EGL Rich UI 7.5.1.5

User Manual

26 July 2010

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Note
Before using this information and the product it supports, read the information in "Notices," on page 199.

This edition applies to version 7.5.1.5 of Rational Business Developer and to all subsequent releases and modifications until otherwise indicated in new editions.

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Chapter 1. Overview of EGL Rich UI

EGL Rich UI is a new technology for writing applications that will be deployed on Web servers. The technology builds on an idea central to EGL: write simple code, which is converted automatically to output that is useful for running a business. The output in this case is client-side JavaScript, called *client-side* because the JavaScript runs in the browser, not on the remote machine that serves the Web page. Client-side JavaScript is important because it makes the Web page more responsive, providing greater flexibility so that the user's experience can go beyond receiving and submitting a page. After the user clicks a radio button, for example, the logic might respond by changing the content of a text box. The change occurs quickly because the JavaScript runs locally and, in most cases, redraws only one area of the page.

An extension of client-side JavaScript is *Ajax*, a technology that permits the runtime invocation of remote code and the subsequent update of a portion of a Web page, even as the user continues working elsewhere on the page. After the user selects a purchase order from a list box, for example, the JavaScript logic might request transmission of order-item details from the remote Web server and then place those details in a table displayed to the user. In this way, the application can access content from the server but can save time by selecting, at run time, which content is transmitted.

A developer writes Rich UI applications using EGL syntax. For advanced purposes, however, a developer can write custom JavaScript or use JavaScript libraries instead of relying on the default behavior provided by EGL. For example, you can use Rich UI to access the following software:

- The Dojo Toolkit (http://dojotoolkit.org/)
- Microsoft Silverlight (http://silverlight.net/)

A Rich UI application can act as the front end for services that access databases and do other complex processing. You can access the following kinds of services, which are described in *Overview of service access*:

- SOAP Web services
- REST Web services that are provided by third parties such as Yahoo and Google
- EGL REST services, which are REST Web services for which the access code is particularly simple

Outline of development tasks

As a Rich UI developer, you do the following tasks in the EGL Rich UI perspective:

1. Create a Rich UI project
2. Create a kind of EGL handler part called an *EGL Rich UI handler*
3. Open the handler in the EGL Rich UI editor and add content to the Rich UI handler in the following ways:
   - By dragging on-screen controls called *widgets* onto a Web page surface. In this situation, you can set widget properties by typing values into dialogs that are part of the Rich UI editor.
   - By coding widget details directly into the Rich UI handler.

- By writing the following kinds of logic directly into the Rich UI handler:
  - Startup logic, which runs when the browser first receives the application from a Web server
  - Event logic, which runs in response to user actions such as a button click

When you are ready to deploy your code, you use the EGL deployment wizard and store output in one of the following locations:

- A Web project that is configured for WebSphere® Application Server
- A Web project that is configured for Apache Tomcat
- A directory whose content is ultimately provided to a simple HTTP server such as the Apache HTTP server. However, Rich UI does not support service access in this case.

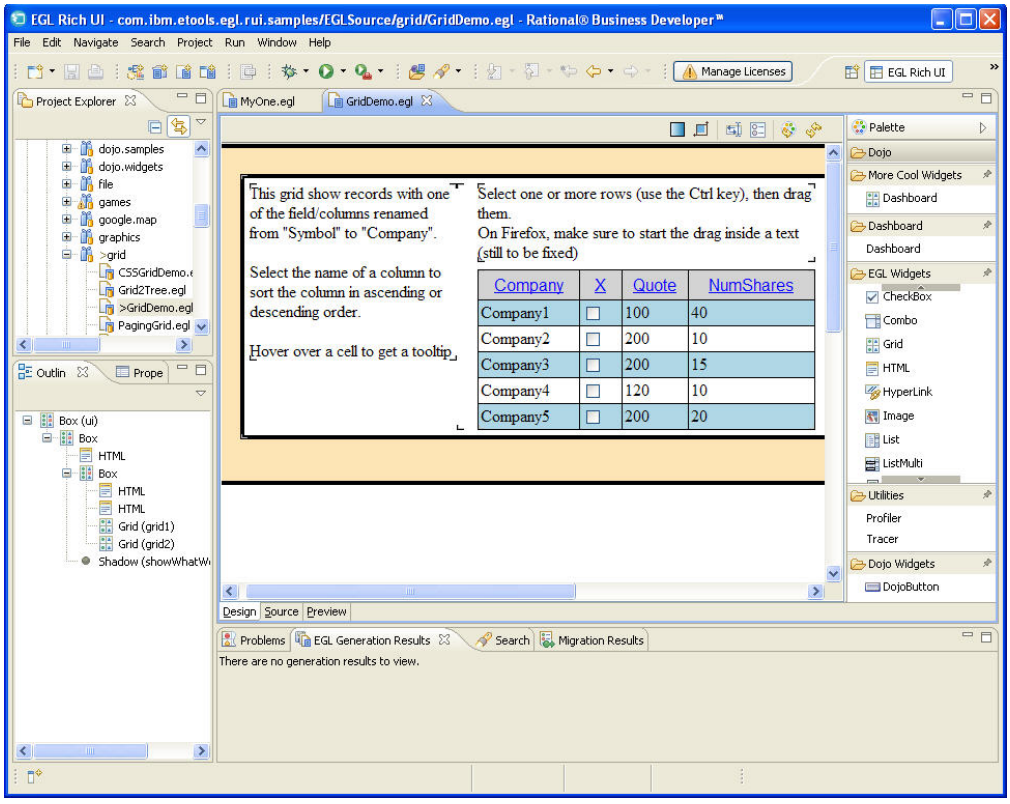
The EGL Rich UI Editor

You can use the EGL Rich UI editor to modify a Rich UI handler and to preview the handler's runtime behavior. The editor includes the following views:

- The Design view is a graphical design area that shows the displayable content of the Rich UI handler. You can drag-and-drop widgets from a palette into the display and then customize those widgets in the Properties view.
- The Source view provides the EGL editor, where you update logic and add or update widgets. The Design view and Source view are integrated: changes to the Design view are reflected in the Source view; and, if possible, changes to the Source view are reflected in the Design view.
- The Preview view is a browser, internal to the Workbench, where you can run your logic. You can easily switch to an external browser if you prefer.

The EGL Rich UI Perspective

Here is the EGL Rich UI perspective as it appears when a Rich UI handler is open in the Rich UI editor:



Starting to work with EGL Rich UI

This topic tells how to start developing applications with EGL Rich UI.

Enabling the Rich UI capability

If you are working in an existing workspace, enable the Rich UI capability:

- Click **Window > Preferences**. The **Preferences** dialog box is displayed.
- Expand **General** and click **Capabilities**. The **Capabilities** page is displayed.
- Click **Advanced**. The **Advanced Capabilities** dialog is displayed.
- Click **EGL Rich UI** and click **OK**.
- Click **Apply** to save your changes and remain on the **Preferences** dialog box. Alternatively, click **OK** to save the changes and exit the page; or click **Cancel** to cancel the changes and exit the dialog box.

Switching to the EGL Rich UI perspective

When you first open the Workbench, switch to the EGL Rich UI perspective:

- Click **Window -> Open Perspective -> Other**
- At the **Open Perspective** dialog, double-click **EGL Rich UI**

Setting the Rich UI editor as the default for EGL files

If most of your EGL work will involve Rich UI, you will want to make the Rich UI editor the default for EGL files:

1. Click **Window > Preferences**. The **Preferences** dialog box is displayed.

2. Expand **General** and **Editors** and click **File Associations**. The **File Associations** dialog is displayed.
3. In the **File types** section, click **.egl**
4. In the **Associated editors** section, click **EGL Rich UI Editor** and, at the right, click **Default**
5. Click **OK**

Accessing the Rich UI samples

We recommend that you use the Rich UI samples to explore the technology:

1. Click **Help** -> **Samples**. The **Help** dialog box is displayed.
2. Expand **Samples**, **Technology samples**.
3. Click **Rich UI technical sample**.
4. If your workbench does not already have the com.ibm.egl.rui project, click the entry to it.
5. Click the entry to import the samples.
6. In the workbench Project Explorer, expand the project **com.ibm.egl.rui.samples**, file **EGL Source**, package **contents**.
7. If you previously set the Rich UI editor to be the default for EGL files, double-click **contents.egl**. Otherwise, right-click **contents.egl** and select **Open with → EGL Rich UI Editor**.
8. Select the **Preview** tab at the bottom of the editor.
9. Follow the on-screen directions and try out the alternatives presented there.

Creating your first Rich UI project

When you want to work outside of the Rich UI samples project, do as follows:

1. Click **File -> New -> Project**. The **New Project** wizard is displayed.
2. Expand **EGL**, click **EGL Project** and then **Next**. The **New EGL Project** page is displayed.
3. Type a project name and select **Rich UI Project**. In most cases, complete the task by clicking **Finish**, However, if you want to consider additional options, continue here:
   a. Click **Next** so that the **EGL Project** page is displayed.
   b. To include the project in the directory that stores the current workspace, select the check box for **Use the default location for the project**; otherwise, specify a different directory by clearing the check box and using the **Browse** mechanism.
   c. An EGL service deployment descriptor lets your application access remote services in a flexible way, so that at configuration time, an installer can change the details of service access. The overhead of including the descriptor is small, and we recommend that you select the check box for **Create an EGL service deployment descriptor** regardless of your intent. Click **Next**. The **EGL Settings** page is displayed.
   d. The **Projects** tab lists all other projects in your workspace. Click the check box beside each project that you want to add to the project's EGL build path.
   e. To put the projects in a different order or to export any of them, click the **Order and Export** tab and do as follows: (i) To change the position of a project in the build-path order, select the project and click the **Up** and

Down buttons; (ii) to export a project, select the related check box; and (iii) to handle all the projects at once, click the **Select All** or **Deselect All** button.

f. Click **Finish**.

Reviewing general information on EGL

EGL Cafe provides is a center of information about the products that include EGL:

http://www.ibm.com/rational/eglcafe

For a concise introduction to EGL, see *Enterprise Web 2.0 with EGL*:

http://www.mc-store.com/5107.html

See the following topics in the *EGL Programmer's Guide* (aside from topics specifically on Rich UI):

- *Using EGL with the Eclipse IDE*
- *Introduction to EGL projects* through *Properties*:
  - In relation to Data parts, ignore references to Form Group and ArrayDictionary
  - In relation to Logic parts, ignore references to Handlers (other than Rich UI handlers) and Programs
  - Ignore Build parts other than the build descriptor and the deployment descriptor
- *Content assist*
- *Searching for EGL files and parts*
- *Setting Preferences in the EGL editor*; specifically, the following topics:
  - *Setting Preferences for folding in the EGL editor*
  - *Setting Preferences for organizing import statements in the EGL editor*
  - *Setting Preferences for source styles*
  - *Enabling and disabling code templates*
- *EGL debugger commands*
- *Setting preferences for the EGL debugger*

Exclude the following subjects when reviewing the *EGL Language Reference*:

- File and database access; related statements such as forEach and get, and related Exception records. When you work with Rich UI, all such access is handled by invoked services.
- The Program-related statements transfer and call.
- User interfaces.
- Record stereotypes other than BasicRecord and ExceptionRecord.
- Details that are specific to Java or COBOL processing; in particular, details related to J2EE, CICS®, IMS™, and z/OS® batch.
- Compatibility with VisualAge® Generator or Informix® 4GL.
- System libraries ConsoleLib, ConverseLib, DliLib, J2eeLib, JavaLib, LobLib, PortalLib SqlLib, VgLib, and VgVar.

See the following topics in the *EGL Generation Guide* (aside from topics specifically on Rich UI):

- *Introduction to EGL generation*
- *Build descriptor part*

Reviewing compatibility issues

Here are the major compatibility issues:

- File, database, and printer access is supported only by service access, not directly by the Rich UI application code. However, Rich UI supports non-structured Record parts, stereotype SQLRecord (as well as stereotypes BasicRecord and ExceptionRecord). Not supported are the Record part properties **containerContextDependent**, **i4glItemsNullable**, and **textLiteralDefaultIsString**.
- Reporting is not directly supported.
- Function overloading is not supported
- Generation of the following outputs is not supported: programs, forms, form groups, data tables, services, or other outputs that are specific to Java or COBOL.
- A version of the **call** statement is supported, but only to invoke services.
- Only the following variations of the **exit** statement are supported: **exit for**, **exit if**, **exit while**, and **exit case**.
- The following statements are not supported: **add**, **close**, **converse**, **continue**, **delete**, **display**, **execute**, **forEach**, **forward**, **get**, **freeSQL**, **goTo**, **move**, **open**, **openUI**, **prepare**, **print**. **replace**, **set**, and **transfer**.
- The following types are supported: ANY, BIGINT, BIN (but only in the absence of decimal places), Boolean, DataItem, DATE, DECIMAL, Delegate, Dictionary, FLOAT, INT, NUM, NUMBER, SMALLFLOAT, SMALLINT, STRING (but only in the absence of a size limit) , TIME, TIMESTAMP, NUM, MONEY, Service parts, Interface parts, External types (stereotype JavaScript), arrays of supported types, and non-structured Basic, Exception, and SQL Record parts.
- The following types are not supported: ArrayDictionary, BIN (with decimal places), BLOB, CHAR, CLOB, DataTable, DBCHAR, HEX, INTERVAL, MBCHAR, NUMC, STRING (with a size limit), PACF, UNICODE, structured Record parts, and parts specific to the technologies Console UI, JSF, reports, Text UI, and Web transactions.
- The following system libraries are not supported: ConsoleLib, ConverseLib, DliLib, DliVar, J2eeLib, JavaLib, LobLib, PortalLib ReportLib, SqlLib, VgLib, and VgVar.
- The following dateTimeLib functions are not supported: **intervalValue()** and **intervalValueWithPattern()**.
- The mathLib function **assign()** is not supported. Also, the data-type restrictions noted earlier limit the support for the following mathLib functions: **abs**, **max**, **min**, **precision**, and **round**.
- The StrLib constant **nullFill** is not supported.
- The following strLib functions are not supported: **byteLen()**, **charAsInt()**, **defaultMoneyForm()**, **defaultNumericFormat()**, **formatNumber()**, **getNextToken()**, **getTokenCount()**, **intAsChar()**, **intAsUnicode()**, **setBlankTerminator()**, **setNullTerminator()**, **unicodeAsInt()**. Also, the data-type restrictions noted earlier limit the support for the following mathLib functions: **getNextToken()** and **indexOf()**.
- The only supported sysLib functions are **conditionAsInt()**, **writeStdError()**, and **writeStdOut()**.
- The only supported sysVar variable is **sysVar.systemType**.

- Literals of type CHAR, DBCHAR, and MBCHAR are not supported.
- The three bitwise operators (**&** | **Xor**) are not supported; nor is the **in** operator.
- Only the following variations of the **is** and **not** operators are supported: use of **sysVar.systemType** and record-specific tests of **blanks** and **numeric**.
- Rich UI code cannot compare a variable of type ANY to a value variable:

```
// Not supported
if (myAny == 1)
   ;
end
```

- The details on using the EGL debugger are slightly different, as described in *Rich UI debugging*.
- Throughout EGL, a property can reference a variable (`theProperty = theVariable`), even if the variable is declared in code that is subsequent to the reference. Rich UI works the same way, with the following exception: a widget of type Widget (a generic type that is used for advanced purposes) must be declared before the widget is referenced.
- A widget is an EGL reference variable. When declaring a widget statically (without the **new** operator), remember to specify a set-value block ({}), as in the following example:

```
myButton Button{};
```

Understanding how browsers handle a Rich UI application

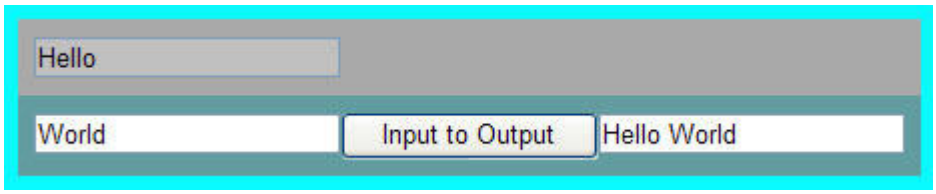
This topic gives details on how browsers handle a Rich UI application at run time. The purpose is twofold:

- To help you learn the technology faster, as is possible if you understand the runtime effect of what you code at development time
- To make it easy for you to do advanced tasks

When a user enters a Web address into a browser, the browser transmits a request to a Web server, which is usually on a second machine. The address identifies a specific server and indicates what content is to be returned to the browser. For example, if you enter the address *http://www.ibm.com*, an IBM® server replies with a message that the browser uses to display the IBM home page. The question that is of interest now is, how does the browser use the message?

The browser brings portions of the message into an internal set of data areas. The browser then uses the values in those data areas to display on-screen controls, which are commonly called *widgets*. Example widgets are buttons and text fields.

Consider the following Web-page content:

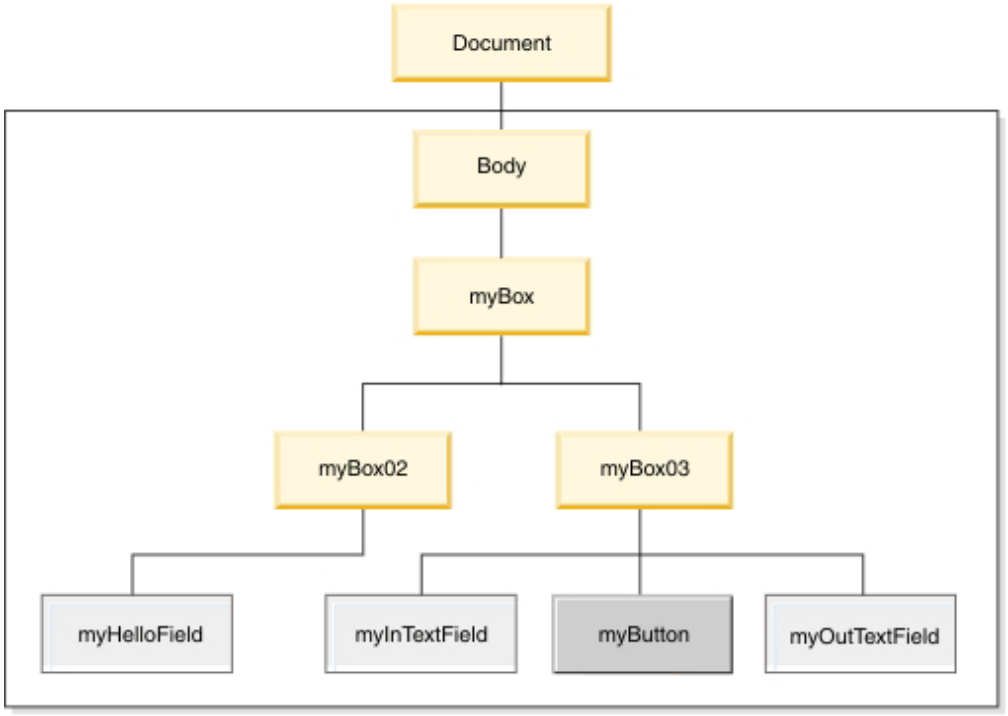


Seven widgets are displayed:

- The enclosing box is `myBox`
- The upper box within `myBox` is `myBox02` and includes the text field `myHelloField`

- The lower box within `myBox` is `myBox03` and includes the text field `myInTextField`, the button `myButton`, and the textField `myOutTextField`

The internal data areas used by the browser are represented as an inverted tree:



The tree is composed of a root, named *Document*, and a set of *elements*, which are units of information. The topmost element that is available to you is named *Body*. The elements subordinate to Body are specific to your application.

A set of rules describes both the tree and how to access the data that the tree represents. That set of rules is called the *Document Object Model* (DOM). We refer to the tree as *the DOM tree*, and we refer to the relationships among the DOM elements by using terms of family relationships:

- `myBox03` and `myInTextField` are *parent* and *child*
- `myBox` and `myButton` are *ancestor* and *descendant*
- `myInTextField`, `myButton`, and `myOutTextField` are *siblings*

In the simplest case (as in our example), a widget reflects the information in a single DOM element. In other cases, a widget reflects the information in a subtree of several elements. But in all cases, the spacial relationship among the displayed widgets reflects the DOM-tree organization, at least to some extent. The following rules describe the default behavior:

- A widget that reflects a child element is displayed *within* the widget that reflects a parent node
- A widget that reflects a sibling element is displayed *below or to the right* of a widget that reflects the immediately previous sibling element

We often use a technical shorthand that communicates the main idea without distinguishing between the displayed widgets and the DOM elements. Instead of

the previous list, we might say, "A widget is contained within its parent, and a sibling is displayed below or to the right of an earlier sibling."

The DOM tree organization does not completely describe how the widgets are arranged. A parent element may include detail that causes the child widgets to be arranged in one of two ways: one sibling below the next or one sibling to the right of the next. The display also may be affected by the specifics of a given browser; for example, by the browser-window size, which the user can update at run time in most cases. Last, the display may be affected by settings in a cascading style sheet.

When you develop a Web page with Rich UI, you declare widgets much as you declare integers. However, the widgets are displayable only if your code also adds those widgets to the DOM tree. Your code can also update the tree—adding, changing, and removing widgets—in response to runtime events such as a user's clicking a button. The central point is as follows: *Your main task in Web-page development is to create and update a DOM tree*.

When you work in the **Design** tab of the Rich UI editor, some of the tasks needed for initial DOM-tree creation are handled for you automatically during a drag-and-drop operation. When you work in the **Source** tab of the Rich UI editor or in the EGL editor, you can write code directly and even reference DOM elements explicitly.

In general terms, you create and update a DOM tree in three steps:

1. Declare widgets of specific *types*—Button for buttons, TextField for text fields, and so forth—and customize the widget properties. For example, you might set the text of a button to "Input to Output," as in our example.
2. Add widgets to the initial DOM tree.
3. Alter the DOM tree by adding, changing, and removing widgets at those points in your code when you want the changes to be displayable.

We say that a widget or its changes are "displayable" rather than "displayed" because a widget in a DOM tree can be hidden from view.

At a given point in runtime processing, a widget can be the child of only one parent.

Rich UI handler part

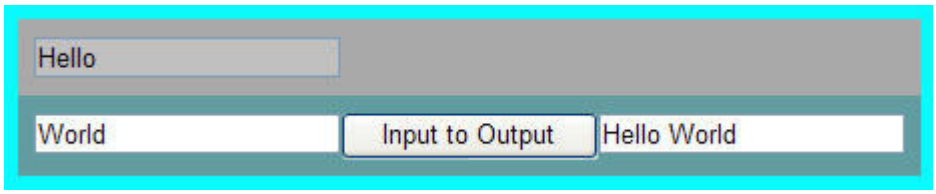
The main component of a Rich UI application is a Rich UI handler part, which is an handler with the stereotype `RUIHandler`. The handler part places widgets on a Web page and handles events such as a user's click of a button. The widgets and functions in one handler part can be made available to others, as described in *Creating a Rich UI application with multiple handlers*.

Here is an example of a Rich UI handler part:

```
import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Button;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.rui.Event;

handler ButtonTest01 type RUIhandler {initialUI = [ myTopBox ],
                          onConstructionFunction = initialization}

   myHelloField TextField
```

```
      { readOnly = true, text = "Hello" };
   myInTextField TextField{};
   myButton Button{ text = "Input to Output", onClick ::= click };
   myOutTextField TextField{};

   myBox03 Box{ padding=8, columns = 3,
                children = [ myInTextField,  myButton, myOutTextField ],
                backgroundColor = "CadetBlue" };

   myBox02 Box{ padding=8, columns = 2, children = [myHelloField],
                backgroundColor = "DarkGray"};

   myTopBox Box{ padding=8, children = [ myBox02,  myBox03 ],
                columns = 1, backgroundColor = "Aqua" };

   function initialization()
   end

   function click(e EVENT in)
      myOutTextField.text = myHelloField.text + " " + myInTextField.text;
   end
end
```

After the user types the word *World* in the bottom left text box and clicks the button, the user interface is as follows:



We use the same example to explain the DOM tree; for details, see "Understanding how browsers handle a Rich UI application."

The Rich UI handler supports the following properties, which are optional:

- **initialUI** specifies which widgets are children of the initial, DOM tree document element. If the array references a named widget multiple times, only the last reference is used, and the others are ignored.
- **onConstructionFunction** specifies the on-construction function, which is a handler function that is invoked when the handler starts running. You can reset the value of **initialUI** in the on-construction function or in a function invoked (directly or indirectly) from this function. However, once the on-construction function ends, the value of **initialUI** is constant.
- **cssFile** specifies a cascading style sheet (a CSS file), which sets display characteristics of an individual widget or of a category of widgets. The property accepts a path relative to the WebContent directory. At deployment, the CSS file is referenced in a <link> entry that is added to the HTML file.

  Here is an example setting:

  ```
  Handler ButtonTest Type RUIHandler
     { children = [ui], cssFile = "buttontest/coolblue.css" }
  ```

  Here is an example CSS file:

  ```
  .EglRuiGridTable
    { border: 3px solid black; }

    .EglRuiGridHeader
  ```

```
{ color:yellow;
  background-color:red;  }

.EglRuiGridCell
{ color:black;
  background-color:aqua; }
```

Please note that if both the **cssFile** property and (as described next) the **includeFile** property are specified, the CSS content referenced by the **cssFile** property takes precedence because, in the deployed HTML file, the <link> entry is embedded *after* the content referenced by the **includeFile** property.

For additional details about Rich UI support for styles, see "Widget styles."

- **includeFile** also specifies a file for inclusion in the deployed HTML. file. Like the **cssFile** property, the **includeFile** property accepts a path relative to the WebContent directory.

  Here is an example setting:

  ```
  Handler ButtonTest Type RUIHandler
     { children = [ui], includeFile = "buttontest/coolblue.css" }
  ```

  Here are details on file types:

  – A file that has an extension other than css or html is included in a <script> element, as shown here:

    ```
    <script>
       <!-- file contents here -->
    </script>
    ```

  – A file that has extension html or css is included as is. If the file extension is css, the style directives must be within a <style> element, as in the following example:

    ```
    <style type="text/css">
       .EglRuiGridTable
       {  border: 3px solid black; }

       .EglRuiGridHeader
       {  color:yellow;
          background-color:red;  }

       .EglRuiGridCell
       {  color:black;
          background-color:aqua; }
    </style>
    ```

    If file extension is html, the following statements apply:

    - If you are working in a Rich UI project, the product may show a warning message when you view a file that includes an xref attribute. For example, here is the content of file MyIncludeFile.html, which resides in the folder WebContent/MyFolder folder at development time:

      ```
      <link REL="STYLESHEET" TYPE="text/css" href="css/dashboard.css">
      ```

      In this example, a warning message indicates that the href value does not refer to an existing file. The message arises because the development-time editor seeks the file WebContent/MyFolder/css/dashboard.css rather than the actual file, which is WebContent/css/dashboard.css. The point is simply this: ensure that the value of the href tag includes a path relative to the WebContent directory and ignore any warning message that indicates a need for a different path.

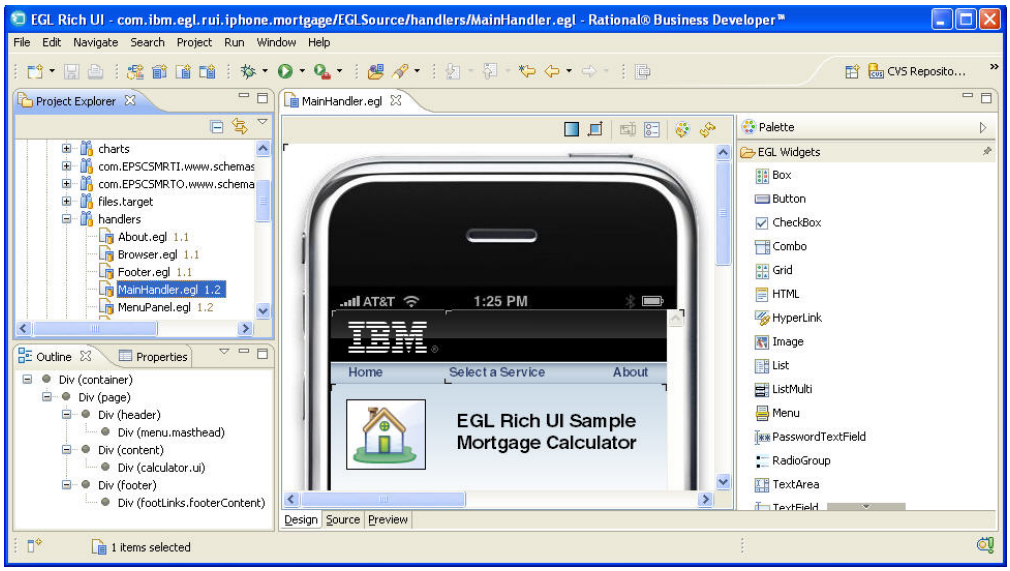
    - The inclusion of an HTML file (such that an <html> element is placed inside the deployed HTML file) is valid, at least in some browsers. Please note that use of the **includeFile** property may require that you take special care to test your application on multiple browsers.

As shown, the box widgets include various properties; in particular, the **children** property, which is the means by which the handler appends children and other descendants to the widgets specified in the **initialUI** array.

Chapter 2. Introduction to the EGL Rich UI editor

You can use the EGL Rich UI editor to modify a Rich UI handler and to preview the handler's runtime behavior.

Here is an example of an open file in the Rich UI editor.



The Rich UI editor includes three views:

- As shown in the example, the Design surface is a rectangular area that shows the displayable content of the Rich UI handler. You can drag-and-drop widgets from the palette into the Design surface or into the Outline view and then customize those widgets in the Properties view. You can also change the placement of widgets by working in the Design surface or in the Outline view.
- The Source view provides an embedded version of the EGL editor, where you update logic and add or update widgets. The Design view and Source view are integrated: changes to the Design view are reflected in the Source view; and, if possible, changes to the Source view are reflected in the Design view.
- The Preview view is a browser, internal to the Workbench, where you can run your logic. You can easily switch to an external browser if you prefer.

Using the Design surface to create a DOM tree

When you drag a widget from the palette to the Design surface, the areas that can receive the widget are called *potential drop locations*, and the color of those areas is yellow by default. When you hover over a potential drop location, the area is called a *selected drop location*, and the color of that area is green by default. You can customize the colors in the Workbench preferences.

When you first drag a widget to the Design surface, the entire surface is a selected drop location, and the effect of the drop is to declare the widget and to identify it as the first element in the Rich UI handler's `initialUI` property. That property accepts an array of widgets at development time. The array is ultimately used to

create a DOM tree, which is a runtime data structure described in *Understanding how browsers handle a Web application*. Specifically, the elements in the Rich UI handler's `initialUI` array become children of the document element, with the order of `initialUI` array elements at development time equivalent to the order of sibling DOM elements at run time.

When you drag another widget to the Design surface, you have the following choices:

- You can place the widget adjacent to the initially placed widget. The effect on your source code is to declare the second widget and to identify it as another element in the `initialUI` array. Your placement of the new widget is either before or after the first widget and indicates where the widget is placed in the array.
- If the initially placed widget was a container—for example, a box—you can place the second widget inside the first. The effect on your source code is to add an element to the `children` property of the container. The effect is ultimately to add a child element to the DOM tree; specifically, to add a child element to the element that represents the container.

Your subsequent work continues to build the DOM tree. You can repeatedly fulfill drag-and-drop operations, with the placement of a widget determining what array is affected and where the widget is placed in the array. The drag-and-drop operation is an alternative to writing a widget declaration and array assignment in the code itself, whether in the **Source** tab of the Rich UI editor or in the EGL editor.

New widget declarations are added to the source code before the declarations that were already there; that is, the order of the statements is opposite to the order of the drag-and-drop operations.

Using the Outline view to update the Design surface

When you are using the Design surface, the Outline view has special capabilities:

- You can drag and drop a widget from the palette to a specific position in the Outline view and (therefore) to a specific position on the Design surface.
- Within the Outline view, you can do as follows:
  - Drag and drop a widget to another position. (If you select a widget with descendents, the widget and its descendents can be dragged to another position.)
  - Delete a widget by right-clicking the widget and clicking **Delete**.
  - Update details about the widget by right-clicking the widget, clicking **Properties**, and following the procedure described in *Setting widget properties and events*.

Understanding the transparency options

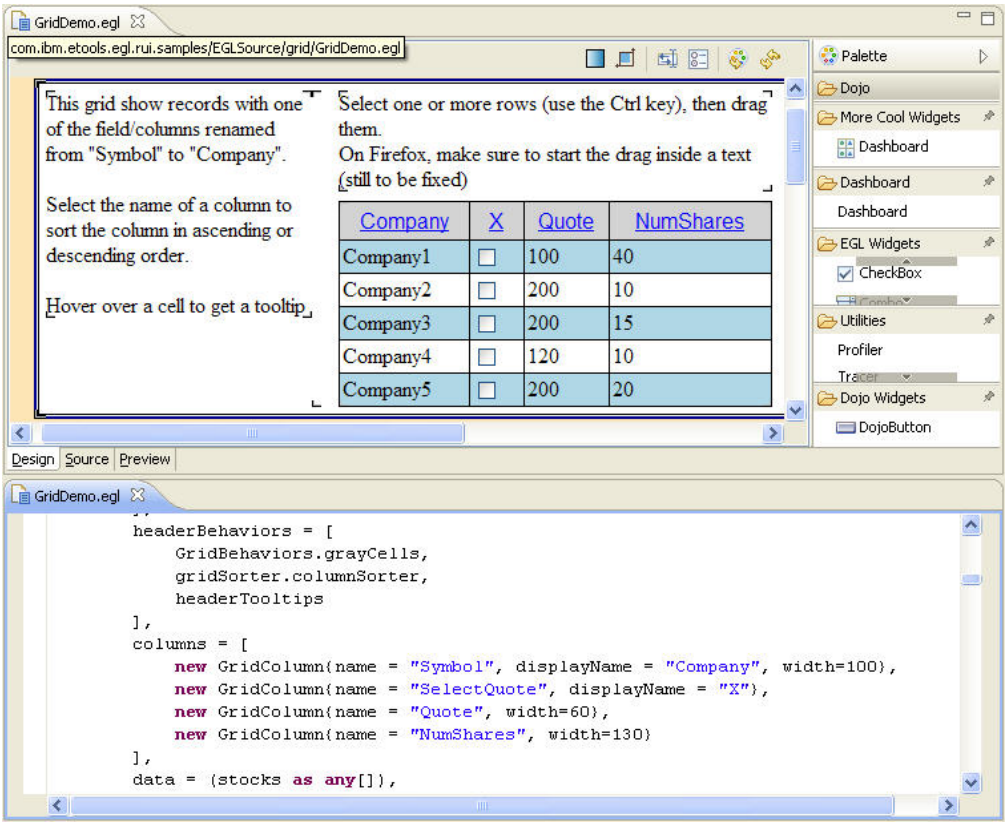
The Design surface is composed of two layers. The bottom layer is the Web browser, which displays widgets, including initial text values. The top layer is an editing overlay, including angle brackets at each corner of each widget.

The background of the top layer can have any of the following characteristics: transparent, a pattern of white and transparent dots, or (on Windows platforms) a white layer with a varying level of transparency. You can set those transparency options by setting a Workbench preference, as described in *Setting preferences for*

Rich UI appearance. When you are working in the editor, you can change the transparency options that are in use for the editing session.

Combining the EGL Rich UI editor and the EGL editor

You can complement the features in the Rich UI editor by opening a single file in both the EGL Rich UI editor and the EGL editor. For example, the following screen shot displays the file GridDemo.egl in two ways. At the top is the Design tab of the Rich UI editor, along with a palette that lists the available Widget types. At the bottom is the EGL editor. Your work in either editor affects the same file and is reflected in the content displayed in the other editor.



Opening the EGL Rich UI editor

As described in *Starting to work with EGL Rich UI*, you can set the EGL Rich UI editor to be the default editor for every EGL file and then, in most cases, you can open the Rich UI editor by double-clicking an EGL file in the Project Explorer. Here are the alternative procedures:

- To open an existing file:
  1. Right-click on the EGL file in the Project Explorer
  2. Select **Open with → EGL Rich UI Editor**
- To create a new file and open it in the Rich UI editor:
  1. Select menu item **File → New → Other**. A wizard is displayed.
  2. Expand **EGL**
  3. Select **Rich UI Handler**
  4. Complete the wizard

If the EGL source editor automatically opens:

- Close the source editor
- Right-click on the empty new file in the Project Explorer
- Select **Open with → EGL Rich UI Editor**

Creating a Web interface in the Rich UI editor

This topic describes how to add, select, move, and delete widgets in the EGL Rich UI editor. In each case, you work on the Design surface, which you access by clicking on the **Design** tab.

To learn the implication of the actions described here, see *Introduction to the EGL Rich UI editor*.

Adding a widget

Add a widget to a Rich UI handler:

1. Click a Widget type in the palette and hold the left mouse button
2. Drag the widget to the Design surface
3. Use the widget-placement guide to help identify where to drop the widget
4. At the selected drop location, release the mouse button

Selecting a widget when multiple widgets overlap

When multiple widgets overlap a given area, click the area repeatedly to cycle through the available widgets, making each one the current one in turn. You can move or delete the current widget as described in the next sections.

Moving a widget

Move a widget from one location to another:

1. Click a widget on the Design surface and hold the left mouse button
2. Drag the widget to the preferred location
3. Use the widget-placement guide to help identify where to drop the widget
4. At the selected drop location, release the mouse button

Deleting a widget

Delete a widget:

- Click the widget and press the **Delete** key; or
- Right-click the widget and, at the popup menu, select **Delete**.

The deletion removes the reference to the widget in the handler-specific `initialUI` property or in the container-widget-specific `children` property, but does not remove the widget declaration from the Rich UI handler.

Using the tools on the Design surface

To design an EGL Rich UI application in the EGL Rich UI editor, click the **Design** tab. Here is the toolbar:

The tools on the Design surface provide the following functionality, as indicated by the hover help that is displayed when you move the mouse over a given tool:

- At the left is the **Show transparency controls** tool, which is a toggle. Click it to display or hide the transparency tools, which are described in *Setting preferences for Rich UI appearance*.
- The second tool is the **Show browser size controls** tool, which is also a toggle. Click it to display or hide the scroll bars that let you specify the browser size within the constraints that you set in the preferences. Again, further details are in *Setting preferences for Rich UI appearance*.
- The next tool is the **Configure bidirectional options** tool, which (if enabled) lets you open the preference page described in *Setting preferences for Rich UI bidirectional text*. See that topic for details on enabling the tool on the Design surface.
- The fourth tool is the **Configure preferences** tool. Click it to access the preferences that are described in *Setting preferences for Rich UI appearance*.
- Second to the right is the **Refresh palette** tool, which searches the Workspace for widgets that have the `@VEWidget` complex property and then refreshes the palette to reflect the outcome of that search.
- At the right is the **Refresh web page** tool. Click it to refresh the Web page, as may be necessary after you change the widgets in an embedded handler. For an introduction to embedded handlers, see *Rich UI handler part*.

Selecting a palette

Two palettes are available to the Rich UI editor. Each provides the same widgets as the other, and in each case you can right-click the palette or one of its drawers to display a menu that provides Eclipse-based options.

The default palette is tied to the Rich UI editor. You can resize the width of the palette or dock it on the left or right.

The other palette is a view, which you can move anywhere in the perspective or detach from the Workbench. If you want the extra flexibility provided by the Palette view, do as follows:

1. Click **Window -> Show View -> Other**. The **Show View** dialog is displayed.
2. Expand **General**.
3. Click **Palette** and then **OK**.

The effect of selecting the Palette view is to close the Rich UI editor palette. If you want to return to the Rich UI editor palette, close the Palette view.

Setting widget properties and events

You use the **Properties** and **Events** tabs when working at the Design surface of the Rich UI editor.

To begin setting widget properties and events, do as follows:

1. Click the **Design** tab or (when the **Design** tab is active) the Outline view.
2. Right-click a widget and select **Properties**. The Properties view is displayed and gives you access to both the **Properties** and **Events** tabs.

Setting properties

At the **Properties** tab, you can add a value to a widget property, and the editor updates when you press Tab or Enter.

To remove a property value from a text box, select the value and press the **Delete** key. To remove a property value from a list box, select the **(none)**.

To handle color selection, do as follows:

1. Click the **color** or **background Color** property, if available. The **Color selection** dialog is displayed
2. Three alternatives are available:
   - To work in the traditional **Color** dialog, click the **Number format** radio button and the subordinate **Color** button. On returning to the **Color selection** dialog, you can also specify whether the numeric color values retained from the **Color** dialog should be saved in RGB or hexadecimal format.
   - To select from a list of named colors instead, click the **Name Format** radio button and select a color.
   - To specify a value of your own, click the **Custom** radio button option. You can specify either an RGB format such as `RGB(236,,233,216)` or a hexadecimal format such as `#ece9d8`.

Creating new functions and enabling events

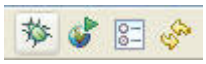
At the **Events** tab, you can identify the Rich UI handler function that will run in response to an event; or you can quickly create a new function.

In the row that lists the event of interest, do one of the following tasks:

- Double-click the second column (named **Function**) and click the name of an existing handler function.
- To create a new function instead, double-click the icon in the third column to display the **New event handler** dialog box. At the dialog box, specify the new function name and click **OK**. By default, the function name (for example, `myButton_onClick`) is the widget name followed by an underscore and the event name.

Running a Web application in the EGL Rich UI editor

To run an EGL Rich UI application in the EGL Rich UI editor, click the **Preview** tab. Here is the toolbar:



The tools at the Preview tab provide the following functionality, as indicated by the hover help that is displayed when you move the mouse over a given tool:

- At the left is the **Debug** tool. For details, see *EGL Rich UI debugging*.
- Second is the **Launch external browser** tool. Click it to place the output of the Rich UI application in an external browser as well as in the Preview view. You can select which external browser is invoked by setting a system preference:
  1. Click **Window -> Preferences**.
  2. At the **Preferences** dialog, expand **General** and click **Web Browser**.

3. The check boxes **Use Internal Web Browser** and **Use External Web Browser** have no effect on Rich UI. However, you can select your external browser by selecting from the list of browsers shown at that dialog and then clicking **OK**.

- The third tool is the **Configure preferences** tool. Click it to access the preferences that are described in *Setting preferences for Rich UI appearance*.
- At the right is the **Refresh Web page** tool. Click it to rerun a generated Web page from the start.

Chapter 3. Rich UI debugging

- You can use the following EGL debugging preferences, as described in "Setting preferences for the EGL debugger:"
  - **Stop at first line of a program**
  - **Set systemType to DEBUG**
  - The settings in the **Service Reference** tab in the Default behavior mapping window
- You do not need to create a runtime configuration to start a debugging session. If you click the Debug icon on the toolbar of the Rich UI Preview view (not the Debug icon on the toolbar of the workbench), a configuration is created for you. A configuration is also created for you if you do as follows:
  1. Right-click the EGL file that contains the Rich UI handler
  2. Click **Debug EGL Rich UI application**

  To launch the previously launched runtime configuration when you click the Debug icon on the workbench toolbar, set this preference:
  1. From the main menu, click **Window** → **Preferences**. The Preferences page is displayed.
  2. Expand **Run/Debug** and click **Launching**. The Launching window is displayed.
  3. Click **Always launch the previously launched application**.
  4. To save your changes and exit the page, click **OK**.
- In the Debug perspective, you complete the usual set of debug activities (**Step Into**, **Step Over**, and so on), as described in the topic "EGL debugger commands." The **Jump to Line** command is not available.
- When a debug session starts, the application runs in an external browser, and you can edit your code, set breakpoints, and inspect variables. The EGL debugger does not support *hotswapping* for Rich UI, which is the processing of changes that were made to declarations and logic statements during a debugging session.
- To end a debugging session, click the red icon in the Debug perspective. When the debugging session ends, you are in the Debug perspective, with your source code open in the EGL editor.

During a debugging session, your Rich UI handler may invoke the source for libraries (which run in a browser) and for services (which run in a simulated server). Here are some implications:

- When you debug the library, the rules are as described earlier
- When you debug the service, the full power of EGL debugging is available to you
- When you debug a library that is invoked from the service, the library is local to the service, and the full power of EGL debugging is available to you

Chapter 4. Rich UI programming model

The next topics further describe the Rich UI programming model.

Rich UI widgets

Rich UI handler parts include *widgets*. Each is a customized, on-screen control, but the term *widget* also refers to the variable declaration that creates the control. A widget can contain business data and can respond to events.

Widget types

The product provides a core set of *widget types*, which you use to declare widgets. The following table lists the main types.

Table 1. Widget types

Category	Type	Purpose
Container	Box	To define a box, which in most cases embeds other widgets. You can indicate how many columns are in the box. If the number of columns is three, for example, the first three embedded widgets are on the first row in the box, the fourth through sixth are on the second row, and so forth. If the number of columns is one, all the embedded widgets are arranged vertically. In any case, the width of a column equals the width of the largest widget in the column, and you can indicate whether the embedded widgets in a given column are aligned at the column's center, right, or left. If you want to show empty cells, include, as children of the box, text labels that lack text. Vertical and horizontal scroll bars appear if necessary to give the user access to widgets that are out of sight.
	Div	To define a division (HTML DIV tag) on the Web page, below the preceding content. The Div widget might be the parent of FloatLeft and FloatRight widgets, providing flexibility in Web-page design.
	FloatLeft	To define a division (HTML DIV tag) on the Web page; in most cases, as a child of a Div, FloatLeft, or FloatRight widget. The widget uses the CSS element float:left.
	FloatRight	To define a division (HTML DIV tag) on the Web page; for example, as a child of a Div, FloatLeft, or FloatRight widget. The widget uses the CSS element float:right.
	Grouping	To display a widget collection in a bordered box. You assign text that is embedded in the top of the border.

Table 1. Widget types (continued)

Category	Type	Purpose
Information	Grid	To define an array of values in a table format. The widget allows you to set the following details: • Column characteristics such as width, height, and color • An array of records whose field values are displayed in the corresponding grid columns, one row per record • *Behaviors*, which are fields that each accept an array of function references. The referenced functions let you update header-row, body-row, or cell characteristics in response to the user's clicking a cell.
	HTML	To present an HTML fragment, which may be provided by a service. The HTML is rendered in a bounded area, with scroll bars if necessary.
	Image	To display a graphic or alternate text.
	Shadow	To create a shadow effect for the widgets that are children of a specified DIV widget.
	Span	To display a string that the user cannot change. The string can include HTML segments (such as this boldfaced code).
	TextLabel	To display a string that the user cannot change. The widget is different from a span because inclusion of an HTML segment (such as this code) is displayed as is, including the angle brackets.
	Tree	To define a tree of displayable nodes.

