners.

During loading time, listeners, such as the *H* and *V* listeners, are invoked if they exist. Therefore, as a rule of thumb, all listeners should be added to a GlgBean *before* a drawing name is set, because this causes the drawing to be loaded.

The *GlgBean* implements all GLG listener interfaces and installs itself as a default listener. Therefore, when a *GlgBean* is subclassed in the application, its callback methods (*H* callback, *V* callback, *Ready* callback, etc.) may be overridden and used directly without creating separate classes for the listeners. The *GlgGraphApplet* and *GlgSubclassExample* examples, located in the `<glg_dir>/examples_java` directory, illustrate how to use callbacks when the *GlgBean* is subclassed.

The *H* listener, *V* listener and *Ready* listener can be added only to the *GlgBean*, while the *Input*, *Select* and *Trace* listeners may also be added to the individual children viewports of the drawing. Only one listener of each type may be installed for each bean or viewport. Installation of a second listener of the same type will replace the first one.

Handling Dynamic Updates

Dynamic attributes of GLG objects are updated via a unified *Resource* Mechanism, which allows any parameter of the drawing to be accessed as a resource name containing the full path of the attribute in the drawing's object hierarchy. Therefore, all dynamic updates are handled by setting the drawing's resources using a few basic GLG methods:

SetDResource to set a double type resource;

SetSResource to set a string type resource;

SetGResource to set a geometric type resource, such as *FillColor*, or *EdgeColor* or the coordinates of a point;

Update to update the drawing to reflect new resource values.

For example, to push a new data value into a graph, the *SetDResource* method is used:

```
SetDResource( "DataGroup/EntryPoint", data_value );
```

where

data_value - a double value for the current iteration.

To set a label string for the graph's axis labels, *SetSResource* is used:

```
SetSResource( "XLabelGroup/EntryPoint", new_label_string );
```

where

new_label_string - a String object whose value is used to set a label string for the current iteration.

To set the *EdgeColor* of the graph's title, *SetGResource* is used:

```
// Set color of a title string to red
SetGResource( "Title/EdgeColor", 1., 0., 0. );
```

For details regarding objects' resources and their usage, refer to the *Objects* chapter on page 23 of the *GLG User's Guide and Builder Reference Manual*.

To update a GLG drawing with new data values, an application should periodically supply new values for dynamic resources of the drawing and repaint the drawing to reflect the changes.

Below is an example of an *UpdateGraphProc* method which updates a GLG graph to reflect new data values. In this method, the *SetDResource* and *SetSResource* methods are used to set new values for the graph's data samples and labels, and *Update* method is used to repaint the drawing to make new resource settings visible.

```
void UpdateGraphProc()
{
    if( !IsReady )
        return;

    // Push next data value
    glg_bean.SetDResource( "DataGroup/EntryPoint", GetData() );

    // Push next label glg_bean.
    SetSResource( "XLabelGroup/EntryPoint", GetLabel() );

    // Make changes visible
    glg_bean.Update();
}
```

In this example, the *GetData* method returns a random data value, and the *GetLabel* method returns the next label for the X axis. In a real world application, a user would provide custom methods to supply data values, label strings and attribute values that need to be dynamically updated. The data may come from a file, database, socket or any other source. The Toolkit provides an open data API which works equally well with a variety of data sources.

As mentioned earlier, an update procedure should be invoked periodically by an application. In Java2, Swing does not support asynchronous updates and is *not* thread-safe, and timers must be used to update graphics synchronously.

Java2 Example of Handling Dynamic Updates

The following code uses a timer to invoke the *UpdateGraphProc* method periodically to handle data updates:

```
public class GlgGraphComponent extends JApplet implements
        ActionListener
{
    GlgJLWBean glg_bean;
    Timer timer = null;
    boolean IsReady = false;

    // Constructor, where Glg bean component is created and added to a
    // native Java container, an Applet in this case.
    public GlgGraphComponent()
    {
        getContentPane().setLayout( new GridLayout( 1, 1 ) );
        glg_bean = new GlgJLWBean();
        getContentPane().add( glg_bean );

        // Add Ready Listener.
        glg_bean.AddListener( GlgObject.READY_CB, new ReadyListener() );
    }

    // Invoked by the browser to start the applet
    public void start()
    {
        super.start();
        glg_bean.SetParentApplet( this );
        glg_bean.SetDrawingName( "bar1.g" );
        StartUpdates();
    }

    // Invoked by the browser to stop the applet.
    public void stop()
    {
        // Unset the drawing
        glg_bean.SetDrawingName( null );
        StopUpdates();
        IsReady = false;
        super.stop();
    }
}
```

```
// Define a class ReadyListener which implements GlgReadyListener
// interface. This class should provide an implementation of the
// ReadyCallback method.
class ReadyListener implements GlgReadyListener
{
    public void ReadyCallback( GlgObject viewport )
    {
        // Enable dynamic updates
        IsReady = true;

        //Place custom initialization code here
    }
}

// Start periodic updates.
void StartUpdates()
{
    if( timer == null )
    {
        Timer timer = new Timer( 30, this );
        timer.setRepeats( true ); timer.start();
    }
}

// Stop updates.
void StopUpdates()
{
    if( timer != null )
    {
        timer.stop();
        timer = null;
    }
}

public void actionPerformed((ActionEvent e)
{
    UpdateGraphProc();
}

// UpdateGraphProc mthod is invoked periodically by a timer.
void UpdateGraphProc()
{
    if( IsReady )
        return;

    // Push next data value
    glg_bean.SetDResource( "DataGroup/EntryPoint", GetData() );

    // Push next label glg_bean.
    SetSResource( "XLabelGroup/EntryPoint", GetLabel() );

    // Make changes visible
    glg_bean.Update();
}
}
```

In this example, the *StartUpdates* method creates a *timer* object with a time interval of 30 milliseconds. The *GlgGraphComponent* class implements *ActionListener* interface and is passed to the timer as an *ActionListener* parameter. When the given time interval elapses, the timer invokes the *actionPerformed* method of the applet, invoking the *UpdateGraphProc* method and causing the drawing or be updated every 30 msec.

As mentioned earlier, Swing is not thread-safe, which means that GLG dynamic updates must be performed in the main thread. Using timer objects is the preferred method of implementing periodic updates. If an application is threaded, the threads should not invoke any GLG methods.

Complete source code for all GLG Java examples can be found in the `<glg_dir>/examples_java` directory. The source code of all GLG Java demos is located in the `<glg_dir>/DEMOS/java_demos/java2` directory.

Handling User Interaction

Overview

User interaction in the *GlgBean*, including mouse clicks, mouse motion and keyboard events, causes input events to be generated. These events are handled by *listeners* added to the *GlgBean*:

- **Input** listener, invoked upon any interaction with the GLG objects;
- **Select** listener, invoked when a named GLG object is selected with the mouse.
- **Trace** listener, invoked for all system events occurring in the *GlgBean*, including mouse clicks and mouse motion.

The **Input** listener is used to handle user interaction in a GLG control widget, as well as process the selection of unnamed and composite objects.

The **Select** listener provides a simplified interface for processing the selection of named objects.

The **Trace** listener is used to trace low level events, such as mouse motion events and locating the cursor for drag and drop functionality in the application.

The following sample code illustrates how to add *Select*, *Input* and *Trace* listeners to a *GlgBean*:

```
glg_bean.AddListener( GlgObject.INPUT_CB, new InputListener() );
glg_bean.AddListener( GlgObject.SELECT_CB, new SelectListener() );
glg_bean.AddListener( GlgObject.TRACE_CB, new TraceListener() );
```

Listener objects must implement certain GLG interfaces, such as **GlgInputListener**, **GlgSelectListener** and **GlgTraceListener**, and provide an implementation of *Input* callback, *Select* callback and *Trace* callback, the corresponding callback methods. These callbacks will be invoked when an input event occurs in a *GlgBean*. The following sample code illustrates the definition of listener objects and their callback methods:

```

class InputListener implements GlgInputListener
{
    public void InputCallback( GlgObject viewport, GlgObject
        message_obj )
    {
    }
}

class SelectListener implements GlgSelectListener
{
    public void SelectCallback( GlgObject vp, Object[] name_array, int
        button )
    {
    }
}

class TraceListener implements GlgTraceListener
{
    public void TraceCallback( GlgObject viewport, GlgTraceData
        trace_info )
    {
    }
}

```

Input, *Select* and *Trace* listeners may be added to the *GlgBean*, or individual child viewports of the drawing.