Table 1. Widget types (continued)

Category	Type	Purpose
Interactive	BidiTextArea	To define a rectangle containing one or more lines of bidirectional text.
	BidiTextField	To define a text box containing a single line of bidirectional text.
	Button	To define a button, which elicits a user click and responds to that click by invoking a function.
	Checkbox	To define a check box, which displays a true-false option and responds to the user input by invoking a function.
	Combo	To define a combo box, which presents one of several selectable options and lets the user temporarily open a dropdown list to select a different option.
	Hyperlink	To define a Web-page link that, if clicked, displays the page in the browser. The page display is not bounded by a layout.
	List	To define a list from which the user can select a single entry.
	Listmulti	To define a list from which the user can select multiple entries.
	Menu	To define a menu bar entry.
	PasswordTextField	To define an input text field whose value is displayed as bullets, as appropriate for accepting a password.
	RadioGroup	To define a set of radio buttons, each of which responds to a click by deselecting the other radio buttons in the same group and (in the typical case) by invoking a function.
	TextArea	To define a rectangle containing one or more lines of text.
	TextField	To define a text box containing a single line of text.
Hover	GridTooltip	To define a special hover help; that is, one or more widgets that are displayed when the user hovers over a grid widget.
	Tooltip	To define a hover help: one or more widgets for display when the user hovers over a widget.
	TreeTooltip	To define a special hover help: one or more widgets for display when the user hovers over a tree widget.

Although the hover types (ToolTip, GridToolTip, and TreeToolTip) are in our list of widgets, each tooltip type is technically a Rich UI handler (EGL handler part, stereotype `RUIHandler`). In this case, the handler code provides a capability similar to that of a Rich UI widget. However, the functions and fields that are available for all widgets are not available for tooltips. For details on the generally available fields and functions, see *Setting widget properties and functions*.

Widget declarations and package names

When you wish to declare a widget, EGL provides two ways to identify the package in which the widget resides. Although those two ways are available when you declare any EGL variable, special automation is available in relation to widgets.

First, you can precede the name of the widget type with the name of the package. Here is the format:

```
widgetName com.ibm.egl.rui.widgets.widgetTypeName;
```

widgetName
Name of the widget

widgetTypeName
Name of the widget type

The EGL Rich UI editor uses the preceding format for the widget-declaration statement after you drag a widget from the palette to the Design surface. For an overview, see *Introduction to the EGL Rich UI editor*.

The second way to identify the package is to include an `import` statement early in the source code. Here is the format, which requires, in place of *widgetTypeName*, either a wild card (*) to reference multiple types or the name of a specific type:

```
import com.ibm.egl.rui.widgets.widgetTypeName;
```

Use of a wild card in place of *widgetTypeName* adds unnecessary code to the generated JavaScript output and is not recommended.

When you write source code, you can insert an `import` statement automatically after you declare a widget:

1. Hold down **Ctrl** and **Shift** and press **O**
2. If a dialog is displayed, choose among same-named widget types; for example, a Button can be from Dojo, Silverlight, or EGL Rich UI

Avoiding a null pointer exception

A widget is an EGL reference variable. When declaring a widget statically (without the **new** operator), remember to specify a set-value block ({}), as in the following example:

```
myButton Button{};
```

Creating additional widgets

You can create your own widgets in either of two ways:

- You can code a Rich UI widget; that is, a Rich UI handler, stereotype `RUIWidget`.
- You can write an EGL external type that is based on JavaScript. The ability to use EGL external types is useful for accessing preexisting JavaScript libraries.

For details on creating widgets, see *Extending the Rich UI widget set*.

Using the Widget type

The EGL Widget type is used when defining a function that accepts a widget whose specific type is not known at development time. The following (unrealistic) example shows how such a function can use the EGL operators **isa** and **as** to make available type-specific properties and functions; for example, the **text** property of the TextField type:

```
import com.ibm.egl.rui.widgets.TextField;

handler MyHandlerPart type RUIhandler{onConstructionFunction = initialization}

   myHelloField TextField{readOnly = true, text = "Hello"};
```

```
   function initialization()
       myInternalFunction(myHelloField);
   end

   function myInternalFunction(theWidget widget in)

      case
         when (theWidget isa TextField)
            myTextField TextField = theWidget as TextField;
            myString STRING = myTextField.text + " World";
            sysLib.writeStdOut(myString);
         when (theWidget isa Button)
            ;
         otherwise
            ;
      end
   end
end
```

The handler displays *Hello world*.

A variable of type Widget must be declared before the widget is referenced in a property; in particular, before the widget is referenced in an **initialUI** or **children** property. (That rule does not apply to variables of specific widget types such as Button or TextField.)

A variable of type Widget is compatible with both Rich UI widgets and external-type widgets.

Widget properties and functions

The Rich UI widgets are written in EGL. With a few exceptions, they are EGL handler parts, stereotype `RUIWidget`. (The exceptions Tooltip, GridTooltip, and TreeTooltip, all of which are stereotype `RUIHandler`.) You can learn the properties and functions that are available for a widget type in any of the following ways:

- When you wish to use a declared widget, use content assist:
  1. Type the widget name and a period
  2. Press **Ctrl-Space**
- Alternatively, inspect the EGL files that contain the widget code. For details on specific widget types, see the com.ibm.egl.rui project, EGLSource folder, com.ibm.egl.rui.widgets package.

Always use dot syntax to access a given function or property; for example, `myWidget.myFunction()` or `myWidget.myProperty`.

Properties available for most widgets

Widget properties are fields that are available to your code at run time. (Most other EGL properties are available only to EGL system code and are not available at run time.)

Style-related properties such as **class** and **style** are available for all IBM-supplied widgets of stereotype `RUIWidget`. For details on styles, see "Widget styles."

The following properties are useful for developing business applications:

- **children** provides access to an array of subordinate widgets, if any; for details, see a later section.

- **class** identifies a cascading style sheet (CSS) class used when displaying the widget.
- **disabled** takes a Boolean that indicates whether the widget is disabled. A disabled widget cannot respond to events and, on most browsers, its text appears in grey.
- **id** takes a string used to assign or retrieve an ID for a specific widget. You can use the ID in a cascading style sheet (CSS) to identify the style characteristics of that widget. Also, if you are integrating EGL with JavaScript libraries, this property lets you assign an ID for use by the JavaScript logic.

  If the widget (for example, a box) corresponds to a DOM subtree rather than to a specific DOM element, the ID is for the topmost DOM element in the subtree. For an introduction to the DOM, see "Understanding how browsers handle a Rich UI application."
- **position** specifies the meaning of the widget's x and y coordinates and takes one of the following values:

  static
  The widget's x and y coordinates are ignored, as is the default behavior. The displayed position changes if you first set the x and y values when the **position** value is **static** and then change the **position** value.

  absolute
  The widget's x and y coordinates are relative to the top left of the browser window, and those coordinates are not affected by the **alignment** value.

  relative
  The widget's x and y coordinates are relative to the top left of the parent. If the widget's parent is the document element, the coordinates are relative to the top left of the viewable area of the browser.
- **tabIndex** takes an integer that identifies the widget's placement in a tab order. For example, a widget assigned a **tabIndex** value of 2 receives focus after the user tabs away from a widget that has a **tabIndex** value of 1. You can use numbers such as 10 and 20 (rather than 1 and 2) to allow for the later addition of other widgets.

  The default tab order is browser specific.
- **x** and **y** values are integers that refer to the x-y coordinate of the widget. The meaning of that coordinate varies in accordance with the value of the **position** property. As suggested in the description of the **position** property, the graphical *origin* is either the top left of the browser window or the top left of a parent widget. The following rules apply:
  - The **x** value is positive to the right of the origin, negative to the left
  - The **y** value is positive below the origin, negative above

  You can place a widget outside of its parent and even outside of the viewable area.
- **zIndex** takes an integer that identifies the widget's position—its nearness to the front—in relation to other widgets at the same x and y location. A widget with a relatively large **zIndex** value (for example, 4) is closer to the front than a widget with a relatively small **zIndex** value (for example, 2). The **zIndex** value has no effect when the value of **position** is static.

The following properties are especially useful for developing new Widget types that are based on stereotype `RUIWidget`:

- **innerHTML** is a string used to assign or retrieve the HTML within a container such as a div, floatLeft, or floatRight widget.

- **innerText** is a string used to assign or retrieve text within a container. You can use **innerText** to provide a text property that is specific to the type.
- **logicalParent** is used for developing Widget types that are containers. When writing the code that adds children to the container, you set the **logicalParent** property so that it refers to the appropriate parent DOM element. For an introduction to the DOM, see *Understanding how browsers handle a Rich UI application*.

  For example, in relation to the child of a box, the **parent** property refers, not the box, but to a DOM TD element within a DOM Table element. However, the **logicalParent** property refers to the DOM Div element that represents the box and is the parent of the DOM Table element.**parent** is for Widget-type development and provides access to a parent DOM element. For an introduction to the DOM, see *Understanding how browsers handle a Rich UI application*.

The following properties are for interacting with users who read Arabic or Hebrew:

- **numericSwap** takes a string ("Yes" or "No") that lets you use Hindi numerals in Arabic. To use Hindi numerals, set **numericSwap** and **reverseTextDirection** to "Yes".
- **reverseTextDirection** takes a string ("Yes" or "No") that indicates whether to reverse the text direction in the widget.
- **symmetricSwap** takes a string ("Yes" or "No") that indicates whether to replace pairs of special characters to preserve the logical meaning of the presented text. If the value is "Yes", the effect is to replace paired characters such as <, >, [, and { with >, <,], and }.
- **textLayout** takes one of two strings: either "Visual" or "Logical":
  - If the setting is "Visual" and the user types "A" and then "B" (and if "A" and "B" are characters in a bidirectional language), the displayed characters are "AB". The order of display is the order of input, left to right, which is also the order in which the data is stored in local memory.
  - If the setting is "Logical", the displayed characters are "BA".

  In most cases, the setting "Visual" is appropriate for Arabic or Hebrew content derived from a machine that runs z/OS or IBM i.
- **widgetOrientation** is for Arabic and Hebrew text. This property takes one of two strings: either "LTR" (left-to-right) or "RTL" (right to left). When you specify "LTR", the widgets acts as a standard non-bidirectional widget. When you specify RTL, the widgets are mirrored; that is, scroll bars for dropdown lists appear on the left, the text-typing orientation for input fields is right-to-left, and the text is right-aligned.

The following properties add accessibility:

- **ariaLive** indicates the level of support provided for assistive technology; that is, for screen readers that are able to notify users of updates to screen regions. The specification for such technology is here:

  http://www.w3.org/TR/wai-aria

  The **ariaLive** value is a quoted string ("off", "polite". "assertive", or "rude"), each of which is described in the specification's section on *property: live*.
- **ariaRole** indicates the role specified for the widget, as used for assistive technology. For details, see the specification mentioned earlier.

  The **ariaRole** value is a quoted string such as "button" or "listbox", each of which is described in the specification's section on *Roles*.

Functions available for most widgets

The following functions are available for all IBM-supplied widgets of type `RUIWidget`:

- The function **fadeIn** causes the widget to *fade in* (to be presented slowly), and the function **fadeOut** causes the widget to *fade out* (to be slowly made invisible):

  ```
  fadeIn (duration int in, callback EffectCallback)
  fadeOut (duration int in, callback EffectCallback)
  ```

  Each function takes two parameters:

  duration
  Number of milliseconds between the start and end of the process, whether the widget is fading in or fading out

  callback
  A reference to a function that is invoked as soon as the widget fades in or out. That function takes no parameters and has no return value. If you do not wish to specify a function, set this argument to `null`.

  Here is an example:

  ```
  myButton.fadeOut(1000, null);
  ```

- The function **focus** causes the widget to receive focus:

  ```
  focus()
  ```

  For example, a button in focus is highlighted, and the user's pressing the ENTER key is equivalent to the user's clicking the button. Similarly, a text field in focus (if not read only) includes a cursor so that the user enters data by typing a printable character without first tabbing to the field.

  The user can press TAB repeatedly to cycle through the available fields. With each keypress, the focus moves either to the next application field or to a field on the browser; for example, to the Web address field.

  Here is an example invocation of **focus**:

  ```
  myButton.focus();
  ```

- The function **morph** lets you change the display of a widget over time. The function repeatedly calls one of your functions; in this way, your code specifies the behavior caused by the runtime invocation:

  ```
  morph (duration int in, callback EffectCallback, morphFunction MorphFunction )
  ```

  The function takes three parameters:

  duration
  Number of milliseconds between the start and end of the process.

  callback
  A reference to a function that is invoked as soon as the process is complete. That function takes no parameters and has no return value. If you do not wish to specify a function, set this second argument to `null`.

  customMorphFunction
  A reference to a *custom morph function*, which is a function invoked repeatedly during the duration mentioned earlier. . The custom morph function takes two parameters: the widget being changed and a float assigned by the EGL runtime. The float is a fraction between 0 and 1 and reflects the progress made toward the end of the duration. (At each invocation of the custom morph function, the value of that float is larger.) That fraction is based on a calculation of how many times the custom morph function is invoked, given the duration available and the amount of time required to run the custom logic. The custom morph function has no return value.

Here is an example:

```
myButton.morph(1000, null, myCustomMorphFunction);
```

- The function **resize** lets you change the size of a widget over time:

  ```
  resize (width int in, height int in,
        duration int, callback EffectCallback)
  ```

  The function takes four parameters:

  width
  : The desired final width, in pixels.

  height
  : The desired final height, in pixels.

  duration
  : Number of milliseconds between the start and end of the process.

  callback
  : A reference to a function that is invoked as soon as the process is complete. That function takes no parameters and has no return value. If you do not wish to specify a function, set this argument to `null`.

  Here is an example:

  ```
  myButton.resize(100, 100, 1000, myFunction);
  ```

Children property and related functions

In "Rich UI widgets," a subset of widgets are categorized as "container widgets." Those widgets include the **children** property, which specifies an array of subordinate widgets. Every element in the array refers to a named widget or to an anonymous one, as described here:

- A named widget is declared outside the children array, as is the case for every widget in the following code:

  ```
  myInTextField TextField{};
  myButton Button{ text = "Input to Output", onClick ::= click };
  myOutTextField TextField{};

  myBox Box{ columns = 3,
              children = [ myInTextField,  myButton, myOutTextField ]};
  ```

  If the array references a named widget multiple times, only the last reference is used, and the other references are ignored.

- An *anonymous declaration* starts with the keyword **new**, cannot be referenced in any of your code, and lets you create a widget at the moment you are thinking about the widget's placement:

  ```
  myInTextField TextField{};
  myTextOutField TextField{};

  myBox box{columns=3,
            children=[myInTextField,
                      new Button{ text = "Input to Output", onClick ::= click},
                      myOutTextField]};
  ```

In many cases, a parent widget is of type Box or Div, and the placement of the children widgets is affected by the parent type:

- A Box widget includes the **columns** property, and the value of that property specifies the default placement of each widget listed in the **children** array. For example, if `columns=1`, the widgets listed in the array are displayed in a single vertical column. Similarly, if `columns=2`, every second widget is displayed in the

second column, and the subsequent widget (for example, the third in the array) is displayed in the first column of a new row.

In general, if the value of **columns** is *n*, the widget at position *n+1* of the array is displayed in the first column of a new row. If you do not specify a **columns** value, the children of the Box widget extend to the right.

- The children of a Div widget extend to the right, with a horizontal scroll bar (if necessary) to provide access to widgets that extend to the right of the viewable area.

Div widgets that are children of another widget are displayed vertically, one underneath the previous.

You can reassign the value of **children** in any function and in this way change the Web page. (Similarly, you can reassign the value of **initialUI** in the on-construction function.) For example, the following syntax is valid, assuming you have declared the widgets specified:

```
myBox.children = [myInTextField, myButton02, myOutTextField];
```

Although you can reassign a **children** (or **initialUI**) array, do not make changes by using dynamic array functions such **appendElement** or the operator **::=**. Instead, use the widget-specific functions **appendChild**, **appendChildren**, **removeChild**, and **removeChildren**. Here is an example, assuming you have declared the widgets specified:

```
Function myFirstFunction(){}
   myBox.appendChild(myOtherButton);
   myBox.appendChildren([myOtherTextField, myOtherButton02]);
   myBox.removeChild(myOtherButton);
   myBox.removeChildren();
end
```

Similarly, you can add or remove children from the top DOM element, as shown here:

```
document.body.appendChild(myOtherButton);
document.body.appendChildren([myOtherTextField, myOtherButton02]);
document.body.removeChild(myOtherButton);
document.body.removeChildren();
```

The functions **appendChild** and **removeChild** each accepts a single widget; **appendChildren** accepts an array of widgets; and **removeChildren** takes no arguments. In the case of **appendChild** or **appendChildren**, the widget declarations can be anonymous or named. In the case of **removeChild**, the widget declarations must be named.

The effect of assigning a widget to a different parent

A specific widget can be the child of only one other widget (or of the document body, as shown in a later example). If a widget has a parent, you can cause the widget to be the child of a different parent. We refer to the reassignment as *re-parenting* the child widget.

Consider the following declaration of `myTopBox`, which is the parent of two other boxes:

```
myTopBox Box{padding = 8, columns = 1, backgroundColor = "Aqua",
   children =[myBox02, myBox03 ]};
```

Assume that the preceding declaration is in a Rich UI handler that makes myBox03 the only element in the **initialUI** array:

```
handler MyTest type RUIhandler{initialUI =[myBox03]}
```

At run time, the assignment to **initialUI** is handled after the declaration of myTopBox. The effect is that myBox03 is re-parented to the document body, leaving myTopBox with only one child, myBox02.

Your code might add myTopBox to the Web page in response to a runtime event such as a user's button click. You can see the effect by running the following code and clicking the button:

```
import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Button;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.rui.Event;

handler MyTest type RUIhandler{initialUI =[myBox03]}

   myTopBox Box{padding = 8, columns = 1, backgroundColor = "Aqua",
      children =[myBox02, myBox03 ]};

   myBox02 Box{padding = 8, columns = 2, backgroundColor = "DarkGray",
      children =[myHelloField ]};

   myBox03 Box{padding = 8, columns = 3, backgroundColor = "CadetBlue",
      children =[myInTextField, myButton, myOutTextField] };

   myHelloField TextField{readOnly = true, text = "Hello"};
   myInTextField TextField{};
   myButton Button{text = "Input to Output", onClick ::= click};
   myOutTextField TextField{};

   function click(e EVENT in)
      document.body.appendChildren([myTopBox]);
   end
end
```

The effect of removing all children from the document body

Consider the following statement:

```
document.body.removeChildren();
```

The effect is twofold:

- Removes all children widgets from the Web page.
- Removes access to the external style sheet, if any. (Style sheets are explained in *Widget styles*.)

If you wish to remove children from the document body without removing access to the external style sheet, remove specific children, as in the following statement:

```
document.body.removeChild(myBox);
```

Widget styles

Many display characteristics of an individual widget depend on whether you include styles. The rules are as follows: :

- You can reference a style class stored in a cascading style sheet (CSS):
  - Every Rich UI application accesses the styles from the CSS file that resides in a Rich UI system project; at this writing, the project name is com.ibm.egl.rui.

To access that CSS file, expand the WebContent folder and css subfolder. We advise you to leave the file untouched because updating it is likely to cause a maintenance problem over time.

– You can override and supplement the provided styles by maintaining your own CSS file. You make that file available to the Rich UI handler part in either of two ways:

  - You can set the part property **cssFile**, which accepts a path relative to the WebContent directory.

    Here is an example setting:

    ```
    Handler ButtonTest Type RUIHandler
       { children = [ui], cssFile = "buttontest/coolblue.css" }
    ```

    Here is an example CSS file:

    ```
    .EglRuiGridTable
    { border: 3px solid black; }

    .EglRuiGridHeader
    { color:yellow;
      background-color:red;  }

    .EglRuiGridCell
    { color:black;
      background-color:aqua; }
    ```

    Please note that if both the **cssFile** property and (as described next) the **includeFile** property are specified, the CSS content referenced by the **cssFile** property takes precedence.

  - You can set the part property **includeFile**, which also accepts a path relative to the WebContent directory.

    Here is an example setting:

    ```
    Handler ButtonTest Type RUIHandler
       { children = [ui], includeFile = "buttontest/coolblue.css" }
    ```

    For details on this option, see *Rich UI handler part*.

• Each widget type provided in Rich UI names a style class for inclusion in the CSS. The class name has the following pattern, where *WidgetTypeName* is the widget-type name such as TextArea:

  `EglRui`*`WidgetTypeName`*

  The purpose of this convention is to let a Web designer establish the styles for each type of widget so that you can achieve consistency across applications.

  Some widgets reference additional class names:

  – The grid widget includes children that reference the style classes EglRuiGridTable, for setting the border style of the grid as a whole; EglRuiGridHeader, for setting characteristics of header cells; and EglRuiGridCell, for setting characteristics of body cells.

  – If a textField widget is read only, the widget references the style class EglRuiTextFieldReadOnly

  – If a passwordTextField widget is read only, the widget references the style class EglRuiPasswordTextFieldReadOnly

  You can see the additional class names in the source for a given widget. Also, if you use the Firefox browser, you can use Firebug to inspect the styling of a displayed widget.

• You can override a style class by setting the widget property **class**, as shown here:

  ```
  loginBox Box { numColumns=2, class="NormalBoxStyle" };
  ```

  Here is an example of the related content in the CSS file:

```
.NormalBoxStyle
   {  color:black;
      background-color:aqua; }
```

All styles in the specified class are in effect in the widget. These styles are inherited in every enclosed widget except when a widget overrides a style, as noted later.

- You can specify a style (or a set of styles) in the **style** property. Here is an example, which includes (in the property value) the syntax used in CSS files:

```
loginBox Box
   { numColumns=2,
     style="background-color:lightgreen;border-style:solid;" };
```

All the CSS styles are available if you use the **style** property. However, for most purposes you can assign values to individual style-related properties. The following declaration is equivalent to the previous one and does not involve CSS syntax:

```
loginBox Box
   { columns=2,
     backgroundColor="lightgreen",
     borderStyle="solid" };
```

Here are the EGL style-related properties:

  - **background**
  - **backgroundColor**
  - **borderStyle** or one of the following subsets: **borderLeftStyle**, **borderRightStyle**, **borderTopStyle**, **borderBottomStyle**
  - **borderWidth** or one of the following subsets: **borderLeftWidth**, **borderRightWidth**, **borderTopWidth**, **borderBottomWidth**
  - **color**
  - **cursor**
  - **font**
  - **fontSize**
  - **fontWeight**
  - **height**
  - **margin** or one of the following subsets: **marginLeft**, **marginRight**, **marginTop**, **marginBottom**
  - **opacity**
  - **padding** or one of the following subsets: **paddingLeft**, **paddingRight**, **paddingTop**, **paddingBottom**
  - **pixelHeight**
  - **pixelWidth**
  - **position**
  - **visibility**
  - **width**

  Except for **background**, **backgroundColor**, **borderStyle**, **cursor**, **font**, and **visibility** (each of which takes a value of type STRING), each property takes a value of type INT and uses pixel as the unit of measure.

- The styles in effect for a given widget are the sum of the styles specified in class and style specifications. In most cases, a style applied to a widget overrides the same styles inherited from enclosing widgets, and the last style specified in a list of widget properties overrides an equivalent style, if any, that was specified earlier in the list.

- If, in defining a widget, you use both the **style** property or an equivalent property (to specify a given style) and the **class** property (to reference a class that includes the same style), the value in the **style** property takes precedence, in most cases.

If you do not specify styles, the default settings of the browser determine characteristics such as the line widths, the spacing between widgets, and the text font.

Best practice for styles

Rich UI projects are likely to be most successful if your company divides the responsibility for two tasks—laying out the user interface, as handled by an EGL developer, and creating the interface look and feel, as handled by a Web designer. To make this division of labor possible, we recommend that you use external style sheets. You can rely on a default class name such as EglRuiTextField. Alternatively, you can assign your own class name by assigning a value to the **class** property for a given widget.

The effect of removing all children from the document body

Consider the following statement:

```
document.body.removeChildren();
```

The effect is twofold:

- Removes all children widgets from the Web page
- Removes access to the external style sheet, if any

If you wish to remove children from the document body without removing access to the external style sheet, remove specific children, as in the following statement:

```
document.body.removeChild(myBox);
```

Sources of additional information

For details on cascading style sheets, consider the following Web sites:

http://www.w3schools.com/css

At this writing, the left side of that Web site includes several links, and the choices under the heading *CSS Basic* are of particular interest for Rich UI. The site search at the right is also useful.

For a complete description of cascading style sheets, see *CSS: The Definitive Guide* by Meyer (O'Reilly Media, Inc., November 2006).

Creating a Rich UI application with multiple handlers

You can use multiple Rich UI handler parts to compose a single application. However, we do not mean to say that you embed one handler part in another. Instead, the handler part declares variables that are each based on another handler part. A variable based on an Rich UI handler part is called an *embedded handler*, as in the following example:

```
embeddedHandler AnotherHandlerPart{};  // declared Rich UI handler
                                          (based on part AnotherHandlerPart)
```

The embedding Rich UI handler can access the global widgets and public functions declared in an embedded Rich UI handler. In particular, the embedding handler can add widgets to its own **initialUI** and **children** arrays. Also, you can embed a handler that invokes services or otherwise handles business processing. A reasonable practice is to use one handler to present the UI and to use other handlers to oversee the backend, business processing.

You access widgets and functions with a dot syntax. In the following outline, the Handler part `AnotherHandlerPart` is assumed to have declared a button named `itsButton`, which is attached to the DOM tree only when that button is included in the **initialUI** array of the embedding handler:

```
handler SimpleHandler type RUIHandler { initialUI = [ embeddedHandler.itsButton ] }
   embeddedHandler AnotherHandlerPart{};
end
```

Similarly, you can add an embedded widget to a **children** array.

You can access a function or property in an embedded widget by extending the a dot syntax. For example, the following statement retrieves the displayed text of the embedded Button itsButton:

```
myString STRING = embeddedHandler.itsButton.text;
```

The **initialUI** array of the embedded handler has no effect at run time. That array is used only when the embedded handler is the basis of a Rich UI application and is not embedded at all.

Event handling in Rich UI

Every widget includes a set of properties for specifying which function is invoked in response to a runtime event. The function in this case is also called an *event handler*.

Events

The next table lists the available events, though widgets of specific types respond to specific events. For example, buttons respond to onClick, but not to onChange. Also note that two user actions involve "gaining the focus" (by tabbing to or selecting the widget) or "losing the focus" (by tabbing to or selecting a different widget).

Table 2. Events

Event	Meaning
onChange	onChange occurs when the user changes a widget and moves the on-screen focus from that widget, even if the user has reversed the change.
onClick	onClick occurs when the user clicks the widget.
onFocusGained	onFocusGained occurs when the widget gains the focus.
onFocusLost	onFocusLost occurs when the widget loses the focus. The equivalent event in JavaScript is onBlur.
onKeyDown	onKeyDown occurs when the user presses any key. On many browsers, the event occurs repeatedly for as long as the user is pressing the key. Each occurrence of onKeyDown is followed by an occurrence of onKeyPress.

Table 2. Events (continued)

Event	Meaning
onKeyPress	onKeyPress occurs when the user presses any key. On many browsers, the event occurs repeatedly for as long as the user is pressing the key. Each occurrence of onKeyPress is preceded by an occurrence of onKeyDown.
onKeyUp	onKeyUp occurs when the user (having pressed a key) releases it.
onMouseDown	onMouseDown occurs when the user presses any mouse button.
onMouseMove	onMouseMove occurs repeatedly when the user moves the mouse while the on-screen cursor is within the boundary of the widget.
onMouseOut	onMouseOut occurs when the user moves the mouse, just as the on-screen cursor moves away from the widget.
onMouseOver	onMouseOver is an event that JavaScript could have named onMouseIn. The event occurs when the user moves the mouse, just as the on-screen cursor moves into the widget. You can use this event, for example, to change the cursor symbol for a particular part of the page.
onMouseUp	onMouseUp occurs when the user (having pressed a mouse button) releases it.
onSelect	onSelect occurs when text is selected in a textArea or textField widget.

The following syntax, for example, declares a Button widget, and the function named click is invoked when the user clicks the widget:

```
myButton Button { text = "Copy Input to Output", onClick ::= click };
```

The operator `::=` appends the function named click to a dynamic array. One implication is that, when you declare the widget, a set of event-related arrays is immediately available to you, with each array named for an event.

If you specify multiple event handlers for a given event, the order in which the event handlers will run is the order of elements in the array. Here is an example of the syntax:

```
myButton Button { text = "Start", onClick ::= click, onClick ::= function02 };
```

You can also use the operator `::=` in your code, to add event handlers to the dynamic array. Here is an example:

```
myButton.onClick ::= function03;
```

In this examples, a user click causes the invocation of the functions click, then function02, then function03.

Event record

Each event handler receives a record that provides details about the event. The event record is of type Event and includes the following fields:

ch INT
The ASCII code for the keystroke, if any, that caused the event.

x INT
The x coordinate (in pixels) relative to the left of a given widget. For example, if the user clicks in the exact middle of a button that is 10 by 10, the value of x is 5.

y INT
The y coordinate (in pixels) relative to the top of a given widget. For example, if the user clicks in the exact middle of a button that is 10 by 10, the value of y is 5.

clientX INT
The x coordinate of the mouse pointer (in pixels) relative to the left of the browser window. For example, if two buttons, each 10 by 10, are side-by-side at the top left of the browser window and the user clicks the exact middle of the second, the value of x is 15.

clientY INT
The y coordinate of the mouse pointer (in pixels) relative to the top of the browser window. For example, if two buttons, each 10 by 10, are side-by-side at the top left of the browser window and the user clicks the exact middle of the second, the value of y is 5.

screenX INT
The x coordinate of the mouse pointer (in pixels) relative to the left of the screen. The value varies in accordance with the display resolution of the workstation.

screenY INT
The y coordinate of the mouse pointer (in pixels) relative to the top of the screen. The value varies in accordance with the display resolution of the workstation.

widget ANY
The widget to which the event is attached.

mousebutton INT
A number that indicates which mouse button was pressed.

The record of type Event also includes the following functions, each of which is without parameters:

allowDefault()
Not in use.

allowPropagation()
Allows event bubbling to embedding widgets, as described in the next section, *Event bubbling*. This setting is in effect by default.

preventDefault()
Not in use.

stopPropagation()
Stops event bubbling, as described in *Event bubbling*.

Event bubbling

After Rich UI runs all the functions for a specific event in a specific widget, the default behavior is for the same event to be processed by each embedding widget, from the parent to the grandparent, and so on in turn. The behavior is called *event bubbling*.

For example, if a button is within a box (named B) that is within a box (named A), the onClick event is available to all three widgets; first, to the button, then to the immediately embedding box (B), and then to the box (A) that embeds the other widgets. Even if the button or B does not include an event handler for the onClick event, the event is available to A.

You can override the default behavior by setting a function in an event handler; specifically, the function **stopPropagation**, which is available from the event record, Here is the syntax:

```
Function click(e Event IN){}
   e.stopPropagation();
end
```

You may want to stop propagation for better performance or to avoid invoking functions in a particular situation.

Even if you stop event bubbling, the response to the event in the current widget is unaffected. For example, if the button in our example responds to an event by running three functions (click, function02, and function03), all those functions run in turn even if function02 invokes `stopPropagation`.

You can stop event bubbling in one event handler and allow it again in a later one. For example, if function02 invokes **stopPropagation** and function03 invokes **allowPropagation**, the event bubbles to the embedding widget. In general, the last propagation setting causes the event to bubble or not.

Custom event types

Rich UI provides a way for you to define event types that are specific to your organization. For details, see *Extending the Rich UI widget set*; in particular, the section on the property **@VEEvent**.

Rich UI validation and formatting

This topic briefly describes the Model, View, and Controller (MVC) way of organizing logic and then explores how Rich UI uses the idea of MVC to support validation and formatting.

MVC

Modern data-processing systems separate the *view* from the *model*, and those terms are variously defined:

- The *view* is the user interface, or the logic that supports the user interface, or the business data in the user interface
- The *model* is a database (or other data storage), or the logic that accesses a database, or the data that is sent to or retrieved from a database

The *controller* is the logic that oversees the transfer of data between the user interface and the database-access logic.

In many cases, the acronym MVC refers to processing across multiple platforms. For example, a Rich UI application on a Windows platform might be considered to be the view (and to include the controller), while a service that accesses a database might be considered to be the model.

We can also consider a division of view from model in the Rich UI application itself. In this case, the terms have the following meaning:

- The *view* is a widget in the user interface. Data that is placed into that widget must be validated before it can be used in other processing. Application data that is intended for display by the widget must be formatted before display.
- The *model* is a data field that is internal to the application.

A new EGL definition, the Controller, lets you tie a specific view—a specific widget—to a specific model. The Controller also oversees validations and format rules, as described later.

You can also define a validation form that identifies a set of display fields and the related Controllers. If you define a validation form or a form that you code for yourself, you can display the error messages that result from validations and formatting. (The Controller-specific function **getErrorMessage** lets the form developer access the message.)

The next sections describe the Controller and how to work with it. For details on creating validation forms, see *Form processing with Rich UI*, which uses the mechanisms described here.

The Controller in Rich UI

Consider the following declarations:

```
nameField TextField;
name String {inputRequired=yes,
             validationPropertiesLibrary=myLibrary,
             inputRequiredMsgKey="requiredMessage"};
```

The declaration of `name` has the following properties:

- **inputRequired** ensures the user will provide input to any widget (a view) that is associated with that the data field (a model)
- **validationPropertiesLibrary** identifies the library (stereotype `RUIPropertiesLibrary`) that includes declarations for use in messages and other text. If you do not include this property, the EGL Runtime accesses default messages. For details on customizing validation messages in Rich UI, see *Use of properties files for displayable text*.
- **inputRequiredMsgKey** identifies a customized validation message

Here is an example declaration of a Rich UI controller:

```
nameController Controller
   { @MVC
      { model=name, view=nameField }
      validators = [myValidationFunction01, myValidationFunction02]
   };
```

The declaration ties a specific model—the `name` field—to a specific view—the `nameField` widget. You control the transfer of data between the model and the view, as follows:

- To transfer data from the view to the model, you validate the data and then commit the validated data. In most cases, the commit step removes formatting characters such as currency symbols.
- To transfer data from the model to the view, you publish the data. In most cases, the publish step formats the data for display.

In our example, the controller declaration also lists a set of *validators*, which are functions that you write and that validate input. Each validator is based on the following Delegate:

```
Delegate
   MVCValidatorFunction(input String in) returns(String?)
end
```

Input to a validator is considered to be valid if the function returns an empty string or null, but not if the validator returns a string with content. Such a string is considered an error message.

In most cases, you commit data only after validating it. Here is the syntax for committing the user input from the `nameField` widget into the `name` field:

```
if (nameController.isValid())
   nameController.commit();
end
```

Validating the user input

A specific controller function—**isValid**—is invoked either because of user action (when the user moves focus away from the widget) or because of developer request (when the code invokes that function). That function controls the controller-specific validation steps, which are as follows:

1. Runs the function referenced by the **retrieveViewHelper** property (not shown in our example), which identifies the function that retrieves the widget content. The function has no parameters and returns a string. You might use this function to convert the input in some way. However, you do not need to set the **retrieveViewHelper** property in most cases. In the absence of that property, the widget content is available as a string, for subsequent processing.
2. Runs the functions referenced by the **unformatters** property (not shown in our example), which identifies an array of functions. You might use these functions to remove formatting characters from the input. The first-listed function accepts the string returned from the **retrieveViewHelper** function. Each of the later-listed functions accepts the string returned from the previous function. You may not need to set the **unformatters** property.
3. Removes the formatting characters from the user input in accordance with that formatting properties, if any, that you specified in the source code. An example of a formatting character is the currency symbol, which is associated with the **currency** property. A second example are the separators specified by the **dateFormat** property.
4. Returns control to the user if a validation error occurs related to data type; for example, the user may have typed a character when the model is a numeric field.
5. Runs the elementary validations, as specified by EGL properties that are set on the *model*, not on the view.

   A later section lists the available properties, which include **inputRequired**, as shown in our example. (That property ensures the user will provide input to any widget that is associated with that the data field.)

   Here are the possible outcomes of the elementary validations:

   - If any of the elementary validations fail, control returns to the user. If the Controller is in a validation form, a message associated with the first failed validation is displayed.

     You can accept the default EGL message for a given validation; but if you want to specify your own message, review the description in *Use of properties files for displayable text*.
   - If all the elementary validations are fulfilled, the validators run, as described next.
6. Runs the validators in the order specified in the controller **validators** array. Each validator accepts the input string without formatting characters such as the currency symbol; and each validator returns a string. If the validator

returns a null or blank, the EGL Runtime considers the validation to have succeeded. However, the following statements apply if the validator returns a different value—for example, a value retrieved from a properties file, as described in *Use of properties files for displayable text*:

- The EGL Runtime considers the validation to have failed
- Control immediately returns to the user; in that case, the subsequent validators do not run
- The returned string is available for use in a form

Changing the display of the invalid input

By default, a widget with invalid content is displayed with a style specified in a Cascading Stylesheet (CSS) class; specifically, the initial class such as EglRuiTextField, along with the following, secondary class: FormErrorEditor. (A Web designer in your company is likely to set up the style sheet for best effect.)

You can assign a different set of CSS classes (or a different CSS ID) in response to validation failure; or you can change another aspect of the displayed output. For example, you can assign CSS classes to a label, as occurs (by default) if you use a validating form. (For details, see *Form processing with Rich UI*).

Here is the procedure for changing the displayed output after validation:

- Set the controller property **validStateSetter**, which identifies a function for the EGL runtime to invoke at the end of validation.
- Create the function, which has two parameters. The first is of type Widget, and the second is of type Boolean. The first parameter receives the widget being validated, and the second indicates whether the validation succeeded.
- In that function, assign a different or additional class (or a different CSS ID) to the widget that has invalid content or, more likely, to the label of that widget.

Committing the validated input

When you run the controller-specific **commit** function, data is transferred from the view to the model. During that process, several functions are invoked, as determined by a set of controller properties that give you many options. Here are the properties:

1. The **retrieveViewHelper** property identifies the function that retrieves the widget content. The function has no parameters and returns a string. You might use this function to convert the input in some way. However, you do not need to set the **retrieveViewHelper** property in most cases. In the absence of that property, the widget content is available as a string, for subsequent processing.
2. The **unformatters** property identifies an array of functions. You might use these functions to remove formatting characters from the input. The first-listed function accepts the string returned from the **retrieveViewHelper** function. Each of the later-listed functions accepts the string returned from the previous function. You may not need to set the **unformatters** property.
3. Formatting characters are removed from the user input in accordance with that formatting properties, if any, that you specified in the source code. An example of a formatting character is the currency symbol, which is associated with the **currency** property. A second example are the separators specified by the **dateFormat** property.
4. The **commitHelper** property identifies the function that assigns a value to the model. The function has a single parameter of type STRING and has no return

value. You may not need to set this property. In its absence, the model receives the string that was provided by an earlier function, if any, and that no longer includes formatting characters.

Publishing the model data

When you run the controller-specific `publish` function, data is transferred from the model to the view. During that process, several functions are invoked, as determined by a set of controller properties that give you many options. Here are the properties:

1. The **retrieveModelHelper** property identifies the function that retrieves the data content. The function has no parameters and returns a string. You might use this function to convert the output in some way. However, you do not need to set the **retrieveModelHelper** property in most cases. In the absence of that property, the model content is made available as a string, for subsequent processing.
2. Formatting characters are added to the user input in accordance with the formatting properties, if any, that you specified in the source code. An example of a formatting character is the currency symbol, which is associated with the **currency** property. A second example are the separators specified by the **dateFormat** property.
3. The **formatters** property identifies an array of functions. You might use these functions to format the output. The first-listed function accepts the string returned from the **retrieveModelHelper** function, with any formatting characters added in step 2. Each of the later-listed functions accepts the string returned from the previous function. You may not need to set the **formatters** property.
4. The **publishHelper** property identifies the function that assigns a value to the model. The function has a single parameter of type STRING and has no return value. You may not need to set this property. In its absence, the view receives the string that was provided by an earlier function, if any, and that includes formatting characters.

Validation and formatting properties

Each of the field-level properties used in Rich UI is described in *Form field properties*. The current section simply lists the properties, each of which is categorized with a single letter:

- F is for formatting. A property in this category removes formatting characters during commit and adds formatting characters during publish. Any of these properties can result in the display of an error message; for example, if an input date is significantly different from the required date format, or if an integer value is a number other than 0 or 1 but is associated with isBoolean.
- V is for input validation.

Here are all the properties:

- currency (F)
- currencySymbol (F)
- dateFormat (F)
- fillCharacter (F)
- inputRequired (V)
- inputRequiredMsgKey (V)
- isBoolean (F)

- isDecimalDigit (V)
- isHexDigit (V)
- lowercase (F)
- minimumInput (V)
- minimumInputMsgKey (V)
- numericSeparator (F)
- sign (F)
- timeFormat (F)
- timestampFormat (F)
- typeChkMsgKey (V)
- uppercase (F)
- validValues (V)
- validValuesMsgKey (V)
- zeroFormat (F)

The following properties are further described in *Use of properties files for displayable text*:

- inputRequiredMsgKey (V)
- minimumInputMsgKey (V)
- typeChkMsgKey (V)
- validValuesMsgKey (V)

You can specify the validation and formatting properties on DataItem definitions, on variables, and on Record fields; but they are in effect for a given Rich UI Controller only if you specify the **@MVC** property when declaring the Controller.

Rich UI date and time support

Rich UI supports a subset of EGL formatting capabilities for Rich UI dates, times, and timestamps; however, intervals are not supported.

Assigning a string to a date, time, or timestamp

Rich UI follows the EGL rules for assigning a string to a variable of type DATE, TIME, or TIMESTAMP. In particular, the following default formats are in use:

- For date variables, strLib.defaultDateFormat
- For time variables, strLib.defaultTimeFormat
- For timestamp variables, strLib.defaultTimestampFormat

The following code assigns a string to a date field:

```
strLib.defaultDateFormat = "yyyy/MM/dd";
d date = "2008/04/08";
```

EGL is forgiving; for example, when one separator is substituted for another:

```
strLib.defaultDateFormat = "yyyy/MM/dd";
d date = "2008-04-08";
```

In a second example of forgiveness, you can omit the separators entirely:

```
strLib.defaultDateFormat = "yyyy/MM/dd";
myDate date = "20100412";
```

Assigning a date, time, or timestamp to a string

Here are the rules for assigning time-related variables to strings:

- To assign a date variable to a string, use **strLib.formatDate**.

  In Rich UI, only the following formatting symbols are valid:

  – yyyy for the 4-digit year
  – yy for the 2-digit year
  – MM for the 2-digit month
  – dd for the 2-digit day
  – separators such as hyphens, slashes, and blanks

  You can set the build descriptor option **formatDate**, which provides a default for the **strLib.formatDate**.
- To assign a time variable to a string, use **strLib.formatTime**.

  In Rich UI, only the following formatting symbols are valid:

  – HH for the 2-digit hour (0 to 23) in military time
  – hh for the 2-digit hour (1 to 12)
  – mm for the 2-digit minute in the hour
  – ss for the 2-digit second in minute
  – a for AM or PM
  – separators such as hyphens, slashes, and blanks

  You can set the build descriptor option **formatTime**, which provides a default for the **strLib.formatTime**.
- To assign a timestamp to a string, use **strLib.formatTimestamp**.

  In Rich UI, only the following formatting symbols are valid:

  – HH for the 2-digit hour (0 to 23) in military time
  – hh for the 2-digit hour (1 to 12)
  – mm for the 2-digit minute in the hour
  – ss for the 2-digit second in the minute
  – SSSSSS for a fractional second; specifically, a 3-digit millisecond followed by three zeros as a result of restrictions in JavaScript
  – a for AM or PM
  – separators such as hyphens, slashes, and blanks

  Note that the character for fractional seconds is S for strLib.formatTimestamp, but is f in the mask used at timestamp declaration.

  You can set the build descriptor option **formatTimestamp**, which provides a default for the **strLib.formatTimestamp**.

If a date is assigned directly to a string (as shown in the previous section), the string is formatted in accordance with the default format. For example, consider the following code:

```
strLib.defaultDateFormat = "yyyy/MM/dd";
t date = "2010-04-12";
myString STRING = date;
```

The value of `myString` is "2010/04/12".

Form processing with Rich UI

The Rich UI controller mechanism relates a single view—a widget—with a single a model—a data field, as described in *Rich UI validation and formatting*. Rich UI also provides a way to simulate traditional form processing, which is characteristic of business software. For example, you may want to create an application that fulfills the following steps:

- The application presents data to the user
- The user accepts the data or types updates; clicks a button or presses a key to submit the data; validates the input; and commits all the validated data to some backend code—in our case, to a service

Rich UI form processing relies on the ValidatingForm widget, which is primarily a collection of form fields. When you declare a form field, you reference a controller and can include the following details:

- A string field named **displayName**, which provides the text for an onscreen label
- A string field named **labelClass**, for the CSS class used to when displaying the label. (By default, the class name is eglRuiTextLabel)

For example, here are example entries for validating a form:

```
employeeForm ValidatingForm { entries = [
   new FormField { displayName="Name:",   controller=nameController },
   new FormField { displayName="Age:",    controller=ageController },
   new FormField { displayName="Salary:", controller=salaryController }
]};
```

The form as a whole has the following functions:

- **isValid** invokes the controller-specific functions of the same name. Field validation occurs in the order in which the form fields are listed in the **entries** array. You may want to update the form-level **isValid** function so that it references functions that provide cross-field validation.
- **validStateSetter** is the default **validStateSetter** function for any controllers referenced in the form, but with an additional behavior.

  If the form-level function is used (that is, if *any* of the controllers lack their own **validStateSetter** function), every form label associated with invalid content is displayed in accordance with the following Cascading Stylesheet (CSS) class: the initial class such as EglRuiTextLabel, along with the following, secondary class: FormErrorLabel.

  The assumption here is that you want the same kind of display for invalid input in any form field.
- **commit** lets you commit all the views to the related models with one command; in our example, the command is `employeeForm.commit`. The order of the view-specific **commit** invocations is the order in which the form fields are listed in the **entries** array. After you invoke the form-level **commit** function, you can transmit all the model data to a service.
- **publish** lets you publish all the models to the related views with one command; in our example, the command is `employeeForm.publish`. The order of the model-specific **publish** invocations is the order in which the form fields are listed in the **entries** array. You can invoke the form-level **publish** command in an application function that receives data returned from a service.

Use of properties files for displayable text

Rich UI lets you define displayable text in an external file used at run time. Here are specific reasons for defining text in this way:

- To override the runtime messages that are available, by default, for failed input validations or for incorrect formatting on input or output
- To assign text to widgets without hard-coding that text in the Rich UI application
- To display text in one or another language so that your code can be used more widely

Overriding validation or formatting messages

If you wish to override validation or formatting messages, do as follows:

- Ensure that you are using the controller mechanism described in *Rich UI validation and formatting*.
- Create a Rich UI properties library—a library part that has the stereotype **RUIProperties**, as described in *RUIPropertiesLibrary stereotype*. For an example that follows, the library name is `myLibrary`, and the library includes declarations of strings named `entryForInputRequired` and `entryForOthers`. Those variable names are case sensitive.
- In a Rich UI handler or other code, specify the property **validationPropertiesLibrary** in a part definition or variable declaration, along with other validation and formatting properties. Here is an example declaration:

  ```
  name STRING {inputRequired = yes,
               lowercase = yes,
               inputRequiredMsgKey = "entryForInputRequired",
               typeChkMsgKey = "entryForOthers",
               validationPropertiesLibrary=myLibrary };
  ```

  The property **validationPropertiesLibrary** is used only when you are overriding validation and formatting messages.
- Set up a properties file and include entries (name-value pairs) for which the names match the values of **MsgKey** properties. In the current example, the properties file includes the following entries:

  ```
  entryForInputRequired=You must specify a value
  entryForOthers=Your input is incorrect
  someText=Not mentioned
  ```

  The properties file is a text file. The entry names are case sensitive and are useful only if they match a string declaration in the Rich UI properties library.