The *GlgBean* provides a default implementation for all GLG listener interfaces and installs itself as a default listener. Therefore, when a *GlgBean* is subclassed in the application, its callback methods may be overridden and used directly without listener registration. Please refer to the *GlgSubclassExample* located in the `<glg_dir>/examples_java` directory

This chapter covers the details of using *Select* and *Input* callbacks. For examples of using a *Trace* callback, please refer to the *GlgDiagramDemo* and *GlgMapDemo* demos in the `<glg_dir>/DEMOS/java_demos` directory.

The **Input** callback is invoked with the following arguments:

```
public void InputCallback( GlgObject viewport, GlgObject message_obj )
```

where

viewport - a GLG viewport object to which an *Input* listener is attached. If the *Input* listener is added to a *GlgBean*, the viewport parameter will be the bean's top level viewport named *\$Widget*.

message_obj - a GLG *message* object containing detailed information regarding the occurred event.

Resources of the **message object** may be used to retrieve information about the occurred event. The following resources are always present in the *message* object regardless of the type of event that triggered it:

Format - Defines the format of the input handler which triggered the event. It may have values such as *Button*, *Slider*, *Knob*, *CustomEvent*, *ObjectSelection*, etc.

Origin - Contains the name of the viewport the event occurred in or the name of the selected object.

FullOrigin - Full pathname of the viewport or the name of the selected object.

Action - Describes the occurred action. Action values depend on the *Format* resource and may have values such as *ValueChanged*, *Activate*, *MouseClicked*, *MouseOver* and so on.

Subaction - Provides additional information about the event.

The rest of the *message* object's resources depend on the event type and are described in the *Handling Input Events in a GLG Control Widget* section and the *Handling Object Selection* section.

The *Select* callback is invoked with the following arguments:

```
public void SelectCallback( GlgObject vp, Object[] name_array, int
                           button )
```

where

vp - the viewport object the *Select* callback is attached to;

name_array - the array of the object names of all selected objects. This array can be traversed to find a particular object name;

button - the mouse button which initiated the event

Handling Input Events in a GLG Control Widget

To handle occurred input events in a GLG control widget, a GLG *message* object passed to the *Input* callback should be used to retrieve the following information:

- the type of the control (*Slider*, *Knob*, *Button*, etc.), defined by the *Format* resource:
- the name of the widget, defined by the *Origin* resource:
- the event action type, which depends on the *Format* resource:
- the resources relevant to a particular control type with particular *Interaction Handlers*, such as the *Value* resource for a dial, *ValueY* or *ValueX* resources for a slider and so on:

The following Swing based sample code illustrates how to handle occurred input events in a *Slider* and *Button* controls. A *GlgJLWBean* is added to the *JApplet* and displays the GLG drawing named "controls.g", which is composed of a dial, slider and button GLG controls. The events coming from the controls are handled in the *Input* callback.

```
public class GlgControlPanel extends JApplet
{
    GlgJLWBean glg_bean;
    static boolean IsStandalone = false;

    // Constructor.
    public GlgControlPanel()
    {
        getContentPane().setLayout( new GridLayout( 1, 1 ) );

        glg_bean = new GlgJLWBean();
        getContentPane().add( glg_bean );

        // Add InputListener to handle user interaction.
        glg_bean.AddListener( GlgObject.INPUT_CB, new
            InputListener(this) );
    }

    //Invoked by a browser to start the applet
    public void start()
    {
        super.start();

        // Set parent applet for the GlgBean and set GLG
        // drawing to be displayed in the bean.
        glg_bean.SetParentApplet( this );
        glg_bean.SetDrawingName( "controls.g" );
    }

    // Invoked by the browser to stop the applet
    public void stop()
    {
        // Unset the drawing.
        glg_bean.SetDrawingName( null );
        super.stop();
    }

    // Define a class InputListener.
    class InputListener implements GlgInputListener
    {
        GlgControlPanel parent;

        public InputListener( GlgControlPanel parent_p )
        {
            parent = parent_p;
        }
    }
}
```

```

public void InputCallback( GlgObject viewport,
                          GlgObject message_obj )
{
    String origin, format, action, subaction;

    origin = message_obj.GetSResource( "Origin" );
    format = message_obj.GetSResource( "Format" );
    action = message_obj.GetSResource( "Action" );
    subaction = message_obj.GetSResource( "SubAction" );

    // Input event occurred in a button
    if( format.equals( "Button" ) )
    {
        if( !action.equals( "Activate" ) )
            return;

        if( origin.equals( "QuitButton" ) )
        {
            if( parent.IsStandalone )
                System.exit( 0 );
            else
                parent.stop();
        }
    }

    // Input event occurred in a slider.
    if( format.equals( "Slider" ) )
    {
        double slider_value;

        // Retrieve a current slider value from a message object
        slider_value =
            message_obj.GetDResource( "ValueY" ).doubleValue();

        // Set a data value for a dial control
        viewport.SetDResource( "Dial/Value", slider_value );
    }

    // Update the viewport to reflect new resource settings
    viewport.Update();
}
}
}
}