Here are the implications of the current example:

- An input-required error at run time results in display of the message "You must specify a value," which is identified by the name `entryForInputRequired`.
- An input of an uppercase letter at run time also results in display of the message "Your input is incorrect." This outcome occurs because the value of the property **typeChkMsgKey** is used in response to a variety of errors; in this case, in response to a user input (the uppercase letter) that is disallowed by the lowercase property.

Here are the rules that explain the behavior just described:

- For a given data field, you can override the default messages associated with each of the following properties:
  - **inputRequired**

  - **minimumInput**
  - **validValues**

  The override relies on one of the following three "MsgKey" properties: inputRequiredMsgKey, minimumInputMsgKey, and validValuesMsgKey.
- Also for a given data field, you can specify a single override for errors related to any of the following properties:
  - **currency**
  - **currencySymbol**
  - **dateFormat**
  - **fillCharacter**
  - **isBoolean**
  - **isDecimalDigit**
  - **isHexDigit**
  - **lowercase**
  - **numericSeparator**
  - **sign**
  - **timeFormat**
  - **timestampFormat**
  - **uppercase**
  - **zeroFormat**

  That single override also relies on the property **typeChkMsgKey**.

Assigning text to widgets

The Rich UI mechanism for displaying text from an external file always relies on using an Rich UI properties library, regardless of the purpose of the text. The following statements apply whenever you use the external file for reasons other than overriding a default message:

- The rules for EGL library access apply. For example, assume that you have a Rich UI properties library named `myLibrary` and a button named `myButton`. Here is one way to assign text (in our example, the string "Not mentioned") to the button in your application:

  ```
  myButton.text = myLibrary.someText;
  ```

  Alternatively, you can reference `myLibrary` in a **use** statement, in which case you do not need to reference the library name in the assignment.
- You can invoke the implicit library function **getMessage** to provide inserts to a properties-file entry.

You can also use the library function **getMessage** to provide inserts to a string inside your code. For details on using inserts, see *RUIPropertiesLibrary stereotype*.

Displaying text in one or another language

You can have several files, one for each language you wish to support. The choice of language is based on the user's browser setting.

A displayable value comes from a properties file whose name has a root (for example, `myLibrary`) and includes a *locale*, which is a code that identifies a human language, For example, *en* is the locale that represents English, and the file name `myLibrary-en` refers to a properties file that provides English text.

Each file name has a root name and the extension `.properties`. The locale is indicated at the end of the root name, before the extension. Locales consist of one to three identifiers, the first preceded with a hyphen and the others (if any) preceded with an underscore. Each additional identifier after the first enables you to indicate a more specific language; in particular, you can specify the dialect, variety, or geographic location of a language.

The identifiers are the language code, country code, and variant code:

- Among the language codes are *en* for English and *es* for Spanish. The language code is part of the Java specification.
- The country code indicates a country where the dialect of the language is spoken. For example, the country code US indicates the United States, and GB indicates Great Britain. In this way, an American English file might be named `myLibrary-en_US.properties`, while a British English properties file might be named `myLibrary-en_GB.properties`. The country code is part of the Java specification.
- The variant code defines a more specific dialect or variety of the language in the properties file. For example, you could use the variant codes A and B to distinguish between two different varieties of Norwegian spoken in Norway. These two files might be named `myLibrary-no_NO_A.properties` and `myLibrary-no_NO_B.properties`. Alternately, you could define a standard type of Norwegian as the locale no_NO and define a variant as no_NO_B. The variant code is not part of the Java specification.

During application deployment, the HTML file that contains the EGL-generated JavaScript references a locale-specific properties file. At runtime, the browser requests that file from the server, and an error results if the file is unavailable.

Accessing an application that uses a specific locale

In most cases, the locale used at run time depends on the browser locale. However, the user can request a different locale by invoking a locale-specific HTML file, perhaps as a result of clicking a hypertext link that you provide. For example, here is HTML that invokes the German version of MyApplication.html from www.example.com (assuming that a German version was deployed there):

```
<a href="www.example.com/MyApplication-de.html">German version</a>
```

Deploying properties files

Store properties files in the WebContent/properties folder of your project. The root of the property file name (for example, `myLibrary`) must be the name specified in the **propertiesFile** property in the the Rich UI properties library.

By working with the Rich UI Deployment wizard, you prepare a Rich UI application for installation on one or another type of Web server. You can do either or both of the following tasks:

- You can select from the list of generally available locales; for example, en for English. Whenever you specify a locale from the list, your selection includes the following application components in the deployed output:
  - A locale-specific properties file that you provide, if any; and
  - Locale-specific *runtime messages*. In the Rich UI deployment wizard, the phrase *runtime messages* refers to messages other than those that can be in the properties file.

- In addition to selecting from a list of generally available locales, you specify new locales. Each new locale is available for only one purpose— to include a locale-specific properties file that you provide. If you identify a new locale, you also must specify one of the generally available locales for use when the new locale is requested. That generally available locale is used for only one purpose—to include runtime messages other than those that can be in the properties file.

RUIPropertiesLibrary stereotype

You set up a Rich UI properties library (stereotype **RUIPropertiesLibrary**) if you wish to retrieve displayable text from external files rather than hard-coding the text in your Rich UI application. The overall mechanism is described in *Use of properties files for displayable text*. You can also use an implicit function in a Rich UI properties library to substitute values in any string.

Here is an example of a Rich UI properties library:

```
Library myLibrary type RUIPropertiesLibrary {propertiesFile="myFile")
   entryForInputRequired STRING;
   entryForOthers STRING;
   someText STRING;
end
```

Any value assigned directly in a declaration (for example, `someText String = "Click!";`) has no effect. Every runtime value comes from an external file, with one exception: if the file does not include a particular entry (for example, if the file does not include an entry for `someText`), the value at run time is the string equivalent of the variable name (for example, "someText").

Property propertiesFile

The property **propertiesFile** refers to the root name of the file. The file (or files, if multiple translations are available) must reside directly in the project's WebContent/properties directory. Do *not* include any of the following details in the root name:

- Path information such as "properties/myFile"
- Hyphens
- Translation-specific information such "en_US"
- The file extension, which is necessarily *properties*

The default value for **propertiesFile** is the name of the library; in this case, "myLibrary".

Function getMessage

Every RUI properties library implicitly includes the function **getMessage**, which lets you add inserts when selecting a message from the properties file or from a string in your code. For example, the following message in a properties file requires two inserts:

```
someText=Promote {0} in the {1} department
```

Here is example code that writes the string "Promote Jeff in the Sales department" to a label:

```
employeeName, departmentName String;
employeeName = "Jeff";
departmentName = "Sales";
```

```
myLabel TextLabel {text =
   myLibrary.getMessage(myLibrary.someText, [employeeName, departmentName]);
```

An alternative invocation has the same effect as the previous one but does not access a properties file:

```
myMessage STRING = "Promote {0} in the {1} department";
myLabel TextLabel {text =
   myLibrary.getMessage(myMessage, [employeeName, departmentName]);
```

Here is the function signature:

```
getMessage(baseMessage STRING in, inserts STRING[] in) returns (fullMessage STRING);
```

baseMessage
A string or a field in an RUI properties library.

inserts
An array of strings, with the first element providing an insert for the placeholder {0}, the second providing an insert for the placeholder {1}, and so on.

fullMessage
The base message with as many placeholders resolved as possible

The inserts are in ascending order, starting at 0, and the placeholders in the message may be in any order and do not need to be in sequence. If an insert does not match a placeholder by number, the insert is unused. If a placeholder is unresolved, the placeholder itself is in the returned message. For example, the returned message is "Promote Jeff in the {1} department" in the following case:

```
employeeName STRING = "Jeff";
myMessage STRING = "Promote {0} in the {1} department";
myLabel TextLabel {text =
   myLibrary.getMessage(myMessage, [employeeName]);
```

You cannot use the function **getMessage** when overriding a validation or formatting message. You cannot pass inserts to such a message.

Browser history

Consider what happens if you access the IBM Web site (http://www.ibm.com) and then the IBM Rational Cafes (http://www.ibm.com/rational/cafe). Two different Web pages are provided from remote servers, and you can click the **Back** and **Forward** buttons in your browser to revisit each of the two sites. In contrast, the main processing in a Rich UI application is solely in your browser. The application may render new content and may even access the server for visual updates, but in most cases, the **Back** and **Forward** buttons are either disabled or direct processing to other Web sites.

In Rich UI, you decide what on-screen content to identify as a separate Web page. You enforce that decision by accessing functions in History, which is a Rich UI handler part provided with the product. By working with History, you can assign pages to the browser history at run time, and the user can use the **Back** and **Forward** buttons to access different pages in the application. Also, you can respond to the user's attempt to close the browser.

The browser-history mechanism does not save the state of a given Web page. You need to code the behavior that makes sense for your application.

Setting up a browser history and event response

To set up the browser history and event response, do as follows:

1. In your Rich UI application, declare a Rich UI handler based on History, as in the following outline:

   ```
   import com.ibm.egl.rui.history.History;
   import com.ibm.egl.rui.history.HistoryChanged;
   import com.ibm.egl.rui.history.OnBeforeUnloadMessageFunction;

   Handler MyApplication Type RUIHandler { onConstructionFunction=start }
      myHistory History {};
   end
   ```

   By declaring a variable based on History, you add `#empty` to the Web address displayed in the user's browser. In regard to subsequent processing, `empty` is the name of the new page. The new page is added to an application-specific browser history, but not to the browser's own history, which retains only the original Web address.

2. In the on-construction function (for example), you can set up access to functions—event handlers—that run in response to specific user events:

   - One such event is either adding a new page to the browser history or navigating to a different page. Later, we show how to add or move to a new page. First, we describe how to set up the event handler.

     To enable a custom response to a new-page event, invoke the **addListener** function and reference an event handler that you code. Here is an example invocation of the **addListener** function:

     ```
     myHistory.addListener(myHistoryChanged);
     ```

     The following Delegate part outlines the characteristics of the referenced event handler:

     ```
     Delegate
        HistoryChanged(newPageName String in)
     end
     ```

     As shown, the event handler for the new-page event accepts a string. If you invoke **addListener** and reference a custom function, the custom function is invoked in the following cases: when the browser adds the initial page named `empty`, and when you add a subsequent page. In each case, the user's browser displays the Web address and includes the page name, which is the address subset that is displayed subsequent to the pound sign (#); also, the EGL Runtime provides that page name to your function.

     Here is an example event handler that is invoked after a new-page event, with `myLabel` assumed to be a widget in the user display:

     ```
     function myHistoryChanged(newPageName String in)
        myLabel.text = "History was changed. Current page name is "+ newPageName;
     end
     ```

     You can register multiple new-page event handlers by running **addListener** multiple times. The referenced functions run in the order of registration. Even if you register the same function multiple times, all the registrations are in effect.

   - A second event is the user's attempt to close the browser or browser tab.

     In this case, invoke the `keepUserOnPage` function and reference an event handler that you code. Here is an example invocation of the `keepUserOnPage` function:

     ```
     history.keepUserOnPage(stayHere);
     ```

     The following Delegate part outlines the characteristics of the referenced event handler:

```
Delegate
   OnBeforeUnloadMessageFunction() returns(String)
end
```

As shown, the event handler for the close-browser event returns a string. That string is displayed in a dialog box that lets the user confirm or reverse the browser close.

Here is an example event handler that is invoked after a close-browser event:

```
function stayHere() returns(String)
  return ("Close the application?");
 end
```

Adding an entry to a browser history

You add an entry to the application-specific browser history by invoking the function **addToHistory**. The following example adds a page named `myNewPage`.

```
myHistory.addToHistory("myNewPage");
```

The implication is as follows:

- The new-page event handler runs; in our example, the handler name is `myHistoryChanged`
- If the user clicks the **Back** button, the Web address in the browser includes the name of the previous page; and then, the **Forward** button is enabled, too.

Navigating to the previous page

You can navigate to the previous page in your application. Here is the example code:

```
myHistory.goBack();
```

The implication is as follows:

- The new-page event handler runs; in our example, the handler name is **myHistoryChanged**
- The Web address in the browser changes, as appropriate
- Subsequent navigation (forward and back) changes to reflect the new Web address

Navigating to the next page

You can navigate to the next page in your application. Here is the example code:

```
myHistory.goForward();
```

The implication is as follows:

- The new-page event handler runs; in our example, the handler name is `myHistoryChanged`
- The Web address in the browser changes, as appropriate
- Subsequent navigation (forward and back) changes to reflect the new Web address

Rich UI Infobus

The Rich UI Infobus is a library that makes available a publish-and-subscribe mechanism, which works as follows:

- A handler subscribes to an event of a specified name. At the time of subscription, the handler also references a function that will receive data when the event occurs. The Infobus then registers the function so that it can be invoked at the appropriate time.

  For example, the following Rich UI handler part subscribes to an event named sample.test and provides a label—a presentation area—that an embedding handler can use:

```
Handler embeddedHandler Type RUIHandler {onConstructionFunction=start}

   feedback TextLabel;

   function start()
     InfoBus.subscribe("com.mycompany.sample.test", showPublish);
   end

   function showPublish(eventName STRING in, data ANY in)
      feedback.text = "The " + eventName + " event occurred and passed " + data;
   end
end
```

  In a more realistic case, the showPublish function might receive a record with several fields and then transmit the data to a remote service.

- The same or a different handler in the same Rich UI application publishes the event, specifying the event name and some event-specific data. At the time of publication, the Infobus invokes the function that was specified at the time of subscription, passing the event-specific data to the function.

  For example, the following handler embeds the previous one, publishes the event, and causes display of the following statement: *The sample.text event occurred and passed input data for a service*:

```
Handler InfoBusTest Type RUIHandler
   { initialUI = [myButton, myDiv] }

   myButton Button{text = "Publish the event", onClick ::= clickHandler};
   myDiv Div { children = [new embeddedHandler{}.feedback] };

   function clickHandler(e Event in)
      InfoBus.publish("com.mycompany.sample.test", "input data for a service");
   end
end
```

  Note that the function **InfoBus.publish** does not include the name of the showPublish function. Instead, the Infobus acts as a mediator, ensuring that the appropriate function is invoked.

Infobus functions

The following Infobus functions are in use:

- **Infobus.subscribe** accepts two arguments: an event name and a reference to the function that the Infobus invokes when the event is published. The event name may include wildcard characters, as described later.

  You must code the function to be invoked. That function is based on the following Delegate part, which indicates that the function can accept whatever type of data you provide when you publish the event:

```
InfoBusCallback(eventName String in, data any in)
```

  Infobus.subscribe also returns a subscription value (type ANY), which you can use to unsubscribe from the event.

- **Infobus.unsubscribe** accepts a single parameter; the value of type ANY returned from Infobus.subscribe. This function has no return value.

- **Infobus.publish** accepts two arguments: an event name and the data that you provide. This function has no return value.

Event names and wild cards

An event name is composed of one or more *tokens*—character symbols such as *sample* and *test* (in our example). each of which is separated from the next by a dot.

You can use **Infobus.subscribe** to subscribe to more than one event. Two wildcard characters are available, and you can use both in the same Infobus.subscribe invocation:

- If an asterisk (*) is used in place of a token, the function registered by Infobus.subscribe is invoked when your code publishes any event whose name matches the event name regardless of the token that you specify in place of the asterisk. For example, if Infobus.subscribe identifies the event name as *com.mycompany.update.*.new.employee*, the function registered by **Infobus.subscribe** is invoked in response to any of the following invocations:

```
InfoBus.publish("com.mycompany.update.sales.new.employee", "some data");

InfoBus.publish("com.mycompany.update.marketing.new.employee", "some data");

InfoBus.publish("com.mycompany.update.outreach.new.employee", "some data");
```

- If a double asterisk (**) is used in place of the last token, the function registered by **Infobus.subscribe** is invoked when your code publishes any event whose name matches the event name regardless of the *series* of tokens (and intervening dots) that you specify in place of the asterisk. For example, if Infobus.subscribe identifies the event name as *com.mycompany.update.sales.***, the function registered by **Infobus.subscribe** is invoked in response to any of the following invocations:

```
InfoBus.publish("com.mycompany.update.sales.new.employee", "some data");

InfoBus.publish("com.mycompany.update.sales.temporary.employee", "some data");

InfoBus.publish("com.mycompany.update.outreach.new.temporary.employee", "some data");
```

For additional details

The Infobus mechanism is based on an implementation of the OpenAjax alliance. You may not need further details on this mechanism, but can get them as follows:

1. Go to the OpenAjax alliance Web site:

   http://www.openajax.org/index.php
2. Click **Wikis > Member Wiki**
3. Type the following string in the **Search** field: *OpenAjax Hub 1.0 Specification PublishSubscribe*

Rich UI does not support the specification phrases related to *filter* or *scope*.

Non-Infobus communication between Rich UI handlers

One way to organize your application is to separate the user interaction, as expressed in one Rich UI handler, from the back-end processing of business data, as expressed in a second Rich UI handler. This section outlines some mechanisms—aside from the Infobus—by which one handler can communicate with another.

Pushing data from the embedding handler

In the simplest case, the embedding handler can invoke a function in the embedded handler:

```
Handler EmbeddingHandler type RUIHandler
   { onConstructionFunction = onConstructionFunction }

   embeddedHandler EmbeddedHandler;

   function onConstructionFunction()
      myString STRING = "Received from somewhere";
      embeddedHandler.function01(myString);
   end
end
```

Using delegates

Another possibility is to cause the embedded handler to invoke a function in the embedding one. In this case, the embedding handler updates the value assigned to a *delegate* in the embedded handler. A delegate is a variable that references a function of a specific *type*; that is, the variable provides access to a function that has a specific set of characteristics.

An example can help you to see the relationships. Consider the following EGL Delegate part, which defines a function that has no parameters or return value:

```
delegate switchPart() end
```

The next example shows how to toggle between two Web pages. Here is the embedded handler, Page2, which declares the delegate named switch:

```
handler Page2 type RUIHandler { onConstructionFunction = myFirstFunction,
                                initialUI = [content] }

 content Box{children = [secondLabel, button], columns = 1};
 secondLabel TextLabel{text = "page2!"};
 button Button{text="switch back to first page", onClick ::= switchToFirst};

 //declaration of a delegate
 switch switchPart{};

 function myFirstFunction()
 end

 function switchToFirst(e Event in)
   switch();
 end
end
```

The question is, what logic runs when switch() is invoked inside the switchToFirst? The answer is in the embedding handler, Page1, which assigns its own function to the delegate:

```
handler Page1 type RUIHandler
  { onConstructionFunction = myFirstFunction, initialUI = [page] }

  page Box{ columns = 1, children = [firstLabel, button]};
  firstLabel TextLabel{text = "page1!"};
  button Button{text = "switch to page 2", onClick ::= switchTo2};

  page2 Page2{};

  function myFirstFunction()
     page2.switch = switchBack;
```

```
  end

  function switchTo2(e Event in)
    page.children = [page2.content];
  end

  function switchBack()
     page.children = [firstLabel, button];
   end
end
```

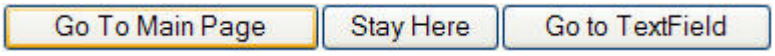
Using delegates to navigate to any of several pages

An extension of the previous example is to define a page handler (we call it MainHandler) that controls the user's subsequent navigation to any of several Web pages. Again, we are creating a page-by-page flow of events, as is the traditional approach to Web applications. You can start with an approach like this, keeping in mind that Rich UI lets you update parts of a Web page in response to a runtime event.

In this example, the Delegate part takes a string and has no return value:

```
delegate SwitchToPagePart( TargetPage STRING in) end
```

Three Rich UI handlers are involved here. Here is the output of the first, ButtonHandler, which shows the available options:



In reviewing the code, note that `switchFunction` is a delegate and that its invocations refer to logic that resides in MainHandler, which is shown later:

```
handler ButtonHandler type RUIHandler{initialUI = [button1, button2, button3]}
   switchFunction SwitchToPagePart;
   button1 Button{text = "Go To Main Page", onClick::= toMain};
   button2 Button {text = "Stay Here"};
   button3 Button{text = "Go to TextField", oncLick::=toText};

   function toMain(e Event in)
     switchFunction("MainHandler");
   end

   function toText(e Event in)
     switchFunction("TextFieldHandler");
   end
end
```

Here is the output of the second handler, TextFieldHandler:

In reviewing the code, note that this Rich UI handler also declares a delegate that is based on SwitchToPagePart and that the user can specify the Web page to present next, even though this handler is not aware of what Web pages are available:

```
handler TextFieldHandler type RUIHandler
   {initialUI = [instructions, Field1, myButton]}

   // a delegate
```

```
   switchFunction SwitchToPagePart;
   instructions TextLabel {text = "Type a page name and click the button."};
   Field1 Textfield{width = 200};
   myButton Button{text = "Go to the specified page", onClick ::= handleEvent};

   function handleEvent(e Event in)
      switchFunction(Field1.text);
   end
end
```

Last, MainHandler simply displays the text "Click to see your options," but could display a splash screen. Here is the code, including logic that displays content stored in other handlers:

```
handler MainHandler type RUIHandler{initialUI = [mainBox]}

   mainBox Box{columns = 1, children = [mainLabel]};
   mainLabel TextLabel{
      text = "Click to see your options.",
      onClick::= mainEvent};
   buttonHandler ButtonHandler{switchFunction = switchTo};
   textFieldHandler TextFieldHandler{switchFunction = switchTo};

   function switchTo(target string in)
      case (strlib.upperCase(target))
         when ("TEXTFIELDHANDLER")
            mainBox.children = [textFieldHandler.instructions,
                                textFieldHandler.Field1,
                                textFieldHandler.myButton];
         when ("BUTTONHANDLER")
            mainBox.children = [buttonHandler.button1,
                                buttonHandler.button2,
                                buttonHandler.button3];
         when ("MAINHANDLER")
            mainBox.children = [mainLabel];
      end
   end

   function mainEvent (e Event in)
      switchTo("ButtonHandler");
   end
end
```

Notifying the embedding handler after a service call

The embedded handler may have no widgets at all, but may call a service. As noted in *Accessing a Service in Rich UI*, service invocation in Rich UI is always *asynchronous*, which means that the requester—the Rich UI handler—continues running without waiting for a response from the service. The user can still interact with the user interface while the Rich UI handler waits for the service to respond. After the invocation, the service does some task and (in most cases) responds to the requester by invoking a function that you code in the Rich UI handler. That function is called a *callback function*.

From within the callback function, the embedded handler might notify the embedding handler. Consider the following EGL Delegate part, which defines a function that has no parameters or return value:

```
delegate notifyPart() end
```

Here's an outline of an embedded handler:

```
handler MyModel type RUIHandler { onConstructionFunction = myFirstFunction }
   //declaration of a delegate
   notify notifyPart{};
```

```
   function myFirstFunction()
      call myService.myOperation(12) returning to myCallback;
   end

   function myCallback(returnValue STRING)
      notify();
   end
end
```

As before, the embedding handler assigns its own function to the delegate:

```
handler MyHandler type RUIHandler { onConstructionFunction = myFirstFunction }

   theModel MyModel;

   function myFirstFunction()
      theModel.notify = myNotification();
   end

   function myNotification()
      // respond, perhaps by accessing details from the embedded handler
   end
end
```

Rich UI drag and drop

You can write code so that a user is able to drag a widget from one location and drop it at another. More broadly, your code can respond to the following user events: a single mouse-down event when the user holds the position; subsequent mouse-move events; and a single mouse-up event. You can fulfill any runtime tasks that are represented by the drag and drop; Rich UI does not define the behavior.

You write the drag-and-drop code by specifying three properties in a widget declaration and by writing functions that are referenced in the corresponding property values. For example, here is the declaration of a button:

```
b1 Button {
   text = "Button 1", position="absolute", x=10, y=10,
   onStartDrag = start, onDrag = drag, onDropOnTarget = drop};
```

Here are the three properties that make drag-and-drop possible:

- `onStartDrag` references a function that the EGL Runtime calls once, at the start of a drag operation. The function has characteristics that are shown in the following Delegate part:

  ```
  Delegate StartDragFunction(widget Widget in,
                             x int in, y int in) returns (Boolean)
  ```

  The function receives a reference to the widget and receives the absolute x and y coordinates of the mouse pointer. The function returns a Boolean value that indicates whether to continue the drag operation.
- `onDrag` references a function that the EGL Runtime calls repeatedly, as the drag operation proceeds; specifically, each time the browser records a mouse-move event. The function has characteristics that are shown in the following Delegate part:

  ```
  Delegate DragFunction(widget Widget in,
                        dropTarget Widget in,
                        x int in, y int in)
  ```

  The function receives references to the widget being dragged and to the widget (if any) over which the mouse pointer is passing. If the mouse pointer is not

passing over any widget, the second argument is null. The function also receives the absolute x and y coordinates of the mouse pointer and has no return value. The function itself should update the position of the widget (or some other image) in response to the mouse-move event.

- `onDropOnTarget` references a function that the EGL Runtime calls once, when the user releases the mouse to end the drag operation. The function has characteristics that are shown in the following Delegate part:

  ```
  Delegate DropOnTargetFunction(widget Widget in,
                       dropTarget Widget in,
                       x int in, y int in)
  ```

  The function receives references to the widget being dropped and to the widget (if any) under the mouse pointer. If no widget is under the mouse pointer, the second argument is null. The function also receives the absolute x and y coordinates of the mouse pointer and has no return value.

Here is an example you can bring into your workspace:.

```
import com.ibm.egl.rui.widgets.TextField;

handler MyHandler type RUIHandler{initialUI =[myTextField]}
   myTextField TextField{text =
                   "What a drag!", position = "absolute", x = 110, y = 210, width = 120,
                   onStartDrag = start, onDrag = drag, onDropOnTarget = drop};
   dx, dy int;

   function start(myWidget Widget in, x int in, y int in) returns(boolean)
      dx = x - myWidget.x;
      dy = y - myWidget.y;
      return(true);
   end

   function drag(myWidget Widget in, drop Widget in, x int in, y int in)
      myWidget.x = x - dx;
      myWidget.y = y - dy;
   end

   function drop(widget Widget in, drop Widget in, x int in, y int in)
   end
end
```

The `start` function calculates the difference between the location of the mouse pointer and the top-left corner of the widget. The effect of using that calculation is that the mouse pointer is displayed at the same place on the widget throughout the operation. To see the effect, run the code twice, clicking the *bottom-right corner* of the widget to start the drag-and-drop operation each time:

1. Run the code as shown
2. Run the code only after replacing the statements in the `drag` function with the following assignments:

   ```
   myWidget.x = x;
   myWidget.y = y;
   ```

Additional examples are in *Rich UI Shadow*.

Rich UI job scheduler

The Rich UI job scheduler is a timer that lets you invoke a customized function after a specified number of milliseconds. You can schedule multiple jobs and can cancel them in response to runtime conditions.

You can try the following example in your workspace:

```
import com.ibm.egl.rui.widgets.Button;
import egl.javascript.Job;

handler MyHandler type RUIhandler { initialUI = [stopButton],
                                    onConstructionFunction = initialization }

   stopButton Button{text="Stop!", onclick ::= pleaseStop};
   doThis Job{runFunction = myRunFunction};

   function initialization()
      doThis.repeat(1000);
   end

   function myRunFunction()
      sysLib.writeStdOut(currentTime());
   end

   function pleaseStop(e event in)
      doThis.cancel();
   end
end
```

Use of this capability requires that you type the following **import** statement:

```
import egl.javascript.Job;
```

You cannot add that statement with the **Ctrl-Shift-O** mechanism that is available for Widget types.

Two definitions may clarify the relationships:

- The *run function* is the function that is invoked when the job is scheduled. The run function in our example is `myRunFunction`.
- The *current function* is the function that is running while the timer is running.

The job scheduler is a variable based on an EGL external type named Job. When you declare the variable, you can set the following properties:

name
Used by the EGL debugger to identify the job scheduler. If you omit this property, the value of **name** is the variable name.

runFunction
Identifies the run function, which has no parameters and no return value.

You can use a job scheduler to invoke the following functions:

schedule (int *milliseconds***)**
Sets a timer immediately for the specified number of milliseconds and causes a subsequent invocation of the run function. The invocation occurs, at earliest, when the timer elapses or when the current function ends, whichever happens last. If you omit *milliseconds*, the invocation occurs, at earliest, as soon as the current function ends.

repeat (int *milliseconds***)**
Sets a timer immediately for the specified number of milliseconds and then causes repeated invocation of the run function.

The timer is reset each time the run function starts. The rule for each invocation of the run function, including the first, is that the invocation occurs, at earliest, when the timer elapses or when the current function ends, whichever happens last.

cancel()
Cancels later invocations of the job.

The invocation of a run function never interrupts the execution of another function. For example, between the time when a job is scheduled and the time when the invocation of the run function is possible, the user might click a button to cause scheduling of an event handler. In that case, the invocation of the job function waits at least until the event handler invokes its own subordinate functions, if any, and ends.

You can create multiple variables of type JOB and in this way schedule multiple jobs and even invoke the same run function. In all cases, only one function can run at a given time, and it runs to completion.

If you use the same variable to reschedule a job, the previous use of that variable is canceled.

Overview of service access

This section gives background information on remote service access, with an emphasis on EGL Rich UI. The underlying purpose of the technologies described here is to provide a calling mechanism, so that one unit of logic—such as your Rich UI application—can exchange data with another unit of logic—a service that might be half a world away.

We can distinguish between two kinds of service technologies:

- Traditional Web services fulfill a Remote Procedure Call (RPC) style. In this case, you pass a business-specific operation name (for example, GetEmployeeData) and a set of arguments. With this style, invoking a service is similar to invoking a function.
- In contrast, REST services conform to the rules of Representational State Transfer (REST). The *RESTful* style is based on the transfer of (at most) a single unit of business data; for example, a set of values that includes an employee number, title, and salary. The invoked service fulfills one of four preset operations:
  - GET, for reading data; for example, to retrieve details on the specified employee
  - POST, for creating data
  - PUT, for updating data
  - DELETE, for deleting data

  When you access a service that fully conforms with the principles of REST, you do not need to include a business-specific operation name such as GetEmployeeData.

A service provider indicates whether a service is deployed as a traditional Web service or as a REST service. An important difference between the two kinds of service technologies is their relative complexity:

- A traditional Web service receives and returns data that is in a format called SOAP. which once stood for Simple Object Access Protocol. The long name was dropped.

  The complexity of a traditional Web service is related not only to the message format, but to the required presence of a configuration file at deployment time. That configuration file is called a Web Services Description Language (WSDL) file, as described later.

  The overall complexity has a benefit for enterprise development, allowing for advanced capabilities related (for example) to security and to coordination among services.
- A traditional REST service exchanges messages but does not require the added complexity of SOAP. Access to this kind of service usually does not involve a configuration file.

  REST involves a different way of thinking about service interaction and construction. To some extent, the EGL implementation lets you access a REST service while thinking about the service as if it fulfilled the RPC style.

The next sections provides additional details about the technologies.

Background on REST

REST involves four main ideas: resource, representation, URI, and action.

A *resource*—for example, a database row with employee data—has (at a given time) a *representation*—what we earlier called a "single unit of business data." A representation might be a set of program values that specify the employee number, title, and salary.

The resource—in our example, the database row—also has a universal resource indicator (*URI*), which is a unique name such as "http://www.example.com/gateway/employee/0020". In this case, the employee number is 0020. In general, the URI gives a name to the resource. Also, the URI provides the main detail needed to access a REST service.

An *action* indicates what is to be done with the resource. As suggested earlier, the possible actions are few: the resource can be *created*, *read*, *updated* , or *deleted*.

The requester of a REST service identifies a resource, specifies an action, and (if the action involves resource creation or update) provides a representation of the resource. However, the practical use of REST does not always conform to this idea, as noted in the next section.

REST and HTTP

The practical application of REST involves Hypertext Transfer Protocol (HTTP), which is a set of rules that governs the runtime transmission of Web pages on the Internet. The HTTP message that invokes a service (or retrieves a Web page) is called a *request*. The HTTP message that returns a status value is called a *response*.

An HTTP request begins with a verb that identifies an action. As suggested earlier, here are the verbs used by Rich UI:

- POST, for creating a resource
- GET, for reading a resource
- PUT, for updating one

- DELETE, for deleting one

In HTTP, a URI may specify the resource of interest in the following ways:

- The URI can include *path variables*, which are variables whose values identify the resource of interest in a direct way, without requiring that a service process the input to determine the resource. In the following example, the employee number is a path variable, and its value is appended to the URI:

  ```
  http://www.example.com/gateway/employee/0020
  ```

  Path variables are appropriate in most cases. You might use multiple path variables, with one separated from the next by a forward slash. That use of multiple variables suggests a hierarchical relationship. For example, the path variables in the following URI refer to a corporate division (Consumer) and, within that division, a corporate department (Sales):

  ```
  http://www.example.com/gateway/employee/Consumer/Sales
  ```

- In relation to a GET operation, the URI can be supplemented with *query parameters*, which are argument-value pairs. In the following example, the question mark (?) precedes the query parameters, and each parameter is separated from the next by an ampersand (&):

  ```
  http://www.example.com/gateway/employee?division=Consumer&dept=Sales
  ```

  In comparison to the use of path variables, the use of query parameters is considered less ideal—less RESTful. Use of query parameters is most appropriate when a service uses the argument-value pairs as input to logic that is in the service and that determines the data of interest.

An HTTP request or response may include HTTP headers, which are argument-value pairs such as Content-Length=2500. An important use of headers is for security. A service may require or allow headers other than those specified in the HTTP definition.

Some REST services do not conform to the REST style

In some cases, a service that uses HTTP and has no SOAP message is called a REST service but does not fully conform to the REST style. Here are some common variations:

- Some REST services use a POST request for tasks other than creating a new resource. EGL lets you avoid sending a representation for a POST request.
- Some REST services require that a DELETE request include a representation (the business data) rather than simply relying on the URI to identify the resource to delete. EGL supports access of REST services that require a representation for a DELETE request, but also supports access of REST services that do not have that requirement.

EGL REST services

When an EGL Rich UI application accesses a REST service written in EGL, the access involves an RPC style that is somewhat like a function invocation. In this case, parameters and a return value identify the data to exchange, and path variables and query parameters are not involved. The service access always uses a POST request, but that detail is hidden by the EGL code.

Background on SOAP

The body of a message exchanged by a REST service contains the business content being transferred. However, the body of a message exchanged by a Web service

contains text in a SOAP format, and within *that* text is the business data. The SOAP message comes after the HTTP headers and is structured as follows:

```
<Envelope>
  <Header>
    <!-- SOAP header detail -->
  </Header>
  <Body>
    <!-- Business data -->
  </Body>
</Envelope>
```

SOAP is usually associated with Web Services Description Language (WSDL). A WSDL file describes a service's interface requirements (operations, parameters, and return values) and gives details needed to access the service at a specific location.

The products that include Rich UI let you easily create and use WSDL definitions. The main benefit of the related, runtime SOAP support is that you can interact with a Web service without being concerned about the most technical details of the transferred data.

Service generation and Rich UI

Service generation is not supported in a Rich UI project. However, you can write service logic in an EGL General or EGL Web project, use that logic as the basis of a SOAP or REST service (which is generated into an EGL Web project), deploy the service to a Web server, and access the deployed service from a Rich UI application.

Sources of additional information

A good introduction to REST is Richardson and Ruby's book *Restful Web Services* (O'Reilly Media, Inc., May 2007).

For an overview of service interaction and some of the RPC-related technologies, see *SOA for the Business Developer* by Margolis and Sharpe (MC Press, May 2007). That text also gives an overview of the following areas, which affect Rich UI:

- Extensible Markup Language (XML), which is the basis of the SOAP format used with a Web service and is sometimes the basis for messages exchanged with a REST service
- XML Schema, which is information—essentially, a code—that is used to validate XML

ExternalType for JavaScript code

EGL lets your Rich UI application access non-generated JavaScript. You may be making general logic available—for example, to provide a random number generator—or you may be referencing a non-EGL widget—for example, to allow use of a DoJo widget inside your code. In either case, your tasks are twofold:

1. To write non-generated JavaScript
2. To develop an EGL external type that makes the JavaScript logic available to a Rich UI application. The JavaScript is said to be the *implementation* of the external type.

When you write the JavaScript, you invoke an EGL-specific function, whether **egl.defineClass**, for general logic, or **egl.defineWidget**, for a widget definition. In each case, the JavaScript is solely for use by EGL and is likely to be invoking other JavaScript that is available to you.

We advise you to avoid using multiple versions of the same runtime library in a given Rich UI application; the use of multiple versions may introduce errors.

The current topic describes the use of **egl.defineClass**. For details on defining a new widget, see *Extending the Rich UI widget set*.

Structuring your general-use JavaScript code

If you are making general logic available —for example, a random number generator—place your JavaScipt file in a subdirectory of the WebContent folder. The file invokes the JavaScript function **egl.defineClass**. Here is the outline:

```
egl.defineClass(
   'packageName', 'className',
   'superclassPackageName', superclassName,
    {
      "constructor": function()
      { },

      "otherFunction": function(parameterList)
      { }
    }
);
```

The italicized details are as follows:

packageName
: The name of the package in which the EGL external type will reside. The package name is case sensitive and is required.

className
: An identifier that you are assigning as the JavaScript class name. The class is a predefined collection of functions, and the name must be the name of the EGL external type **JavaScriptName** property, which defaults to the name of the external type. The class name is case sensitive and is required.

superclassPackageName
: Optional. The name of the package in which the EGL external type for a super class resides. The package name is case sensitive; and if you specify this value, you must also specify *superclassName*.

superclassName
: Optional. The name of a super class, which is also the name of an EGL external type that makes the superclass available to EGL source code. The superclass name is case sensitive; and if you specify this value, you must also specify *superclassPackageName*.

parameterList
: List of function parameters.

The function named "constructor" is optional and, if present, runs as soon as you declare an EGL variable of the external type. That function cannot have any parameters and can be in any position in the list of functions.

You may define multiple classes in a single JavaScript file, but the convention is to include only one class, with the same name as the file. For example, here is the code in file RandomNumberGenerator.js, which makes available a random number generator:

```
egl.defineClass(
   'randomNumber', 'RandomNumberGenerator',

   {
      "constructor" : function()
      {
         this.upperLimit = 100;
      },

      "setUpperLimit" : function(limit)
      {
         this.upperLimit = limit;
      },

      "getUpperLimit" : function()
      {
         return this.upperLimit;
      },

      "generateRandomNumber" : function()
      {
         return Math.floor(Math.random()*this.upperLimit);
      }
   }
);
```

Writing the external type

In relation to JavaScript, the EGL External Type stereotype is **JavaScriptObject**, as shown in the following example:

```
package randomNumber;

import com.ibm.egl.rui.JavaScriptObject;
import com.ibm.egl.rui.JavaScriptProperty;

ExternalType RandomNumberGenerator type JavaScriptObject
   {
      relativePath = "randomnumber",
      javaScriptName = "RandomNumberGenerator"
   }

   upperLimit int {@JavaScriptProperty{getMethod = "getUpperLimit",
                                       setMethod = "setUpperLimit"}};

   function generateRandomNumber() returns(int);
end
```

The external type can include the **extends** clause, to reference an external type that represents a super class, as in the following example outline:

```
ExternalType MyType extends OtherType type JavaScriptObject

end
```

The external type also can include the following part-level properties:

relativePath
The location of the JavaScript file in relation to the WebContent folder.

javaScriptName
The name of the JavaScript file.

includeFile
Identifies other CSS, JavaScript, or HTML files that are made available at run time. The path specified in **includeFile** is relative to the WebContent directory; an example is "JS/myFile.js".

The following file might be used if you were using the external type to reference a DoJo widget, as described in *Extending the Rich UI widget set with DoJo*:

```
<script type="text/javascript" src="http://o.aolcdn.com/dojo/1.0.0/dojo/dojo.xd.js">
</script>

<style type="text/css">
   @import "http://o.aolcdn.com/dojo/1.0.0/dijit/themes/dijit.css";
   @import "http://o.aolcdn.com/dojo/1.0.0/dijit/themes/tundra/tundra.css";
   @import "http://o.aolcdn.com/dojo/1.0.0/dojo/resources/dojo.css"
</style>

<script>
   dojo.require("dijit.form.Button");
   dojo.require("dijit.form.Slider");
</script>
```

That file loads the Dojo widget library and Dojo CSS files and starts the Dojo runtime.

As shown in the example of an external type, a field in that type can include the following field-level property:

@JavaScriptProperty
This complex property is required if you wish to access, from your EGL code, a JavaScript global field (a field of the form `this.myField`). If you wish to assign a value from your EGL code, the JavaScript must define the field in the function named "constructor". However, you can retrieve a value from the JavaScript field regardless of where the field is defined in the JavaScript.

In general, **@JavaScriptProperty** identifies JavaScript functions that get and set the JavaScript field value. You can use this property without specifying function names if the names of the functions are built with the word *get* or *set* followed by the variable name. For example, if the variable is `UpperLimit` and the JavaScript class includes functions named `getUpperLimit()` and `setUpperLimit()`, you only need to add the complex property, as in this example:

```
UpperLimit INT { @JavaProperty{} };
```

The property fields in **@JavaScriptProperty** are as follows:

getMethod
A string (enclosed in quotation marks) containing the name of the get method for the specified variable (do not include parentheses). The method has no parameters, and its return value has the same type as the field.

setMethod
A string (enclosed in quotation marks) containing the name of the set method for the specified variable (do not include parentheses). The method has one parameter that has the same type as the field. By convention the setMethod does not have a return value, but no error condition results if the method returns a value.

If you specify only one of the two property fields, EGL assumes that the unspecified function is not available. An error does not occur unless an expression that causes invocation of the function that is assumed to be missing.

JavaScript field names are case sensitive, as is the field name in the external type.

Relationship of EGL and JavaScript data types

Table 3. EGL and JavaScript data types

EGL type	JavaScript type (case-sensitive)
STRING	String
BOOLEAN	Boolean
SMALLINT, INT, FLOAT, SMALLFLOAT	Number
BIGINT, DECIMAL, MONEY, NUM	egl.JavaScript.BigDecimal (as described in a later section)
DATE, TIME, TIMESTAMP	Date

EGL arrays are passed to JavaScript as JavaScript arrays. If an EGL type (such as an array) is set to null, the JavaScript code receives a JavaScript null.

egl.JavaScript.BigDecimal

The supplied JavaScript class egl.javascript.BigDecimal can precisely represent numbers with a very large number of digits. This class also has methods for performing mathematical operations with BigDecimals.

The native numeric type in JavaScript is the Number class, which is a floating-point representation of numbers. It is imprecise and cannot represent many values. Rounding errors may occur when you do math with values of the Number class.

A BigDecimal object cannot be changed once it has been created. For example, to add two BigDecimal values, write the code as follows:

```
var result = bigDecimal1.add( bigDecimal2 );
```

The result is lost if you write the code as follows:

```
bigDecimal1.add( bigDecimal2 );
```

The egl.javascript.BigDecimal constructor takes one argument, which is a String containing the desired value for the BigDecimal. Numbers in String form must have at least one digit and may not contain a blank. They may have a leading sign, may have a decimal point, and may be in exponential notation. Here are some valid arguments:

- "0"
- "12"
- "-76"
- "12.70"
- "+0.003"
- "17."
- ".5"
- "4E+9"

- "0.73e-7"

Here are JavaScript methods that use objects of egl.javascript.BigDecimal (such objects are identified as *bd*, and Number objects are identified as *n*):

- abs() returns the absolute value of the BigDecimal
- add(*bd*) returns the sum of the current object and the argument.
- compareTo(*bd*) returns -1 if the current object is less than the argument, 1 if the current object is greater than the argument, or 0 if they're equal.
- divide(*bd*) returns the result of dividing the current object by the argument.
- divideInteger(*bd*) returns the integer part of the result of dividing the current object by the argument.
- equals(*obj*) -- The parameter obj is any object. Returns true if the argument (which can be any object) is a BigDecimal with the same value and scale (number of decimal digits) as the current object. Returns false is the argument is not a BigDecimal, or is a BigDecimal with a different value or scale.
- max(*bd*) returns the current object or the argument, whichever is greater.
- min(*bd*) returns the current object or the parameter, whichever is smaller.
- movePointLeft(*n*) Returns a BigDecimal that is equivalent to the current object (a Number), but with the decimal point shifted to the left by the specified number of positions.
- movePointRight(*n*) returns a BigDecimal that is equivalent to the current object (a Number), but with the decimal point shifted to the right by the specified number of positions.
- multiply(*bd*) returns the result of multiplying the current object by the argument.
- negate() returns the negation of the current object.
- pow(*bd*) returns the result of raising the current object to the specified power. The power must be in the range -999999999 through 999999999 and must have a decimal part of zero.
- remainder(*bd*) divides the current object by the argument and returns the remainder.
- setScale(*n*, *mode*) returns a BigDecimal with the given *scale* (number of decimal digits). The argument *n* is a Number, and the optional argument *mode* is a constant, as described later.

  If *n* is larger than the current scale, the method adds trailing zeros to the decimal part of the number. If *n* is smaller than the current scale, the method removes trailing digits from the decimal part of the number, and *mode* indicates how to round the remaining digits. Here are the possible values of *mode*:

  – The default (egl.javascript.BigDecimal.prototype.ROUND_UNNECESSARY) indicates that no rounding is necessary.
  – egl.javascript.BigDecimal.prototype.ROUND_CEILING causes rounding to a more positive number.
  – egl.javascript.BigDecimal.prototype.ROUND_DOWN causes rounding toward zero.
  – egl.javascript.BigDecimal.prototype.ROUND_FLOOR causes rounding to a more negative number.
  – egl.javascript.BigDecimal.prototype.ROUND_HALF_DOWN causes rounding to the nearest neighbor, where an equidistant value is rounded down.

  - egl.javascript.BigDecimal.prototype.ROUND_HALF_EVEN causes rounding to the nearest neighbor, where an equidistant value is rounded to the nearest even neighbor.
  - egl.javascript.BigDecimal.prototype.ROUND_HALF_UP causes rounding to the nearest neighbor, where an equidistant value is rounded up.
  - egl.javascript.BigDecimal.prototype.ROUND_UP causes rounding away from zero.
- scale() returns the number of digits after the decimal point, as a Number.
- signum() returns -1 if the number is negative, zero if the number is zero, and 1 if the number is positive.
- subtract(*bd*) returns the result of subtracting the parameter from the current object.
- toString() returns a String representation of the BigDecimal object.

The following constants are also defined by BigDecimal:

- egl.javascript.BigDecimal.prototype.ZERO is BigDecimal with the value zero.
- egl.javascript.BigDecimal.prototype.ONE is a BigDecimal with the value one.
- egl.javascript.BigDecimal.prototype.TEN is a BigDecimal with the value ten.