```

In the above example, the *Format* resource retrieved from the *message* object is used to determine the type of control the event occurred in. The *Format* represents the type of control, such as *Slider* for a slider control, and *Button* for a button control. The type of *Interaction Handler* of a control may be found in the *GlgBuilder* in the *Properties* dialog for that control in the *Handler* field. A complete list of the various GLG *Interaction Handlers* may be found in the *Message Object* section on page 98 of the *GLG Programming Reference Manual*.

The *Origin* resource is used to determine the name of the control which caused an input event to occur. If necessary, the *FullOrigin* resource may be used to retrieve the full pathname.

In this example, if the event occurred in a slider, the slider's value retrieved from the *message* object is reflected in a dial. For a vertical slider, the slider's value is represented by the *ValueY* resource. The value of a dial is represented by the *Dial/Value* resource, where *Dial* is the viewport name of the dial control.

For complete source code, please refer to the *GlgControlPanel* and *GlgControlBean* examples, located in `<glg_dir>/examples_java` directory.

Handling Object Selection

There are several ways to handle object selection in a GLG Java application. The selection of an object occurs when the user clicks on a GLG object with the mouse or moves the mouse over it.

- **Select** callback may only be used to process object selection of *named* objects clicked with the mouse. The *Select* callback provides a simplified interface for handling object selection and is invoked with a list of names of all objects selected. This list can be traversed to retrieve individual object names.
- **Input** callback may be used to process **custom events** added to GLG objects. A custom event, such as a *MouseClicked* or *MouseOver*, may be added to an object in the *GlgBuilder*. At run-time, when a user clicks on this object with the mouse, the *Input* callback will be invoked with a *message* object containing event information, including a custom event label, the event type, the selected object, etc.

This method is convenient for handling selection of complex objects. For example, an application may display node objects containing a text label and an icon. The application might need to handle a selection event when the user selects either the label or the icon object with the mouse. This can be easily achieved by adding a custom *MouseClicked* event for the node object in the *GlgBuilder* and processing this event in the *Input* callback.

An application may also need to differentiate between various types of selection, such as node and link selection. This may be achieved by using a custom event label which differs between link and a node objects. In the *Input* callback, an application would retrieve the *EventLabel* resource of the *message* object and check the *EventLabel* string for differences such as "NodeSelection" or "LinkSelection."

The following sample code illustrates such usage:

```
String event_label = message_obj.GetSResource( "EventLabel" );
String action = message_obj.GetSResource( "Action" );
//....
if( action.equals( "MouseClicked" ) )
{
    // Process node selection
    if( event_label.equals( "NodeSelection" ) )
    {
        //...
    }
    // Process link selection
    else if( event_label.equals( "LinkSelection" ) )
    {
        //...
    }
}
```

The `GlgMapDemo` is an example of handling node and link selection using custom selection events.

Addition of *custom events* to GLG objects is available only in the Enterprise Edition of the `GlgBuilder`. Please refer to the *Custom Mouse Events* section on page 127 of the *GLG User's Guide and Builder Reference Manual* for details.

- **Input** callback may be used to handle object selection on either mouse move or mouse click events using **object IDs**. It may be used to process events of both named and unnamed objects and process complex selections more efficiently. There is a performance increase due to the usage of object IDs instead of parsing strings when using object names.