JavaScriptObjectException

If a non-generated JavaScript function is invoked by way of an external type and if the function throws an error, the invocation causes an EGL **JavaScriptObjectException**. Like every EGL exception, the **JavaScriptObjectException** has **message** and **messageID** fields.

If a JavaScript error object is caught, the **message** field is set from the equivalent field of the error object. Otherwise, the **message** field receives a string that is equivalent to the value thrown by the JavaScript function.

Here is the additional field in **JavaScriptObjectException**:

name
If a JavaScript error object is caught, the **name** field is set from the equivalent field of the error object. Otherwise, the **name** field receives an empty string.

Extending the Rich UI widget set

You can use EGL to create a new widget type or can use JavaScript.

Rich UI widgets

A Rich UI widget is written in EGL and is of type `RUIWidget` (specifically, egl.ui.rui.RUIWidget). You often need to do only as follows:

- Specify an HTML tag name in property **tagName**. Alternatively, specify a declared Widget in property **targetWidget**, in which case the following statements apply:
  - The HTML tag that is the basis of the referenced widget's type is the basis of the Widget type that you are defining
  - You can use the name of the referenced widget to access the functions and properties defined for that widget's type

  If you specify both **tagName** and **targetWidget**, the latter applies.

- Specify the **@VEWidget** complex property if you want the widget to be represented in the developer's palette.
- Specify the **@EGLProperty** complex property for each EGL property. The values of EGL properties are set when a developer creates a widget that is based on the widget type that you are writing.
- Specify an on-construction function and set a CSS class name in that function.
- Build the functionality from other widgets.

Here is the outline of an H3 definition, which requires no **import** statements:

```
Handler H3 type RUIWidget{tagName = "h3", onConstructionFunction = start,
   @VEWidget{
    category = "New Widgets",
    template = "my.package.H3{ text=\"The Heading Text\" }",
    smallIcon = "icons/h3small.gif",
    largeIcon = "icons/h3large.gif"  }}

   text String  { @EGLProperty { getMethod=getText, setMethod=setText },
                  @VEProperty{}};
   function start()
      class = "EglRuiH3";
   end

   function setText(textIn String in)
      text = textIn;
      this.innerText = textIn;
   end

   function getText() returns (String)
      return (text);
   end
end
```

Given this definition, you can create widgets that are based on the type H3. For example, the following declaration creates a box with a nested H3 widget:

```
ui Box { children = [
            new H3 { text = "Summary" }
        ]};
```

@VEWidget

When you write a Rich UI widget (or an external-type widget—type egl.ui.rui.Widget—as described in another topic), you can specify the complex property **@VEWidget**. The EGL editor uses the details of any @VEWidget property in the workspace, adding entries to the palette when you refresh the palette. The property has the following fields:

category (type STRING)
In the palette, the category in which the widget is listed. The categories are listed in alphabetical order.

If the category does not exist, a new category will be created with the name you specify. The category is particularly useful to distinguish same-named widgets such as Rich UI buttons and Dojo buttons.

description (type STRING)
In the palette, the description that is displayed when the user hovers over the widget entry.

displayName (type STRING).
In the palette, the widget name. The names are listed in alphabetical order within a category.

The default value is the name of either the external type or the handler of type RUIWidget.

template (type STRING)
The part of the widget type declaration that follows the widget name, excluding the semicolon. In our example, the declaration includes a set-value block, as is necessary to avoid an error. Here is an example declaration:

```
myH3 my.package.H3{ text="The Heading Text" };
```

If you want the EGL system code to specify the widget type and to include a qualifier (such as `my.package`) only if necessary, start the template string with the **typeName** variable. Here is an example:

```
template = "${typeName}{}"
```

Here is a related declaration, assuming that the widget type shown earlier is in the same package as the handler that receives the declaration:

```
myH3 H3{};
```

Here is another example:

```
template = "${typeName}{ text=\"The Heading Text\" }"
```

Here is the related declaration:

```
myH3 H3{ text="The Heading Text" };
```

smallIcon (type STRING)
The path for the gif file that contains the small icon that is displayable on the palette. The path is relative to the project directory. For example, if the project is com.egl, the gif files listed earlier are in com.egl/icons.

largeIcon (type STRING)
The path for the gif file that contains the large icon that is displayable on the palette. The path is relative to the project directory. For example, if the project is com.egl, the gif files listed earlier are in com.egl/icons.

container (type @VEContainer)
Specify the **container** field as follows:

```
container{@VEContainer{}}
```

The presence of **container** has the following implications:

- At run time, the widget can include other widgets.
- At development time, the EGL developer can drag-and-drop other widgets into the widget being defined.
- The widget must include a field named **children**. The field named **children** must be of type Widget[] ; and you must define the property **@EGLProperty** for that field, as described later.

In addition, **@VEWidget** lets you specify which RUIWidget properties and events (as well as external-type properties and events) are to be displayed in the **Properties** view. For example, a displayed entry for **backgroundColor** is provided for any handler of type RUIWidget (or even for a widget provided by an external type); but **backgroundColor** may not be appropriate for the widget you are defining. Here are the **@VEWidget** property fields that filter the properties and events that are otherwise displayed by default:

eventFilter (STRING[])
An array of event names (such as `["onClick", "OnScroll"]`) to include or exclude from display, depending on the value of **eventFilterType**.

eventFilterType (type INT)
One of the following values (either the integer or the related constant):

1. RUILib.EXCLUDE_ALL excludes all the events defined for RUIWidget (type egl.ui.rui.RUIWidget) and, in the case of external types, for Widget (type egl.ui.rui.Widget). In this case, any values for **eventFilter** are ignored.
2. RUILib.EXCLUDE_ALL_EXCEPT excludes all the events defined for RUIWidget and Widget except those specified in the value of **eventFilter**.
3. RUILib.INCLUDE_ALL includes all the events defined for RUIWidget and Widget. In this case, values for **eventFilter** are ignored.
4. RUILib.INCLUDE_ALL_EXCEPT includes all the events defined for RUIWidget and Widget except those specified in the value of **eventFilter**.

propertyFilter (STRING[])
An array of property names (such as `["font", "fontSize"]`) to include or exclude from display, depending on the value of **propertyFilterType**.

propertyFilterType (type INT)
One of the following values (either the integer or the related constant):

1. RUILib.EXCLUDE_ALL excludes all the properties defined for RUIWidget (type egl.ui.rui.RUIWidget) and, in the case of external types, for Widget (type egl.ui.rui.Widget). In this case, any values for **propertyFilter** are ignored.
2. RUILib.EXCLUDE_ALL_EXCEPT excludes all the properties defined for RUIWidget and Widget except those specified in the value of **propertyFilter**.
3. RUILib.INCLUDE_ALL includes all the events defined for RUIWidget and Widget. In this case, values for **propertyFilter** are ignored.
4. RUILib.INCLUDE_ALL_EXCEPT includes all the events defined for RUIWidget and Widget except those specified in the value of **propertyFilter**.

Here is an example of an external type for which the only displayed event types are **onScroll** and **onChange** and for which the only displayed properties are **color** and **backgroundColor**:

```
ExternalType DojoButton extends DojoBase type JavaScriptObject {
    relativePath = "dojo/widgets",
    javaScriptName = "DojoButton",
    includeFile = "dojo/widgets/dojobutton.html",
    @VEWidget{
        category = "Dojo",
        template = "dojo.widgets.DojoButton { text = \"Button\" }",
        displayName = "Button",
        smallIcon = "icons/ctool16/dijit_button_pal16.gif",
        largeIcon = "",
        propertyFilterType  = RUILib.EXCLUDE_ALL_EXCEPT,
        propertyFilter  = ["color", "backgroundColor"],
    eventFilterType  = RUILib.EXCLUDE_ALL_EXCEPT,
        eventFilterType  = ["onScroll", "onChange"]
    }
```

Changes to **@VEWidget** are available to the EGL editor only if you refresh the palette. You refresh the palette by clicking the Refresh palette tool on the Design surface, as noted in *Using the tools on the Design surface*.

@EGLProperty

@EGLProperty identifies EGL functions that get and set the EGL field value when an EGL Rich UI application uses the property. You can use this property without specifying function names if the names of the functions are specified with the word *get* or *set* followed by the variable name. For example, if the variable is `UpperLimit` and the Rich UI Widget type includes functions named `getUpperLimit()` and `setUpperLimit()`, you only need to add the complex property, as in this example:

```
UpperLimit INT { @EGLProperty{} };
```

The property fields in **@EGLProperty** are as follows:

getMethod
A string (enclosed in quotation marks) containing the name of the get method for the specified variable (do not include parentheses). The method has no parameters, and its return value has the same type as the field.

setMethod
A string (enclosed in quotation marks) containing the name of the set method for the specified variable (do not include parentheses). The method has one parameter that has the same type as the field. By convention the setMethod does not have a return value, but no error condition results if the method returns a value.

To indicate that a field is read only or write only, you can specify only one of the two property fields. If the Rich UI application tries to read or write to a property for which the read or write is not supported, an error occurs before the EGL generator accesses the application code.

@VEProperty

When you write a Rich UI widget (or an external-type widget, as described in another topic), you can ensure that widget-specific properties are in the **Properties** view whenever you use the EGL editor to create a widget of the new type. You make the properties available by setting **@VEProperty** for each widget field that you want to list in the **Properties** view. **@VEProperty** is useful only when the **@VEWidget** and **@EGLProperty** properties are set.

Here are example uses of **@VEProperty**::

```
mySimpleProperty String {
   @EGLProperty{},
   @VEProperty{category = "Basic"}};

myChoiceProperty String{
   @EGLProperty{},
   @VEProperty{category = "Advanced",
               propertyType = "choice",
               choices = [
                  @VEPropertyChoice {displayName = "3D", id = "3"},
                  @VEPropertyChoice {displayName = "4D", id = "4"}
               ]}};
```

Not shown are the functions that get and set the EGL properties.

The property fields in **@VEProperty** are as follows:

category
The category in which the property is listed in the **Properties** view. If the category does not exist, a new category is created with the name you specify. The **category** field takes a string.

The categories in the **Properties** view are in reverse order of their initial reference in the Rich UI widget or external type. The last-specified category is listed first, and the categories that are available for all widgets are displayed last. Similarly, the properties in a given category are in reverse order of declaration in the Rich UI widget or external type.

propertyType
The type of value required in the property. By default, the type is the type of the field in the widget definition. The only valid value for propertyType is *choice*, which is used if you intend to specify an array of choices, as shown in the previous example.

choices
An array of **@VEPropertyChoice** elements, each of which includes at least the first of the following two fields:

displayName
A string that represents the choice in the **Properties** view. This value is required.

id A string that holds the content assigned to the property in the Rich UI application. This value is required. The type of the assigned value must be the same as the type of the property that is receiving the value.

Changes to **@VEProperty** are available to a file in the EGL editor only if you refresh the palette and the file. To refresh the palette, click the Refresh palette tool on the Design surface, as noted in *Using the tools on the Design surface*. To refresh the file, click the Refresh Web page tool on the Preview tab, as noted in *Running a Web application in the EGL editor*.

@VEEvent

When you write a Rich UI widget that uses the **targetWidget** property (or when you write an external-type widget, as described in another topic), you can declare event types that are not otherwise defined. In this way, you can let the business developer think more clearly about defining a sequence of tasks. Also, the developer can assign an event handler at the **Events** view.

The next example shows use of a customized button (MyButton), which uses the property **@VEEvent**. If you try out the example in your workspace, note that the EGL developer can now use the EGL editor for the following purposes: to create a button of type MyButton and to assign event handlers for the newly defined events (**onPreClick** and **onPostClick**).

Here is a handler that accesses a button of type MyButton:

```
package pkg;

import com.ibm.egl.rui.widgets.Button;

handler MyHandler type RUIhandler {initialUI = [ someButton ]}

   someButton MyButton{text = "fresh",
                       onPreClick ::= respondToPreClick,
                       onClick ::= respondToClick,
                       onPostClick ::= respondToPostClick};
```

```
   function respondToPreClick(e Event in)
      sysLib.writeStdout("in pre");
   end

   function respondToClick(e Event in)
      sysLib.writeStdout("in click");
   end

   function respondToPostClick(e Event in)
      sysLib.writeStdout("in post");
   end

end
```

Here is the definition of MyButton:

```
package pkg;

import com.ibm.egl.rui.widgets.Button;
handler MyButton type RUIWidget {

   targetWidget = internalButton,
   @VEWidget{
     category = "New EGL Widgets",
     template = "pkg.myButton{ text=\"myButton\" }"}
   }

   text string {@EGLProperty{setMethod = setText,
                             getMethod = getText},
                @VEProperty{}};

   internalButton Button{onClick ::= respondToClick};

   onPreClick EventHandler[] {@VEEvent{}};
   onClick EventHandler[] {@VEEvent{}};
   onPostClick EventHandler[] {@VEEvent{}};

   private function setText(text String in)
     internalButton.text = text;
   end

   private function getText() returns (String)
     return ( internalButton.text );
   end

   private function respondToClick(e Event in)

      preSize int = onPreClick.getSize();
      clickSize int = onClick.getSize();
      postSize int = onPostClick.getSize();

      for (i int from 1 to preSize by 1)
         OnPreClick[i](e);
      end

      for (i int from 1 to clickSize by 1)
         OnClick[i](e);
      end

      for (i int from 1 to postSize by 1)
         OnPostClick[i](e);
      end
   end
end
```

Changes to **@VEEvent** are available to a file in the EGL editor only if you refresh the palette and the file. To refresh the palette, click the Refresh palette tool on the Design surface, as noted in *Using the tools on the Design surface*. To refresh the file, click the Refresh Web page tool on the Preview tab, as noted in *Running a Web application in the EGL editor*.

@Override

Use the **@Override** property if want to override a function that is available in any widget. For example, the definition of the Box widget overrides the function **removeChild**, as shown here:

```
function removeChildren()  {@Override}
  // EGL statements are here
end
```

For a list of functions that are available in all widgets, see *Widget properties and functions*.

External type widgets

You can create an external type widget by writing custom JavaScript or by accessing specialized JavaScript libraries.

To create a new Rich UI widget based on JavaScript, do as follows:

1. Create a JavaScript file to contain the code for the widget. Invoke egl.defineWidget and specify the following arguments:
   - The package name of the EGL external type that defines the widget; for example, egl.rui.widgets)
   - The name of the widget class (for example, Button); that class name is the name of the external type you will create
   - The package name of the EGL external type that defines the parent widget; however, if that parent type is widget (the most elemental choice), specify egl.ui.rui
   - The name of the parent widget class (for example, Label)
   - The HTML element type (for example, button)

   Here is the example:

   ```
   egl.defineWidget( 'egl.rui.widgets', 'Button',
                     'egl.rui.widgets', 'Label',
                     'button', { } );
   ```

2. Within the curly brackets ({ }), define the JavaScript functions to reflect the following outline, separating one function from the next with a comma:

   ```
   "functionName" : function(/*parameters*/)
   { //JavaScript Source }
   ```

   Here is an example:

   ```
   "getSelected" : function() {
      return this.check.checked;
   },
   "setSelected" : function(value) {
      this.check.checked = value;
   },
   "toString" : function() {
      return "[CheckBox, text=\""+this.egl$$DOMElement.innerHTML+"\"]";
   }
   ```

3. Each widget can specify the following functions for the JavaScript runtime to invoke:

- The function **constructor** is invoked whenever a new widget instance is created, and that function can be used, for example, to initialize data
- The function **egl$$initializeDOMElement** is invoked whenever the HTML element is being created for the widget, and that function can be used, for example, to set initial properties on the element
- The function **childrenChanged** is invoked whenever the application developer updates the new widget's **children** property, if any.

Each widget also has a field called **this.egl$$DOMElement**, which represents the HTML element (or top-level HTML element) created for the widget.

4. In an EGL source file, create an EGL external type that extends from egl.ui.rui.Widget or from an existing widget. The External Type needs a stereotype of **JavaScriptObject**, as described in *External type for JavaScript*.

Extending the Rich UI widget set with Dojo

You can write widgets that are based on Dojo, a popular JavaScript library that is described at http://dojotoolkit.org.

We provide a sample named dojo, which includes the following four files:

- Button.egl introduces the following EGL external type, which uses the text field from the native Rich UI Button type extended by the new widget:

```
ExternalType Button extends Button type JavaScriptObject
   { relativePath = "dojo",
     javaScriptName = "Button",
     includeFile = "dojo/dojo.html"
   }
end
```

  As shown, the implementation language is JavaScript, and use of the Button type requires access to dojo.html.
- Button.js contains the JavaScript implementation that is referenced in the external type definition. The JavaScript identifies the new widget and defines the following functions:
  - `egl$$initializeDOMElement` loads Dojo and defines code to enable event handlers (written by the EGL developer) to respond to onClick events. The function then replaces the DOM node with a Dojo equivalent and causes the EGL widget to refer to the Dojo node.
  - `setText` ensures that the new widget can write text into the Dojo-specific DOM node.
  - `getText` ensures that the new widget can retrieve text from the Dojo-specific DOM node.
- dojo.html is an HTML file containing two script tags for inclusion in the EGL-generated JavaScript. The first of the two tags accesses a version of the Dojo library, which is being provided at a Web site hosted by America Online. The second of the two tags indicates that a specific widget definition (dijit.form.Button) will be retrieved from the Dojo library.

  In your own projects, you might download and install Dojo into your workspace and refer directly to the dojo.js file that is included with the Dojo distribution you downloaded. The benefits are as follows:
  - Your code is insulated from changes that a Dojo provider might make to its version of the JavaScript file
  - You can work with Dojo without needing to access an external Web site
- DojoSample.egl is EGL code that demonstrates use of the new widget.

Notice that DojoSample.egl, the code written for interacting with the new widget, is all-but identical to the code written to interact with the Rich UI button in the buttontest sample (file OneButton.egl); the APIs are the same, for ease of use by the EGL developer.

You can place the files Button.egl, Button.js, and dojo.html in a standalone project and store that project in a repository so that others in your organization can use the Dojo functionality without their needing to maintain duplicate JavaScript implementations. Also, you can expose additional DoJo widgets to EGL developers; for example, by coding Tree.egl and Tree.js to provide the Dojo Tree widget.

As shown in the sample, you need to be aware of an unusual requirement when you create widgets with Dojo. When any Rich UI application is running, a hierarchy of EGL widgets is in memory, and each widget refers to one or more nodes of the document object model (DOM). The difference when you work with Dojo is that you first replace native DOM elements with nodes that are specific to Dojo and then ensure that the EGL widgets refer to those nodes.

Extending the Rich UI widget set with Silverlight

You can write widgets that are based on Silverlight, a browser plugin that is described at http://silverlight.org. Silverlight uses an XML dialect called XAML for defining user interfaces and uses the .Net platform for handling events. You can access the Silverlight runtime from the browser by running JavaScript code.

We provide a sample named Silverlight, which includes the following files:

- Button.egl introduces the following EGL external type, which extends the Rich UI Widget type:

```
ExternalType Button extends Widget type JavaScriptObject
   {
      relativePath = "silverlight",
      javaScriptName = "Button",
      includeFile = "silverlight/Silverlight.html"
   }
   text String
      { @JavaScriptProperty
         { getMethod="getText", setMethod="setText" } };
end
```

  As shown, the implementation language is JavaScript, and use of the Button type requires access to Silverlight.html.
- Button.js contains the JavaScript implementation that is referenced in the external type definition. The JavaScript identifies the new widget and defines the following functions:
  - `setText` ensures that the new widget can write text into the DOM node
  - `getText` ensures that the new widget can retrieve text from the DOM node
  - `egl$$update` defines an XAML fragment and enables EGL event handling for the onClick event
- Canvas.xaml contains an empty container for Button.js to use as a canvas when painting a button.
- Silverlight.html is an HTML file containing a script tag for inclusion in the EGL-generated JavaScript.
- Demo.egl is EGL code that demonstrates use of the new widget.

Notice that Demo.egl, the code written for interacting with the new widget, is all-but identical to the code written to interact with the Rich UI button in the buttontest sample (file OneButton.egl); the APIs are the same, for ease of use by the EGL developer.

You can place the files Button.egl, Button.js, canvas.xaml and Silverlight.html in a standalone project and store that project in a repository so that others in your organization can use the Silverlight functionality without their needing to maintain duplicate JavaScript implementations. Also, you can expose additional Silverlight examples, such as an image carousel or a videoplayer.

Silverlight is a trademark of Microsoft Corporation.

Chapter 5. Accessing a service in EGL Rich UI

Service invocation in Rich UI is always *asynchronous*, which means that the requester—the Rich UI handler—continues running without waiting for a response from the service. The user can still interact with the user interface while the Rich UI handler waits for the service to respond. After the invocation, the service does some task and, in most cases, responds to the EGL Runtime, which in turn invokes a Rich UI function that you code: a *callback function*. The invocation by the EGL Runtime is described as *issuing a callback*.

To invoke a service from Rich UI, you create an EGL Interface part that includes properties indicating how the service is accessed at run time. You then create a variable based on the Interface part and use the variable in a **call** statement. The **call** statement includes the details necessary for the EGL Runtime to issue a callback.

EGL Rich UI Proxy

The *EGL Rich UI Proxy* is runtime software that is installed with your Rich UI application if the deployment target is WebSphere Application Server or Apache Tomcat. The EGL Rich UI Proxy handles communication between the application and any services that are accessed by the application:

- In relation to a Web-service request, the proxy receives the request from the application, reads a WSDL file on the server, formats a SOAP message for transmission to the service, and sends a service request. On receiving a response from the service, the proxy reformats that response for use in the callback function and sends the response to the application.
- In relation to a REST service, the process is similar but simpler, with no use of a WSDL file.

The Rich UI application uses the EGL Rich UI Proxy to access every invoked service, even services that are on the same server. However, if you install your Rich UI application to an HTTP server (for example, to Apache HTTP server), the Proxy is not available and service access is not supported.

Accessing a REST service in Rich UI

The basic tasks required to access any service in Rich UI are as follows:

1. Create an Interface part.
2. Create a variable based on that part.
3. Code a **call** statement
4. Code a callback function that is referenced in the **call** statement
5. In most cases, you also specify an onException function, which receives an exception from the service call if the service returns an exception instead of business content

Creating an Interface part to access a REST service

You define an EGL Interface part in a file made available to the EGL library or Rich UI handler that invokes a service. The Interface part may be in the same EGL package or may be imported from a separate package.

An EGL Interface part includes one or more *function prototypes*, which are descriptions that tell how to write code to access a given service operation. A function prototype includes the operation name, parameters (if any), and return type (if any). The prototype does not include the operation's logic, which is available only in the service.

The Interface part of an EGL REST service is simpler than for a non-EGL REST service, and we describe each Interface part in turn.

Interface part for accessing an EGL REST service

Here is an example Interface part for accessing an EGL REST service; the example includes a single function prototype:

```
Interface EmployeeService
   Function GetEmployeeDetail(employeeCode STRING IN,
                              employeeSalary FLOAT OUT,
                              employeeStatus STRING INOUT)
            returns(myEmployeeRecordPart);
end
```

As shown, you can specify a variety of EGL data types and can use the modifiers IN, OUT, and INOUT.

You can create the Interface part automatically:

1. In the Project Explorer, right click the EGL file that defines the service
2. **Click EGL Services > Extract EGL Interface**
3. Specify details on the **New EGL Interface part** dialog and click **Finish**

In short, the Interface part for an EGL REST service reflects the same rules as an Interface part for an EGL Web SOAP service.

Interface part for accessing a third-party REST service

Here is an example Interface part for accessing a third-party REST service:

```
Interface WeatherForecast
   Function GetWeatherByZipCode(zipcode string in) returns(myRecordPart)
      {@GetRest{uriTemplate="/GetWeatherByZipCode?zipCode={zipcode}",
                requestFormat = JSON,
                responseFormat = JSON}};
end
```

If the purpose of the Interface part is to describe the operations available in a third-party REST service (not an EGL REST service), you must specify a complex property for each function prototype. The name of the property indicates the HTTP verb used to access the service: the property name is @GetREST for GET (as shown in the previous example), @PostREST for POST, @PutREST for PUT, and @DeleteREST for DELETE. We refer to those complex properties as the @xREST properties because the same three property fields are in each, as described in the section *@xREST properties*.

In the **call** statement used to access a third-party REST service, the argument passed to a given function parameter has one of two purposes:

- In most cases, the argument provides a value that Rich UI includes in the URI. We show this usage later, when describing the @xREST properties. Those values are not passed to the service logic; they are values that are embedded in the URI.

- In the case of one argument (at most), the argument is a representation processed by the service; for example, a record that contains values used to create a database-table row. Here are details:
  - If the property is @PostREST or @PutREST for a given operation, the additional argument is present, and we call the related parameter the *representation parameter*. (In practice, the argument also may be necessary if the property is @DeleteREST; the need for such an argument depends on the service provider.) If the @GetREST property is present, all the arguments assigned to the function parameters are used to construct the URI.
  - A callback function receives the value, if any, that is returned by the service.

In short, if the function prototype has a parameter that is not identified in the property field **uriTemplate** (for **@PostREST**, **@PutREST**, or **@DeleteREST**), that parameter is a representation parameter. Either of the following cases is an error:

- Specifying more than one representation parameter
- Specifying a representation parameter when **@GetREST** is in use

For details on the data types valid for a given parameter, see "Specifying parameters for service access in Rich UI."

You do not need to create an Interface part. Instead, you can use IRest, which is an Interface part that is provided for you and that can be the basis of a variable used to access any REST service. We describe that Interface part in the section "Using a provided Interface part for a 3rd-party REST service." In any case, the next section describes the @xREST properties.

@xREST properties used for third-party REST services

Each of the @xREST complex properties has the fields **uriTemplate**, **requestFormat**, and **responseFormat**:

- **uriTemplate** is an outline of part or all of the URI used to access the service
- **requestFormat** is the format for the representation of the resource sent to the service
- **responseFormat** is the format for the value returned to the callback function

Here are further details:

uriTemplate

A string that (in most cases) outlines a *relative URI*; which is composed of the *last* qualifiers in the URI that will be used to access the service. The string also may include query parameters. The first URI qualifiers—the base URI—are specified in one of three ways:

- When you declare a variable based on the Interface part, you can set the base URI. In this case, the base URI is set at development time, with no change possible at configuration time or run time. This usage is simple and fast, but inflexible.
- Alternatively, when you declare a variable based on the Interface part, you can identify an entry in a deployment descriptor. In this case, an initial value for the base URI is in the deployment descriptor, and at configuration time, a code installer can change that value.
- Regardless of how you specify an initial value for the base URI, you can run the function serviceLib.setServiceLocation to change the value at run time.

If you do not set the base URI, the value of **uriTemplate** includes the complete URI.

In most cases, the value of the **uriTemplate** property has two aspects:

- The value of the **uriTemplate** property can include a constant value. Those characters are present in (or after) every URI that is used to access the function. In the previous example, the value of **uriTemplate** includes a query parameter, and the constant value is as follows:

  ```
  /GetWeatherByZip?zipcode=
  ```

  If we change our example to include a path variable instead of the query parameter, the constant value is as follows:

  ```
  /GetWeatherByZip/
  ```

- The value of the **uriTemplate** property can include substitution variables, each of which is a function-parameter name within curly braces. The previous example includes a single substitution variable:

  ```
  {zipcode}
  ```

  For our original example with a query parameter, here is a relative URI and query parameter used to access the service:

  ```
  /GetWeatherByZip?zipcode=02135
  ```

  If we use a path variable in place of the query parameter, here is a relative URI:

  ```
  /GetWeatherByZip/02135
  ```

  A further detail is that RichUI automatically performs a URL encoding on each substitution value that is specified in a **call** statement, with one exception. For example, if your **call** statement indicates that the value for a given substitution variable is "Jeff Smith", Rich UI converts the string to "Jeff%20Smith" so that the URI is valid. However, if the value of a substitution value begins with *http*, Rich UI does no URL encoding because the **call** statement is specifying an argument that provides a complete URL. If you are responsible for URL encoding, review the documentation on system function **serviceLib.convertToURLEncoded**.

The default value of the **uriTemplate** field is an empty string so that, by default, you can specify the complete URI by setting the base URI.

requestFormat

A value that indicates the format of the representation sent to the service:

- XML, to indicate that the format is Extensible Markup Language
- NONE, to indicate that the representation is a string (or a value compatible with a string) and is sent as is
- JSON, to indicate that the format is JavaScript Object Notation
- FORM, to indicate that the format is form data, which is a record composed of argument-value pairs. In the following example of the value sent to the service, each argument is separated from the next by an ampersand (&):

  ```
  division=Consumer&dept=Sales
  ```

  For a given field in the Record part that is the basis of form data, you can specify the property **FormName**. That property lets you work with an argument name that is an EGL reserved word or is not valid in EGL. Here is an example use of **FormName**:

  ```
  record anyRecord
     continue boolean {FormName="continue-content"};
  end
  ```

The runtime code uses the value of **FormName** as the name of the argument transmitted to the service. Here is a representation that might be sent to the service, in our example:

```
continue-content=yes
```

The default value of the property **FormName** is the name of the record field. In our example, the default is `continue`.

You cannot override the value of **FormName** when you declare a record that is based on the Record part.

If the representation is a record, the following statements apply:

- The default value of **requestFormat** is *XML*.
- *JSON* is also valid.
- *FORM* is valid, too, but only if every field in the record is of type STRING or is of a type that is assignment-compatible with STRING. *FORM* is not valid if the record references another record.

responseFormat

A value that indicates the format of the representation returned to the callback function:

- XML, to indicate that the returned representation is in XML format
- NONE, to indicate that the returned representation is a string
- JSON, to indicate that the returned representation is in JSON format

If the return value is a string (or a value compatible with string), the default value of **responseFormat** is *NONE*, which is the only valid format. If the return value is a record, the default value of **responseFormat** is *XML*, and *JSON* is also valid.

You can specify an @xREST property without assigning values to the property fields. Here is an example:

```
Interface IEmployeeService
   Function GetEmployeeDetail() returns(myRecordPart)
      {@GetRest{}};
end
```

The lack of property fields has the following meaning:

- The complete REST service URI—such as *http://www.ibm.com/myservice*—must be provided in some way, with no detail being provided in the Interface part. For details on the three choices for specifying the base URI, see the earlier description of **uriTemplate**.
- If the representation parameter (or, for @GetREST, the return value) is a string, the EGL Runtime does no conversion. You must handle the conversion and can use any of the following functions for that purpose:
  - serviceLib.convertFromJSON
  - serviceLib.convertToJSON
  - XMLLib.convertFromXML
  - XMLLib.convertToXML
- If the representation parameter is a record, the EGL Runtime converts the related argument to Extensible Markup Language (XML) format.
- For @GetREST, if the return value is a record, the EGL Runtime converts that record from XML format.

Declaring an interface to access a REST service

To give additional details on how to access the REST service, you declare a variable in the EGL library or Rich UI handler that invokes the service. That variable is based on the Interface part.

For example, here is a declaration based on the Interface part `WeatherForecast`:

```
myService WeatherForcast {@RESTBinding {baseURI="http://www.ibm.com/gateway"}};
```

In that declaration, you can specify either of two properties, each of which gives you a way to specify the following details:

- The initial value of the base URI.
- The *session cookie ID*, which is a string that identifies the session cookie provided to the EGL Rich UI Proxy from a service. The service logic in this case is *stateful*, which means that the user and logic can participate in a multistep conversation. This setting is meaningful only if an EGL external type makes an IBM i program or service program available as an EGL REST service. For background information, see "Accessing IBM i programs as Web services."

  When you use stateful REST services, the connection and all the associated IBM i resources are retained until the session on the service side is invalidated. The service-side session is invalidated when the requesting code invokes **serviceLib.endStatefulServiceSession()** or when the application server invalidates the session, typically because of a timeout.

The two properties are **@RESTBinding** and **@BindService**. You can use **@RESTBinding** to specify the base URI and session-cookie ID directly in your code, as is simple but inflexible. You can use **@BindService** to specify those details in a deployment descriptor, as allows for changes at configuration time.

Here is a description of those two properties, which are mutually exclusive:

@RESTBinding
Use this property to specify, in your code, the base URI in the code, the session cookie ID, or both. **@RESTBinding** includes the following fields:

baseURI
A string that identifies the first qualifiers in the URI being used to access the service. The default value of **baseURI** is an empty string.

sessionCookieID
The name of a session cookie. The default value is JSESSIONID, which is always the session ID when your application runs on Apache Tomcat.

If your application runs on WebSphere Application Server, you can override the value specified in **sessionCookieID** by setting a value for the **defaultSessionCookieID** build descriptor option.

@BindService
Use this property to use a deployment-descriptor entry to identify the base URI, the cookie-session-ID, or both. The property has one field:

bindingKey
Identifies the deployment-descriptor entry that includes the two details.

You can specify **@BindService** without specifying the **bindingKey** field, in which case the property identifies the deployment-descriptor entry that has the same name as the Interface part. Here is an example of that usage, which refers to the deployment-descriptor entry named WeatherForecast:

```
MyService WeatherForecast {@BindService{}}
```

Coding a call statement and callback functions for service access

Here is the syntax of the **call** statement used in Rich UI:

```
call serviceName.operationName(argumentList)
   returning to myCallbackFunction onException myExceptionHandler
   {timeout = milliseconds};
```

serviceName
Name of a variable based on an Interface part.

operationName
Name of the Interface part function prototype.

argumentList
List of arguments, each separated from the next by a comma.

A change made to a parameter value in the service has no effect on the value of the argument variable provided in the **call** statement.

For details on the restrictions placed on parameters sent to a third-party (non-EGL) REST service, see *Specifying parameters for service access in Rich UI*,

myCallbackFunction
Name of a callback function or delegate that is available to the call statement. In most cases, the function or delegate is in the same Rich UI handler or in a library. A later section describes the callback function.

myExceptionHandler
Optional. Name of a exception handler or delegate that is available to the **call** statement. In most cases, the exception handler or delegate is in the same Rich UI handler or in a library. A later section describes the exception handler.

If you do not have your own exception handler, you can specify the following delegate: **serviceLib.serviceExceptionHandler**. Here are some implications:

- By default, the effect of specifying that delegate is to automatically invoke a system function that writes the content of the exception **message** field to the standard output. In the product, the standard output is the console view. In an external browser, the standard output is the bottom of the Web page.
- Alternatively, you can make customized exception handling consistent throughout a set of applications. First, assign a different exception handler to the delegate; for example, by writing a setup function in your own library (such as in `myLibrary`) and by including the following statement in that function:

  ```
  serviceLib.serviceExceptionHandler = myLibrary.myExceptionHandler;
  ```

  Second, invoke the setup function in Rich UI handler on-construction functions. For every service invoked by a **call** statement (if the statement includes **serviceLib.serviceExceptionHandler**), the EGL Runtime responds to a runtime exception by running the customized exception handler; in this case, by running `myLibrary.myExceptionHandler`.

milliseconds
The maximum valid number of milliseconds that elapse between the following events: when the EGL Rich UI Proxy (on the Web server) invokes a service and when the Proxy receives a response. If more time elapses, the EGL Runtime throws a **ServiceInvocationException**.

You can set a default value for *milliseconds* in the **defaultServiceTimeout** build descriptor option. The **defaultServiceTimeout** build descriptor option has no default value set, meaning that if you do not specify a value for either **defaultServiceTimeout** or for *milliseconds*, the service call will not time out. For more information, see "defaultServiceTimeout" on page 132.

Keystroke assistance for the call statement

The following kinds of keystroke assistance are available:

- After you type the **returning to** or **onException** keyword in the **call** statement, you can request content assist by typing **Ctrl-Space**. In each case, a list of functions is displayed and you can select one.
- If you type the **call** statement with the ending semicolon and include reference to a callback or onException function that does not exist, you can request the Workbench to create the missing logic:
  - Press **Ctrl-1**
  - Alternatively, right click after the semicolon and respond to the dropdown menu by selecting **Create Callback Functions**

Callback function

The callback function receives the values, if any, that are in the response sent by the service. The callback itself has no return value.

If the callback function is invoked from a third-party REST service, the function may have zero or one parameter, If a parameter is specified, its type must match the type of the return value specified in the Interface part, and the parameter modifier is IN.

If the callback function is invoked from a Web SOAP service or from an EGL REST service, the relationship of the function parameters and the service-invocation parameters is best described by example:

- Consider the following function prototype in an Interface part:

```
Interface EmployeeService {}
   Function GetEmployeeDetail(employeeCode STRING IN,
                              employeeSalary FLOAT OUT,
                              employeeStatus STRING INOUT)
            returns(myEmployeeRecordPart);
end
```

- Here is an interface declaration and **call** statement used to invoke the service:

```
myInterface EmployeeService;

call myInterface.GetEmployeeDetail("A123", 25.8, "Full-time")
     returning to myCallback onException myExceptionHandler;
```

- Here is the outline of a callback function:

```
Function myCallBack(salary FLOAT IN,
                    status STRING IN,
                    myRecord myEmployeeRecordPart IN)
    // statements here
end
```

  The callback function includes one parameter for each service-operation parameter that is OUT or INOUT, and the order of those parameters in the callback function is the same as the order in the service operation. The service-operation return value is represented as the last parameter in the callback function.

In general, the rule for designing the callback function for a Web SOAP service or an EGL REST service is as follows:

- The callback function has a series of parameters that are in the same order as the OUT and INOUT parameters in the service invocation
- If the service invocation has a return value, the callback function includes an additional, last parameter to accept the return value
- Each parameter in the callback function has the modifier IN

OnException function

The onException function has the following characteristics:

- The onException function has no return value
- The function accepts an Exception record of type **AnyException**, and you can test that record to determine the specific type received

Here is the outline of an onException function:

```
Function myExceptionHandler(exp AnyException)
   case
      when (exp isa ServiceBindingException)
         ;
      when (exp isa ServiceInvocationException)
         ;
      otherwise
         ;
   end
end
```

Errors of various kinds are possible:

- In a service binding; that is, in how the service access is specified in your code, possibly involving a problem in the deployment descriptor
- In the communication of the Rich UI application with the EGL Rich UI Proxy
- In the EGL Rich UI Proxy
- In the communication of the EGL Rich UI Proxy with the service
- In the service

A problem in a service binding results in a **ServiceBindingException**. Other problems result in a **ServiceInvocationException** or (less likely) a **RuntimeException**.

Using a provided Interface part for a 3rd-party REST service

The following Interface part is provided for accessing a third-party (non-EGL) REST service:

```
interface IRest
   function invokeGet(reqURL string in) returns(string)
      {@getRest {uriTemplate="{reqURL}"}};
   function invokePost(reqURL string in, representation string in) returns(string)
      {@postRest {uriTemplate="{reqURL}"}};
   function invokePut(reqURL string in, representation string in) returns(string)
      {@putRest {uriTemplate="{reqURL}"}};
   function invokeDelete(reqURL string in, representation string in) returns(string)
      {@deleteRest {uriTemplate="{reqURL}"}};
end
```

By using this Interface part as is, you avoid having to write one of your own. However, the work required to code the **call** statement is different, as shown in the following example:

```
myVar IRest;
myResource String = ServiceLib.convertToJson(myRec);
call myVar.invokePost("http://www.example.com", myResource)
    returning to myCallbackfunction;
```

The differences are as follows:

- You do not pass multiple arguments that are used as substitution values. Here are different ways to construct the URI:
  - You can pass the whole URI (as shown in the example)
  - You can also specify the whole URI in the variable declaration, as shown here:

    ```
    myVar IRest {@RESTService {baseURI="http://www.example.com"};
    myResource String = ServiceLib.convertToJSON(myRec);
    call myVar.invokePost("", myResource)
        returning to myCallbackfunction;
    ```

  - You can rely on the variable declaration to provide the base URI and then pass a relative URI
- When you invoke a service with POST, PUT, or (possibly) DELETE, you need to ensure that the representation (a string) is in the format required by the REST service, as shown by use of one of the following functions:
  - **serviceLib.convertToJSON**, for JSON conversion; or
  - **XMLLib.convertToXML**, for XML conversion.

If you need a function prototype that has a different characteristic—for example, a DELETE operation that does not require you to pass a representation—create a similar Interface part, but change the function prototype InvokeDelete or add a prototype with a different name. Here is a changed prototype:

```
function invokeDelete(reqURL string in) returns(string)
   {@deleteRest {uriTemplate="{reqURL}"}};
```

Specifying parameters for service access in Rich UI

An Interface (or Service) part is used for service access and includes function prototypes such as the following one:

```
Function GetEmployeeDetail(employeeCode STRING IN,
                           employeeSalary FLOAT OUT,
                           employeeStatus STRING INOUT)
         returns(myEmployeeRecordPart);
```

This topic lists the rules for specifying parameters in a function prototype used in Rich UI.

First, if the prototype is used to access an EGL REST or SOAP service, the prototype can include IN, OUT, and INOUT parameters.

Second, the following statements apply to a prototype used to access a third-party (non-EGL) REST service:

- The IN modifier is required for each parameter
- If a parameter is used to help construct the URI or the query string, the following rules apply:
  - The parameter's name must match the name of the substitution variable in the URI template
  - The parameter's data type can be a primitive type or related data item

  - The primitive type must be STRING or one the following types, which are assignment-compatible with STRING: FLOAT, BIN, or one of the integer equivalents to BIN (INT, SMALLINT, or BIGINT)
- The value of a representation parameter can be a string, one of the previously mentioned assignment-compatible types, or a non-structured Record part whose only fields fulfill the following rules:
  - The field is of type STRING or is assignment-compatible with STRING.
  - The field is based on a non-structured Record part. Specifically, the field can be based on a Record part that includes only strings (or assignment-compatible values) or other non-structured Record parts. The nesting of records within records can be to any level.

Accessing IBM i programs as Web services: overview

You can use EGL to expose the logic in an IBM i called program or service program by way of an EGL external type. The EGL generator uses that external type to create an EGL REST or SOAP service so that an application that is acting as a service requester can access any of the following kinds of IBM i programs: rpgle, cbl, cblle, sqlrpgle, sqlcbl, and sqlcblle.

To access an IBM i program:

1. Create an external type (type **HostProgram**)
2. In the Services deployment section of the EGL deployment descriptor editor, select that external type and enter other appropriate information.
3. Deploy the resulting Web service to a JEE-compliant application server.

It is difficult to design the Record parts that will become the basis of the records used during service invocation. However, if you use IBM Rational® Business Developer for i for SOA Construction, you can use a wizard to create content in two projects:

- The service project (a Web project) includes the following components, which are used to develop the code that accesses the IBM i program:
  - An external type, stereotype **HostProgram**, which includes function prototypes that mirror the signatures of functions in the IBM i program of interest
  - EGL structured Record parts that are referenced by parameters and return values in the function prototypes
  - A deployment descriptor with an entry that includes the following details: a URI for accessing the service, a reference to the external type, and a set of connection parameters for accessing the program from IBM WebSphere Application Server or Apache Tomcat.
  - A Program Call Markup Language (PCML) file, as noted later.
- The client project (a Rich UI project) includes the following components, which are used to develop the EGL Rich UI application that accesses the service:
  - An Interface part that is like the external type placed in the service project
  - A set of non-structured Record parts that are referenced by parameters and return values in the function prototypes of the Interface part; the fields in those Record parts are equivalent to the bottommost (leaf) fields in the structured Record parts
  - A deployment descriptor with an entry that accesses the service

Some IBM i (non-EGL) host programs are *stateful*:

- A stateful program retains information between invocations so that the user and program can participate in a multistep conversation.
- When you are providing access to a stateful host program and you set up the deployment descriptor of the Web project that includes the external type, you must specify that the service is a REST service, not a SOAP service. To indicate that the host program is stateful, customize the deployment descriptor by selecting the **Stateful** checkbox in the deployment descriptor editor.
- The stateful aspect of host-program access is made possible by a session cookie that is provided by the service to the EGL Rich UI Proxy. The cookie holds an identifier for the HTTP session. You identify the session cookie when you declare a variable based on the Interface part, as noted in "Declaring an interface to access a REST service."
- The EGL Rich UI Proxy retains the session ID in between service invocations. To release runtime resources after you invoke the service for the last time in your application, invoke the **serviceLib.endStatefulServiceSession()** function.

The HTTP session detail is retained on the service-access variable. For stateful services, the life span of the session of the requester depends on where the variable is declared. For example, if the variable is declared in a function invocation, the session of the requester lasts as long as the function is in scope. If the variable is declared on a library, the session of the requester is retained until the library goes out of scope. If you are accessing a stateful REST service, ensure that you declare the variable in such a way that the variable does not go out of scope prematurely.

External type that provides access to an IBM i program

Here is an example of an external type that provides access to an IBM i program.

```
ExternalType GETREC type HostProgram {platformData=[@i5OSProgram{ programName="GETREC",
                        programType=NATIVE, isServiceProgram=false, libraryName="*LIBL"}]}
   function GETREC(CUST CUSTa10, EOF char(1), COUNT decimal(2,0)){ hostName="GETREC"};
end
```

The **platformData** property accepts an array. In this example, the array has a single entry for the **@i5OSProgram** complex property. The property fields for **@i5OSProgram** are as follows:

programName
The name of the program on IBM i. The default is the name of the external type.

programType
Either EGL (for a program written in EGL) or native (for a program written in COBOL or RPG). The default is *NATIVE*.

isServiceProgram
A Boolean indicating whether the program is an IBM i service program. The default is *false*.

libraryName
The IBM i library. The default is *LIBL.

The **hostName** property is available for a function prototype and identifies the name of the program function. The default is the name of the function prototype.

Correspondence in data type between IBM i and EGL record fields

The Workbench converts the IBM i data types from the host source into a Program Call Markup Language (PCML) definition. The Workbench then uses that definition to create the external type and records.

The PCML file is retained for two reasons. First, you can update the file for use as the input in subsequent runs of the wizard. For example, you might put together a PCML definition that corresponds to entry points in several programs. If you use that definition as an input file, the external type created by the wizard can reflect all the entry points. Second, IBM technical-support representatives can use the retained PCML file as a debugging tool, if necessary.

The following table lists the corresponding data types in IBM i structured records and EGL structured records.

Table 4. Corresponding data types in IBM i structured records and EGL structured records

IBM i		**Rules**	**EGL data type in the EGL external type**
char		charType = single byte	CHAR (PCML length)
		charType = double byte	UNICODE (PCML length)
int	2 byte signed	precision != 16, length=2	SMALLINT
	2 byte unsigned	precision = 16, length = 2	INT
	4 byte signed	precision != 32, length = 4	BIGINT
	4 byte unsigned	precision = 32, length = 4	BIGINT
	8 byte signed	length = 8	BIGINT
packed			DECIMAL (PCML length, PCML precision)
zone			NUM (PCML length, PCML precision)
float		length = 4	SMALLFLOAT
		length = 8	FLOAT
byte			HEX (PCML length * 2)

You might need to update the Workbench-created EGL record fields that correspond to IBM i types that are not supported by EGL or are not converted by PCML. Details about PCML are available in the online information center for IBM WebSphere Development Studio Client for iSeries®: http://publib.boulder.ibm.com/infocenter/iadthelp/v7r0/topic/com.ibm.etools.iseries.webtools.doc/topics/rdtcattr.html.