A *message* object passed to the *Input* callback will contain an array of all objects selected with the mouse. This array can be traversed to retrieve individual object IDs. The array contains objects on the lowest level of the object hierarchy. For example, if an object group is selected, subobjects at the cursor position will be reported instead of the group object itself. The *GetParent* method can be used to obtain the group's ID. This method requires the use of the GLG Extended API.

In order to receive selection events, the **ProcessMouse** attribute of a viewport must be set. The *ProcessMouse* flag may have the following values:

None - disables processing of any custom and object selection events;

Click - enables processing of the mouse click events;

Click & Move - enables processing of both mouse click and mouse move events.

To summarize, a user's options for handling object selection are:

- With the **Basic** or **Professional** Edition of the Toolkit and only the GLG **Standard API**, use the *Select* callback.
- With the **Enterprise** Edition of the Toolkit and only the GLG **Standard API**, use the *Select* callback for selection of named objects or *Input* callback for custom event handling.
- With the GLG **Extended API**, the *Input* callback may be used to operate with object IDs.

Clearly, any combination of these options may be used, provided that the corresponding API and/or GlgBuilder features are available.

Details and code samples are provided below.

Using *Select* Callback

The following code sample illustrates the use of the *Select* callback to handle the selection of objects named *SolventValve* and *SteamValve*. The complete source code may be found in the GlgProcessDemo demo located in the `<glg_dir>/DEMOS/java_demos/*java` directory.

```
public void SelectCallback( GlgObject vp, Object[] name_array, int
                           button )
{
    ....
    if( name_array == null )
        return;

    for( int i=0; ( name = (String) name_array[i] ) != null; ++i )
    {
        if( name.equals( "SolventValve" ) ||
            name.equals( "SteamValve" ) )
        {
            if( button == 1 )
                OpenValve( name );
            else
                CloseValve( name );
        }
    }
}
```

One advantage of using the *Select* callback is its simple interface. However, when dealing with complex objects such as nodes which contain a collection of objects, using the *Select* callback may become tedious, since it involves string parsing. It also requires unique object names.

To handle the selection of complex objects, lack of or collision of object names, or when complete control over object selection is required, the *Input* callback should be used.

Using Input Callback to Handle Custom Events

As discussed earlier, for the purposes of handling complex objects, custom events may be added to GLG objects in the `GlgBuilder`. In order for custom events to be received in the `Input` callback, objects with custom events must have the `HasResources` flag set to `True`, and either the viewport containing these objects or any parent viewport must have the `ProcessMouse` flag set to process mouse click and/or mouse move events.

When a custom event occurs, the `Input` callback is invoked and the `message` object passed to it contains the following resources:

The **Format** resource has a value **CustomEvent**. To retrieve this resource from the `message` object:

```
String format = message_obj.GetSResource( "Format" );
```

The **Action** resource has a value **MouseClicked** for `MouseClickedEvent`, or **MouseOver** for `MouseOverEvent`. To retrieve this resource:

```
String action = message_obj.GetSResource( "Action" );
```

The **EventLabel** resource possesses the value of a custom label of this event. Custom event label may be set in the `GlgBuilder` or programmatically using the Extended API. To retrieve this resource:

```
String custom_label = message_obj.GetSResource( "EventLabel" );
```

The **Object** resource is the ID of the selected object with the custom event attached. This resource may be retrieved as follows:

```
GlgObject selected_object =  
    message_obj.GetResourceObject( "Object" );
```

Usually the `GetResourceObject` method of the Extended API is used to retrieve an object ID. However, if using the Standard API, resources of the selected object may be accessed using `Object/<ResName>`. For example, to access the `Name` resource of the selected object, the following method of the Standard API can be used:

```
String obj_name = message_obj.GetSResource( "Object/Name" );
```

The **OrigObject** resource is the ID of the selected object. For example, if a `MouseClickedEvent` is added to an object group, `OrigObject` will reflect an object inside the group which was selected with the mouse, whereas the `Object` resource will be the group itself. `OrigObject` and `Object` resources may be used the same way. To retrieve the object ID of the `OrigObject`, use

```
GlgObject selected_object =  
    message_obj.GetResourceObject( "OrigObject" );
```

To access the selected object's resources, use `OrigObject/<ResourceName>`. For example, to query the selected object name, use

```
String obj_name = message_obj.GetSResource( "OrigObject/Name" );
```