Some host structures do not have corresponding EGL types. Here is a COBOL example:

```
01 P1 PIC 9(5) USAGE BINARY.
01 P2.
       02 P2A PIC X(5) OCCURS 1 to 10 TIMES
                      DEPENDING ON P1.
```

Correspondence in data type between equivalent EGL record fields

The following table lists the corresponding data types in structured and non-structured records. You might need to update the Workbench-created non-structured record fields that are of type HEX or INTERVAL.

Table 5. Corresponding data types in structured and non-structured records

Data Type in Structured Record	Data Type in Non-Structured Record
BOOLEAN	BOOLEAN
CHAR, DBCHAR, MBCHAR, STRING, UNICODE	STRING
HEX	HEX
DATE	DATE
TIME	TIME
TIMESTAMP	TIMESTAMP
INTERVAL	INTERVAL
DECIMAL, BIN(length), BIGINT, INT, MONEY, NUM, SMALLINT, SMALLFLOAT	Corresponding numeric types
BIN(length, decimalPlaces) where decimalPlaces > 0	NUM(length, decimalPlaces)
NUMC(length, decimalPlaces)	NUM(length, decimalPlaces)
PACF(length, decimalPlaces)	NUM(length, decimalPlaces)

Accessing IBM i programs as Web services: keystroke details

The EGL generator creates a SOAP Web service or EGL REST Web service so that an application acting as a service requester can access any of the following kinds of IBM i programs: rpgle, cbl, cblle, sqlrpgle, sqlcbl, and sqlcblle. For background information, see *Accessing IBM i programs as Web services: overview*. This topic describes the keystroke details, which can be fulfilled in the product *IBM Rational Developer for i for SOA Construction*.

Prerequisites are as follows:

- Your Workspace includes a Web or General project to contain (a) the external type that represents your IBM i program, and (b) the structured Record parts that are used as the basis of records exchanged between the Web service and the IBM i program.
- Your Workspace includes a Rich UI project to contain the Interface and non-structured Record parts that your Rich UI application uses to access the IBM i code at run time.
- You have a connection from the Workspace to your IBM i system. The connection is available in the Remote Systems Explorer perspective.

Please note that the wizard described here does not handle creation of an Interface part to access a Web (SOAP) service. For that case, do as follows:

1. Generate the deployment descriptor, which creates the WSDL file and places it in WebContent/WEB-INF/wsdl
2. Right-click the WSDL file, select **EGL Services → Create EGL client interface**, and fulfill the steps specified in the wizard, remembering to place the Interface part in the Rich UI project

Creating external types and structured Record parts

To create the external types and structured Record parts, do as follows:

1. In the Remote Systems Explorer perspective, right-click the entry for IBM i program source or for an existing Program Call Markup Language (PCML) definition.
2. Select **EGL Services → Create EGL: External Type, Interface, and records**
3. The first of two **New EGL part** dialog boxes is displayed. In the middle of the box, select an external type to create. At the bottom of the box, click the check boxes that indicate whether you want to create a Web (SOAP) service, a Web (REST) service, or both. If you select **Create REST Web services**, you can create an Interface part and non-structured Record parts for use by the Rich UI application. If you do not want the Interface and Record parts, clear **Create EGL Rich UI Interface for REST Web service**. Later, if you want an Interface part for the REST service, do as follows: right click the external type, select **EGL Services → Extract EGL Interface**, and fulfill the steps specified in the displayed wizard, remembering to place the Interface part in the Rich UI project.
4. Click **Next**. The second **New EGL part** dialog box is displayed:
   a. In the **Source folder** field, specify the project that receives the external type and structured Record parts. Also specify a backslash (\) and the source folder.
   b. In the **Package** field, specify the package name. We strongly recommend you specify a package name; otherwise, no other project can access the parts in the project you identified.
   c. In the **EGL source file name** field, specify the file name.
5. In the subsequent fields, specify the details for a given external type, being careful to specify whether the program is a service program:
   a. In the **ExternalType Name** field, specify the name to create for the external type itself
   b. In the **Host Program Name** field, specify the name of the link-edited host program
   c. In the **Host Program Library** field, specify the library name for the link-edited host program
   d. If the program is a service program, select **Service Program**; otherwise, clear that field and select the appropriate entry in the **Host Program Type** list box, where you indicate whether the host program is NATIVE (written in COBOL or RPG) or EGL (written in EGL).
   e. In the **Entrypoints** field, select the program functions to expose as service functions. To select all, click **Select All**. To clear all, click **Deselect All**.
   f. To overwrite same-named files for the external types, select **Overwrite existing files**. To protect yourself against overwriting existing files, clear the check box.
6. Click **Next**.

Creating Web (REST) services

If you are creating Web (REST) services, the **New EGL REST Service** dialog box is displayed. Do as follows, taking special care to indicate whether the IBM i program is stateful:

1. In the **Source folder** field (if available), specify a Web or General project, along with the source folder that contains the deployment descriptor. The REST service is an output that is created at deployment-descriptor generation time.
2. In the **EGL deployment descriptor file name** field (if available), specify the name of the deployment descriptor.
3. In the middle box, select the entry for **enableGenerate**, for each service you want to generate. If you already generated a REST service, you can save time at generation time by specifying, in the deployment descriptor, that you do not wish to generate the service. However, if you change any aspect of the deployment-descriptor entry, you need to regenerate the service.

   You can change the URI field, which identifies the low-level qualifier for the address used to access the REST service. For details on the address, see *Adding Web service deployment information to the deployment descriptor*.

   For a given service, ensure that the last entry reflects whether the IBM i program is stateful or not. Click on the entry to change the value.
4. To overwrite same-named REST-service entries in the deployment descriptor, select **Overwrite existing files**. To protect yourself against overwriting existing entries, clear the check box.
5. In the last section (if available), click the **Add** button to modify or add a protocol used to access the IBM i program from the Web service. The **Add Protocol** dialog box is displayed. Specify a protocol name, along with the additional information specified in the EGL Generation Guide, *Deployment descriptor options for service clients*. To return to the **New EGL REST Service** dialog box, click **Finish**.
6. Click **Next** to continue your work in the wizard or (if possible) click **Finish** to complete your work.

Creating Interface parts

If you indicated that you want to include Interface and Record parts with the REST services, the **New EGL Interface part** dialog box is displayed. Do as follows:

1. In the **Source folder** field, specify the Rich UI project that receives the Interface part, along with the source folder.
2. In the **Package** field, specify the package name. We strongly recommend you specify a package name; otherwise, no other project can access the parts in the project you identified.
3. In the **EGL source file name** field, specify the file name.
4. In the subsequent fields, specify the details for a given Interface part and the related Record parts:
   a. In the **Interface Name** field, specify the name to create for the Interface part
   b. In the **functions** area, identify each IBM i function that will be represented in the Interface part. The wizard creates a non-structured Record parts for each parameter that is not a primitive type.
5. To overwrite existing files, select **Overwrite existing files**. To protect yourself against overwriting existing files, clear the check box.

Creating Web (SOAP) services

If you are creating Web (SOAP) services, the **New EGL Web Service** dialog box is displayed. Do as follows:

1. In the **Source folder** field (if available), specify a Web or General project, along with the source folder that contains the deployment descriptor. The Web service is an output that is created at deployment-descriptor generation time.
2. In the **EGL deployment descriptor file name** field (if available), specify the name of the deployment descriptor.
3. In the middle box, select the entry for **enableGenerate**, for each service you want to generate. If you already generated a Web service, you can save time at generation time by specifying, in the deployment descriptor, that you do not wish to generate the service. However, if you change any aspect of the deployment-descriptor entry, you need to regenerate the service.
4. To overwrite same-named SOAP-service entries in the deployment descriptor, select **Overwrite existing files**. To protect yourself against overwriting existing entries, clear the check box.
5. In the last section (if available), click the **Add** button to modify or add a protocol used to access the IBM i program from the Web service. The **Add Protocol** dialog box is displayed. Specify a protocol name, along with the additional information specified in the EGL Generation Guide, *Deployment descriptor options for service clients*. To return to the **New EGL Web Service** dialog box, click **Finish**.
6. Click **Finish** to complete your work in the wizard.

Accessing a SOAP (Web) service in Rich UI

The basic tasks required to access any service in Rich UI are as follows:

1. Create an Interface part.
2. Create a variable based on that part.
3. Code a **call** statement
4. Code a callback function that is referenced in the **call** statement
5. In most cases, you also specify an onException function, which receives an exception from the service call if the service returns an exception instead of business content

Creating an Interface part to access a Web service in Rich UI

An EGL Interface part includes one or more *function prototypes*, each of which identifies an operation available in a service. As shown in the following example, a function prototype has an ending semicolon (;) and includes a function name, parameter list, and (optionally) a return type:

```
Interface WeatherForecast
   Function GetWeatherByZipCode(zipcode string in) returns(myRecordPart);
end
```

In relation to a Web service, the function prototypes can include parameters that have the modifiers IN, INOUT, or OUT.

Rich UI provides a way to create an Interface part based on the WSDL file:

- Bring the WSDL file for the Web service into your EGLSource folder; for example, into a subfolder named wsdl

- In the Project Explorer, right click the WSDL file and, at the menu, click **EGL Services**, then **Create EGL Client Interface**
- Following the directions of the wizard that creates the Interface part. You might put that part into a EGLSource subdirectory named interfaces.

Rich UI writes useful comments into the file that holds the Interface part, as noted in *Declaring an interface to access a Web service in Rich UI*.

Declaring an interface to access a Web service in Rich UI

To provide additional details about how to access the Web service, you can create a variable based on the Interface part.

```
myService WeatherForcast {@WebBinding
                            {wsdlLocation="wsdl/weatherForecast",
                             wsdlService="wsdlforecast",
                             wsdlPort="wsdlport"};
```

In that declaration, you can specify either of two properties, each of which gives you a way to specify details that indicate how to access the Web service: **@WebBinding** and **@BindService**. You can use **@WebBinding** to specify the WSDL-file detail directly in your code. Use **@BindService** to specify those details in a deployment descriptor; this property allows for changes at configuration time. In either case, the product tooling helps you specify details.

The two properties are mutually exclusive:

@WebBinding
Use this property to specify, in your code, the details that indicate how to access the Web service. You do not need to create the **@WebService** complex property. Rich UI writes the details in a comment, which is stored in the file that holds the Interface part created from a WSDL file. Here are the property fields:

wsdlLocation
A string that identifies the name and location of the WSDL file. The location is relative to the `EGLSource` folder. For example, if the file is named `weatherForecast.wsdl` and is in the `EGLSource` folder, the string is "weatherForecast.wsdl". If the file is in `EGLSource/wsdl`, the string is "wsdl/weatherForecast.wsdl".

wsdlService
A string that identifies the name of the wsdl:service element in the WSDL file.

wsdlPort
A string that identifies the name of the wsdl:port element within the wsdl:service element in the WSDL file.

uri
If specified, a string that overrides the URL specified in the WSDL file. If the service is available at a location other than the one specified in the WSDL file, such as a different version of the service used for production or testing, you can enter that location here and use that version of the service instead. By default, this value is null.

@BindService
Use this property to use a deployment-descriptor entry to indicate how to access the Web service. Later, when you create a Web binding in the

deployment descriptor, the product tooling provides defaults for most of the WSDL-file details described earlier (specifically, **wsdlLocation**, **wsdlService**, and **wsdlPort**).

The **@BindService** property has one field:

bindingKey
Identifies the deployment-descriptor entry that includes the two details.

You can specify **@BindService** without specifying the **bindingKey** field, in which case the property identifies the deployment-descriptor entry that has the same name as the Interface part. Here is an example of that usage, which refers to the deployment-descriptor entry named WeatherForecast:

```
MyService WeatherForecast {@BindService{}}
```

Each SOAP service invocation uses a new HTTP session, and no session information is retained from invocation to invocation. Your code cannot usefully call a service that is using session variables, which retain information from invocation to invocation.

Copying a JSON string to and from an EGL variable

This topic describes the EGL record that corresponds to a JavaScript Object Notation (JSON) string. Other topics describe the functions—**serviceLib.convertFromJSON** and **serviceLib.convertToJSON**—that are used by a Rich UI developer to convert JSON data to or from a variable, as may be necessary to access a third-party REST service. A failure in either function causes a **RuntimeException**.

JSON and EGL records

You can define a record to use when accessing a JSON string such as the following one:

```
{ "EmpNo":10,"LastName":"Smith" }
```

Within the brackets of a JSON string, each identifier-and-value pair (such as "Empno":10) is the name and value of a JSON field. To create a record part that matches the JSON string, ensure that each field name in the record part exactly matches (in character and case) each corresponding field name in the JSON string, as shown in the following example:

```
Record MyRecordPart
   EmpNo INT;
   LastName STRING;
end
```

You can use any primitive type other than BLOB or CLOB. An EGL record field is also valid if based on a DataItem part that is, in turn, based on one of the supported primitive types.

The EGL property **JSONName** lets you work with a JSON string in which a field name is an EGL reserved word or is not valid in EGL. Here is a variation of the example JSON string:

```
{ "Emp-No":10,"LastName":"Smith" }
```

The problem in this case is that you cannot create an EGL record-field name that includes a hyphen. However, you can use the property **JSONName** to retain the JSON field name in the Record part, as shown here:

```
Record MyRecordPart
   EmpNo INT; {JSONName = "Emp-No"}
   LastName STRING;
end
```

(You cannot override the value of **JSONName** when you declare a record that is based on the Record part.)

In many situations, the record you use to access a JSON string includes records. However, when you are using records and invoke `serviceLib.convertFromJSON` or `serviceLib.convertToJSON`, you reference only a single record, which is based on the topmost (most inclusive) record part of all the record parts needed. For example, the following JSON string might be returned from a getTime service that calculates the number of seconds since January 1, 1970:

```
{"Result":{"aTimestamp":1191871152}}
```

A general rule is that each bracketed clause in the JSON string is equivalent to an EGL record. In the current example, you need to define two record parts. The record you would use in `serviceLib.convertFromJSON` or `serviceLib.convertToJSON` is based on the following part, which has a field called Result:

```
Record MyTopPart
   Result MyTimestampPart;
end
```

Given the structure of the JSON string, the next record part has a field named `aTimestamp`:

```
Record MyTimestampPart
   aTimestamp BIGINT;
end
```

As shown, each JSON identifier (which precedes a colon) requires the presence of a field in a record. If a JSON field name is an EGL reserved word (for example, "TimeStamp"), you must access `serviceLib.convertFromJSON` or `serviceLib.convertToJSON` by using a dictionary rather than a record. We show this variation later in this topic.

Here is another example, which (although reformatted for readability) is from http://json.org/, a Web site that describes JSON in detail:

```
{"Menu":
  { "id": "file", "value": "File", "popup":
     {"Menuitem":
       [
         {"value": "New", "onClick": "CreateNewDoc()"},
         {"value": "Open", "onClick": "OpenDoc()"},
         {"value": "Close", "onClick": "CloseDoc()"}
       ]
     }
  }
}
```

(At this writing, that example and others are at http://json.org/example.html.)

The topmost (most inclusive) record part includes a field named `Menu`:

```
Record MyTopPart
   Menu MyMenuPart;
end
```

To build the other record parts, we consider each bracketed clause in the JSON string. The next record part (MyMenuPart) includes fields named id, value, and popup:

```
Record MyMenuPart
   id STRING;
   value STRING;
   popup MyPopupPart;
end
```

The next record part includes an array named MenuItem:

```
Record MyPopupPart
   MenuItem MyElementPart[];
end
```

The last record part includes fields named value and onClick:

```
Record MyElementPart
   value STRING;
   onClick STRING;
end
```

To further explore how to use a record when accessing a JSON string, see the Rich UI sample geocode.records.

JSON and EGL dictionaries

An EGL dictionary contains a set of entries, each comprising both a key and a value of any type, as in the following variable declaration:

```
myRef Dictionary
{
   ID = 5,
   lastName = "Twain",
   firstName = "Mark"
};
```

You interact with the dictionary as described in "Dictionary part" and related topics in the EGL help system.

The following JSON string might be returned from a getTime service that calculates the number of seconds since January 1, 1970:

```
{"Result":{"aTimestamp":1191871152}}
```

You can decide to translate the JSON string (from the leftmost to the rightmost bracket) to a dictionary named myTime, which is declared without detail:

```
myTime Dictionary;
```

A general rule is that each bracketed clause in the JSON string is equivalent to an EGL dictionary. In relation to our example JSON string, the function serviceLib.convertFromJSON treats the symbol at the left of the first colon (:) as the key of a dictionary entry. The key is Result, which is case sensitive. Here (as in all cases) the content to the right of a colon is the value associated with the key whose name is at the left of the colon.

The embedded brackets indicate that the value of Result is an anonymous dictionary. As before, the colon within those brackets distinguish between a key (aTimestamp) and a value (1191871152). In short, you can think of the output of the function serviceLib.convertFromJSON as follows:

```
myTime Dictionary
{
   Result = new Dictionary{ aTimestamp = 1191871152 }
};
```

You can access the content of aTimestamp by using dotted syntax:

```
numberOfSeconds BIGINT = myTime.Result.aTimestamp;
```

On occasion, dotted syntax is not valid. The Yahoo getTime service, for example, returned the following content, including the EGL reserved word *Timestamp*:

```
{"Result":{"Timestamp":1191871152}}
```

To access a value whose key is an EGL reserved word, you must use bracket syntax. The following EGL code is valid for the data returned from the Yahoo getTime service:

```
numberOfSeconds BIGINT = myTime.Result["Timestamp"];
```

Here again is the Menu example from http://json.org/:

```
{"Menu":
  { "id": "file", "value": "File", "popup":
     {"Menuitem":
       [
         {"value": "New", "onClick": "CreateNewDoc()"},
         {"value": "Open", "onClick": "OpenDoc()"},
         {"value": "Close", "onClick": "CloseDoc()"}
       ]
     }
  }
}
```

In this example, the dictionary has a single entry whose key is named Menu. The value associated with that key is an anonymous dictionary, as indicated by the brackets that embed the string "id" and all the strings that follow. That anonymous dictionary includes the keys id, value, and popup, along with the values of those keys. You may never have the kind of complexity introduced by the key called popup, but the problem is workable. You can see the relationships in the example JSON string.

Here is a question for you to consider: What statement is necessary to access the string "OpenDoc()", assuming that the function `serviceLib.convertFromJSON` has copied the previous JSON string to a dictionary called myMenu?

The answer is as follows:

```
myString STRING = myMenu.Menu.popup.MenuItem[2].onClick;
```

The following EGL dictionary reflects the current example:

```
myMenu Dictionary
{  Menu = new Dictionary
   { id = "file",
     value = "File",
     popup = new Dictionary
     { MenuItem = new Dictionary[]
       { new dictionary {value = "New", onClick = "CreateNewDoc()" },
         new dictionary {value = "Open", onClick = "OpenDoc()" },
         new dictionary {value = "Close", onClick = "CloseDoc()"}
       }
     }
   }
};
```

To work with the function serviceLib.convertToJSON, begin by creating a dictionary that is structured as shown in the previous examples. The following two rules apply:

- Each dictionary in a hierarchy of dictionaries is equivalent to a bracketed clause in the JSON string
- Each key is assigned a primitive value, a dictionary, a record, or an array of dictionaries or records.

To further explore how to use a dictionary record when accessing a JSON string, see the Rich UI sample geocode.dictionaries.

JSON and both records and dictionaries

You can mix records and dictionaries in the following cases:

- When you prepare to invoke serviceLib.convertFromJSON with a record
- When you prepare to invoke serviceLib.convertToJSON with a record or dictionary

You might include a dictionary in a record to access the following JSON string:

```
{"Result":{"Timestamp":1191871152}}
```

You can define the following part:

```
Record ResultRecordPart
   Result Dictionary;
end
```

Your code can access the timestamp value as follows:

```
   myResult ResultRecordPart;
   milliseconds BIGINT;
  serviceLib.convertFromJSON(resp.body, myResult);
  milliseconds = myResult.Result["Timestamp"] as BIGINT;
```

A general rule is that, if you associate an incoming JSON clause with a dictionary, you can access data within the clause only by using a dictionary syntax. A complex example is as follows:

```
{"Menu":
  { "id": "file", "value": "File", "popup":
     {"Menuitem":
       [
         {"value": "New", "onClick": "CreateNewDoc()"},
         {"value": "Open", "onClick": "OpenDoc()"},
         {"value": "Close", "onClick": "CloseDoc()"}
       ]
     }
  }
}
```

To prepare to access the content, you can define the following parts:

```
Record MyTopPart
   Menu MyMenuPart;
end

Record MyMenuPart
   id STRING;
   value STRING;
   popup Dictionary;
end
```

The following EGL dictionary reflects the structure named popup:

```
popup Dictionary
{ MenuItem = new Dictionary[]
   { new Dictionary {value = "New", onClick = "CreateNewDoc()" },
     new Dictionary {value = "Open", onClick = "OpenDoc()" },
     new Dictionary {value = "Close", onClick = "CloseDoc()"}
   }
}
```

(We show that dictionary for illustration. The substructure of a Dictionary may be useful when you are invoking serviceLib.convertToJSON, but is not used when you are invoking serviceLib.convertFromJSON .)

The following code accesses the string "OpenDoc()":

```
myTop MyTopPart;
itemString STRING;
serviceLib.convertFromJSON(resp.body, myTop);
itemString = myTop.Menu.popup.MenuItem[2].onClick;
```

Copying an XML string to and from an EGL variable

This topic describes the EGL record that corresponds to an Extensible Markup Language (XML) string. Other topics describe the functions—**serviceLib.convertFromXML** and **serviceLib.convertToXML**—that are used by a Rich UI developer to convert XML data to or from a variable, as may be necessary to access a third-party REST service. The last section includes sources of additional information on XML.

XML and EGL records

You can define an EGL Record part that is the basis of a record (or array of records) used to process an XML string. The Record part includes details that are found in an XML Schema, which is a language for validating an XML string.

When you use the function **XMLLib.convertToXML**, you write the content of the EGL record to an XML string. When you use the function **XMLLib.convertFromXML**, you write the XML string into the EGL record; and if the string does not fulfill a validation rule specified in the record, the EGL Runtime issues an **RuntimeException**.

Here is an example XML string, which is shown on several lines for clarity:

```
<Employee>
   <EmpNo>10</EmpNo>
   <Name>Smith</Name>
</Employee>
```

Here is a Record part that matches the example XML string:

```
Record Employee {XMLStructure = xmlStructureKind.sequence}
   EmpNo INT;
   Name STRING;
end
```

In most cases, the Record part includes a set of field names that each match (in character and case) the name of an element or attribute in the XML string. If the names do not match, you use EGL properties to specify the XML element or attribute name.

EGL support for XML has two aspects:

- Assigning the XML string from a record. If you are converting a record to an XML string, you can accept defaults when creating the string or can explicitly specify details such as the name that the EGL Runtime assigns to an element or attribute in the XML string.
- Validating the XML string being written to a record. If you are writing an XML string to a record, the EGL Runtime issues a **RuntimeException** in the following cases:
  - An element or attribute name does not match an equivalent record-field name (or does not match an override that you specify in a property field); or
  - There is a mismatch in the structure of the XML string and the related record.

Keep in mind this twofold usage: in one case, for XML-string assignment, and in another case, for validation.

Here is an example of an XML string that includes an attribute:

```
<Sample color="green"></Sample>
```

The attribute value for `color` is stored in a second record. The two Record parts are as follows:

```
Record root
   Sample Sample? {@XMLElement {nillable = true}};
end

Record Sample {@XMlStructure = xmlStructureKind.simpleContent}
   color STRING {@XMLAttribute{}};
   value STRING;
end
```

The EGL Runtime can read the XML shortcut (`<Sample color="green"/>`), but can write only the longer form:

- The written output is as follows if `root.Sample` is an empty string (""):

  ```
  <root><Sample color="green"></Sample></root>
  ```

- The written output is as follows if `root.Sample` is null and if (as mentioned later) the property field **nillable** is set:

  ```
  <root><Sample xsi:nil="true"></Sample></root>
  ```

Here is a third example XML string:

```
<Employee>
   <EmpNo department="Sales">10</EmpNo>
   <Name>Smith</Name>
</Employee>
```

Here as the two Record parts:

```
Record Employee{XMLStructure = xmlStructureKind.sequence}
   EmpNo EmpNumber;
   LastName STRING;
end

Record EmpNumber {XMLStructure = xmlStructureKind.simpleContent}
   department STRING {@XMLAttribute{}};
    value INT;
end
```

Any of the following data types is valid for a Record field:

- STRING or one of the following types, which are assignment-compatible with STRING: FLOAT, BIN, or one of the integer equivalents to BIN (INT, SMALLINT, or BIGINT).
- A data item that is based on one of those primitive types.
- Another non-structured Record part. The fields of that part are restricted to the previously stated types or to another non-structured Record part. A Record part referenced within a Record part can only include fields of the types listed here.
- Arrays of the preceding types.

Fields of type ANY are not supported.

One Record part can be referenced from another Record part at any level of nesting.

Nullable fields

A record field related to an XML element may be nullable as indicated by a question mark. For example, the following `EmpNo` field is not nullable, but the `name` field is:

```
Record Employee
   EmpNo INT;
   Name STRING?;
end
```

Two rules apply when the EGL Runtime is reading an XML String into a record:

- If the field (for example, `EmpNo`) is not nullable, the EGL Runtime throws a **RuntimeException** when trying to read an element that is missing or has no value
- If the field (for example, `Name`) is nullable, the EGL Runtime does not throw an exception when trying to read an element that is missing or has no value; and in the latter case, any attributes in the valueless element are retained

For details on the different ways the EGL Runtime treats a null when writing a record to an XML string, see the property **@XMLElement** (or **@XMLRootElement**), property field **nillable**.

Record part properties

You can use the following properties when you define a Record part:

- The complex property **@XMLRootElement** provides naming and data-type details about the root XML element, which is the topmost, most inclusive element in the XML string.
- The simple property **XMLStructure** identifies the characteristics of a set of XML elements.

Details on those properties are in "@RootElement" and "XMLStructure."

You cannot override those properties when you declare a record based on the Record part.

Record field properties

You can use the following properties when you define a field in a Record part or when you declare a record based on the Record part:

- The complex property **@XMLElement** provides details for a Record field that represents an XML element. By default, that property is in effect.
- The complex property **@XMLAttribute** provides details for a Record field that represents an XML attribute.

Details on those properties are in "@XMLElement" and "@XMLAttribute."

Namespaces

Rich UI supports reading and writing XML strings that contain namespaces. You can reference a namespace in the property **@RootElement**, **@XMLElement**, and **@XMLAttribute**.

If the XML contains a default namespace, you must reference the namespace when defining the record fields for each XML element in that namespace. Note that an XML attribute is never in a default namespace; an attribute either has a namespace prefix or is not in a namespace.

Additional information on XML

Many Web sites give background detail on XML and on the most popular XML-validation format, XML Schema (XSD). Here are a few suggestions that are present at this writing:

- W3 Schools offers XML and XSD tutorials, which you can access at the following site, where you search for XML or XSD:

  http://www.w3schools.com
- Both XML and XSD are covered in *SOA for the Business Developer* by Margolis and Sharpe (MC Press, May 2007), which is available from the following site:

  http://www.mc-store.com/5079.html
- A detailed overview of XML Schema is available from the World Wide Web Consortium:

  http://www.w3.org/TR/xmlschema-0/

To gain a full understanding of the alternatives available to you in EGL, review the topics for the XML-related properties.

@XMLAttribute

The complex property **@XMLAttribute** is specified on a Record-part field and identifies characteristics of an XML attribute. The property includes the following field:

name

The name of the XML attribute. The default value is the name of the record field.

If you are writing a record to an XML string, the value of the property field is assigned to the attribute in the XML string. If you are reading an XML string into a record, the EGL Runtime issues a **RuntimeException** if a mismatch is found between the actual and expected attributes.

namespace

The XML namespace associated with the XML attribute. If you are writing the record to an XML string, the possibilities are as follows:

- If you specify a namespace, the EGL Runtime places the attribute in that namespace, assigning a prefix to the attribute name
- If you do not specify a namespace, the attribute is not in any namespace

When reading an XML string into the record, the EGL Runtime issues **RuntimeException** if a mismatch is found between the actual and expected namespace status of the attribute.

@XMLElement

The complex property **@XMLElement** is specified on a record field and identifies characteristics of an XML element. The property includes the following fields:

name
The name of the XML element. The default value is the name of the record field.

If you are writing a record to an XML string, the value of the property field is assigned to the element in the XML string. If you are reading an XML string into a record, the EGL Runtime issues an **RuntimeException** if the name of the topmost XML element does not match the value of the property field.

namespace
The XML namespace (if any) that is associated with the XML element. You must specify the namespace explicitly even if it is a default namespace.

If you specify a namespace, the following statements apply:

- If you are writing a record to an XML string, a namespace prefix is assigned automatically
- If you are reading an XML string into a record, an **XMLProcessingException** occurs if the element is not in the specified namespace

If you do not specify a namespace, the following statements apply:

- If you are writing a record to an XML string, a namespace prefix is not specified
- If you are reading an XML string into a record, an **XMLProcessingException** occurs if the element is in any namespace

nillable
A Boolean value indicates whether the element to be written to an XML string is nillable. The choice is as follows:

- If the value is *false* (the default), the EGL Runtime does not write an element to the XML string when the content is null
- If the value is *true*, an attempt to write a null from the record to the XML string results in an empty element that includes the attribute value `xsi:nil="true"` and has no other attributes

The nullable aspect of a record field affects what occurs when the EGL Runtime reads an XML string into a record. For details, see *Copying an XML string to and from an EGL variable*.

@XMLRootElement

The complex property **@XMLRootElement** provides naming and data-type details about the root XML element, which is the topmost, most inclusive element in the XML string. The property fields are as follows:

name
The name of the root XML element. The default value is the name of the Record part.

If you are writing a record to an XML string, the value of the property field is assigned to the topmost element in the XML string. If you are reading an XML string into a record, the EGL Runtime issues a **RuntimeException** if the name of the topmost XML element does not match the value of the property field.

namespace
The XML namespace (if any) that is associated with the root XML element. You must specify the namespace explicitly even if it is a default namespace.

If you specify a namespace, the following statements apply:

- If you are writing a record to an XML string, a namespace is assigned. In this case, the EGL Runtime assigns a namespace prefix
- If you are reading an XML string into a record, a **RuntimeException** occurs if the element is not in the specified namespace, whether the namespace in the XML string is specified by a prefix or by a namespace default

If you do not specify a namespace, the following statements apply:

- If you are writing a record to an XML string, a namespace prefix is not specified, and the element is not in a namespace
- If you are reading an XML string into a record, a **RuntimeException** occurs if the element is in a namespace

nillable
A Boolean value that indicates whether the element to be written to an XML string is nillable. The choice is as follows:

- If the value is *false* (the default), the EGL Runtime does not write an element to the XML string when the content is null
- If the value is *true*, an attempt to write a null from the record to the XML string results in an empty element that includes the attribute value `xsi:nil="true"` and has no other attributes

The nullable aspect of a record field affects what occurs when the EGL Runtime reads an XML string into a record. For details, see *Copying an XML string to and from an EGL variable*.

XMLStructure

The simple property **XMLStructure** identifies the potential structure of the XML elements that are represented by fields in a Record part. In this topic, we show examples that describe what happens when you transfer record data to an XML string. However, the relationships also apply in the opposite direction, when the EGL Runtime validates the transfer of an XML string to an input record.

The supported values for **XMLStructure** are as follows:

sequence (the default)
On output, the XML string must include every field in the Record part, in the order in which the Record fields are listed. The following Record part and XML string are related:

```
Record Employee {XMLStructure = XMLStructureKind.sequence}
   EmpNo INT;
   LastName STRING;
end
```

```
<Employee>
   <EmpNo>10</EmpNo>
   <LastName>Smith</LastName>
</Employee>
```

choice

On output, the XML string must include one and only one subordinate element that corresponds to a record field. For example, consider the following Record part:

```
Record Employee{XMLStructure = XMLStructureKind.choice}
   ImmigrationStatus STRING?;
   YearsOfCitizenship INT?;
end
```

Either of the following XML strings is valid:

```
<Employee>
   <ImmigrationStatus>A1</ImmigrationStatus>
</Employee>
```

```
<Employee>
   <YearsOfCitizenship>20</YearsOfCitizenship>
</Employee>
```

In this case, the XML string cannot include both kinds of elements.

If a record has the XMLStructure value "choice", each field must be nullable, as is indicated by the question marks in our example. Furthermore, the value of one field must be non-null, and the value of only one field can be non-null. The function **XMLLib.convertToXML** issues a **RuntimeException** if all fields in the input record are null or if more than one field is non-null.

simpleContent

On output, the simple content transferred to an XML string is the value of a field in a superior record (a field written as an XML element), along with a set of attributes. For example, the following boldface Record part and XML content are related:

```
Record Employee{XMLStructure = XMLStructureKind.sequence}
   EmpNo EmpNumber;
   LastName STRING;
end

Record EmpNumber {XMLStructure = XMLStructureKind.simpleContent}
   department STRING {@XMLAttribute{}};
   value INT; // any field name is acceptable here
end
<Employee>
   <EmpNo department="Sales">10</EmpNo>
   <LastName>Smith</LastName>
</Employee>
```

The subordinate record (here, `EmpNumber`) may include zero to many fields that are of type STRING and that have the property **@XMLAttribute**. The property indicates that a given field represents an attribute. The same subordinate record may have a field that lacks the property **@XMLAttribute**; and that non-attribute field, if any, holds the value of the related element. The non-attribute field may have any name.

unordered

The XML string includes the specified elements in any order. The following Record part describes either of the subsequent XML strings:

```
Record Employee {XMLStructure = XMLStructureKind.unordered}
   EmpNo INT;
   LastName STRING;
```

```
end

<Employee>
   <LastName>Jones</LastName>
   <EmpNo>20</EmpNo>
</Employee>

<Employee>
   <EmpNo>20</EmpNo>
   <LastName>Jones</LastName>
</Employee>
```

Those values constitute the enumeration **xmlStructureKind**.

ServiceLib entries for Rich UI

This topic describes the serviceLib functions that are available when you are coding a Rich UI application.

Table 6. serviceLib system functions available in Rich UI

System function and invocation	Description
result = bindService (*string*)	Specifies a binding name that refers to an element in the EGL deployment descriptor file.
convertFromJSON (*json*, *variable*)	Converts a JSON string into a record or dictionary.
result = convertFromURLEncoded (*url*)	Returns a version of a Universe Resource Locator (URL) that is decoded; for example, the returned string has a space rather than the following combination: %20.
result = convertToJSON (*variable*)	Converts a record or dictionary into a JSON string.
result =convertToURLEncoded (*input*)	Returns a version of a Universe Resource Locator (URL) that is encoded so that the string can be used for service invocation.
endStatefulServiceSession (*interface*)	Releases runtime resources used to support access of EGL REST services that provide access to stateful IBM i programs.
result = getCurrentCallbackResponse()	Provides access to details from the HTTP response that is received by a callback function or onException function after a service invocation.
result = getOriginalRequest()	Provides access to an HTTP request. If the function is invoked a callback or onException function, the HTTP request was sent to the service during the specific call that caused the service to invoke the callback or onException function. If **serviceLib.getOriginalRequest()** is invoked elsewhere, the HTTP request was provided during the most recent service call.
result =getRestRequestHeaders (*interface*)	Returns the HTTP request headers available in an Interface variable that is used to access a REST service. The return value is an EGL dictionary.

Table 6. serviceLib system functions available in Rich UI (continued)

System function and invocation	Description
result = getRestServiceLocation (*interface*)	Returns the base URI used to access the REST service. The return value is a string.
result = getWebServiceLocation (*variable*)	Returns the URL that provides access to a Web (SOAP) service.
setHTTPBasicAuthentication (*userID*, *password*)	Gives the user access to a Web application when that access is protected by JEE basic authentication. The function lets you provide a user ID and password, which are automatically encrypted for inclusion in an HTTP header.
setProxyBasicAuthentication (*userID*, *password*)	Gives the user access to the EGL Rich UI Proxy when that access is protected by JEE basic authentication. The function lets you provide a user ID and password, which are automatically encrypted for inclusion in an HTTP header.
setRestRequestHeaders (*interface*, *headers*)	Sets the HTTP headers that are transmitted to a REST service. The headers are in an EGL dictionary.
setRestServiceLocation (*interface*, *baseURI*)	Sets the base URI used to access the REST service.
setWebServiceLocation (*variable*, *string*)	Sets the URL that provides access to a Web (SOAP) service.

bindService()

The **serviceLib.bindService()** system function specifies a binding name that refers to an element in the EGL deployment descriptor file. For more information on this file, see Overview of EGL deployment descriptor file.

Syntax

```
serviceLib.bindService(bindingKey STRING in)
returns (variable Service | Interface)
```

bindingKey
This corresponds to the **name** field in an **eglBinding** element in the EGL deployment descriptor file. EGL uses this element to find the requested service.

variable
A Service or Interface variable that your code uses to access the service.

convertFromJSON()

The **serviceLib.convertFromJSON()** system function converts a JSON string into a record or dictionary. For details on the conversion, see *Copying a JSON string to and from an EGL variable.*

Syntax

```
serviceLib.convertFromJSON(json STRING in,
                           variable VariableType out)
```

json
A JSON string

variable
The name of a non-structured record or dictionary

convertFromURLEncoded()

The **serviceLib.convertFromURLEncoded()** system function returns a version of a Universe Resource Locator (URL) that is decoded; for example, the returned string has a space rather than the following combination: %20. You might use this function if a REST service returned a URL and you wished to process the value of a query parameter. This function is the complement of **ServiceLib.convertToURLEncoded()**.

Syntax

```
ServiceLib.convertFromURLEncoded(url STRING in)
   returns(output STRING)
```

url The valid URL

output
The decoded string

convertToJSON()

The **serviceLib.convertToJSON()** system function converts a record or dictionary into a JSON string. For details on the conversion, see *Copying a JSON string to and from an EGL variable*.

Syntax

```
serviceLib.convertToJSON(variable VariableType out)
   returns (json STRING)
```

variable
The name of a non-structured record or dictionary

json
A JSON string

convertToURLEncoded()

The **ServiceLib.convertToURLEncoded()** system function converts a string into a Universe Resource Locator (URL), which identifies a Web page or represents the resource that will be accessed by a REST service. The function is useful if you wish to use a URL that includes spaces or other characters that are not valid in the URL. For example, if your URL includes query parameters and the value of a parameter includes a space, the function returns a valid URL, with a plus sign (+) in place of the space.

Syntax

```
   ServiceLib.convertToURLEncoded(input STRING in)
                                  returns(url STRING)
```

input
The input string

url The valid URL

endStatefulServiceSession

The **serviceLib.endStatefulServiceSession()** system function releases runtime resources used to support access of EGL REST services that provide access to stateful IBM i programs. You specify the session ID (or accept a default) when you declare the interface variable.

For details on how EGL provides access to IBM i called programs and service programs, see *Accessing IBM i programs as Web services*.

Syntax

```
serviceLib.endStatefulServiceSession(variable Service | Interface in)
```

variable
A variable used to access the service. The variable is based on a Service or Interface part.

getCurrentCallbackResponse

The system function **serviceLib.getCurrentCallbackResponse** provides access to details from the HTTP response that is received by a callback function or onException function in a Rich UI application.

Syntax

```
serviceLib.getCurrentCallbackResponse()
   returns (result HTTPResponse)
```

The invocation returns a record that is based on the Record part **HTTPResponse**, which is provided for you and has the following fields:

body, type STRING?
The value returned from the service;

- In the case of a REST service, **body** contains the value in one of three formats (XML, JSON, or NONE), as described in *Creating an Interface part to access a REST service*. In the case of an EGL REST service, the format is JSON.
- In the case of a Web (SOAP) service, **body** contains the returned SOAP message, which the EGL Rich UI proxy converted to JSON format.

headers, type Dictionary
headers contains a set of name-value pairs. Each entry key in the dictionary is the name of an HTTP header that is returned from the service, and the related value (a string) is the value of that header.

status, type INT
status contains the HTTP status code in the response.

Important status codes include 200 (OK) and 404 (Not Found). For a complete list, go to the Web site of the World Wide Web Consortium (http://www.w3.org/) and search for "HTTP status code."

statusMessage, type STRING
statusMessage contains the HTTP status message in the response.

Important status messages include *OK* (code 200) and *Not Found* (code 404). For a complete list, go to the Web site of the World Wide Web Consortium (http://www.w3.org/) and search for "HTTP status code."

getOriginalRequest

The **serviceLib.getOriginalRequest()** system function provides access to an HTTP request. If the function is invoked in a callback or onException function, the HTTP request was sent to the service during the specific call that caused the service to invoke the callback or onException function. If **serviceLib.getOriginalRequest()** is invoked elsewhere, the HTTP request was sent to the service during the most recent invocation of the **call** statement; and in the absence of a previous **call** statement, the HTTP request fields are empty.

Syntax

```
result HTTPRequest = serviceLib.getOriginalRequest()
```

The invocation returns a record that is based on the Record part **HTTPRequest**, which is provided for you and has the following fields:

body, type STRING?
The value sent to the service:

- In the case of a REST service, **body** contains the value in one of four formats (XML, JSON, NONE, or FORM), as described in *Creating an Interface part to access a REST service*. In the case of an EGL REST service, the format is JSON.
- In the case of a Web service, **body** contains the SOAP message in JSON format.

headers, type Dictionary
Contains a set of name-value pairs. Each entry key in the dictionary is the name of an HTTP header that was sent to the service, and the related value (a string) is the value of that header.

method, type STRING
One of the HTTP verbs available to Rich UI:

- GET (for reading a resource)
- POST (for creating a resource)
- PUT (for updating one)
- DELETE (for deleting one)

queryParameters, type Dictionary
A set of name-and-value pairs that were included in the service invocation at run time.

uri, type String
Contains the address of the resource; for example, *http://www.example.com/getTime*. This string includes the values of path variables and query parameters.

getWebServiceLocation()

The **serviceLib.getWebServiceLocation()** system function returns the URL that provides access to a Web (SOAP) service.

If the service binding in your deployment descriptor file for the service is not specified as Web, EGL throws a **ServiceBindingException**. For more information about the deployment descriptor file, see Overview of EGL deployment descriptor file.

Syntax

```
serviceLib.getWebServiceLocation(variable Service | Interface in)
returns (url STRING)
```

variable
A service or interface variable that your code uses to access the service.

url The returned URL, which is similar to this example:

```
"http://www.ibm.com/myService"
```

getRestRequestHeaders()

The **serviceLib.getRestRequestHeaders()** system function gets the HTTP request headers from a variable that is used to access a REST service. This function is available only from the handlers and libraries used in Rich UI.

Syntax

```
serviceLib.getRestRequestHeaders(variable Service | Interface in) returns (headers Dictionary)
```

variable
A variable used to access the service. The variable is based on a Service or Interface part.

headers
A dictionary. Each entry key is the name of an HTTP header, and the related value (a string) is the header value.

getRestServiceLocation()

The **serviceLib.getRestServiceLocation()** system function returns the base URI used to access a REST service.

Syntax

```
serviceLib.getRestServiceLocation(variable Service | Interface in)
   returns (baseURI STRING)
```

variable
A variable used to access the service. The variable is based on a Service or Interface part.

baseURI
A string that identifies the first qualifiers in the URI that is associated with *variable*. Subsequent qualifiers in the URI are specified in the Service or Interface part definition on which *variable* is based.

setHTTPBasicAuthentication()

The **serviceLib.setHTTPBasicAuthentication()** system function provides simple HTTP header authentication that uses 64–bit encryption.

HTTP Basic Authentication is a transport layer protocol that is used when invoking a Web service over HTTP. The key-value pair in the HTTP request header consists of the following parts:

- The key "Authorization"
- The value, a string composed of "Basic" + base64Encrypt(*userid*:*password*).

The **serviceLib.setHTTPBasicAuthentication()** function is available for the following subset of EGL-generated code:

- Java programs and services
- z/OS CICS COBOL programs and services

For details about the required CICS configuration, see “Deploying a Web service requester to CICS.”

Syntax

```
serviceLib.setHTTPBasicAuthentication(variable Service | Interface in,
userID STRING in,
password STRING in)
```

variable
A variable that your code uses to access the service. This variable is a service or interface variable. EGL throws a ServiceBindingException if *variable* is not a Web service variable.

userID
The ID that you use to access the service

password
The password that you use to access the service

Example

The following example shows the **setHTTPBasicAuthentication()** function in context:

```
try
  serviceLib.setHTTPBasicAuthentication(accountServices,
      userID, password);
  onException(sbe ServiceBindingException)
    sysLib.setError(sbe.message);
end
```

Compatibility

Table 7. Compatibility considerations for setHTTPBasicAuthentication()

Platform	Issue
COBOL generation	The **setHTTPBasicAuthentication()** function is supported only for z/OS CICS.

setProxyBasicAuthentication()

The **serviceLib.setProxyBasicAuthentication()** system function gives the user access to the EGL Rich UI Proxy when that access is protected by JEE basic authentication. The function lets you provide a user ID and password, which are automatically encrypted for inclusion in an HTTP header. For background information, see *EGL Rich UI security*,

The function adds the following key-value pair to the HTTP request header:

- The key is *authorization*
- The value is a string composed of *Basic* and the encrypted user ID and password, which are protected automatically with 64-bit encryption

You compromise security if you hardcode the user ID and password in your logic. We recommend that you pass the user ID and password from a logon screen; for example, with the following code:

```
userid TextField { width = 100 };
password  PasswordTextField { width = 100 };

// the following statement runs in response to a button click
setProxyBasicAuthentication( userid.text, password.text );
```

You use **serviceLib.setProxyBasicAuthentication()** as part of application-managed security. You can use the function to implement EGL single signon, as described in *EGL Rich UI security*.

Syntax

serviceLib.setProxyBasicAuthentication(*userID* **STRING** in,
password **STRING** in)

userID
The user ID used to access the EGL Rich UI Proxy

password
The related password

You specify the two values without encryption.

setRestServiceLocation()

The **serviceLib.setServiceLocation()** system function sets the base URI used to access a REST service.

Syntax

```
serviceLib.setRestServiceLocation(variable Service | Interface in,
                                  baseURI STRING in)
```

variable
A variable used to access the service. The variable is based on a Service or Interface part.

baseURI
A string that identifies the first qualifiers in the URI that will be used to access the service when a later **call** statement includes *variable*. Subsequent qualifiers in the URI are specified in the Service or Interface part definition on which *variable* is based.

setWebServiceLocation()

The **serviceLib.setWebServiceLocation()** system function sets the URL that provides access to a Web (SOAP) service.

If the service binding in your deployment descriptor file for the service is not specified as Web, EGL throws a **ServiceBindingException**. For more information about the deployment descriptor file, see Overview of EGL deployment descriptor file.

Syntax

```
serviceLib.setWebServiceLocation(variable Service | Interface in,
url, STRING in)
```

variable
A variable that your code uses to access the service. This is a service or interface variable.

url The URL of the service, as in the following example:

```
"http://www.ibm.com/myService"
```

Related concepts

Overview of EGL deployment descriptor file

Related reference

EGL library serviceLib
The serviceLib functions get and set service variable information.

EGL library XMLLib

This topic describes the XMLLib functions and variable definitions.

The following table lists the system functions in the XMLLib library.