The code sample below illustrates how to process custom events in the *Input* callback. The complete source code may be found in the `GlgObjectSelection` example located in the `<glg_dir>/examples_java` directory.

```

public class GlgObjectSelection extends JApplet
{
    GlgJLWBean glg_bean;

    // Constructor.
    public GlgObjectSelection()
    {
        glg_bean = new GlgJLWBean();
        getContentPane().add( glg_bean );

        // Add InputListener to the GlgBean.
        glg_bean.AddListener( GlgObject.INPUT_CB, new InputListener() );
    }

    // Invoked by a browser to start the applet
    public void start()
    {
        super.start();
        glg_bean.SetParentApplet( this );
        glg_bean.SetDrawingName( "obj_selection.g" );
    }

    // Define a class InputListener.
    class InputListener implements GlgInputListener
    {
        public void InputCallback( GlgObject viewport, GlgObject
            message_obj )
        {
            String origin, format, action, subaction,
                selection_string = "";

            origin = message_obj.GetSResource( "Origin" );
            format = message_obj.GetSResource( "Format" );
            action = message_obj.GetSResource( "Action" );
            subaction = message_obj.GetSResource( "SubAction" );

            if( format.equals( "CustomEvent" ) )
            {
                String custom_event =
                    message_obj.GetSResource( "EventLabel" );

                // Handle custom events of type MouseEvent.
                if( action.equals( "MouseClicked" ) )
                {
                    // Retrieve the name of the selected object containing
                    // the custom event.
                    String obj_name =
                        message_obj.GetSResource( "Object/Name" );
                }
            }
        }
    }
}

```



```

public void InputCallback( GlgObject viewport, GlgObject message_obj
{
    String  origin, format, action, subaction;

    origin = message_obj.GetSResource( "Origin" );
    format = message_obj.GetSResource( "Format" );
    action = message_obj.GetSResource( "Action" );
    subaction = message_obj.GetSResource( "SubAction" );

    if( format.equals( "ObjectSelection" ) )
    {
        GlgObject selection_array =
            message_obj.GetResourceObject( "SelectionArray" );

        if( selection_array != null )
        {
            int size = selection_array.GetSize();
            for( int i=0; i<size; ++i )
            {
                GlgObject object =
                    (GlgObject) selection_array.GetElement( i );
                String obj_name = object.GetSResource( "Name" );

                // Process object selection here
                // .....
            }
        }
    }
}

```

2. Using GLG Components in Java2

Various aspects of using GLG in Java2 should be taken into account throughout application development.

Various GLG bean classes used to display graphics

GlgJBean is a *heavyweight Swing*-based Java bean that can be used as a top-level container for other Swing components. **GlgJLWBean** is a *lightweight Swing*-based Java bean. **GlgBean** is an *AWT* based Java bean component.

If a Swing application creates children of a GLG bean, such as a menu or dialog popup, *GlgJBean* or *GlgJLWBean* should be used to display the graphics rather than *GlgBean*, since Swing objects can be added only to a Swing-based component.

Performance optimization

Lightweight Swing components do not have a native window, and using them to display graphics may cause performance problems due to the damage repair that takes place upon component intersection. *Lightweight* Swing objects are designed for light interface objects, such as buttons and menus. However, for displaying dynamic graphics, it is more efficient to use *heavyweight* components, such as *GlgJBean* and *GlgBean*.

Mixing heavyweight and lightweight components in a Swing application

Since *lightweight* components do not have a native peer, they cannot be displayed in front of *heavyweight* components. Therefore, if various components intersect, all of them must be either *heavyweight* or *lightweight*.

For example, if a Swing application creates a *heavyweight* component, such as *GlgJBean*, to display graphics, then a *popup menu* created to appear in front of it must also be *heavyweight*.

To make a particular popup menu object a *heavyweight* component, the `JPopupMenu.setLightWeightPopupEnabled(false)` method can be used.

To make all menus in the application *heavyweight* components, the static method `setDefaultLightWeightPopupEnabled(false)` can be used.

Using Java Applet in a browser

By default, browsers do not have the Java virtual machine installed. In order to run a Java applet in a browser, *Sun's Java Plug-in* should be installed and enabled on the client machine.

Using timers for periodic dynamic updates

In *Java2*, *Swing* does not support asynchronous updates and is *not thread-safe*. *Timers* must be used to update graphics synchronously.