Table 8. XMLLib system functions

System function and invocation	Description
convertFromXML (*XMLstring* in, *variable* out)	Converts an XML string into a non-structured record. For details on the conversion, see *Copying an XML string to and from an EGL variable*.
result = convertToXML (*variable* in)	Converts a non-structured record into an XML string. For details on the conversion, see *Copying an XML string to and from an EGL variable*.

convertFromXML()

The **XMLLib.convertFromXML()** system function converts an XML string into a record. For details on the conversion, see *Copying an XML string to and from an EGL variable*.

Syntax

```
XMLLib.convertFromXML(xmlString STRING in,
                      variable Record Part out)
```

xmlString
An XML string.

variable
The name of a non-structured record.

convertToXML()

The **XMLLib.convertToXML()** system function converts a record into an XML string. For details on the conversion, see *Copying an XML string to and from an EGL variable*.

Syntax

```
serviceLib.convertToXML(variable Record Part out)
                        returns (xmlString STRING)
```

variable
The name of a non-structured record

xmlString
An XML string

Chapter 6. EGL library RUILib

This topic describes the system functions in the RUILib library.

Table 9. RUILib system functions

System function and invocation	Description
result = getTextSelectionEnabled ()	Indicates whether the user can select text from a Rich UI widget that you are developing. The function is not used when you are developing a Rich UI handler.
result = getUserAgent ()	Provides access to the value of the HTTP header HTTP_USER_AGENT, which is sent by the user's browser during application invocation. The value is useful if you need to write code that varies by browser type or version,
setTextSelectionEnabled(*trueOrFalse* in)	Sets a value that specifies whether the user is able to select text from a Rich UI widget that you are developing. The function is not used when you are developing a Rich UI handler.
sort (*sortArray* in, *sortFunction*)	Repeatedly invokes a secondary sort function, first with array elements 1 and 2, then with elements 2 and 3, and so on. The invocations of the secondary sort function continue and repeat, as necessary, until the array reflects the requirement specified in that secondary function, which you develop.

getTextSelectionEnabled()

The system function **getTextSelectionEnabled()** indicates whether the user can select text from a Rich UI widget that you are developing. By default, the user cannot select text, but you can change the behavior of the application by setting **setTextSelectionEnabled()**.

The **RUILib.getTextSelectionEnabled()** system function is used only when you are developing a new Rich UI widget, not when you developing a Rich UI handler.

Syntax

```
result BOOLEAN = RUILib.getTextSelectionEnabled()
```

result
A Boolean value that indicates whether text selection is enabled.

getUserAgent()

The system function **RUILib.getUserAgent()** provides access to the value of the HTTP header HTTP_USER_AGENT, which is sent by the user's browser during application invocation. The value is useful if you need to write code that varies by browser type or version.

Syntax

```
result STRING = RUILib.getUserAgent()
```

result
The HTTP_USER_AGENT value that is sent by the user's browser.

setTextSelectionEnabled()

The system function **RUILib.setTextSelectionEnabled()** sets a value that specifies whether the user is able to select text in a Rich UI widget that you are developing.

The function is used when you are developing a Rich UI widget, not when you are developing a Rich UI handler.

Syntax

```
RUILib.setTextSelectionEnabled(trueOrFalse BOOLEAN)
```

trueOrFalse
A Boolean value that causes text selection to be disabled (as is the default) or enabled.

sort()

The system function **RUILib.sort()** repeatedly invokes a secondary sort function, first with array elements 1 and 2, then with elements 2 and 3, and so on. The invocations of the secondary sort function continue and repeat, as necessary, until the array reflects the requirement specified in that secondary function, which you develop.

Syntax

```
RUILib.sort(array ANY[] in,sortFunction SortFunction)
```

array
An array to be sorted.

sortFunction
The secondary sort function, which you code. The structure of that function is as follows:

```
Delegate
   SortFunction(ValueA ANY in, valueB ANY in) returns (INT)
end
```

The secondary sort function returns a value that indicates which of the two values is greater than the other. If the first element is greater, the function returns -1; if the two are identical, the function returns 0; if the second is greater, the function returns 1.

Chapter 7. Overview of EGL Rich UI generation and deployment

This topic reviews the ideas behind generation and deployment and describes the steps necessary to prepare for the deployment task.

Generating a handler or library in Rich UI

When you generate an EGL Rich UI handler or library, the output is a JavaScript file with no embedding HTML. Two generation modes are available, as specified in the preferences for Rich UI:

Development mode
The output has information required by the EGL debugger and the EGL Rich UI editor.

Deployment mode
The output lacks the extra information but is smaller and more efficient. Deployment mode is appropriate immediately before you add fully tested code to a production environment.

The workbench automatically generates individual Rich UI handlers and libraries. You can also generate an EGL file as follows:

1. In the Project Explorer, right click on the EGL file or on an icon that represents a higher level of organization that includes the file: a package, folder, or project. A dropdown menu is displayed.
2. Click **Generate**.

You must generate a handler part before you can use it as the basis of an embedded handler.

Generation is guided by the presence of a build descriptor in your project. The Workbench provides a default build descriptor, which you can customize. For details on options and values, see “Build descriptor options used with JavaScript.”

You can generate JavaScript only in the Workbench, not in the EGL SDK.

Deploying a Rich UI application

In relation to EGL Rich UI, the word *deploy* refers primarily to the creation of an HTML file that embeds previously generated JavaScript output. The Rich UI deployment step is available only in the Workbench and precedes adding the HTML file to a target environment such as WebSphere Application Server.

Rich UI supports the following target environments:

- WebSphere Application Server
- Apache Tomcat
- Local directory

If you target WebSphere Application Server:

- The Rich UI deployment wizard writes the generated HTML file and all supporting files (such as graphics and properties files) to the WebContent folder

of a Web project. The supporting files include graphics and properties files, as well as the EGL Rich UI Proxy. The files in the WebContent folder can be incorporated into a WAR file for installation on a Web server.

For details on the EGL Rich UI Proxy, see "Accessing a service in EGL Rich UI."

- The wizard also creates an Enterprise Application project, which is installable as an Enterprise Archive (EAR) file. The EAR file acts as a container for the WAR file.
- The HTML file is stored in a WebContent subfolder that corresponds to the name of the package where the Rich UI handler is stored. If the package name in the Rich UI project has multiple qualifiers (for example, `com.example.myPackage`), the subfolder is a hierarchy of folders (for example, `/com/example/myPackage`).

If you target Apache Tomcat:

- The Rich UI deployment wizard writes the generated HTML file and all supporting files (such as graphics and properties files) to the WebContent folder of a Web project. The supporting files include graphics and properties files, as well as the EGL Rich UI Proxy. The files in the WebContent folder can be incorporated into a WAR file for installation on a Web server.

  For details on the EGL Rich UI Proxy, see "Accessing a service in Rich UI."
- An Enterprise Archive (EAR) file is not provided for Apache Tomcat because that Web server does not support the use of EAR files.
- The HTML file is stored in a WebContent subfolder that corresponds to the name of the package where the Rich UI handler is stored. If the package name in the Rich UI project has multiple qualifiers (for example, `com.example.myPackage`), the subfolder is a hierarchy of folders (for example, `/com/example/myPackage`).

If you target a local directory:

- The Rich UI deployment wizard writes the generated HTML file and all supporting WebContent files to a directory.
- The likely production environment—an HTTP server such as the Apache HTTP server—does not support EAR or WAR files.
- EGL Rich UI does not provide a proxy and does not support service access.
- The HTML file is stored in a directory subfolder that corresponds to the name of the package where the Rich UI handler is stored. If the package name in the Rich UI project has multiple qualifiers (for example, `com.example.myPackage`), the subfolder is a hierarchy of folders (for example, `/com/example/myPackage`).

In each case, the Rich UI deployment wizard supports globalization, as noted in "Use of properties files for displayable text." When you specify a name for the HTML file, the deployment wizard adds locale detail to the name, along with the file extension `.html`. For example, if you specify `myFile.htm` and request an output that uses runtime messages in English, the wizard creates the file named `myFile.htm_en_US.html`.

EGL compresses the application to reduce the size of generated HTML files during deployment and uses gzip to compress the files the server sends to the browser. EGL uses compression only when the workbench is in Deployment mode.

You can deploy a Rich UI application by running the Rich UI Deployment wizard in the Workbench, but cannot deploy an application in the EGL SDK.

Preparing to use the Rich UI deployment wizard

To prepare to use the Rich UI deployment wizard, do as follows:

1. Click **Window -> Preferences**. The **Preferences** dialog is displayed.
2. Expand **EGL** and click **Rich UI**.
3. Set the dropdown list to the value of interest:
   - **Development**, to include the extra information required by the EGL debugger and the EGL Rich UI editor; or
   - **Deployment**, to exclude that information.
4. Click **OK**. A message is displayed to indicate that a regeneration is required.
5. Click **OK**. The effect is that all the generated JavaScript in your workspace will be available for the same purpose, whether for use in the Workbench (Development mode) or for distribution (Deployment mode).

Deploying a Rich UI application to Apache Tomcat

This topic describes how to prepare to deploy a Rich UI application, when the deployment target is Apache Tomcat.

Setting the deployment target

To begin the process:

1. In the Project Explorer, right click on the EGL file that contains the Rich UI handler, or right click on a higher level of organization that includes the file: the package, folder, or project. A dropdown menu is displayed.
2. Click **Deploy Rich UI application**. The first wizard dialog is displayed.
3. If you originally selected a higher level of organization such as a project, select a Rich UI handler.
4. Select the deployment target **Apache Tomcat**.
5. If you wish to retain the details you will specify. select the **Save deployment configuration** checkbox. If you save a deployment configuration, you can use the **Redeploy Rich UI application** option later, to quickly deploy the same Rich UI application in a way that reflects the most recently saved configuration.
6. Click **Next**. The **Deployment Details** dialog is displayed.

Setting deployment details

To set the deployment details:

1. Specify the name of the HTML file you are deploying.

   The deployment wizard adds locale detail to the name, along with the file extension `.html`. For example, if you specify `myFile.htm` and, as described later, you request an output for the English locale, the wizard creates the file named `myFile.htm_en_US.html`.
2. Specify an existing Web project that is configured for use with Apache Tomcat; or create a new Web project.

   If you are creating a new Web project, do as follows:

   a. Specify the project name.

   b. If you wish to select a Tomcat server that you already defined in the Workbench, choose from a dropdown list and continue working at step 3. If you wish to define a new Tomcat server, click the **New** button to display the **New Server Runtime Environment** dialog.

c. Expand **Apache** and select the Apache Tomcat version that is used to configure the new project.
d. Click **Next**. The **Tomcat Server** dialog is displayed.
e. To select a directory where the specified Apache Tomcat version is already installed, specify the directory name or use the **Browse** mechanism. Alternatively, to install a new version from the Apache Web site, do as follows: (i) click **Download and Install**, displaying the **Feature License** dialog; (ii) select **I accept the terms of the licensing agreement**; (iii) click **Finish**, displaying the **Browse for folder** dialog; (iv) select a folder in which to install the new version; and (v) click **OK**.
f. Specify the Java Runtime edition (JRE) to use with Apache Tomcat, either by selecting a specific JRE or by selecting the Workbench default. To change the Workbench default, click **Installed JRE** and, at the **Installed JREs** dialog, select, add, or search for a different JRE and click **OK**.
g. Click **Finish**.

3. Under **Globalization settings**, select all the locales that you are supporting. You can select from the list of generally available locales. In addition, you can specify new locales. To understand the distinction, see *Use of properties files for displayable text*.

   To select a generally available locale, select the locale in the left box and click the double right arrows (>>). To remove a generally available locale that was previously chosen, select the locale in the right box and click the double left arrows (<<)

   To specify a new locale, click the **New Locale** button. The **Create a new locale** dialog is displayed. There, do as follows:

   a. Specify a locale code and description, as well as a locale for EGL runtime messages, which are messages other than those included in a properties file that you provide.
   b. Click **OK**. The new entry is added to the Rich UI locale list in the Workbench preferences. For details, see *Setting preferences for Rich UI*.

4. Click **Next** to specify the subset of workspace files that you wish to include in your output. The **Additional Artifacts** dialog is displayed.

Selecting additional artifacts

Your last tasks in the Rich UI deployment wizard are as follows:

1. To select files or groups of files that are to be made available to the user, select check boxes. To deselect files or groups of files that are not to be made available to the user, clear check boxes. Expand or contract projects, folders, and packages, as needed to access file entries.
2. Click **Finish**.

Deploying a Rich UI application to a local directory

This topic describes how to prepare to deploy a Rich UI application, when the deployment target is a local directory, as is especially useful when you intend to install the application on a simple HTTP server.

Setting the deployment target

To begin the process:

1. In the Project Explorer, right click on the EGL file that contains the Rich UI handler, or right click on a higher level of organization that includes the file: the package, folder, or project. A dropdown menu is displayed.
2. Click **Deploy Rich UI application**. The first wizard dialog is displayed.
3. If you originally selected a higher level of organization such as a project, select an Rich UI handler.
4. Select the deployment target **Local Directory**.
5. If you wish to retain the details you will specify. select the **Save deployment configuration** checkbox. If you save a deployment configuration, you can use the **Redeploy Rich UI application** option later, to quickly deploy the same Rich UI application in a way that reflects the most recently saved configuration.
6. Click **Next**. The **Deployment Details** dialog is displayed.

Setting deployment details

To set the deployment details:

1. Specify a directory name in **Deployment Directory** or use the **Browse** mechanism.
2. Specify the name of the HTML file you are deploying.

   The deployment wizard adds locale detail to the name, along with the file extension `.html`. For example, if you specify `myFile.htm` and, as described later, you request an output for the English locale, the wizard creates the file named `myFile.htm_en_US.html`.
3. Specify the application context root, which is the second qualifier used in the Web address used to access the Rich UI application. For example, if the domain name is `www.example.com` and the application context root is `myApplication`, the Web address is as follows:

   ```
   www.example.com/myApplication
   ```
4. Under **Globalization settings**, select all the locales that you are supporting. You can select from the list of generally available locales. In addition, you can specify new locales. To understand the distinction, see *Use of properties files for displayable text*.

   To select a generally available locale, select the locale in the left box and click the double right arrows (>>). To remove a generally available locale that was previously chosen, select the locale in the right box and click the double left arrows (<<)

   To specify a new locale, click the **New Locale** button. The **Create a new locale** dialog is displayed. There, do as follows:

   a. Specify a locale code and description, as well as a locale for EGL runtime messages, which are messages other than those included in a properties file that you provide.

   b. Click **OK**. The new entry is added to the Rich UI locale list in the Workbench preferences. For details, see *Setting preferences for Rich UI*.
5. Click **Next** to specify the subset of workspace files that you wish to include in your output. The **Additional Artifacts** dialog is displayed.

Selecting additional artifacts

Your last tasks in the Rich UI deployment wizard are as follows:

1. To select files or groups of files that are to be made available to the user, select check boxes. To deselect files or groups of files that are not to be made

available to the user, clear check boxes. Expand or contract projects, folders, and packages, as needed to access file entries.

2. Click **Finish**.

Deploying a Rich UI application to WebSphere Application Server

This topic describes how to prepare to deploy a Rich UI application, when the deployment target is WebSphere Application Server.

Setting the deployment target

To begin the process:

1. In the Project Explorer, right click on the EGL file that contains the Rich UI handler, or right click on a higher level of organization that includes the file: the package, folder, or project. A dropdown menu is displayed.
2. Click **Deploy Rich UI application**. The first wizard dialog is displayed.
3. If you originally selected a higher level of organization such as a project, select an Rich UI handler.
4. Select the deployment target **WebSphere Application Server**.
5. If you wish to retain the details you will specify. select the **Save deployment configuration** checkbox. If you save a deployment configuration, you can use the **Redeploy Rich UI application** option later, to quickly deploy the same Rich UI application in a way that reflects the most recently saved configuration.
6. Click **Next**. The **Deployment Details** dialog is displayed.

Setting deployment details

To set the deployment details:

1. Specify the name of the HTML file you are deploying.

   The deployment wizard adds locale detail to the name, along with the file extension `.html`. For example, if you specify `myFile.htm` and, as described later, you request an output for the English locale, the wizard creates the file named `myFile.htm_en_US.html`.
2. Specify one of the following options:
   - An existing Web project that is configured for use with WebSphere Application Server; or
   - A new Web project. In this case, you specify the project name and click the **New** button to display the **New Server Runtime Environment** dialog, where you expand **IBM** and select the version of WebSphere Application Server that is used to configure the new project. If you need to identify a previously unspecified installation of WebSphere Application Server, click **Create a new local server** and, at the next page, use the **Browse** mechanism to select the directory in which WebSphere Application Server is installed.
3. Under **Globalization settings**, select all the locales that you are supporting. You can select from the list of generally available locales. In addition, you can specify new locales. To understand the distinction, see *Use of properties files for displayable text*.

   To select a generally available locale, select the locale in the left box and click the double right arrows (>>). To remove a generally available locale that was previously chosen, select the locale in the right box and click the double left arrows (<<)

To select a new locale, click the **New Locale** button. The **Create a new locale** dialog is displayed. There, do as follows:

a. Specify a locale code and description, as well as a locale for runtime messages other than those that can be included in a properties file that you provide.

b. Click **OK**. The new entry is added to the Rich UI locale list in the Workbench preferences. For details, see *Setting preferences for Rich UI*.

4. Click **Next** to specify the subset of workspace files that you wish to include in your output. The **Additional Artifacts** dialog is displayed.

Selecting additional artifacts

Your last tasks in the Rich UI deployment wizard are as follows:

1. To select files or groups of files that are to be made available to the user, select check boxes. To deselect files or groups of files that are not to be made available to the user, clear check boxes. Expand or contract projects, folders, and packages, as needed to access file entries.
2. Click **Finish**.

Build descriptor options used with JavaScript

This topic lists the build descriptor options used with JavaScript, which is the generated language for EGL Rich UI.

Table 10. Build descriptor option descriptions and default values

Build descriptor option	Default value	Description
defaultDateFormat	MM/dd/yyyy	Controls the initial runtime value of the **strLib.defaultDateFormat** system variable.
defaultServiceTimeout	No default value	Specifies the maximum valid number of milliseconds that elapse between the following events: when the EGL Rich UI Proxy (on the Web server) invokes a service and when the Proxy receives a response.
defaultSessionCookieID	JSESSIONID	Identifies the session cookie provided to the EGL Rich UI Proxy from a service.
defaultTimeFormat	HH:mm:ss	Controls the initial runtime value of the **strLib.defaultTimeFormat** system variable.
defaultTimeStampFormat	An empty string	Controls the initial runtime value of the **strLib.defaultTimeStampFormat** system variable.
deploymentDescriptor	No default value	Contains the name of the EGL deployment descriptor. That descriptor provides service-binding detail when you are generating a service, as well as service-binding detail when you are generating a logical unit (program, library, handler, or service) that invokes a service.

Table 10. Build descriptor option descriptions and default values (continued)

Build descriptor option	Default value	Description
eliminateSystemDependentCode	YES	Indicates whether, at generation time, EGL ignores code that will never run in the target system.
nextBuildDescriptor	No default value	Identifies the next build descriptor in the chain.
system	No default value	Specifies the target runtime environment of the generated code. For Rich UI, JavaScript is specified automatically in the Workbench.

defaultDateFormat (build descriptor option)

The **defaultDateFormat** build descriptor option controls the initial runtime value of the **strLib.defaultDateFormat** system variable, which contains one of the masks that can be used to create the string returned by the **strLib.formatDate** system function. Other details depend on the target language:

- When you are generating a COBOL program, if you do not specify the **defaultDateFormat** build descriptor option, the default value for the **strLib.defaultDateFormat** system variable is set by the "Long Gregorian date format" specified in the language-dependent options module specified for your runtime installation. For z/OS, refer to the program directory for your runtime product for details.
- When you are generating Java code, the **defaultDateFormat** build descriptor option specifies the generated value for the **vgj.default.dateFormat** Java runtime property (if you have set the **genProperties** build descriptor option to GLOBAL or PROGRAM). That property then sets the initial runtime value of the **strLib.defaultDateFormat** system variable.
- When you are generating JavaScript code, the default value of the **defaultDateFormat** build descriptor option is *MM/dd/yyyy*.

For further details on system variables and functions, see the *EGL Language Reference*.

defaultServiceTimeout

The **defaultServiceTimeout** build descriptor option specifies the maximum valid number of milliseconds that elapse between two events:

- In the case of a Rich UI application, the events are when the EGL Rich UI Proxy (on the Web server) invokes a service and when the Proxy receives a response
- In the case of another EGL requester, the events are when the EGL Runtime invokes a service and when that code receives a response

If the response takes longer than the specified maximum, the EGL Runtime throws a **ServiceInvocationException**.

Setting a timeout is partly a matter of trial and error:

- Take into account a variety of factors, such as local network traffic, internet traffic, and server response time. Those factors mean that two invocations of the same service are likely to take a different amount of time under different conditions.

- Consider the nature of your application. If your code is waiting for a credit approval, you might set a high timeout value to avoid charging the user twice. If your code is making a bid in an online auction bid, you might set a low timeout value so that the user can make an additional bid quickly.
- Use timeout values that vary from one another by one or more seconds.

The option **defaultServiceTimeout** is available for Rich UI and EGL-generated Java. For Rich UI, you can override the value by setting the **timeout** property on the **call** statement that invokes the service.

The default is an infinite wait. (In EGL version 7.5.1, the default was 10,000).

defaultSessionCookieID

The **defaultSessionCookieID** build descriptor option identifies the session cookie provided to the EGL Rich UI Proxy from a service. The service logic in this case is *stateful*, which means that the user and logic can participate in a multistep conversation. This setting is meaningful only if the service is an EGL external type that makes an IBM i called program or service program available as an EGL REST service. For background information, see *Accessing IBM i programs as Web services*.

The default value is JSESSIONID, which is always the session ID, regardless of any setting in EGL, when your application runs on Apache Tomcat.

Depending on how your code is accessing the service, you can override the value of the build descriptor option **defaultSessionCookieID** in one of two ways:

- When you declare a variable based on an Interface part; or
- When you configure the deployment descriptor for the requester.

For details on that choice, see *Declaring an interface to access a REST service*.

defaultTimeFormat (build descriptor option)

The **defaultTimeFormat** build descriptor option controls the initial runtime value of the **strLib.defaultTimeFormat** system variable, which contains one of the masks that can be used to create the string returned by the **strLib.formatTime** system function. Other details depend on the target language:

- When you are generating a COBOL program, if you do not specify the **defaultTimeFormat** build descriptor option, the default value for the **strLib.defaultTimeFormat** system variable is "HH:mm:ss".
- When you are generating Java code, the **defaultTimeFormat** build descriptor option specifies the generated value for the **vgj.default.timeFormat** Java runtime property (if you have set the **genProperties** build descriptor option to GLOBAL or PROGRAM). That property then sets the initial runtime value of the **strLib.defaultTimeFormat** system variable.
- When you are generating JavaScript code, the default value of **defaultTimeFormat** build descriptor option is *HH:mm:ss*.

For further details on system variables and functions, see the *EGL Language Reference*.

defaultTimeStampFormat (build descriptor option)

The **defaultTimeStampFormat** build descriptor option controls the initial runtime value of the **strLib.defaultTimeStampFormat** system variable, which contains one

of the masks that can be used to create the string returned by the **strLib.formatTimeStamp** system function. Additional details depend on the target language:

- When you are generating a COBOL program, if you do not specify the **defaultTimeStampFormat** build descriptor option, the default value for the **strLib.defaultTimeStampFormat** system variable is "yyyy-MM-dd HH:mm:ss:SSSSSS".
- When you are generating Java code, the **defaultTimeStampFormat** build descriptor option specifies the generated value for the **vgj.default.timestampFormat** Java runtime property (if you have set the **genProperties** build descriptor option to GLOBAL or PROGRAM). That property then sets the initial runtime value of the **strLib.defaultTimeStampFormat** system variable.
- When you are generating JavaScript code, the default value of the **defaultTimeStampFormat** build descriptor option is an empty string.

For further details on system variables and functions, see the *EGL Language Reference*.

deploymentDescriptor

The **deploymentDescriptor** build descriptor option contains the name of the EGL deployment descriptor. That descriptor provides service-binding detail when you are generating a service, as well as service-binding detail when you are generating a logical unit (program, library, handler, or service) that invokes a service. The EGL deployment descriptor is distinct from non-EGL JEE deployment descriptors.

The **deploymentDescriptor** option has no default value.

For an overview of services, along with keystroke details, see *Overview of service-oriented architecture (SOA)* and subsequent sections in the Programmer's Guide. For language details, see *Service part*.

Chapter 8. Setting preferences for Rich UI

Set the initial Rich UI preferences as follows:

1. From the main menu, click **Window** → **Preferences**. The **Preferences** page is displayed.
2. Expand **EGL** and then **Rich UI**. The **Rich UI** dialog box is displayed.
3. Select one of two values in the **Generation mode** list box:

   Development mode
   The generated output has information required by the EGL debugger and the EGL Rich UI editor.

   Deployment mode
   The generated output lacks the extra information but is smaller and more efficient. Deployment mode is appropriate immediately before you add fully tested code to a production environment.
4. In the **Locales** area, specify the locales that are available in the Rich UI editor and in the Rich UI deployment wizard. The settings are used for globalization. The availability of a locale means that you can invoke and deploy a Rich UI application that provides messages appropriate to the locale. For details, see *Use of properties files for displayable text*.

   To add a locale, do as follows:

   a. Click **Add**. The **Create a new locale** dialog is displayed.
   b. Specify a locale code and description.
   c. Specify a locale for the EGL runtime messages, which are provided by the EGL Runtime and are distinct from the messages included in a properties file that you customize.
   d. Click **OK**.

   To remove a locale from the list, do as follows:

   a. Double-click a locale entry
   b. Click **Remove**

   At the **Rich UI** dialog box, you can click into the **Locale Description** or **Locale Code** column and change the content. Also, by clicking in the **Runtime Messages Locale** column and selecting from a list, you can assign a locale for the EGL runtime messages, even if that locale is distinct from the locale used for the messages that you provide.
5. If you want to return the settings on the **Rich UI** dialaog to the original product settings, click **Restore Defaults**.
6. Click **Apply** to save your changes and remain in the **Preferences** page. Alternatively, click **OK** to save the changes and exit the page; or click **Cancel** to cancel the changes and exit the page.

Setting preferences for Rich UI appearance

Begin to set the appearance of the Rich UI editor as follows:

1. From the main menu, click **Window** → **Preferences**. The **Preferences** dialog box is displayed.
2. Expand **EGL** and **Rich UI**; and then click **Appearance**. The **Appearance** page is displayed, with three tabs: **General**, **Browser size**, and **Languages**.

We describe each tab in turn. On completing the tabs, do as follows:

1. If you want to return the settings on the **Appearance** pane to the original product settings, click **Restore Defaults**.
2. Click **Apply** to save your changes and remain on the **Preferences** dialog box. Alternatively, click **OK** to save the changes and exit the dialog box; or click **Cancel** to cancel the changes and exit the dialog box.

General tab

At the General tab, do as follows:

1. In the **Editor tab** section, select **Design**, **Source**, or **Preview** to indicate which tab to initially use whenever you open the Rich UI editor.
2. In the **Widget creation** section, indicate whether the Rich UI editor must prompt you for a variable name each time you drag a widget from the palette to the Design surface. If you clear the checkbox, the Rich UI editor creates its own variable name, which is the widget type name (for example, *Button*) followed by a sequentially assigned integer. For example, the assigned names might be *Button1*, *Button2*, *Box1*, and so forth.
3. In the **Transparency** section, indicate how to handle the transparency controls, which vary how widgets are displayed in the **Design** tab of the Rich UI editor. The transparency controls are particularly useful when you are working on a Design surface with many widgets that are close together.

   The Design surface is composed of two layers. The bottom layer is the Web browser, which displays widgets, including initial text values. The top layer is an editing overlay, including angle brackets at each corner of each widget. The background of the top layer can have any of the following characteristics: transparent, or a pattern of white and transparent dots, or (on Windows platforms) a white layer with a varying level of transparency.

   The transparency options provided in the **Appearance** pane affect the behavior of the Rich UI editor every time you open the editor. However, when you are working in the editor, you can change the transparency options that are in use for the editing session. The options are as follows:

   a. Select or clear the check box **Show transparency controls** to indicate whether to display the transparency controls. When you start working with Rich UI, you are likely to prefer hiding the controls, as is the default setting for this preference.
   b. Next, select one of the following transparency modes, which affect the background of the top layer of the Design surface:
      - **Fully transparent** means that the background is transparent.
      - **Dotted transparency pattern** means that the background is a pattern of white and transparent dots. The refresh rate of your monitor may cause the pattern to shimmer.
      - On Windows platforms, **Variable transparency** means that the background is a white layer with a varying level of transparency. You vary the level by changing the numeric value of a slider. The dotted transparency pattern described earlier is roughly equivalent to the variable transparency pattern at 38%.
   c. The checkbox named **Enable semi-transparency while dragging** allows use of a temporary transparency mode as you drag a widget from the palette to the Design surface or from one location on the Design surface to another. Selecting the checkbox means that the temporary mode is the dotted transparency pattern. Clearing the checkbox means that your usual

transparency mode remains in effect. The checkbox has no effect if your usual transparency mode is the dotted transparency pattern.

4. In the **Colors** section, specify details on the following issues:
   - The border of the currently selected widget
   - The potential drop locations for a widget being dragged from the palette to the Design surface or from one location on the Design surface to another
   - The *selected drop location*, which is a potential drop location over which the widget is hovering during a drag-and-drop operation

   For the border and each location, you can click the adjacent button to display a color dialog, where you can choose or refine a color. Also, for the border and the selected drop location, you can select (or clear) a check box to include (or exclude) the displayed pattern.
5. In the **Performance** section, select the radio button that reflects your current need, whether for greater responsiveness or for less usage of runtime resources such as memory. One effect of selecting **Optimize to use fewer resources** is that you increase the amount of time needed to display content when you select the **Design** or **Preview** tab.
6. In the **Dependencies** section, you can cause the Rich UI editor to prompt you before adding a project to the EGL build path. The nature of project dependencies is described in *The EGL build path*.

   The dependency issue arises in this case because the Widget types available in the palette may be from any project in the workspace. The prompt, if any, occurs when you attempt to drop a widget for which the type is defined in a project that is not already in the EGL build path.

   Select the checkbox to cause a prompt, which lets you add the entry to the EGL build path or to cancel the operation. Clear the checkbox to add the entry automatically.

Browser size tab

In the **Browser size** tab, you set the browser size that is appropriate for a specific kind of device such as a cell phone. Specifically, you set options that are in effect whenever you open the Rich UI editor. However, when you are working in the editor, you can change the browser-size options for the file being edited.

The options are as follows:

1. Select or clear the check box **Browser size controls** to indicate whether to display the controls when a file is opened in the Rich UI editor. When you start working with Rich UI, you are likely to prefer hiding the controls, as is the default setting for this preference.
2. Change the numeric values of the sliders to specify the default height and width in pixels. The default you set becomes the browser size that is provided initially in the Rich UI editor. Similarly, change the numeric values of the sliders to specify the minimum and maximum height and width that are valid in any file open in the Rich UI editor. You can change the maximum and minimum only by returning to the **Appearance** page.

Languages tab

In the **Languages** tab, you assign values that determine what messages to use when you run Rich UI applications in the Preview tab of the Rich UI editor or in an external browser. For details on the use of locales, see *Use of properties files for displayable text*.

When you work in the **Languages** tab, you choose among locales that are listed in the **Rich UI** pane, as described in *Setting preferences for Rich UI*. Your tasks are as follows:

1. In the **Runtime messages locale** list box, select the locale for the EGL runtime messages, which are provided by the EGL Runtime and are distinct from the messages included in a properties file that you customize.
2. In the **Rich UI handler locale** list box, select the locale for the messages included in a properties file, if any, that you customize.

Setting preferences for Rich UI bidirectional text

When you establish preferences for Rich UI bidirectional text, you provide initial values for the bidirectional settings assigned to widgets as they are dragged from the palette and dropped on the Design surface.

You can set these preferences only if you previously enabled bidirectional text as follows:

1. From the main menu, click **Window → Preferences**. The **Preferences** dialog box is displayed.
2. Expand **EGL** and select **Bidirectional text**. The **Bidirectional text** page is displayed.
3. Select the **Enable bidirectional support** checkbox. After this check box is selected, the other options are available.
4. To display and edit the bidirectional text fields in visual mode (the way the text will be displayed), select **Enable visual data ordering**.
5. For languages that read from right to left, select **Enable right-to-left orientation**.

Here are the steps for setting the Rich UI preferences:

1. From the main menu, click **Window → Preferences**. The **Preferences** dialog box is displayed.
2. Expand **EGL**, **Rich UI**, and then **Appearance**; and click on **Bidirectional text**. The **Bidirectional text** page is displayed.
3. Establish the following settings:

   Widget Orientation

   The setting is either **LTR** (left-to-right) or **RTL** (right to left):

   - When you specify **LTR**, the widgets acts as a standard non-bidirectional widget
   - When you specify **RTL**, the widgets are mirrored; that is, scroll bars for dropdown lists appear on the left, the text-typing orientation for input fields is right-to-left, and the text is right-aligned

   Text Layout

   The setting is either **Visual** or **Logical**:

   - If the setting is **Visual** and the user types "A" and then "B" (and if "A" and "B" are characters in a bidirectional language), the displayed characters are "AB". The order of display is the order of input, left to right, which is also the order in which the data is stored in local memory.
   - If the setting is **Logical**, the displayed characters are "BA".

   In most cases, **Visual** is appropriate for Arabic or Hebrew content derived from a machine that runs z/OS or IBM i.

Reverse Text direction
The setting indicates whether to reverse the text direction in the widget.

Symmetric Swapping
This setting indicates whether to replace pairs of special characters and in this way to preserve the logical meaning of the presented text. If the value is "Yes", the effect is to replace paired characters such as <, >, [, and { with >, <,], and }.

Numeric Swapping
Lets you use Hindi numerals in Arabic text. To use Hindi numerals, set **numericSwap** and **reverseTextDirection** to **Yes**.

4. If you want to return the settings on the **Bidirectional text** pane to the original product settings, click **Restore Defaults**.
5. Click **Apply** to save your changes and remain on the **Preferences** dialog box. Alternatively, click **OK** to save the changes and exit the dialog box; or click **Cancel** to cancel the changes and exit the dialog box.

Setting preferences for Rich UI deployment

Preferences guide the behavior of the Rich UI deployment wizard. We introduce that wizard in *Overview of Rich UI generation and deployment*.

Set the deployment preferences as follows:

1. From the main menu, click **Window** → **Preferences**. The **Preferences** dialog box is displayed.
2. Expand **EGL** and **Rich UI** and then click **Deployment**. The **Deployment** page is displayed.
3. In the **Prompts** area, indicate what is to occur when the generation mode is Development and you run the Rich UI deployment wizard. Selecting the check box means that the wizard must prompt you to change the generation mode to Deployment. Clearing the check box means that the deployment will proceed without a prompt, and no regeneration occurs; the generation mode remains Development.
4. In the **Rich UI Application locales** area, you select which locales are supported by default when you run the Rich UI deployment wizard. For details on the use of locales, see *Use of properties files for displayable text*. All the locales that are available to you in the **Rich UI Application locales** area are listed in the **Rich UI** pane, as described in *Setting preferences for Rich UI*.
5. If you want to return the settings on the **Deployment** page to the original product settings, click **Restore Defaults**.
6. Click **Apply** to save your changes and remain on the **Preferences** dialog box. Alternatively, click **OK** to save the changes and exit the dialog box; or click **Cancel** to cancel the changes and exit the dialog box.

Chapter 9. Securing a Rich UI application

Implementing security is an integral part of Web application development that you should consider carefully when you design a Rich UI application. In the rush to unveil new dynamic, interactive Web applications, developers sometimes forgo adding security measures. Attackers know how to exploit the vulnerabilities of applications. All kinds of organizations have been victimized, with results ranging from simple embarrassment to the public distribution of sensitive data. The best approach to avoid such problems is to eliminate weaknesses before they can be exploited.

Typically, security is configured after a Rich UI application is deployed; however, the security design should be determined early and integrated with the design of the application. When you apply security early in the development cycle, the process can be easier and you can avoid problems that might be costly if found late in the cycle.

You should also evaluate JSF applications that are rewritten into Rich UI applications for security issues. Even if the JSF application was not originally secure, the introduction of the EGL Rich UI Proxy in V7.5.1 presents security risks that must be mitigated. You might need to change the design of the application.

This section contains considerations that are specific to securing the resources that are related to Rich UI applications. It also provides a quick overview and examples of how to configure and use Java™ Enterprise Edition (JEE) authentication and Secure Sockets Layer (SSL). Security is not available when you preview a Rich UI application from the EGL Rich UI editor. Because security is a large and complex topic, also consult the online documentation of your application server and other security documentation.

Overview of Rich UI security

Security can be managed either by a Web container (the environment in which an application runs) or by the application itself. A Web container is synonymous to a JEE application server, such as IBM WebSphere Application Server or Apache Tomcat. Web container-managed security is also known as JEE or J2EE security. Security that is written by the developer of the application, application-managed security, is also known as custom security. Both kinds of security have advantages and drawbacks that you must understand before you implement them.

You can choose to use either declarative or programmatic security. In declarative security, security policies are defined outside of the application in deployment descriptors or configuration files so the application is security-unaware. With programmatic security, the application code contains explicit security calls.

Web container-managed (JEE) security is declarative because security constraints are defined in deployment descriptors or configuration files. JEE security can also be programmatic because it includes some security-related APIs that can be called from within an application. Application-managed (custom) security is programmatic because security is handled completely from within the application.

Major components of security include authentication, authorization, confidentiality, and integrity:

Authentication
The method by which the identity of a user is verified. Typically, authentication occurs by providing a user id and password in a login screen.

Authorization
The process of determining whether a user has permission to access a particular resource

Confidentiality
Guarantees that the data that is passed between a sender and recipient is protected from eavesdroppers.

Integrity
Ensures that the data that flows between a sender and recipient was not modified in transit

Authentication and Authorization

Authentication and authorization support can be provided by the following:

- Web container-managed (JEE) security that is provided by application servers, such as WebSphere Application Server or Apache Tomcat.
- Application-managed (custom) security that is written in the application.

Consider using JEE security to protect your Rich UI application in the following cases:

- The entire Rich UI application needs to be secured.
- You do not need to access security-related information from within the Rich UI application.
- You do not want to write security-related code in your application.

Consider using custom security to protect your Rich UI application in the following cases:

- Access to some or all of your Rich UI application needs to be restricted.
- You want to access the user id, password, or both from within the application.
- You want to combine the authentication of your Rich UI application with the authentication of other resources that the application uses in a process called EGL single sign-on. For more details, see "EGL single sign-on.".

Web container-managed (JEE) security

Web container-managed security transfers the responsibility of user authentication and authorization to the container, allowing the EGL developer to focus on business logic.

Two common types of JEE authentication are basic and form-based. In JEE basic authentication (also known as HTTP basic authentication), when a client, such as a browser, requests a Web page from a server without providing a user id and password, the server sends back a 401 response code. The client then prompts the user for a user id and password by displaying a default login dialog to the user. The client resends the request to the server, including the user id and password in the HTTP header. If the user is authenticated, the server returns the requested page. If the user id and password are invalid, the server returns a 401 response code and the client prompts the user again. In JEE form-based authentication, you can use a customized login screen with the look and feel of the application instead

of the browser-provided login dialog. The user id and password are passed to the server in the form data instead of in the HTTP header of the request.

JEE security uses roles to manage access to resources. Certain roles are allowed access to certain resources. Users and groups are mapped to appropriate roles. For example, the user bob might be mapped to the role administrator.

JEE authorization can be declarative or programmatic. Declarative authorization is available because security information is specified in deployment descriptors. The application servers access these deployment descriptors to determine if a specific user is assigned to a role and decides whether a particular resource can be accessed by that role. While JEE security also includes programmatic authorization through the use of APIs, such as isUserInRole(), these functions are not available from within a Rich UI application. Therefore, Rich UI applications should perform authorization either declaratively or through custom, user-provided code.

User registries, such as Lightweight Directory Access Protocol (LDAP) directory servers or relational databases used with JEE security, are external to the JEE environment. A system administrator must perform administrative tasks, such as adding a new user to the repository.

While JEE security is available through WebSphere Application Server and Apache Tomcat, it is not available from the Workbench. You need to deploy a Rich UI application to WebSphere or Tomcat to apply and test security.

To determine if JEE security is appropriate for your situation, review the documentation in this chapter and the more detailed online documentation for your application server.

Application-managed (custom) security

If Web container-managed security is not suitable for your needs, you can build custom security into your Rich UI application. Although custom security requires that you add security-related code to your Rich UI application, you cannot avoid it if JEE security alone is not sufficient to express the security model of an application. If you prefer, you can combine both forms of security.

Custom authorization can provide a more granular level of authorization than JEE roles. You might want to use custom security to authenticate users before they can access restricted parts of your application.

Confidentiality and Integrity

Although you can use JEE security to secure Web resources from unauthenticated or unauthorized users, JEE security cannot prevent the data that flows between a client and server from being intercepted or read. For these purposes, you can use Secure Sockets Layer (SSL). SSL guarantees data integrity, ensures that messages between a client and server are not tampered with or modified, and provides confidentiality through encryption. SSL also includes server authentication, which allows a client to confirm the identity of a server, and client authentication, which allows a server to confirm the identity of a client.

It is important that you authenticate over SSL, whether you use JEE form-based, JEE basic, or custom authentication. For more information about SSL, see "Overview of SSL."

Resources to secure

When you determine which resources to secure, review all of the components that have a URL mapping and that your Rich UI application accesses:

Generated HTML file

EGL generates a Rich UI application into an HTML file. HTML files are generated into the WebContent folder (or into a subfolder in the WebContent folder) of your deployed project. If an HTML file is secure, you must authenticate before you access the Rich UI application that is defined in the HTML file. To secure the entire HTML file, you can use JEE authentication. To restrict sensitive areas of the Rich UI application, you can use custom security.

EGL Rich UI Proxy

The EGL Rich UI Proxy handles communication between the HTML file that EGL generates for a Rich UI application and Web services Because of the Same Origin policy for JavaScript™, the HTML file cannot invoke a Web service that has a different origin (defined as protocol, domain, and port) than that of the HTML file. To get to Web services on different origins, the HTML file uses a Java servlet known as the EGL Rich UI Proxy. All Web services that are invoked in a Rich UI application are accessed through the proxy.

The EGL Rich UI Proxy servlet is of the type com.ibm.javart.services.RestServiceServlet and is shipped with the EGL runtime in fda7.jar. The servlet is deployed to the same project as your generated HTML file. While the HTML file runs in a browser, the EGL Rich UI Proxy runs on an application server.

Because the URL of the EGL Rich UI Proxy is visible in the JavaScript that EGL generates for your Rich UI application, you must prevent the proxy from being used by anyone other than your Rich UI client to invoke Web services. If you leave the proxy unsecured, it can be used to instigate JavaScript hijacking attacks. If your Rich UI application does not use the EGL Rich UI Proxy (that is, if the application invokes no Web services), remove access to the proxy from your deployed project. For more information, see *Removing access to the EGL Rich UI Proxy servlet*. Otherwise, you can use JEE basic authentication to prevent the proxy from being invoked by an unauthenticated client. While this action cannot guarantee protection against Web threats, it can reduce the possibility of one occurring.

If both the HTML file and EGL Rich UI Proxy are secure, authentication is required only before you can access the HTML file. If the EGL Rich UI Proxy is secure and the HTML file is not, authentication is required before you can access the proxy (that is, before the application calls a Web service that is invoked through the proxy).

EGL Web service

To secure EGL Web services that are generated into a Web project, you can use JEE security through HTTP basic authentication. In HTTP basic authentication, you access secure Web services by passing a valid user id and password in the HTTP header. EGL provides a system function in ServiceLib, setHTTPBasicAuthentication, which sets these values in the header. Precede each call to a secure Web service with a call to setHTTPBasicAuthentication.

To avoid security exposures, never hardcode the user id and password into the Rich UI application. Instead, the Rich UI application should display a user-defined login screen to prompt the user for the values to pass to setHTTPBasicAuthentication. Once you obtain the password, you can store it in your Rich UI handler or a library for future Web service calls. Whenever you need a different set of credentials to pass to a Web service, you must prompt the user again.

JSF versus Rich UI applications

Differences exist between generated and deployed JSF applications and Rich UI applications. You should understand these ramifications because they can affect the type of security you choose to implement.

For JSF applications, each JSF handler is associated with a Faces JSP. The JSF handler and EGL parts it references are generated into Java. Each JSP is generated into its own file and has its own URL, which might need to be secured from unauthenticated users using JEE security. When securing URLs, you can choose to include some or all of the JSPs in your JSF application. Depending on your choices, you can keep some JSPs in your JSF application public and restrict other JSPs to authenticated users.

For Rich UI applications, EGL generates the contents of all the Rich UI handlers in an application into JavaScript in a single HTML file. If your Rich UI application calls EGL Web services, you must generate those services into Java because Web services run on an application server, not in a Web browser. The HTML file that EGL generates for a Rich UI application is associated with a single URL that can be secured with JEE security. If you choose to secure a URL with JEE security, users will be prompted to authenticate before they can access any part of your Rich UI application. If you want to make some of the areas of your Rich UI application public, you cannot use JEE authentication. Instead, use custom security to prompt users to log in before they can access the restricted parts of your application.

Another major difference between JSF and Rich UI applications is that the EGL Rich UI Proxy, which Rich UI applications use to call Web services, is not needed by JSF applications because JSF handlers are generated into Java instead of JavaScript.

Using Web container-managed (JEE) authentication

After you deploy a Rich UI application, you can secure the resources in your deployed project from unauthenticated users by using the Web container-based, JEE security that is provided by WebSphere Application Server or Apache Tomcat. After resources, such as the HTML file generated for your Rich UI application, are secured with JEE security, users will have to authenticate before they can access those resources. Every action that the Web container or JRE takes on behalf of the user is done only if the user belongs to a set of roles that have permission to take that action. The user is only requested to authenticate once even if multiple resources are secured.

In JEE authentication, a system administrator performs administration tasks, such as adding or deleting user data from a repository, independently of the applications that access the repository. Application servers support various types of repositories, or realms, such as the local OS registry, LDAP directories, and custom directories such as relational databases and flat files. You can use these repositories to store user ids, passwords, and other security information.

To secure the entire Rich UI application, the EGL Rich UI Proxy, and Web services, you can use JEE security.

In JEE role-based security, access to resources is granted to roles, which are then mapped to actual user registry entries. Security information, such as roles and constraints, are defined declaratively, or outside of the application, in deployment descriptors such as web.xml and application.xml. . In V7.5.1, you must use declarative JEE security with Rich UI applications. The J2EELib system functions that are available for programmatic security from JSF handlers (**getRemoteUser()**, **isUserInRole()**, and **getAuthenticationType()**) are not available from Rich UI handlers.

In both JEE basic and form-based authentication, the password is encoded using the Base64 encoding scheme, a format that is easy to decode. To ensure that the password is not compromised, use SSL in conjunction with these types of authentication. For an introduction to SSL, see "Overview of SSL."

For more details on Web container-managed authentication, see WebSphere Application Server or Apache Tomcat documentation.

Defining URL patterns for Rich UI resources

Security constraints define how the content of a Web project is protected. To use JEE security to protect a resource, in the security constraints in the deployment descriptor (web.xml) of your deployed project, specify the URLs of the resources to secure.

The following sections contain information on how to secure the various components of a Rich UI application:

- *Securing the HTML file by using form-based authentication*
- *Securing the EGL Rich UI Proxy by using basic authentication*
- *Securing EGL Web services by using basic authentication*

Those sections also refer to URL patterns.

To secure all the resources that are in the WebContent folder of a deployed project, specify /* as the URL pattern. Specifying /* as your URL pattern secures your HTML page, EGL Rich UI Proxy, and SOAP and REST services.

Securing the HTML file by using form-based authentication

To secure your Rich UI application, you can use JEE form-based authentication (the most popular Web authentication method in use) for which you to supply your own customized login page that contains a user id and password. Users cannot access any part of the Rich UI application until they authenticate. The encoding scheme for the password is Base64 encoding, which can be easily decoded. To ensure password confidentiality, use SSL connections with form-based authentication. When you use form-based authentication, error handling, such as displaying specific error messages, is difficult to implement. If an authentication error occurs, an error page is returned with the status code of the response set to 401.

For sample login and error pages that you can use with form-based authentication, see "Sample login and error pages for JEE form-based authentication."

To secure the HTML file that EGL generates for a Rich UI application named RSSReader, specify a URL pattern of /RSSReader.html. If RSSReader.html is in a subdirectory of WebContent named Secured, specify a URL pattern of /Secured/RSSReader.html.

When you use form-based authentication to secure the HTML file, include the EGL Rich UI Proxy in the security constraint. To secure the EGL Rich UI Proxy, specify a URL pattern of /___proxy (three underscores). By specifying this pattern, you prevent unauthenticated users from accessing the proxy. After logging in, users will gain access to the EGL Rich UI Proxy as well as the HTML file.

Securing the EGL Rich UI Proxy by using basic authentication

Use JEE basic authentication to secure the EGL Rich UI Proxy. Require users to authenticate to the proxy before it can be used to process Web service calls. If you require users to authenticate, you prevent unauthenticated clients from accessing the proxy for illegal purposes.

To secure the EGL Rich UI Proxy, in a security constraint in your web.xml, specify a URL pattern of /___proxy (three underscores).

By using JEE basic authentication, the Web server uses a browser-provided dialog to collect a user id and password. This dialog looks like the following dialog for Mozilla® Firefox® V2.0:

If you use this login dialog, you cannot customize the dialog to look like the rest of your Rich UI application. The dialog is redisplayed until a valid user id and password are entered. The HTTP standard requires that when login fails, the server returns a response code of 401. This response code is presented to the user on an error page with a generic error message.

If you use JEE security to protect both the HTML file and EGL Rich UI Proxy, use form-based authentication. When a user requests the HTML file, the login page that is specified for form-based authentication is displayed. After users authenticate, they can also access the proxy, bypassing the browser-provided dialog.

If you want to protect sensitive parts of your application without securing the entire Rich UI application, you can use custom security. You can combine authentication for custom security with JEE authentication of the EGL Rich UI Proxy in a process called EGL single sign-on. In EGL single sign-on, you use a

user-defined login screen to capture credentials that allow the end user to authenticate to more than one resource, including the EGL Rich UI Proxy. To prevent the user from seeing the browser-provided dialog, use EGL single sign-on.

Removing access to the EGL Rich UI Proxy servlet

If your Rich UI application does not call Web SOAP or REST services, the EGL Rich UI Proxy will not be used. In this case, you have three options:

1. Remove the EGL Rich UI Proxy servlet from the web.xml of your deployed project so a third party cannot access it.
2. Use JEE basic authentication to secure the proxy.
3. Leave the proxy unsecured.

Option 1 is the best option for EGL. It is simple and removes all security risks that are related to the proxy, as described in *EGL Rich UI Proxy*. Option 2 is valid, but it requires more work from the EGL developer or a security administrator. For directions on how to use JEE basic authentication to secure the EGL Riche UI Proxy, see *JEE security example*. If you choose Option 3, you leave the EGL Rich UI Proxy vulnerable to security threats.

To remove access to the EGL Rich UI Proxy:

1. Double-click on the deployment descriptor (WebContent/WEB-INF/web.xml) of your deployed Web project to open it with the Deployment Descriptor Editor.
2. Click the **Servlets** tab.
3. In the Servlets and JSPs pane, click **EGLRichUIProxy**.
4. In the URL Mappings pane, select **/___proxy->EGLRichUIProxy**.
5. Click **Remove**.
6. Save your changes and exit the Deployment Descriptor Editor.

If you want to invoke Web services from your Rich UI application later, edit the `web.xml` and add a servlet URL mapping into EGLRichUIProxy by using the URL pattern /___proxy.

Securing EGL Web services by using basic authentication

You can use JEE security and basic authentication to secure EGL Web services that are generated into an EGL Web project. If you are only securing services in your project, specify "BASIC" as your authentication type.

To secure all EGL SOAP services in a Web project, in a security constraint in the web.xml, specify a URL pattern of /services/*. You can replace the asterisk with a specific name to secure a specific SOAP service. To secure a specific function in a SOAP service, specify the service and function name, as in /services/accountService/checkBalance.

To secure all EGL REST services in a Web project, in a security constraint in the web.xml, specify a URL pattern of /restservices/*. You can replace the asterisk with a specific name to secure a specific REST service. To secure a specific function in a REST service, specify the service and function name, as in /restservices/accountService/checkBalance.

Using application-managed (custom) authentication

If you do not want to use JEE authentication to secure your HTML file, you can incorporate custom security into your Rich UI application. You must still use JEE security to protect the EGL Rich UI Proxy and Web services.

When you use custom security, your Rich UI application must include a user-defined login screen. To hide the password as it is being typed, use the PasswordTextField widget in your Rich UI handler. Your Rich UI application can require authentication to occur either at the beginning of the application or before accessing a restricted area. You can integrate this form of security into the rest of the application.

The first step in defining custom security is to determine which parts of the application should be secured (that is, which parts can be accessed only after logging in with a valid user id and password). Even if you are not using JEE security protect to the HTML file, use JEE security to secure the EGL Rich UI Proxy. This is an important factor to remember when you design your Rich UI application. A design that uses EGL single sign-on will reduce the number of times a user will have to authenticate.

When authenticating with custom security, use SSL to ensure that the user id and password are secure during transmission between the browser and server. For an introduction to SSL, see *Overview of SSL*.

EGL single sign-on

Combining application and proxy authentication

By using EGL single sign-on, you can combine the following aspects of security into a single step: authentication to your application (protected by custom security) and authentication to the EGL Rich UI Proxy (protected by JEE security). You can also include authentication to Web services.

Although the user registries that you use for authentication to the application, EGL Rich UI Proxy, and Web services do not need to be the same, the user ID and password used during EGL single sign-on must exist in all the relevant user registries to prevent an authentication error.

For EGL single sign-on, the Rich UI application must define a login screen that contains a user ID field, password field, and command button, as in the following example:

```
useridLabel TextLabel { text = "User ID:", width = 80 };
useridField TextField { width = 100 };
useridBox  Box { children = [ useridLabel,
                 useridField ], margin = 3 };
passwordLabel TextLabel { text = "Password:", width = 80 };
passwordField PasswordTextField { width = 100 };
passwordBox Box { children = [ passwordLabel,
                  passwordField ], margin = 3};
button Button { text = "Log in", onClick ::= authenticate };
ui Box { background = "blue",
         children = [ useridBox, passwordBox, button ],
         columns = 1, width = 200 };
```

Whenever a Web service is called, a request is sent to the EGL Rich UI Proxy. Because the proxy is secured with JEE basic authentication, a user must log in before accessing it. If a user has not logged in yet, a browser-provided login screen

that is similar to the example in "Using basic authentication to secure the EGL Rich UI Proxy" will be displayed the first time a Web service is invoked.

With EGL single sign-on, when the user authenticates to the Rich UI application using the user-defined login screen above, EGL passes those credentials (user ID and password) to JEE security to use to authenticate to the proxy also. Therefore, authenticating to the application is combined with authentication to the proxy in one step. For EGL single sign-on to work, design the Rich UI application so that the Web service for authentication to the application is invoked before any other Web service. Doing so bypasses the browser-provided login dialog.

To implement EGL single sign-on, use the **ServiceLib.setProxyBasicAuthentication()** system function to pass the user ID and password to authenticate to the proxy. Before you call the service to log in to the application, invoke this system function. The authenticate function for the EGL code above might look like the following example:

```
function authenticate( e Event in )
   ServiceLib.setProxyBasicAuthentication(useridField.text,passwordField.text );
   srvc LDAPLoginService{ @bindService };
   call srvc.login( useridField.text, passwordField.text )
                    returning to loginCallback onException loginException;
end
```

Adding Web service authentication

Typically, to authenticate to a secure Web service, a Rich UI application must prompt the user for a user ID and password. However, you can pass the user ID and password that you use for EGL single sign-on to a secure Web service. To do so, invoke the **ServiceLib.setHTTPBasicAuthentication()** system function before you call the secure Web service and pass it the user ID and password used for EGL single sign-on.

```
function withdraw( e Event in )
   ServiceLib.setHTTPBasicAuthentication(srvc, useridField.text,
                                         passwordField.text );
   srvc BankingService{ @bindService };
   call srvc.withdraw( useridField.text, passwordField.text )
                       returning to withdrawCallback onException withdrawException;
end
```

Handling authentication errors

If you use EGL single sign-on to authenticate to your application and to the EGL Rich UI Proxy, authentication to the proxy occurs before authentication to your application. Because the EGL Rich UI Proxy is secured using JEE basic authentication, the Web container, not the application, handles login failures. Because the Web container steps in, you can no longer authenticate in a single step. At this point, the user must authenticate to the EGL Rich UI Proxy first, and log in to the application, Web services, or both afterward.

If users enter an invalid password for EGL Rich UI Proxy authentication on the login screen, a browser-provided login dialog is displayed so that they can try to authenticate again. In JEE basic authentication, the Web container prompts the browser to display this dialog until the user logs in successfully. The application cannot access the password that a user enters on this dialog.

After users enter valid credentials for the EGL Rich UI Proxy, they must authenticate to the application, Web services, or both. The application should direct users to re-enter a valid user ID and password in the user-defined login screen and to click the "Login" button again.

If an error occurs when users authenticate to a Web service that is secured with HTTP basic authentication, control falls into the exception handler that is specified on the call statement. Your Rich UI application must detect this error and present appropriate instructions to the user to reauthenticate. The following example shows the specifics of this kind of error:

Web service authentication error

Configuration
A Web service is secured using JEE basic authentication.

Problem
A valid user ID and password for the Web service are not found in the HTTP header.

Error A ServiceInvocationException is thrown with message ID "EGL1539E" and message, "An exception occurred while communicating with the service. URL: {0}" is issued where {0} is the URL of the Web service. detail1 of the ServiceInvocationException is set to "401"; detail2 is set to "Unauthorized"; detail3 is set to "Server returned HTTP response code: 401 for URL: {0}", "name": "egl.core.ServiceInvocationException".

Solution
Call **ServiceLib.setHTTPBasicAuthentication()** to set a valid user ID and password in the HTTP header before consuming the Web service.

If both EGL Rich UI Proxy and Web service authentication are successful but an error occurs when you try to authenticate to your application, your Rich UI application must handle the error. When the Web service returns, control passes to the callback or "returning to" function that is specified on your call statement.

Accessing user repositories

You can use various types of repositories, such as LDAP directories, relational databases, and flat files with either JEE or custom security. You can use EGL single-sign on to access different repositories to authenticate to the application, proxy, and Web services. For single-sign on to succeed, the user id and password that the end user enters in the login screen must exist in each of the various repositories.

The most popular type of repository is a Lightweight Directory Access Protocol (LDAP) directory, which is a specialized database that is optimized for read access and that organizes its data in a tree structure. Before you access an LDAP directory for JEE authentication, configure the application server to connect to the LDAP directory server. For WebSphere Application Server, specify this information in the Administrative Console; for Apache Tomcat, specify this information in the \conf\server.xml file.

You can also use EGL code that is generated into Java and running on a server to access an LDAP directory. To use EGL code to access an LDAP directory, define either an EGL REST or SOAP service. The service can use EGL external types that map to JNDI LDAP Java classes to access an LDAP directory. Here is an example of EGL code that establishes a connection to an LDAP directory server:

```
// External types needed to access an LDAP directory server.
externalType ControlArray type  JavaObject
         { JavaName = "Control[]", PackageName = "javax.naming.ldap" }
end

externalType InitialDirContext type JavaObject
         { JavaName = "InitialDirContext",
         PackageName = "javax.naming.directory" }
   function modifyAttributes( name String in,
               mods ModificationItemArray in );
end

externalType InitialLdapContext extends InitialDirContext type JavaObject
         { JavaName = "InitialLdapContext",
         PackageName = "javax.naming.ldap" }
   constructor( environment Hashtable in, connCtls ControlArray in );
end

externalType ModificationItemArray extends Object type JavaObject
         { JavaName = "ModificationItem[]",
         PackageName = "javax.naming.directory" }
end

   // Instantiate a hashtable for binding criteria.
   // Hashtable is already defined within EGL.
   hashtable Hashtable = new Hashtable();

   // Properties can be found at
   // http://java.sun.com/j2se/1.4.2/docs/guide/jndi/jndi-ldap.html.

   // Set JNDI environment properties.
   // userid and password are passed in as strings.
   hashtable.put( "java.naming.factory.initial",
            "com.sun.jndi.ldap.LdapCtxFactory" );
   hashtable.put( "java.naming.provider.url",
            "ldap://localhost:389/o=sample" );
   hashtable.put( "java.naming.security.principal",
            "uid=" + userid + ",ou=people,o=sample");
   hashtable.put( "java.naming.security.credentials", password );
   hashtable.put( "java.naming.security.authentication", "simple" );
   hashtable.put( "java.naming.referral", "follow" );
   hashtable.put( "java.naming.security.protocol", null );

   // Set LDAP-specific properties.
   hashtable.put( "java.naming.ldap.version", "3" );

   // Connect to the LDAP directory server.
   ctx InitialLdapContext = new InitialLdapContext( hashtable, null );
   if ( ctx != null )
      // Retrieve data
      ...
   end
```

For more sample EGL code, including code that retrieves and modifies data in an LDAP directory, see "EGL LDAP Access" or "J2EE Security with EGL LDAP Access" in the IBM Rational® Business Developer documentation (in the "Contents" under "Samples").

Adding a new user to a repository

If your Rich UI application requires security, you have two options to give new users permission to access the secure areas: a system or security administrator can add a new user to the repository or the Rich UI application can contain code to add a new user to the repository. The method that you choose depends largely on the level of security that you need. For example, if the user must be a company

employee or must possess a bank account to access a Web site, a system administrator likely wants to tightly control access to the repository. On the other hand, if the repository is mainly a way to keep a log of users and new users constantly request access, it might be inconvenient or impractical to go through a system administrator. In this case, an application might add new users to the repository.

Note that the tighter your user registry is controlled, the tighter the security will be of your Rich UI application and EGL Rich UI Proxy. Although securing your EGL Rich UI Proxy with JEE security prevents unauthenticated users from accessing the proxy, it does not prevent malicious authenticated users from using the proxy to inflict damage. Therefore, when you require new users to go through a system administrator, the EGL Rich UI Proxy will be more secure than if you allow the application to add new entries to the user registry.

If you must add new users to a repository with your Rich UI application, you can write EGL code to add the users. This code must run on an application server. You can write the code as either a Web service or a JSF application.

If you use a Web service to write the code to add a new user, the EGL Rich UI Proxy has to invoke the code. If the proxy is secure, a new user cannot access it. Therefore, you can use a Web service to add a new user only if the proxy is not protected by JEE security.

If you use JEE security to secure the proxy, you can use a JSF application to add a new user to the repository. To link to a JSF application in a new window to update the repository, the Rich UI handler can use a hyperlink widget that is similar to the following example:

```
registerLink Hyperlink = new Hyperlink { target = "_blank",
href = "http://localhost:9080/LDAPSample/ldapLogin.faces",
text = "Click here to register" };
```

To close the window after authentication completes, the JSF page can invoke a JavaScript "window.close".

Authentication summary

During the design phase of your Rich UI application, determine the type of security that you need and integrate that security with the rest of your application. If your entire Rich UI application needs to be secured and you do not need to access security credentials from within the application, consider using JEE authentication. Otherwise, you might need to implement custom security.

To secure the EGL Rich UI Proxy, use JEE security. If you use JEE form-based authentication for your HTML file, include the URL pattern of the proxy in your security constraint. Otherwise, use JEE basic authentication to secure the proxy. If your application requires custom security or calls secure Web services, consider using EGL single sign-on to eliminate the need for a user to log in more than once.

You can secure Web services using by JEE basic authentication and set a user id and password in the HTTP header before invoking them by using the ServiceLib.setHTTPBasicAuthentication system function.

Use SSL, described in *Overview of SSL*, to secure data transmitted to and from your Rich UI application. Securing data is vital to keeping your passwords from being compromised.

The following table summarizes the combinations of resources that you can secure with JEE or custom authentication. For each of the eight scenarios (columns), an "X" represents a secure resource. These scenarios assume that the HTML file is calling Web services. Otherwise, remove access to the EGL Rich UI Proxy by deleting its URL mapping from the deployment descriptor. The safer scenarios are identified with an "*".

Table 11. Authentication scenario

	1	**2**	**3***	**4**	**5***	**6***	**7**	**8***
HTML file		x			x		x	x
EGL Rich UI Proxy			x		x	x		x
Web service				x		x	x	x

Scenario descriptions

1. In this scenario, the proxy is publicly accessible. If possible, do not implement this scenario. Secure the proxy with JEE basic authentication (scenario 3).
2. Although the HTML file is secured with either JEE or custom security, the proxy is still publicly accessible. If possible, do not implement this scenario. Secure the proxy with JEE authentication (scenario 5).
3. In this scenario, the proxy is secured with JEE basic authentication. This scenario is safer than the first two.
4. In this scenario, the proxy is publicly accessible. If possible, do not implement this scenario. Secure the proxy with JEE authentication (scenario 6).
5. If Web service does not require security, this scenario can be safe. If both the HTML file and proxy are secured with JEE security, use form-based authentication to require the user to log in only once. If the HTML file is secured with custom security and the credentials to log in to the HTML file match those used to log in to the proxy, use EGL single sign-on to combine application authentication with JEE authentication to the proxy.
6. Although the Rich UI application does not require authentication, a user-defined login screen is required to obtain Web service credentials, which should never be hardcoded into the application. If the credentials that are used to log in to the Web service match those that are used to log in to the proxy, use EGL single sign-on to combine Web service authentication with JEE basic authentication to the proxy.
7. In this scenario, the proxy is publicly accessible. If possible, do not implement this scenario. Secure the proxy with JEE authentication (scenario 8).
8. If both the HTML file and proxy are secured with JEE security, use form-based authentication. A user-defined login screen is required in the application to authenticate to the secure Web services. Thus, the user must log in twice. If the credentials to authenticate to the HTML file, the proxy, and Web services match, consider securing the HTML file with custom authentication. Then use EGL single sign-on to capture credentials for all three types of resources.

Authorization

You can perform authorization through JEE security or through the application itself. JEE security uses roles to manage access to resources. A logical security role has permission to access certain resources. Actual users and groups who are mapped to that logical role can access those resources. The web.xml deployment descriptor specifies the type of access that is granted to each role. For WebSphere Application Server, roles are bound to users and groups in the application.xml. For Apache Tomcat, the binding occurs in a repository such as the tomcat-users.xml file, LDAP directory, or relational database.

Although you can check authorization in a JSF application by calling the J2EELib.isUserInRole and J2EELib.getRemoteUser EGL system functions, these system functions are not available from a Rich UI application in V7.5.1 because the JEE security that is used from a Rich UI application must be declarative.

If JEE authorization is not suitable for your Rich UI application, perhaps because programmatic security is unavailable or the overhead of administering JEE security roles is too high, authorization can be accomplished using your own application code. One way to implement authorization is to organize user entries into groups in a repository like an LDAP directory. You can then invoke a Web service from your Rich UI application to retrieve an entry from the repository and check if a user is in a group that has access a certain resource.

For details concerning authorization, see your WebSphere Application Server, Apache Tomcat, or LDAP directory server documentation.

JEE security example

The following example shows how to use JEE basic authentication to secure an EGL Rich UI Proxy in a Web project to which a Rich UI application has been deployed.

For WebSphere Application Server, perform the following steps:

1. In the `web.xml`, specify security criteria
2. In the `application.xml`, specify security criteria
3. Use the Administrative Console to enable security
4. Enable security in the server configuration

For Apache Tomcat, perform the following steps:

1. In the `web.xml`, specify security criteria
2. In `tomcat-users.xml`, bind roles to users and groups

Specifying security criteria in web.xml

You can specify security criteria in the deployment descriptor of your deployed project (web.xml) in two ways:

- By using the Security Editor.
- By editing the `web.xml` in the Deployment Descriptor Editor.

The Security Editor is used in this example because it provides an easy way to specify and view security criteria.

Using the Security Editor

You can use the Security Editor to define the following things in `web.xml`:

- Security roles
- Security constraints
- Authentication method

From the Project Explorer in the EGL Rich UI perspective, open the Security Editor by double-clicking on the **Security Editor** icon of your deployed project.

Defining security roles

In JEE role-based security, users must be assigned roles to access resources. Roles are mapped to actual user registry entries.

- In the Create a Security Role dialog, click **OK**.
- In the Add Roles window, type user as the role name and click **Add**.
- Click **Finish**.

Defining security constraints

To specify the resources that are protected and the roles that have access to the resources, define a security constraint.

1. In the Resources pane, expand the folder with your project name, Servlets, EGLRichUIProxy, and Servlet Mappings. Under Servlet Mappings, you should see /___proxy.
2. To secure the proxy and allow anyone in the user role to access the proxy, drag the user role from the Security Roles pane to /___proxy in the Resources pane.
3. To see the security constraints, in the Resources pane, right click on /___proxy (user) and click **Assign Roles**. In the Select Roles window, select user and click **Advanced>>>**. You should see the userConstraint security constraint that is mapped to user, which specifies how you can access the /___proxy secure resource. The userConstraint security constraint contains the default HTTP method access (GET, PUT, HEAD, TRACE, POST, DELETE, OPTIONS). Click **OK**. To change the defaults for your security constraints, in the Security Editor, click **Security Preferences**.

Selecting an authentication method

To specify an authentication method:

1. Click **Authentication**.
2. For the authentication method, click **BASIC**.
3. To name the example, type Sample registry.
4. Click **OK**.
5. Save your changes and close the Security Editor.

Defining a user data constraint

A user data constraint specifies how data is protected while it is in transit between a client and server. If you do not want to use the default user data constraint (NONE), you must specify the user data constraint directly into the web.xml because that information is not available from the Security Editor.

You can set a user data constraint to a value of NONE, INTEGRAL, or CONFIDENTIAL. An INTEGRAL value guarantees content integrity, preventing tampering of messages in transit between a client and server. A CONFIDENTIAL setting guarantees confidentiality, preventing reading of data by others during the transfer. If you use a value of INTEGRAL or CONFIDENTIAL, requests must be submitted over SSL.

To specify a user data constraint in the `web.xml`:

- From the EGL Rich UI perspective, open the deployment descriptor of your deployed project by double-clicking on the deployment descriptor.
- Select the Security tab.
- Under Security Constraints, click **userConstraint**.
- To require that requests be submitted over SSL, under User Data Constraint, select INTEGRAL or CONFIDENTIAL.

Specifying security criteria in application.xml for WebSphere

When you use WebSphere Application Server, you can specify security criteria in the deployment descriptor of your Enterprise Application project (application.xml) in two ways:

- By using the Security Editor
- By editing application.xml

The Security Editor is used in the following example because it provides an easy way to specify and view security criteria.

Using the Security Editor

To bind the roles that are defined in your `web.xml` to actual users and groups in your user registry, use the Security Editor. This binding information is stored in the deployment descriptor of your Enterprise Application project (`application.xml`).

To open the Security Editor from the Project Explorer in the EGL Rich UI perspective, double-click on the Security Editor icon of your deployed project.

Defining security role bindings

To define security role bindings:

1. Click **Role Mapping**.
2. In the WAS Specific Role Mappings window, click **user**.
3. Click **Map User**.
4. In the Map User window, click **All Authenticated Users**.
5. Click **OK**.
6. In the WAS Specific Role Mappings window, click **OK**.
7. Save your changes and close the Security Editor.

Enabling security by using the Administrative Console for WebSphere

To enable application and administrative security:

1. From the Servers view in the Workbench, start a WebSphere V6.1 or V7.0 server.
2. Right click on the server, click **Administration → Run administrative console**, .

3. When you are prompted, type a user id. Because administrative security is not yet enabled, the user id is not really used.
4. In the Administrative Console, take the following steps:
   a. Expand Security.
   b. For WebSphere V6.1, select Secure administration, applications, and infrastructure.
   c. For WebSphere V7.0, select Global security.
   d. From the Available realm definitions, select the type of user registry to use. In this example, use Local operating system.
   e. Click **Set as current**.
   f. Click **Configure**. The configuration page for the realm opens.
   g. Enter the properties. Note the Primary administrative user name, which you must also enter in the User ID field of the server configuration that is described in the next section. For Local operating system, type the user id that you use to log in to your operating system.
   h. Click **OK** to return to Secure administration, applications, and infrastructure for WebSphere V6.1 or Global security for WebSphere V7.0.
   i. Click **Enable administrative security**, which also selects Enable application security.
   j. Clear the Use Java 2 security to restrict access to local resources checkbox.
   k. Click **Apply** → **Save**.
   l. Exit the Administrative Console and stop the server. Before you start the server again, follow the instructions in "Enable security in the server configuration for WebSphere."

Enabling security in the server configuration for WebSphere

To enable security in the server configuration:

1. To open your WebSphere Application Server V6.1 or V7.0 server in the Servers view, double click **WebSphere Application Server V6.1 or V7.0**.
2. For WebSphere V6.1, under the Server section, select SOAP as the server connection type.
3. For WebSphere V7.0, under the Server section, click **Manually provide connection settings** and select SOAP as the server connection type.
4. Under the Security section, click **Security is enabled on this server**. Type the user ID and password that you set in your Administrative Console. The **User ID** field should match the Primary administrative user name field in the Configuration page of your realm in the Administrative Console. For this example, type the password that you use to log in to your operating system.
5. Save your changes and exit the server configuration.
6. Start the server. If an authentication error occurs, ensure that the user id and password in your server configuration match those that you used to log in to your operating system.

Binding roles to users and groups in tomcat-users.xml

When you use Apache Tomcat V5.5 or V6.0, the user repository in a production environment is typically an LDAP directory or relational database, but by default is the tomcat-users.xml file. In the tomcat-users.xml file, which is located in the

```
<tomcat-users>
<user name="bob" password="guesswhat" roles="user"/>
</tomcat-users>
```

Running a Rich UI application with a secure proxy

When a Web service is invoked from a Rich UI application, a request for that Web service is sent to the EGL Rich UI Proxy. Before you can access the proxy, you must enter a valid user id and password into a browser-specific dialog, such as the following dialog for Mozilla Firefox V2.0. For this example, the user id and password that you use to log in to your operating system are also used to authenticate to the EGL Rich UI Proxy.

You can use EGL single sign-on to combine custom authentication to your application with JEE authentication to the EGL Rich UI Proxy and bypass this dialog.

WebSphere Application Server hints and tips

If you want to turn off administrative security but cannot start the server to run the Administrative Console, you can turn off administrative security from the command line:

1. Go to the WebSphere Application Server install directory.
2. Type bin\wsadmin.bat –conntype NONE
3. When the system prompt redisplays, type securityoff.
4. When you are finished, type quit.

After turning off administrative security, clear the **Security is enabled on this server** checkbox in the server configuration before restarting the server.

When testing your Rich UI application, after authenticating with JEE security, if you make a change to your application or configuration and want to retest authentication, you might have to stop the server and exit the Workbench in order to clear all saved values. For Windows®, before you restart, use the Task Manager to ensure the java.exe process for the server has finished.

If you have trouble starting your server with administrative security enabled, make sure you specified SOAP as your server connection type in your WebSphere server configuration.

Sample login and error pages for JEE form-based authentication

In JEE form-based authentication, you can specify a customized login page and an error page. The login page, which prompts the user to enter a user id and password, refers to a special j_security_check servlet. Two HTTP request parameters (form input fields) must always be in the request, one called j_username and the other, j_password.

When the Web container receives a request for the j_security_check servlet, it passes the request to the security mechanism of the application server to perform the authentication. If authentication fails, the error page is displayed. Below is code for a sample login page. Copy and save this code in login.jsp under the WebContent folder.

```
<%@ page language="java" contentType="text/html; charset=ISO-8859-1"
    pageEncoding="ISO-8859-1"%>
<!DOCTYPE html PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
    "http://www.w3.org/TR/html4/loose.dtd">
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<title>Sample Login Page for JEE Security</title>
<style type="text/css">H1 {color: navy}</style>
</head>
<body>
<table width="500" border="0">
   <tbody>
      <tr>
         <td colspan="3" width="80%" align="center"><b><font face="Verdana"size="+2"
             color="#15406a">Sample Login</font></b><hr>
         </td>
      </tr>
      <tr>
         <td colspan="3" width="560" height="65">
         <form method="POST" action="j_security_check">
         <div>
         <table width="100%" border="1" bgcolor="#e9e9e9">
            <tbody>
               <tr>
                  <td align="right" width="169"
                      bgcolor="#e9e9e9"><b>
                      <font face="Verdana">User id:</font></b></td>
                  <td width="315"><input type="text" name="j_username"></td>
               </tr>
               <tr>
                  <td align="right" width="169" bgcolor="#e9e9e9">
                      <font face="Verdana"><b>Password:</b></font></td>
                  <td width="315"><input type="password" name="j_password"></td>
               </tr>
               <tr bgcolor="white">
                  <td align="right" width="169" bgcolor="white"></td>
                  <td width="315"><input type="submit" value="Login"></td>
               </tr>
            </tbody>
         </table>
         </div>
         </form></td>
      </tr>
      <tr>
         <td colspan="3" width="560" align="center" height="58" valign="top">
            <script> document.write(Date()+".")
            </script>
         </td>
```

```
      </tr>
   </tbody>
</table></body>
</html>
```

The following code is for a sample error page. Copy and save this code in error.jsp under the WebContent folder.

```
<%@ page language="java" contentType="text/html; charset=ISO-8859-1"
    pageEncoding="ISO-8859-1"%>
<!DOCTYPE html PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
    "http://www.w3.org/TR/html4/loose.dtd">
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<title>Sample Error Page for JEE Security</title>
<style type="text/css">H1 {color: navy}</style>
</head>
<body>
<table width="500" border="0">
   <tbody>
      <tr>
         <td colspan="3" width="80%" align="center"><b><font face="Verdana" size="+2"
             color="#15406a">Sample Login Error</font></b><hr>
         </td>
      </tr>
      <tr>
         <td colspan="3" width="560" align="center" height="58"
             valign="top"><br>Authentication error.
             Please check your user id and password, and try again.</td>
      </tr>
   </tbody>
</table></body>
</html>
```

Preventing client-side security threats

Unfortunately, the technologies that provide a richer interactive experience can also make applications less secure. Rich UI applications are susceptible to the security vulnerabilities that threaten any Web 2.0 applications including cross-site scripting, SQL injection, and JavaScript hijacking.

When you use EGL, you are protected from some of these client-side threats. For example, EGL prevents malicious data being sent to the client using either JavaScript Object Notation (JSON) or XML. It also guards its usage of "eval" in runtime code. However, it is very difficult for EGL to defend against certain types of attacks like cross-site scripting and SQL injection without limiting the types of applications customers can write.

You can prevent unauthenticated clients from calling the proxy and reduce the possibility of proxy misuse by securing the EGL Rich UI Proxy with JEE security. However, securing the proxy with JEE security does not prevent authenticated users from using the proxy for unintended purposes. The more tightly your user registry is controlled, the safer your proxy will be. Therefore, for security reasons, a system administrator should control the access of your user registry.

You can keep a log of the end users who have accessed your Rich UI application if you are using your own login screen, rather than one supplied through JEE form-based authentication or the browser-provided login dialog from JEE basic authentication. (In your Rich UI application, you cannot retrieve user ids from the application server if you are using JEE security.) This log could help you determine

the guilty party if an authenticated user is illegally using your EGL Rich UI Proxy for anything from calling Web services on other domains to instigating JavaScript hijacking attacks. Also check the documentation of your application server to see if it maintains logs that might be of help to you.

Overview of SSL

Secure Sockets Layer (SSL) ensures data integrity and confidentiality, and is used extensively for securing communications. SSL is a protocol that runs above TCP/IP and below higher-level application protocols such as HTTP and LDAP.

To initiate an HTTP-based SSL connection, the client uses a URL that starts with HTTPS:// instead of with HTTP://. Always use an SSL-enabled port with the HTTPS protocol.

In SSL, a server authenticates itself to the client, and the client optionally authenticates itself to the server, insuring against imposters. By using SSL, you can prevent the interception and tampering of messages and provide confidentiality through encryption.

Although much of the SSL material in these topics applies to both WebSphere and Tomcat, *SSL example* focuses solely on WebSphere Application Server. For instructions on how to install and configure SSL for Tomcat, see Apache Tomcat documentation

Using SSL with Rich UI applications

When the HTML file that EGL generates for your Rich UI application is requested, a connection is made between the browser and the server to which your Rich UI application (including the EGL Rich UI Proxy) was deployed. Whenever a Web service is invoked in your Rich UI application, the EGL Rich UI Proxy creates a new connection between its server and the one on which the Web service is deployed. These connections are independent of one another and can use different protocols.

Requesting an HTML file with the SSL protocol (HTTPS) results in an SSL connection between the browser and server. If you use JEE authentication to secure an HTML file or the EGL Rich UI Proxy, require SSL to protect the user id and password from eavesdroppers as they are transmitted between the browser and server. When you use JEE authentication, to require SSL for the request, set the user data constraint in the `web.xml` to INTEGRAL or CONFIDENTIAL.

When you use custom authentication, you have various options to require HTTPS for the HTML file request. For instance, you can configure your Web server to redirect all HTTP requests to HTTPS. To redirect a specific HTML request, consider purchasing or writing a Java redirect filter, which you can specify on the Filters tab of your `web.xml`. You can use these filters to redirect certain HTTP requests to their HTTPS equivalent.

When a Web service is invoked with the SSL protocol, the EGL Rich UI Proxy creates a new SSL-enabled connection between its server and the one on which the Web service is deployed. When you secure Web services with HTTP basic authentication, require SSL to protect the user id and password during transmission. To require SSL for the request, set the user data constraint in the `web.xml` of the Web service project to INTEGRAL or CONFIDENTIAL. After you require SSL, invoke the Web service by using the HTTPS protocol.

When you invoke a secure Web service with SSL, ensure that the Rich UI application also uses the SSL protocol to protect the user id and password in the channel between the browser and server.

SSL-related errors

As suggested in the following examples, an occur might occur if the EGL Rich UI Proxy or Web service requires SSL but HTTPS is not used on the request.

Proxy

Configuration

The EGL Rich UI Proxy is secured by using JEE basic authentication and includes a CONFIDENTIAL or INTEGRAL user data constraint.

Problem

HTTP is used to request the proxy instead of HTTPS. (Because of the Same Origin policy for JavaScript, the protocol that is used to request the HTML file is the protocol that is used to request the proxy. The same is true for the domain name and port number.)

Errors

A ServiceInvocationException is thrown with messageID "CRRUI3658E" and the message, "An error occurred on proxy at '{0}' while trying to invoke service on '{1}'" where {0} is the URL of the proxy and {1} is the URL of the Web service. detail1 of the ServiceInvocationException is set to "302"; detail2 is set to "Found".

A ServiceInvocationException is thrown with messageID "EGL1546E" and the message, "The request could not be converted to a service call. The received request was "."

Solution

Request the HTML file with HTTPS instead of HTTP.

Web service

Configuration

A Web service is secured by using JEE basic authentication and includes a CONFIDENTIAL or INTEGRAL user data constraint.

Problem

HTTP is used to request the Web service instead of HTTPS.

Error A ServiceInvocationException is thrown with messageID "CRRUI3655E" and the message, "An error occurred while processing response object: 'ReferenceError: urlString is not defined'". detail1 of the ServiceInvocationException is set to "302"; detail2 is set to "Found".

Solution

Request the Web service with HTTPS instead of HTTP.

SSL terminology

A *key store* is a file that contains public and private keys. Public keys are stored as signer certificates and are sent to the clients that request them. Private keys are stored in the personal certificates and are never sent to others.

A *trust store* is a file that contains public keys, which are stored as signer certificates from target servers whom you have deemed trustworthy. If the target uses a self-signed certificate, extract the public certificate from the server key store and add the extracted certificate into the trust store as a signer certificate. Otherwise, add the CA root certificate to your trust store.

A *certificate* is sent from the server to the client during SSL authentication to confirm the identity of the server. Certificates contain data such as the owner's name and email address, duration of validity, web site address, and certificate ID of the person who certifies or signs this information. Trusted parties called Certificate Authorities (CAs) issue digital certificates. For internal Web sites that do not need a CA certificate, you can use WebSphere Application Server to create self-signed certificates.

In SSL server authentication, the client prompts the server to prove its identity. The opposite occurs in client authentication, which is also supported through SSL, but not covered here. Client authentication is used when the server needs to send confidential financial information to a customer but wants to verify the identity of the recipient first.

How SSL works

SSL uses both symmetric and asymmetric encryption algorithms. Symmetric algorithms use the same key to encrypt and decrypt data. They are faster than asymmetric algorithms but can be insecure. Asymmetric algorithms use a pair of keys. Data encrypted using one key can only be decrypted using the other. Typically, one of the keys is kept private while the other is made public. Because one key is always kept private, asymmetric algorithms are generally secure; however, they are much slower than symmetric algorithms. To reap the benefits of both algorithms, SSL encapsulates a symmetric key that is randomly selected each time inside a message that is encrypted with an asymmetric algorithm. After both the client and server possess the symmetric key, the symmetric key is used instead of the asymmetric ones.

When server authentication is requested, SSL uses the following process:

1. To request a secure page, the client uses HTTPS.
2. The server sends the client its public key and certificate.
3. The client checks that the certificate was issued by a trusted party (usually a trusted Certificate Authority) that the certificate is still valid, and that the certificate is related to the contacted site.
4. The client uses the public key to encrypt a random symmetric encryption key and sends it to the server, along with the encrypted URL required and other encrypted HTTP data.
5. The server decrypts the symmetric encryption key using its private key and uses the symmetric key to decrypt the URL and HTTP data.
6. The server sends back the requested HTML document and HTTP data that are encrypted with the symmetric key.
7. The client decrypts the HTTP data and HTML document using the symmetric key and displays the information.

SSL example

The following example illustrates how to use WebSphere V6.1 or V7.0 to create and use your own SSL-enabled port. Before WebSphere Application Server V6.1 was released, certificates were managed through the use of an external tool called

iKeyman. As of WebSphere Application Server V6.1, you can use the Administrative Console to manage both certificates and keys. Although you can use WebSphere V6.0 with SSL to run Rich UI applications, the instructions for doing so are not included here. The differences between V6.1 and V7.0 are described below.

For instructions on how to install and configure SSL for Tomcat, see Apache Tomcat documentation.

Create an SSL-enabled port

To create a sample SSL-enabled port, take the following steps. For more details, see your WebSphere Application Server documentation.

Changing your key store and trust store passwords

In the following procedure, you create a new self-signed certificate in your WebSphere Application Server default key store and import the certificate into your default trust store. Before you use the default key and trust stores, change their passwords from the defaults to another value to create a more secure environment. To change your key store and trust store passwords:

1. Start your WebSphere V6.1 or V7.0 server
2. Right click on the server and click **Administration**.
3. Click **Run administrative console**.
4. Log in to the Administrative Console.
5. Expand Security and click **SSL certificate and key management**.
6. Under Related Items, click **Key stores and certificates**.
7. For WebSphere V6.1, click **NodeDefaultKeyStore**.
8. For WebSphere V7.0, click **NodeDefaultKeyStore**. Click **Change password**.
9. Type your new password into the Change password and Confirm password fields.
10. Click **OK**.
11. Repeat this process for NodeDefaultTrustStore.

Creating a personal certificate

A self-signed certificate is useful when you are testing or when your Web site is behind a firewall. Otherwise, obtain a certificate from a Certificate Authority. To create a personal certificate:

1. From your list of key stores and trust stores, click **NodeDefaultKeyStore**.
2. Under Additional Properties, click **Personal certificates**.
3. For WebSphere V6.1, click **Create a self-signed certificate**.
4. For WebSphere V7.0, click **Create → Self-signed certificate**.
5. Type the following values for the certificate:

   Alias
   SampleCert

   Common name
   Sample Server

   Organization
   IBM

6. Click **OK**.

In the list of certificates, you should now see samplecert.

Creating an SSL configuration

WebSphere Application Server uses SSL configurations for SSL-based transports. To create an SSL configuration:

1. From the left-hand pane, expand Security and click **SSL certificates and key management**.
2. Under Related Items, click **SSL configurations**.
3. Click **New**.
4. Type the following values:

   Name
   SampleConfig

   Trust store name
   NodeDefaultTrustStore

   Keystore name
   NodeDefaultKeyStore
5. Click **Get certificate aliases**.
6. Ensure that samplecert is selected as the Default server certificate alias and the Default client certificate alias.

Click **OK**, and click **Save**. In the list of SSL configurations, you should see SampleConfig.

Creating a Web container transport chain

Create a Web container transport chain to use the SSL configuration that you created:

1. For WebSphere V6.1, from the left-hand pane, expand Servers and click **Application servers**.
2. For WebSphere V7.0, from the left-hand pane, expand Servers and Server Types. Click **WebSphere application servers**.
3. Click **server1** or your server name.
4. Under Container Settings, expand Web Container Settings and click **Web container transport chains**.
5. Click **New**.
6. In the Transport chain name field, type SampleInboundSecure.
7. To select the Transport chain template, from the drop-down list, click **WebContainer-Secure(templates/chains | webcontainer-chains.xml#Chain_2)**.
8. Click **Next**.
9. In the Select a port page, type the following values:

   Port
   SamplePort

   Host
   *

   Port number
   9444

If port 9444 is already in use, pick another port number and use that number for the rest of the exercise.

10. Click **Next**.
11. Click **Finish** → **Save**.

SampleInboundSecure is now listed as a Web container transport chain. Associate the sample SSL configuration with this transport chain:

1. Click **SampleInboundSecure**.
2. Click **SSL inbound channel**.
3. Under SSL Configuration, from the Select SSL Configuration drop-down list, select **SampleConfig** .
4. Click **OK** → **Save**.

Adding the SSL-enabled port to the virtual host

Add port 9444 to the virtual host:

1. In the left-hand pane, expand Environment and click **Virtual Hosts** .
2. Click **default_host**.
3. Under Additional Properties, click **Host Aliases**.
4. On the Host Aliases page, click **New**.
5. Keep * as the host name. Change the port to 9444.
6. **OK** → **Save**. In the list of ports, you should see 9444.

Stop and restart the server. Port 9444 is now an SSL-enabled port.

Using the new SSL-enabled port to run a sample

To use your port, start a WebSphere V6.1 or V7.0 server. On your WebSphere server, install the EAR that contains your deployed Rich UI application. To request an HTML file such as RSSReader.html in the RSSReaderSample context, take one of the following steps:

- Open a browser such as Internet Explorer, Safari®, or Mozilla Firefox. Enter a URL in your browser using the newly-enabled SSL port: https://localhost:9444/RSSReaderSample/RSSReader.html
- In your Project Explorer, right-click on an HTML file of an application that has been published to WebSphere. Click **Run As**, then click **Run on Server**.

If you are using a self-signed certificate, you might see a "Security Alert", "Website Certified by an Unknown Authority", or another warning, depending upon the browser. This warning indicates that the certificate was signed by an unknown certifying authority. Click the "View Certificate" or "Examine Certificate" button to verify if the certificate is correct. If so, continue.

If the Common Name on the certificate does not match the domain name in the requested URL (localhost, in this case), you might also see a "Security Error: Domain Name Mismatch" error. To verify the certificate, click the View Certificate button, and continue as appropriate. To prevent "man-in-the-middle" attacks, where a rogue program intercepts all communication between a client and server, the client must verify the server domain name that is specified in the certificate.

Preventing SSL handshaking exceptions

To prevent SSL handshaking exceptions, ensure that the certificate of a server can be found in the trust store of a client. If the certificate is not found in the trust store and the client is a browser, a security alert dialog is displayed. A user can use the dialog to view the certificate and select whether to proceed.

When a Web service is invoked from a Rich UI application, the EGL Rich UI Proxy establishes a HTTP or HTTPS connection between the proxy and Web service. This connection is independent of the connection between the browser and proxy. If the Web service has an HTTPS protocol, the connection between the proxy and Web service uses SSL. Because no browser is available to display a security alert and prompt for a response, the certificate that belongs to the server of the Web service must be in the trust store of the server of the EGL Rich UI Proxy before the connection is initiated. Otherwise a handshaking error occurs.

To obtain a copy of the server's certificate when calling a third-party Web service, enter the URL of the Web service in a browser over HTTPS. The way in which you receive the certificate of the server varies depending on the browser. A common way is through a "View Certificate" button, Details tab, and "Copy to File" button. Save the certificate to a file. Use the Administrative Console to open the trust store of your EGL Rich UI Proxy and import the saved certificate as a signer certificate.

Alternatively, you can connect to the remote SSL host and port and receive the signer certificate during the handshake by using the "Retrieve from port" option. If you try to use the SSL-enabled port 9444 you created in "SSL Example" to request a Web service called from an HTML file requested on the WebSphere default SSL port 9443, you a handshaking error occurs. To fix this problem, import the certificate that is associated with port 9444 into the trust store that is associated with port 9443:

1. Start the WebSphere V6.1 or V7.0 server that contains your EGL Rich UI Proxy. The proxy is deployed to the same location as the generated HTML file of your Rich UI application.
2. Right click the server. Click **Administration → Run administrative console**.
3. Log in to the Administrative Console.
4. Expand Security and click **SSL certificates and key management**.
5. Under Related Items, click **Key stores and certificates**.
6. Click the appropriate trust store.
7. Click **Signer certificates**.
8. Click **Retrieve from port**.
9. Specify the following values:

   Host
   localhost

   Port
   9444

   SSL configuration for outbound connection
   NodeDefaultSSLSettings

   Keystore name
   SampleCert
10. Click **Retrieve signer information → OK**.

Restart the server. You should now be able to request a Web service on port 9444 from port 9443 without receiving a handshaking error.

SSL transport between WebSphere Application Server and LDAP

If you use an LDAP directory as your registry, WebSphere Application Server verifies the password of a user by using the standard ldap_bind, which requires sending the password to the LDAP directory server. A password can flow in clear text when you use a non-SSL channel between WebSphere and the LDAP directory server. To use SSL, create a certificate for the LDAP directory and import it into the trust store of your server. Also enable SSL on your LDAP directory server. For more details, see LDAP directory server and application server documentation.

IBM Rational AppScan

IBM Rational AppScan® is a Web application security assessment suite that you can use to identify and fix common Web application vulnerabilities. Use Rational AppScan® to scan and test the code that EGL generates for your EGL Rich UI application to pinpoint any critical areas that are susceptible to a Web attack. For more information on the Rational AppScan product line, see http://www-306.ibm.com/software/rational/offerings/websecurity/webappsecurity.html.

Chapter 10. Reference to widgets

Here are the main Widget types:

- BidiTextArea
- BidiTextField
- Box
- Button
- Checkbox
- Combo
- Div, FloatLeft, and FloatRight
- Grid
- Grouping
- HTML
- Hyperlink
- Image
- List
- Listmulti
- Menu
- PasswordTextField
- RadioGroup
- Shadow
- Span
- TextArea
- TextField
- TextLabel
- Tooltip
- Tree and TreeToolTip

Rich UI BidiTextArea

A bidiTextArea widget defines a rectangle containing one or more lines of bidirectional text.

The following properties are supported:

- **numColumns**, which holds an integer that represents the number of columns in the text area
- **numRows**, which holds an integer that represents the number of rows in the text area
- **readOnly**, which holds a Boolean that indicates whether the text area is protected from user input
- **text**, which holds a string for display in the text area

The following functions are available, none of which returns a value:

- **append** adds content to the content already in the text area. The only parameter is the string to be added.

- **setRedraw** redraws the text area. The only parameter is a Boolean, which indicates whether to redraw the area.
- **select** causes the widget to receive focus and, on most browsers, selects the text. The function has no parameters.

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.BidiTextArea;
```

Rich UI BidiTextField

A bidiTextField widget defines a text box containing a single line of bidirectional text.

The following properties are supported.

- **text**, which holds a string for display in the text field.
- **readOnly**, which holds a Boolean that indicates whether the text field is protected from user input.

The following function is supported:

- **select** causes the widget to receive focus and, on most browsers, selects the text. The function has no parameters.

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.BidiTextField;
```

Rich UI Box

A Rich UI box widget defines a box that embeds other widgets.

You can indicate how many columns are in the box. If the number of columns is three, for example, the first three embedded widgets are on the first row in the box, the fourth through sixth are on the second row, and so forth. If the number of columns is one, all the embedded widgets are arranged vertically. In any case, the width of a column equals the width of the largest widget in the column, and you can indicate whether the embedded widgets in a given column are aligned at the column's center, right, or left.

Vertical and horizontal scroll bars appear if necessary to give the user access to widgets that are out of sight.

The following properties are supported:

- **alignment**, which holds an integer value that indicates how the content is aligned in each column: 0 for left, 1 for center, or 2 for right
- **children**, which holds an array of widgets, as described in *Widget properties and functions*
- **columns**, which holds an integer that identifies the number of columns in the box

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Box;
```

Rich UI Button

In most cases, a Rich UI button widget invokes a function in response to a user click. The following properties are supported:

- **text**, which holds a string for display on the button
- Properties described in "Widget properties and functions."

The following function is supported:

- **select** causes the button to receive focus and, on most browsers, selects the button text. The functions has no parameters.
- Functions described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Button;
```

Rich UI Checkbox

A Rich UI checkbox displays a true-false option and responds to the user input by invoking a function. The following properties are supported:

- **text**, which holds a string for display
- **selected**, which holds a Boolean that indicates whether the checkbox is selected

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Checkbox;
```

Rich UI Combo

A Rich UI combo widget defines a combo box, which presents one of several selectable options and lets the user temporarily open a dropdown list to select a different option.

Here is example code:

```
import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Combo;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.rui.Event;

Handler ListExample Type RUIHandler
   { initialUI = [myBox] }

   myBox Box{columns=2, children= [myCombo, myTextField]};

   myCombo Combo
   {
      values = ["one", "two", "three", "four"],
      selection = 2, onChange ::= changeFunction
   };
```

```
   myTextField TextField
      {text = myCombo.values[myCombo.selection]};

   Function changeFunction(e Event IN)
      myTextField.text = myCombo.values[myCombo.selection];
   end
end
```

The following properties are supported:

- **values**, which holds an array of strings that each represent a selectable option.
- **selection**, which is integer that represents the position of the string in the array. If you set the value of **selection** before displaying the combo box, the specified string is displayed initially; otherwise, the first string is displayed initially.

  The first string in the array is at position 1, not 0.

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Combo;
```

Rich UI Div, FloatLeft, and FloatRight

A Rich UI div widget defines a division (HTML DIV tag) on the Web page, below the preceding content. The widget might be the parent of floatLeft and floatRight widgets, providing flexibility in Web-page design. A floatLeft widget uses the CSS element float:left, and the floatRight widget uses the CSS element float:right.

At this writing, the following site offers "Floatutorial," which is a tutorial on designing a Web page with float:left and float:right:

http://css.maxdesign.com.au

Supported EGL properties and functions are described in "Widget properties and functions."

Use of each widget requires the appropriate **import** statement:

```
import com.ibm.egl.rui.widgets.Div;
import com.ibm.egl.rui.widgets.FloatLeft;
import com.ibm.egl.rui.widgets.FloatRight;
```

Rich UI Grid and GridTooltip

A Rich UI grid widget defines an array of values in a table format. The widget allows you to set the following details:

- An array of records whose field values are displayed in the corresponding grid columns, one row per record
- *Behaviors*, which are fields that each accept an array of function references. When a user clicks a cell, the referenced functions run in array-element order. Each function can update cell characteristics. The result is that you can specify style characteristics, as well as actions such as sorting by column or displaying a tooltip. (A tooltip is a hover help, which is a box that is displayed when the user stops the mouse and the cursor is on a particular area of the grid.)

A Delegate part named **CellBehavior** describes the characteristics of each function referenced by the **behaviors** and **headerBehaviors** field of a grid widget:

```
Delegate
   CellBehavior(grid Grid in, cell TD in, row any in,
                rowNumber int in, column GridColumn in)
end
```

grid
The grid that is passed to the function.

cell
An internal widget that represents the grid cell. That widget is based on the HTML TD (table data) tag.

row
The record that represents the row data. (As noted later, you assign values to the grid by setting the grid's `data` property, which takes an array of records of a type that you specify. The values for a given grid row are retrieved from an element of that array.)

rowNumber
The row number, which ranges from 1 to the value of property `totalRows`, which contains the number of rows in the grid.

column
The record that represents the column description. (As noted later, you describe the columns by setting the grid's columns property to an array of records of type GridColumn. The values for a given column are retrieved from an element of that array.

Rich UI provides a number of functions that you can reference in the behavior fields: For details, see the following files in the com.ibm.egl.rui project, EGLSource folder, com.ibm.egl.rui.widgets package:

- GridBehaviors.egl
- GridSelector.egl
- GridSorter.egl
- GridToolTip.egl (which we mention again, later in this topic)

Supported properties and functions

The following properties are supported in the Grid widget:

- **data**, which is of type ANY and holds an array of records defined by the developer. The data in a given record field is presented in the grid only if the name of the field is matched by the name of a grid column, as specified in the `columns` property. In the grid declaration, list the **data** property after the other properties.

  Here is an example:

  ```
  stocks Stock[] = [
     new Stock{Symbol = "Company1", Quote = 100, NumShares = 40, SelectQuote = false},
     new Stock{Symbol = "Company2", Quote = 200, NumShares = 10, SelectQuote = false},
   ];

  Grid myGrid {..., data = stocks as any[]};
  ```

- **columns**, which holds an array of records of the following type:

```
Record GridColumn
   displayName String;
   name String;
   width int;
end
```

displayName
The column title. If this field is not specified, the column title is the value of the *name* field.

name
The default column title, as well the name of the `data` record field that provides the value for the column.

width
Number of pixels in the column.

- **totalRows** is a read-only property that contains the number of rows in the grid.
- **behaviors** is an array of delegates of type **CellBehavior**. You specify an array of functions that are invoked every time the user clicks any row other than the header row. The functions are invoked in the order specified in the array.
- **headerBehaviors** is an array of delegates of type **CellBehavior**. You specify an array of functions that are invoked every time the user clicks a header row. The functions are invoked in the order specified in the array.

The following rules are in effect:

- Except in the case of the referenced widgets in **children** or **initialUI** properties, Rich UI requires that you declare a value before you reference it. If a grid property refers to an array that is outside the grid declaration (as in our previous example of the **data** property), the array must be specified before the grid declaration.
- When declaring a grid, ensure that you list the **behaviors**, **headerBehaviors**, and **column** properties before the **data** property.
- If, when writing statements in functions, you change the value of the **behaviors** or **headerBehaviors** property, invoke the grid-specific function **layouts()** to reset the widget.

In relation to Grid (but not GridTooltip), other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires some or all of the following statements:

```
import com.ibm.egl.rui.widgets.Grid;
import com.ibm.egl.rui.widgets.GridBehaviors;
import com.ibm.egl.rui.widgets.GridSelector;
import com.ibm.egl.rui.widgets.GridSorter;
import com.ibm.egl.rui.widgets.GridToolTip;
```

Grid Tooltips

If you wish to include a tooltip for a grid, you have two main alternatives:

- If you wish the tooltip to be displayed whenever the cursor hovers over the grid and not to vary according to the cell, row, or column, assign the grid as a whole to a tooltip. For details, see *Rich UI Tooltip*. You might declare a tooltip as a global widget and enable it (making it active) in some function; for example, in the on-construction function or in a function identified in the **behaviors** or **headerBehaviors** property.
- If you wish the tooltip to specify different tooltip information for a given cell, row, or column, you can specify a grid tooltip, which is similar to a tooltip but

always requires that you specify a grid-tooltip provider function. That function returns a box that provides the content to display to the user.

Here is the process for creating a grid tooltip:

- Reference the following function when you assign an array for the **behaviors** property: GridToolTip.setToolTips. Access to that function requires that you include the following import statement:

  ```
  import egl.rui.widgets.GridToolTip;
  ```

- Declare a grid tooltip globally, as in the following example, which references a grid-tooltip provider (the function to invoke) and a delay (the number of milliseconds between the start of the hover and the invocation of the provider):

  ```
  gridTooltip GridTooltip { provider = tooltipText, tooltip.delay = 1000 };
  ```

- Create a grid-tooltip provider function with the name specified in the GridToolTip **provider** property (in this example, the function is tooltipText). The grid-tooltip provider function has the parameter and return-value characteristics outlined in the following Delegate part:

  ```
  Delegate GridTooltipTextProvider(row any in, fieldName String in, td TD in) returns(Box)
  end
  ```

  row
  The row provided to the function. You can use the input argument to access a specific value. For example, consider the case in which the data is as follows:

  ```
  stocks Stock[] = [
     new Stock{Symbol = "Company1", Quote = 100, NumShares = 40, SelectQuote = false},
     new Stock{Symbol = "Company2", Quote = 200, NumShares = 10, SelectQuote = false}
   ];
  ```

  You can determine which row is being provided by code such as in the following example:

  ```
  if (row.Quote as int == 200)
     // place content in a tooltip and return the tooltip
  end
  ```

  fieldName
  Name of the column provided to the function.

  td An internal widget that represents the grid cell. That widget is based on the HTML TD (table data) tag.

- You do not enable the grid tooltip; it is enabled as soon as you declare it.

You can have only one grid tooltip per grid.

Example

Here is an example that you can try in your workspace and that includes a tooltip for the header row and a grid tooltip elsewhere:

```
import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Grid;
import com.ibm.egl.rui.widgets.GridBehaviors;
import com.ibm.egl.rui.widgets.GridColumn;
import com.ibm.egl.rui.widgets.GridSelector;
import com.ibm.egl.rui.widgets.GridTooltip;
import com.ibm.egl.rui.widgets.TextArea;
import com.ibm.egl.rui.widgets.Tooltip;
import egl.ui.rui.Widget;
```

```
Record Filler
  F1 String;
  F2 String;
  F3 String;
end

handler myGrid1 type RUIhandler {initialUI = [ myBox ]}

  gridSelector GridSelector { color = "lightgreen" };
  filler Filler[] = [
     new Filler{F1 = "R3, C1", F2 = "R3, C2", F3 = "R3C3"},
    new Filler{F1 = "R4, C1", F2 = "R4, C2", F3 = "R4C3"}
  ];

  myFirstGrid Grid{
      behaviors   = [
       GridBehaviors.whiteCells,
       GridBehaviors.alternatingColor,
       GridBehaviors.tightCells,
       gridSelector.enableSelection,
      gridTooltip.setTooltips
      ],
      headerBehaviors = [
         GridBehaviors.grayCells,
         headerTooltips
      ],
     columns = [
       new GridColumn{name = "F1", displayName = "Column 1 Header", width=120},
          new GridColumn{name = "F2", displayName = "Column 2 Header", width=120},
       new GridColumn{name = "F3", width=50}
     ],
     data = [
       new Dictionary { F1 = "Row 1, Column 1", F2 = "Row 1, Column 2", F3 ="me"},
       new Dictionary { F1 = "Row 2, Column 1", F2 = "Row 2, Column 2", F3 = "you"},
       filler[1], filler[2]
     ]

   };

   myBox Box{ backgroundcolor = "peachpuff", padding=8,
              children=[myFirstGrid], marginbottom=15};

   HtooltipText String = "This is a Header tooltip";
  headerTooltip Tooltip { text = HtooltipText, delay=1000 };

   function headerTooltips(grid Grid in, td Widget in, row any in,
                           ignoreRowNumber int in, column GridColumn in)
      headerTooltip.enable(td);
   end

   gridTooltip GridTooltip { provider = tooltipText, tooltip.delay = 1000 };
   tooltipArea TextArea { width=450, height=100, paddingLeft=7, marginLeft=7 };

   function tooltipText(row any in, fieldName String in, td Widget in) returns(Box)
     tooltipArea.text =
          "In function tooltipText (a tooltip provider):" +
          " \n   fieldName is the column name ('"+fieldName+"')." +
          "\nYou can access cell content:" +
          "\n   td.innerText is '"+td.innerText+"'. \nThanks to EGL dynamic access" +
         "\n   row[fieldName] is also '"+row[fieldName] + "'.";
          return (tooltipBox);
   end

   tooltipBox Box {columns=1, width=475, children = [ tooltipArea ]};
end
```

Rich UI Grouping

A Rich UI grouping widget displays one or more widgets inside a box. In addition to those widgets, you specify text that is embedded in the topmost border of the box.

The following properties are supported:

- **text**, which holds a string for display in the topmost border of the box.
- **contents**, which represents a Div tag. You can set the children by assigning widgets to **contents.children**, as shown here:

```
import com.ibm.egl.rui.widgets.CheckBox;
import com.ibm.egl.rui.widgets.Grouping;

handler MyOne type RUIHandler{initialUI =[myGrouping]}
    myCheckbox checkbox{};
    myGrouping Grouping {text = "Test", backgroundColor = "yellow", width = 100,
       contents.children = [myCheckbox]};
end
```

Supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Grouping;
```

Rich UI HTML

A Rich UI HTML widget presents an HTML fragment, which may be provided by a service.

The following properties are supported:

- **text**, which holds the HTML fragment and is of type STRING
- **width**, which is the width of the bounded area, in pixels
- **height**, which is the height of the bounded area, in pixels

Other supported properties and functions are described in "Widget properties and functions."

The following example is rendered as ***Rich*** UI:

```
Handler GridDemo type RUIHandler {children = [myHTML]}

   myHTML HTML
   {
      text = "Rich UI",
      height = 30, width=160
   };
```

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.HTML;
```

Rich UI Hyperlink

A Rich UI hyperlink defines a Web-page link that, if clicked, goes to the target page.

The following properties are supported:

- **text** specifies the string displayed on the page
- **target** specifies a string that identifies the window in which the new Web page opens. Here are the valid values:
  - "_top" opens the page in the current window, taking up the entire page. This behavior is also in effect if you specify "_self", "_parent", or no value for **target**.
  - "_blank" opens the page is a different browser or browser window.
- **href** specifies the Web address of interest

Supported properties and functions are described in "Widget properties and functions."

The following example renders a link to the IBM Web site, and the displayed text is "IBM":

```
Handler Hyper type RUIHandler {children = [myHyperlink]}

   myHyperlink HyperLink
   {
      text = "IBM",
      target = "_blank",
      href = "http://www.ibm.com"
   };

end
```

If the Web page to which you are linking takes up the Preview view, you can clear the page as follows:

- Double-click the **Link Preview with Editor** button (the two arrows); or
- Load an EGL file that contains a different Rich UI handler.

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Hyperlink;
```

Rich UI Image

A Rich UI image widget presents a graphic.

The following properties are supported:

- **src**, which holds the Web address for the graphic
- **text**, which holds the text shown in browsers that cannot display the graphic or when the mouse hovers over the image

Other supported properties and functions are described in "Widget properties and functions."

The following example renders a graphic or the word "Gears":

```
Handler GridDemo type RUIHandler {children = [myImage]}

   myImage Image
```

```
   {
      src =
      "http://www.ibm.com/developerworks/i/spaces/feature/d-aw-s-alphaworks.jpg",
      text = "Gears"
   };

end
```

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Image;
```

Rich UI List

A Rich UI list widget defines a list from which the user can select a single entry.

Here is example code, which displays the list value in a text field:

```
import com.ibm.egl.rui.widgets.List;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.rui.Event;

Handler MyHandler Type RUIHandler
   { initialUI = [myList, myTextField]}

   myList List
   {
      values = ["one", "two", "three", "four"],
      selection = 2, onChange ::= changeFunction
   };

   myTextField TextField
      {text = myList.values[myList.selection]};

   Function changeFunction(e Event in)
      myTextField.text = myList.values[myList.selection];
   end
end
```

The following properties are supported:

- **values**, which holds an array of strings that each represent a selectable option.
- **selection**, which holds an integer that represents the position of the string in the array. If you set the value of **selection** before displaying the list box, the specified string is displayed in boldface.

  The first string in the array is at position 1, not 0.
- **size**, which holds an integer that indicates how many strings to display from the **values** array. The default is to display all the strings, with no scroll bar:
  - If the value of **size** is smaller than the number of strings, only the specified number of strings is displayed. A scroll bar provides access to the other strings.

    Initially, only the last strings are displayed.
  - If the value of **size** is greater than the number of strings, additional spaces are added to the bottom of the list box. The user cannot select content from one of those spaces, which are only for display.

  If you do not set the **size** property, Internet Explorer 6 displays the widget as a combo box (a combination text box and list box).

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.List;
```

Rich UI ListMulti

The Rich UI listMulti widget defines a list from which the user can select multiple entries. The following properties are supported:

- **values**, which holds an array of strings that each represent a selectable option.
- **selection**, which holds an array of integer that represent the position of the strings in the **values** array. If you set the value of **selection** before displaying the list box, the specified strings are displayed in boldface.

  The first string in the array is at position 1, not 0.
- **size**, which holds an integer that indicates how many strings to display from the **values** array. The default is to display all the strings, with no scroll bar:
  - If the value of **size** is smaller than the number of strings, only the specified number of strings is displayed. A scroll bar provides access to the other strings.

    Initially, only the last strings are displayed.
  - If the value of **size** is greater than the number of strings, additional spaces are added to the bottom of the list box. The user cannot select content from one of those spaces, which are only for display.

  If you do not set the **size** property, Internet Explorer 6 displays the widget as a combo box (a combination text box and list box).

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.ListMulti;
```

Rich UI Menu

A Rich UI menu widget defines a menu, which is displayed as a single, top-level entry such as **File**. The menu has subordinate menu items that each can provide additional options. To create a menu bar, you can declare a box widget that contains a series of menus, as shown in the following example:

```
menuBar Box{ font = "Arial", children = [
   fileMenu,
   otherMenu,
   helpMenu  ]};
```

You are likely to place the menu bar in a larger box, which includes the overall Web page. Here is partial code from a later example:

```
handler MyHandler type RUIhandler{initialUI =[ui], onConstructionFunction = start}

ui Box{columns = 1, margin = 12, background = "#eeeeee",
   children =[ menubar,
               new Box{ borderStyle = "solid", borderColor = "orange", borderTopWidth = 25,
               padding = 11, children =[changeTextBox]}
             ]};
```

The basic idea is that you specify an array of menu items for each menu, and each menu item references (at most) two functions:

- The *item-type function* sets up relationships at run time and is invoked when the menu item is being readied for display
- The *item-action function* responds to the user who selects the menu item. However, in some cases when you declare a menu item, you do not reference the item-action function.

For example, here is the array of items for the file menu, followed by the file menu declaration:

```
fileMenuItems menuItem[] =[
   new MenuItem{item = "Clear", itemType = MenuBehaviors.simpleText, itemAction = menuAction},
   new MenuItem{item = "Type", itemType = MenuBehaviors.simpleText, itemAction = menuAction}];

fileMenu Menu{menubehaviors ::= MenuBehaviors.BasicMenu, title = "File",
              options = fileMenuItems, onMenuOpen = closeMenu};
```

Supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statements:

```
import com.ibm.egl.rui.widgets.Menu;
import com.ibm.egl.rui.widgets.MenuBehaviors;
import com.ibm.egl.rui.widgets.MenuItem;
```

Please note that you must declare a set of menu items before declaring the menu in which the items are displayed. We explain menu development with this ordering in mind.

MenuItem

The fields for type **MenuItem** (a Record part) reference the item-type and item-action functions. We describe the **MenuItem** fields before describing the function characteristics. Here are the fields:

id An optional value to associate the menu item with a CSS entry.

item
A value passed to the item-type function. Rich UI provides a few functions and you can code your own; but assuming you use the existing choices, the value of the **item** property is one of the following values:

- A string to display as a submenu item. Only in this case do you specify an item-action function in the menu-item declaration.
- A widget to display as a submenu item.
- An array that is composed of (a) a submenu title and (b) an array that references a set of subordinate submenu items. The following fragment shows this alternative and is from a later example:

```
new MenuItem{item =["Special", [myTimeItem, myReadOnlyItem]],
             itemType= MenuBehaviors.subMenu }];
```

itemType
A reference to the item-type function.

Rich UI provides three functions that allow for the options described in relation to the **item** property:

- The function **simpleText** is appropriate if **item** is a string to display
- The function **widgetItem** is appropriate if **item** is widget
- The function **subMenu** is appropriate if **item** is an array of string and subordinate submenu items

All those functions are available in the Rich UI library **MenuBehaviors**.

itemAction
A reference to the item-action function. Specify this value only if the value of the field **item** is a string.

The item-type function has the characteristics defined in the following Delegate part:

```
Delegate
   MenuItemType(newItem any in, itemAction MenuItemSelection, parentMenu Menu in)
      returns (any)
end
```

newItem
The item you specify when declaring the menu item.

itemAction
A reference to the item-action function, as is always required in the item-type function.

In general, a Delegate part named **MenuItemSelection** describes the item-action function, as noted later.

parentMenu
The menu that contains the menu item.

Here is the Delegate part named **MenuItemSelection**, which describes the item-action function:

```
Delegate MenuItemSelection(parentMenu Menu, item any in) end
```

parentMenu
The menu that contains the menu item.

item
The menu item.

The item-action function (in outline) might be as follows:

```
function menuAction(parentMenu Menu, item any in)
   if(parentMenu == fileMenu)
      case(item as string)
         when("Clear")
            ;
         otherwise
            ;
         end
   else
      if(parentMenu == helpMenu)
         ;
      else
         ;
      end
   end
end
```

Menu

The fields for type Menu are as follows:

menuBehaviors
A reference to a function that is invoked during creation or re-display of the menu, so that styles and functionality are applied to the menu. The reference is added to the **menuBehaviors** array by use of the append syntax (`::=`). You can

have repeated entries (the syntax is as shown in the example), and when a user selects a menu, the referenced functions run in array-element order. In our example, the **menuBehaviors** property references the function **basicMenu**, which is available in the Rich UI library **MenuBehaviors**. You can use the function **basicMenu** directly or can use it as a basis for your own function.

A Delegate part named **MenuBehavior** describes the characteristics of the function being referenced. We describe the Delegate part later.

In the menu declaration, list the **behaviors** property before the other properties.

title
The string to display.

options
An array of menu items.

onMenuOpen
A reference to a function that runs when the user selects the menu. The function has no return value and has a single parameter of type Menu and qualifier IN. Here is an example, which ensures that the user's selection of one menu shuts any other open menu:

```
function closeMenu(keepOpen Menu IN)
   if(keepOpen != fileMenu)
      fileMenu.hideOptions(false);
   end
   if(keepOpen != otherMenu)
      otherMenu.hideOptions(false);
   end
   if(keepOpen != helpMenu)
      helpMenu.hideOptions(false);
   end
end
```

Here is the Delegate part named **MenuBehavior**, which describes each function invoked in response to a menu selection at run time:

```
Delegate
   MenuBehavior(menu Menu in, titleBar TextLabel, optionsBox Box, options MenuItem[])
end
```

menu
The menu.

titleBar
A text label that contains the menu title you assigned.

optionsBox
A box that contains a child for every item in the menu. The function **basicMenu** assigns rules for highlighting those children in response to mouse movements at run time:

```
for (index int from 1 to optionsbox.children.getSize() by 1)
   widget Widget = optionsBox.children[index];
   widget.onMouseOver ::= highlight;
   widget.onMouseOut ::= removemenuhighlight;
end
```

options
An array of the menu items.

The function **layouts()** resets widget behaviors, as described in the following rules:

- When declaring a menu, ensure that you list the **menuBehaviors** property first.

- If, when writing statements in functions, you change the value of the **menuBehaviors** property, invoke the menu-specific function **layouts()** to reset the widget.

Example

You can bring the following example into your workspace to see the relationships described earlier.

```
package myPkg;

import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.CheckBox;
import com.ibm.egl.rui.widgets.HTML;
import com.ibm.egl.rui.widgets.Menu;
import com.ibm.egl.rui.widgets.MenuBehaviors;
import com.ibm.egl.rui.widgets.MenuItem;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.rui.Event;

handler MyHandler type RUIhandler{initialUI =[ui], onConstructionFunction = start}
    {}

ui Box{columns = 1, margin = 12, background = "#eeeeee",
         children = [
         menubar,
         new Box{
         borderWidth = 2, borderStyle = "solid", borderColor = "orange",
         borderTopWidth = 50, padding = 11,
         children =[changeTextBox]}]};

   menuBar Box{font = "Arial", children =[fileMenu, otherMenu, helpMenu]};
   changeTextBox TextField{text="here"};
   readonlyCheck CheckBox{Text = "Read Only", onChange::= setReadOnly};


   myTimeItem menuItem{
      item = "Time?",
      itemType = MenuBehaviors.simpleText,
      itemAction = tellTime };

   myReadOnlyItem MenuItem {
      item = readOnlyCheck,
      itemType = MenuBehaviors.widgetItem };

   fileMenuItems menuItem[] =[
                  new MenuItem{item = "Clear",
                               itemType = MenuBehaviors.simpleText, itemAction = menuAction},
                  new MenuItem{item = "Type",
                               itemType = MenuBehaviors.simpleText,
                               itemAction = menuAction} ];

   otherMenuItems menuItem[] =[
                  new MenuItem{item =["Special", [myTimeItem, myReadOnlyItem]],
                               itemType= MenuBehaviors.subMenu }];

   helpItems menuItem[] =[new MenuItem{item = "About",
                                       itemType = MenuBehaviors.simpleText,
                                       itemAction = showHelp} ];

   fileMenu Menu{menubehaviors ::= MenuBehaviors.BasicMenu, title = "File",
                 options = fileMenuItems, onMenuOpen = closeMenu};

   helpMenu Menu{menubehaviors ::= MenuBehaviors.BasicMenu, title = "Help",
                 options = helpItems, onMenuOpen = closeMenu};
```

```
   otherMenu Menu{menubehaviors ::= MenuBehaviors.BasicMenu, title = "Other",
                  options = otherMenuItems, onMenuOpen = closeMenu};

   helpArea HTML{onClick ::= hideHelp, position = "absolute", x = 70, y = 60,
                 backgroundColor = "lightyellow", width = 400, padding = 11,
                 borderWidth = 3, borderStyle = "solid", height = 50,
                 text = "Helpful detail is here. <p>Click this box to continue working.</p>"};

   function start()

   end

   function tellTime(parentMenu Menu, item any in)
      changeTextBox.text = dateTimeLib.currentTime();
   end

   function menuAction(parentMenu Menu, item any in)
      if(parentMenu == fileMenu)
         case(item as string)
            when("Clear")
               changeTextBox.text = "";
            otherwise
               changeTextBox.select();
            end
      else
         if(parentMenu == helpMenu)
            ;
         else
            ;  // parentMenu == widgetMenu
         end
      end
   end

   function setReadOnly(e Event in)
      changeTextBox.readOnly = !(changeTextBox.readOnly);
   end

   function closeMenu(keepOpen Menu in)

      if(keepOpen != fileMenu)
         fileMenu.hideOptions(false);
      end

      if(keepOpen != otherMenu)
         otherMenu.hideOptions(false);
      end

      if(keepOpen != helpMenu)
         helpMenu.hideOptions(false);
      end
   end

   function showHelp(parentMenu Menu, item any in)
      document.body.appendChild(helparea);
   end

   function hideHelp(e Event in)
      document.body.removeChild(helparea);
   end
end
```

Rich UI PasswordTextField

A Rich UI passwordTextField widget defines an input text field whose value is displayed as bullets, as appropriate for accepting a password. The following properties are supported:

- **text**, which holds a string for display in the text field.
- **readOnly**, which holds a Boolean that indicates whether the text field is read only. The default is *false*, which means that the text field can accept user input.

The following function is supported:

- **select** causes the widget to receive focus and, on most browsers, selects the text. The function has no parameters.

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.PasswordTextField;
```

Rich UI RadioGroup

A Rich UI radioGroup widget (or, more simply, a radio group) displays a set of radio buttons, which are arranged horizontally. The group elicits a user click on any of the buttons and responds to the click by deselecting the group's previously selected radio button, if any.

If you specify the onClick event for the radio group, the user's click invokes a function. The same function is invoked in response to a click on any button; and in the typical case, the function first determines which button was clicked and then responds to the selection.

At this time in Internet Explorer, your code cannot preselect a radio button before displaying the radio group.

Here is example code:

```
import egl.ui.rui.Event;
import com.ibm.egl.rui.widgets.RadioGroup;
import com.ibm.egl.rui.widgets.TextField;

Handler OneRadioButton Type RUIHandler
   { initialUI = [myTextField, myRadioGroup] }

   myTextField TextField { text = "Monday?" };

   myRadioGroup RadioGroup
   { groupName = "abc", options = ["Monday", "Tuesday"], onClick ::= myRadioHandler };

   Function myRadioHandler(e Event in)
      if (myRadioGroup.selected == "Tuesday")
        myTextField.text = "Tuesday!";
      else
        myTextField.text = "Monday!";
      end
   end
end
```

The following properties are supported:

- **groupName**, which takes a string representing the name of the radio group, as needed by some browsers. This property is required.
- **options**, which refers to an array of strings that are displayed as the text of a set of radio buttons, one string per button
- **selected**, which is a field that can be accessed at run time, as shown in the example

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.RadioGroup;
```

Rich UI Shadow

A Rich UI shadow widget creates a shadow effect for the widgets that are children of a Div widget.

We offer examples for you to try in your workspace. First, a simple demonstration:

```
import com.ibm.egl.rui.widgets.Div;
import com.ibm.egl.rui.widgets.Shadow;
import com.ibm.egl.rui.widgets.TextLabel;

handler MyHandler type RUIHandler{initialUI =[myShadow]}

   myTextLabel TextLabel{text = "Text with a Shadow"};
   myShadow Shadow{x = 20, y = 20, width = 100,
                   div = new Div{padding = 5,
                         backgroundColor = "salmon", children =[myTextLabel]}};
end
```

Our second example uses **position** and **visibility** properties to help give a visual effect during a drag-and-drop operation:

```
import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Div;
import com.ibm.egl.rui.widgets.Shadow;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.rui.Widget;

handler MyHandler type RUIHandler{initialUI =[myBox, shadow, myOtherBox]}

   const OTHERBOXX INT = 30;
   const OTHERBOXY INT = 50;

   myTextField TextField{
     text = "What a drag!",
     width = 120,
     backgroundColor = "white",
     onStartDrag = start, onDrag = drag, onDropOnTarget = drop};

   myBox Box { children = [ myTextField{} ]};

   shadow Shadow { zIndex = 2, position = "absolute", visibility="hidden",
                   div = new Div { } };

   myOtherBox Box {position = "absolute", zIndex = 1,
                   x = OTHERBOXX, y = OTHERBOXY,
                   width = 200, height = 200, backgroundColor = "blue"};

   dx, dy int;
```

```
   function start(myWidget Widget in, x int in, y int in) returns(boolean)
      dx = x - myWidget.x;
      dy = y - myWidget.y;

      myTextField.position = "static";
      shadow.div.children = [ myTextField ];
      shadow.visibility = "visible";
      return(true);
   end

   function drag(myWidget Widget in, drop Widget in, x int in, y int in)

      shadow.x = x - dx;
      shadow.y = y - dy;
   end

   function drop(widget Widget in, drop Widget in, x int in, y int in)

      shadow.visibility = "hidden";
      myTextField.position = "relative";
      myTextField.x = shadow.x - OTHERBOXX;
      myTextField.y = shadow.y - OTHERBOXY;

      myOtherBox.children = [ myTextField ];
   end
end
```

Our third example shows a way to test the location of a dragged widget:

```
package pkg;

import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Div;
import com.ibm.egl.rui.widgets.Shadow;
import com.ibm.egl.rui.widgets.TextField;
import egl.ui.position;
import egl.ui.rui.Widget;

handler MyHandler type RUIHandler{initialUI =[shadow, , myBox, myOtherBox1, myOtherBox2]}

   myTextField TextField{
      text="What a drag!", width=120, backgroundColor="white",
      onMouseOver::=mouseOver, onMouseOut::=mouseOut,
      onStartDrag=start, onDrag=drag, onDropOnTarget=drop };

   myBox Box { children=[  myTextField{} ]};

   shadow Shadow { zIndex=2, position="absolute",
                   visibility="hidden", div=new Div { } };

   myOtherBox1 Box {
      padding=10, margin=10, width=200, height=200, backgroundColor="lightblue",
      borderColor="black", borderWidth=2, borderStyle="solid" };

   myOtherBox2 Box { padding=10, margin=10, width=200, height=200,
                     backgroundColor="lightyellow",
                     borderColor="black", borderWidth=2, borderStyle="solid" };

   dx, dy int;

   function mouseOver(e Event in)
      myTextField.cursor = "move";
   end

   function mouseOut(e Event in)
      myTextField.cursor = "";
   end
```

```
   function start(myWidget Widget in, x int in, y int in) returns(boolean)
      dx = x - myWidget.x;
      dy = y - myWidget.y;
      myTextField.position="static";
      shadow.div.children=[ myTextField ];
      shadow.visibility="visible";
      return(true);
   end

   function drag(myWidget Widget in, drop Widget in, x int in, y int in)
      shadow.x=x - dx;
      shadow.y=y - dy;

      if (inside(x, y, myOtherBox1))
         myOtherBox1.backgroundColor = "lightgreen";
      else
         myOtherBox1.backgroundColor = "lightblue";
      end

      if (inside(x, y, myOtherBox2))
         myOtherBox2.backgroundColor = "lightgreen";
      else
          myOtherBox2.backgroundColor = "lightyellow";
      end
   end

   function drop(widget Widget in, drop Widget in, x int in, y int in)
      shadow.visibility="hidden";
      myTextField.position="static";

      if (inside(x, y, myOtherBox1))
         myOtherBox1.children=[ myTextField ];
      end

      if (inside(x, y, myOtherBox2))
         myOtherBox2.children=[ myTextField ];
      end
   end

   function inside(x int in, y int in, widget Widget in) returns(boolean)
      return (x>=widget.x && x<=widget.pixelWidth + widget.x &&
              y>=widget.y && y<=widget.pixelHeight + widget.y);
   end
end
```

The main property of the shadow widget is **div**, which takes a widget of type Div.

Supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Shadow;
```

Rich UI Span

A Rich UI span lets you display a string that the user cannot change. The widget is different from a text label because inclusion of an HTML segment (such as this boldfaced code) causes the display of HTML-coded content such as **this boldfaced code**.

Here is an example:

```
import com.ibm.egl.rui.widgets.Div;
import com.ibm.egl.rui.widgets.Span;
import egl.ui.color;

handler myOne type RUIHandler{initialUI =[myDiv]}
   myDiv Div{children = [mySpan01, mySpan02, mySpan03]};
   mySpan01 Span{text = "mix blue ", color = "blue"};
   mySpan02 Span{text = " and yellow ", backgroundColor = "black", color = "yellow"};
   mySpan03 Span{text = " to see green", color = "green"};
end
```

The main supported property is **text**, which takes the string to display. Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.Span;
```

Rich UI TextArea

A Rich UI textArea widget defines a rectangle containing one or more lines of text.

Here is example code:

```
import com.ibm.egl.ui.rui.Event;
import com.ibm.egl.rui.widgets.RadioButton;
import com.ibm.egl.rui.widgets.TextArea

Handler OneRadioButton Type RUIHandler
   { children = [myTextArea, myRadioButton] }

   myTextArea TextArea
      { text = "Monday? I'm really busy on Monday. How about Tuesday?"
        numColumns = 15, numRows = 5 };

   myRadioButton RadioButton
   { text = "Tuesday", selected = false, onClick ::= myRadio };

   Function myRadio(e Event)
      myTextField.text = "Tuesday!";
   end
end
```

The following properties are supported:

- **numColumns**, which holds an integer that represents the number of columns in the text area
- **numRows**, which holds an integer that represents the number of rows in the text area
- **readOnly**, which holds a Boolean that indicates whether the text area is protected from user input
- **text**, which holds a string for display in the text area

The following functions are available, none of which returns a value:

- **append** adds content to the content already in the text area. The only parameter is the string to be added.
- **select** causes the widget to receive focus and, on most browsers, selects the text. The function has no parameters.
- **setRedraw** redraws the text area. The only parameter is a Boolean, which indicates whether or not to redraw the area.

Supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.TextArea;
```

Rich UI TextField

A Rich UI textField widget defines a text box containing a single line of text.

Here is example code:

```
import egl.ui.rui.Event;
import com.ibm.egl.rui.widgets.RadioGroup;
import com.ibm.egl.rui.widgets.TextField;

Handler OneRadioButton Type RUIHandler
   { children = [myTextField, myRadioGroup] }

   myTextField TextField
      { text = "Monday?", readOnly = true };

   myRadioGroup RadioGroup
   { options = ["Monday", "Tuesday"], onClick ::= myRadioHandler };

   Function myRadioHandler(e Event)
      if (myRadioGroup.selected == "Tuesday")
         myTextField.text = "Tuesday!";
         myTextField.readOnly = false;
      else
          myTextField.text = "Monday!";
      end
   end
end
```

The following properties are supported.

- **text**, which holds a string for display in the text field.
- **readOnly**, which holds a Boolean that indicates whether the text field is protected from user input.

The following function is supported:

- **select** causes the widget to receive focus and, on most browsers, selects the text. The function has no parameters.

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.TextField;
```

Rich UI TextLabel

A Rich UI textLabel widget displays a string that the user cannot change. The widget is different from a span because inclusion of an HTML segment (such as this code) is displayed as is, including the angle brackets.

Here is an example:

```
import com.ibm.egl.rui.widgets.Div;
import com.ibm.egl.rui.widgets.TextLabel;
import egl.ui.color;

handler myOne type RUIHandler{initialUI =[myDiv]}
   myDiv Div{children = [myLabel01, myLabel02, myLabel03]};
   myLabel01 TextLabel{text = "mix blue ", color = "blue"};
   myLabel02 TextLabel{text = " and yellow ", backgroundColor = "black", color = "yellow"};
   myLabel03 TextLabel{text = " to see green", color = "green"};
end
```

The following property is supported:

- **text**, which takes the string to display

Other supported properties and functions are described in "Widget properties and functions."

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.TextLabel;
```

Rich UI Tooltip

A Rich UI tooltip widget defines *hover help*: text or widgets that are displayed when the user hovers over a widget. A tooltip is displayed only if you enable the tooltip widget, as described in this section. You can use the same tooltip for several widgets, and you can enable the tooltip for a given widget in response to a runtime event.

Here is an example Rich UI handler, which displays a button and assigns hover help that says, "To toggle the text, click the button!":

```
Handler Test Type RUIHandler { initialUI = [theButton], onConstructionFunction= begin }

 theButton Button { text = "Start", onClick ::= click };
 theToolTip Tooltip { text = "To toggle the text, click the button!", delay = 800 };

 function begin()
  theToolTip.enable(theButton);
 end

 Function click(e Event in)
  if (theButton.text == "Start")
   theButton.text = "Stop";
  else
   theButton.text = "Start";
  end
 end
```

The following tooltip widget properties are supported:

- **text**, which holds a string for display. If you specify a string here, the **provider** property is not used.
- **delay**, which holds an integer that represents the number of milliseconds between the start of the user's hover and the display of the hover help
- **provider**, which refers to a function that returns a box for display within the hover help. For example, assume your Rich UI handler displays a button that says "Start". You can create a tooltip that is enabled for the button and that displays a hypertext link in the hover help:

Here is the provider function that makes the output possible:

```
Function GoToWebsite(myWidget any in) returns(Box)
   myLink html{text =
      "You can rely on <a target = \"_blank\", href=\"http://www.ibm.com\">IBM</a>";
   myBox Box{children = [mylink]};
   return (myBox);
end
```

A Delegate part named ToolTipTextProvider describes the access characteristics of any function that is referenced by the `provider` property. Specifically, the Delegate part indicates that the provider function has one parameter type and returns a box:

```
Delegate TooltipTextProvider(widget any in) returns(Box) end
```

The following tooltip widget function is supported:

- `enable(`*`widget`* `in)` enables the tooltip for a particular widget, as shown in our first example.

Use of this widget requires the following statement:

```
import com.ibm.egl.rui.widgets.ToolTip;
```

Rich UI Tree and TreeTooltip

A Rich UI tree widget defines a set of tree nodes. The tree itself has two properties:

- **children** is a dynamic array that points to the subordinate tree nodes.
- **behaviors** is an array of function references. When a node is added to the tree, the referenced functions run in array-element order, Each function can update node characteristics. Those functions can set style characteristics and can perform actions such as showing or hiding the node.

  For each function listed in the **behaviors** fields of a tree widget, the parameter list must match the following Delegate part, and the function must not return a value:

  ```
  Delegate TreeNodeBehavior(node TreeNode) end
  ```

  Rich UI provides a number of functions that can be referenced in the **behaviors** property. For details, see the following files in the com.ibm.egl.rui project, EGLSource folder, com.ibm.egl.rui.widgets package:

  – TreeBehaviors.egl
  – TreeToolTip.egl

The following rules relate to the behaviors of either a tree or (as noted later) a tree node:

- Except in the case of the referenced widgets in **children** or **initialUI** properties, Rich UI requires that you declare a value before you reference it. If the **behaviors** property refers to an array external to the tree or tree node declaration (as in our example), that array must be specified before the declaration.
- When you declare a tree or tree node, ensure that you list the **behaviors** property first; in particular, before the **children** property.

- If, when writing statements in functions, you change the value of the **behaviors** property, invoke the tree-specific (or tree-node-specific) function **layouts()** to reset the widget.

In relation to the types Tree and TreeNode (but not TreeTooltip), other supported properties and functions are described in "Widget properties and functions."

Use of a tree requires the following statements:

```
import com.ibm.egl.rui.widgets.Tree;
import com.ibm.egl.rui.widgets.TreeBehaviors;
import com.ibm.egl.rui.widgets.TreeNode;
import com.ibm.egl.rui.widgets.TreeToolTip;
```

TreeNode

The Rich UI tree widget includes a set of tree nodes, each of which is a widget of type TreeNode. Here are the tree-node properties:

- **text** is the value displayed for the node.
- **children** is a dynamic array that points to the subordinate tree nodes.

TreeToolTip

The tree tooltip is equivalent to the widget described in *Rich UI tooltip*. However, in this case, the provider function accepts a tree node.

The example in the next section shows use of a tree tooltip.

Example

Here is an example that you can try in your workspace:

```
import com.ibm.egl.rui.widgets.Box;
import com.ibm.egl.rui.widgets.Button;
import com.ibm.egl.rui.widgets.TextArea;
import com.ibm.egl.rui.widgets.TextLabel;
import com.ibm.egl.rui.widgets.TreeNode;
import com.ibm.egl.rui.widgets.TreeNodeBehavior;
import com.ibm.egl.rui.widgets.TreeTooltip;
import egl.ui.rui.Event;

handler MyTreeExample type RUIhandler {initialUI = [ myBox1 ]}

   myBox1 Box{ backgroundColor = "yellow", padding=8, columns = 1,
               children = [ myTextArea, myTree ] };

   myTextArea TextArea {numRows = 5, numColumns = 50,
               text = " This tree shows 2 children, each with 2 children."};

   myTreeNodeA TreeNode{backgroundColor = "cyan",text="Child 1",
                        children =[myTreeNode1, myTreeNode2] };

   myTreeNode1 TreeNode{backgroundColor = "lightblue",text="Gchild 1-1" };
   myTreeNode2 TreeNode{backgroundColor = "lightgreen",text="Gchild 1-2" };

   myTreeNodeB TreeNode{backgroundColor = "orange", text="Child 2",
           children =[myTreeNode3,
                      new TreeNode{backgroundColor = "burlywood", text = "Gchild 2-2"}] };

   myTreeNode3 TreeNode{backgroundColor = "lightpink", text="Gchild 2-1" };

   myBehaviors TreeNodeBehavior[] = [ click, tooltip.setTooltips ];
```

```
   myTree Tree{backgroundColor = "lavender", behaviors = myBehaviors,
               children =[myTreeNodeA, myTreenodeB]};

   tooltip TreeTooltip { provider = showTooltip, tooltip.delay = 1000 };

   function click(node TreeNode in)
      node.span.cursor = "pointer";
      node.onClick ::= handleNodeClick;
      node.onMouseOver ::= showFeedback;
      node.onMouseOut ::= hideFeedback;
   end

   function showTooltip(node TreeNode) returns(Box)
      tooltipText TextLabel { };
      tooltipResponse Box { children = [ tooltipText ] };
      tooltipText.text = "Tooltip for " + node.text;
      return (tooltipResponse);
   end

   function showFeedback(e Event in)
      node TreeNode = e.widget;
      color any = node.backgroundColor;
      node.setAttribute("originalBG", color);
      node.span.backgroundColor = "yellow";
  end

   function hideFeedback(e Event in)
      node TreeNode = e.widget;
    node.span.backgroundColor = node.getAttribute("originalBG");
   end

   function handleNodeClick(e Event in)
      node TreeNode = e.widget;
      if (node.span.color == "red")
      node.span.color = "black";
         node.span.fontWeight = "normal";
      else
         node.span.color = "red";
         node.span.fontWeight = "bold";
      end
   end
end
```

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Printed in USA