Inside the Workbench
A guide to the workbench internals

Summary
This article describes how the Eclipse 3.1 workbench works, in particular the infrastructure for views and editors. The goal is to teach you about important classes in the workbench, and how they interact. A familiarity with the basic workbench APIs for views, editors, action sets, and so forth is assumed.

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Table of Contents

1 Introduction

This document describes workbench internals and not API. The design of internals changes frequently. For information on newer Eclipse versions, the latest version of this document can be found on the UI development resources page .

Figure 1: Ownership of views and editors

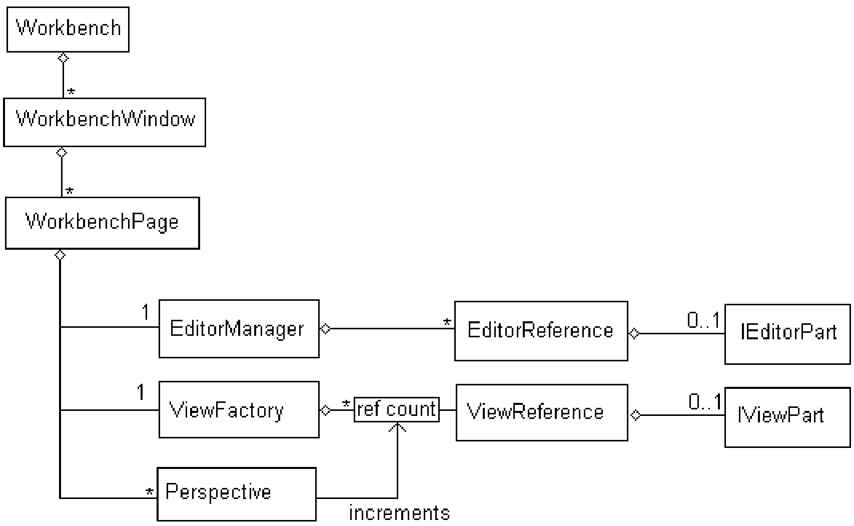


Figure 1 shows how views and editors are owned by the workbench.

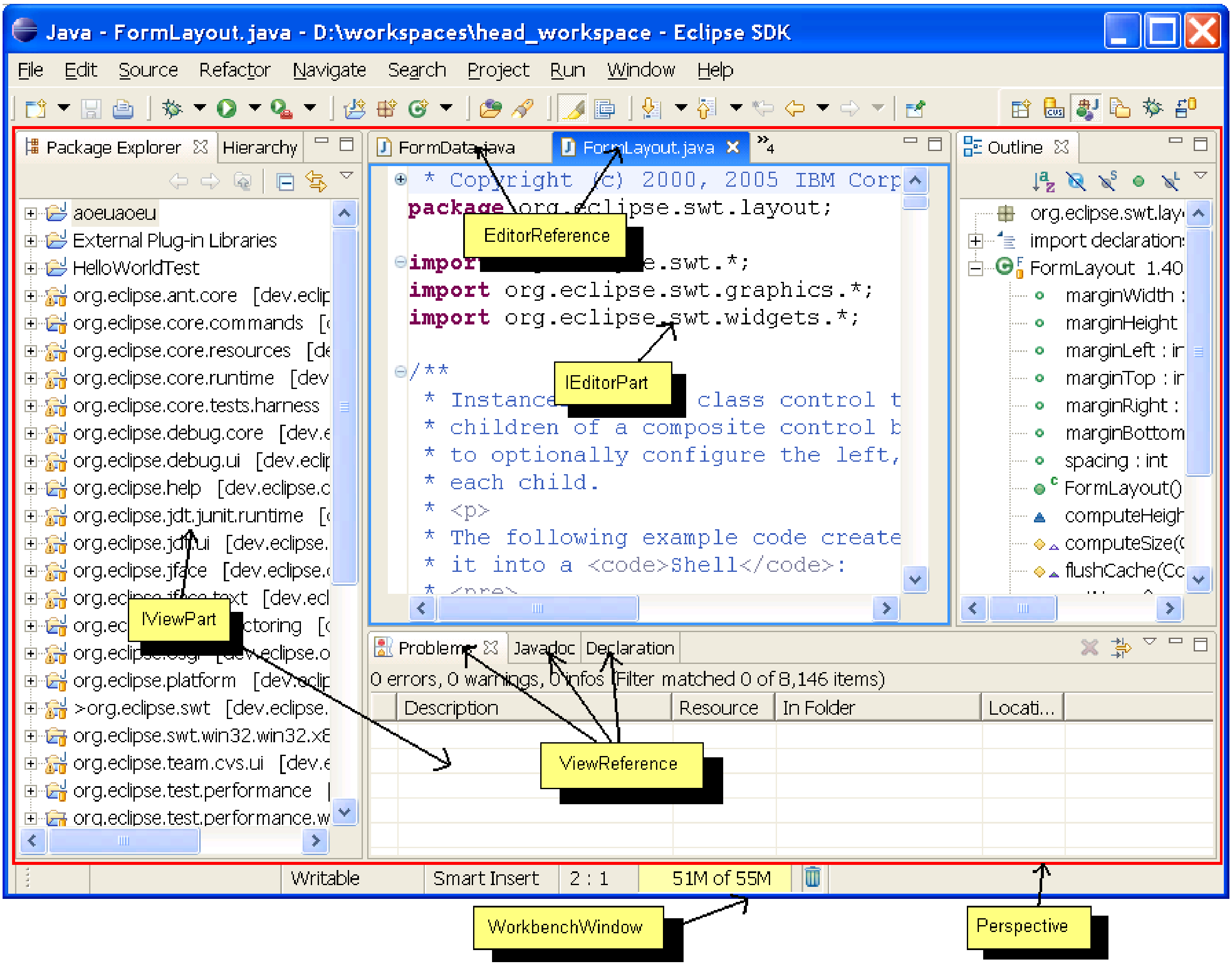
The Workbench contains one or more WorkbenchWindows, each of which contain zero or more WorkbenchPages. The WorkbenchWindow supplies the trim widgets, and the WorkbenchPage supplies the window contents. In theory, a WorkbenchWindow can contain any number of pages, but in practice there is never more than 1 page in a window.

Views and editors are owned by the page, through a ViewFactory and EditorManager respectively. EditorManager stores the list of editors and their shared resources, and ViewFactory stores a reference counted list of views. The workbench works in terms of EditorReferences and ViewReferences, and in this article the terms "editor" or "view" will refer to these classes specifically. In situations where the distinction between editors and views is not important, we will simply use the term "part". The implementation of the part (typically an IEditorPart or IViewPart) is created lazily when it is first needed. As shown in Figure 2, a part reference exists for every tab but the implementation is only created the first time it becomes visible.

The page owns a set of perspectives. Perspectives contain a layout and information about what action sets to enable. Although perspectives appear to contain views and the editor area, they only own a layout. The page itself maintains a reference count for how many perspectives are using each view, and has complete ownership of the parts and editor area.

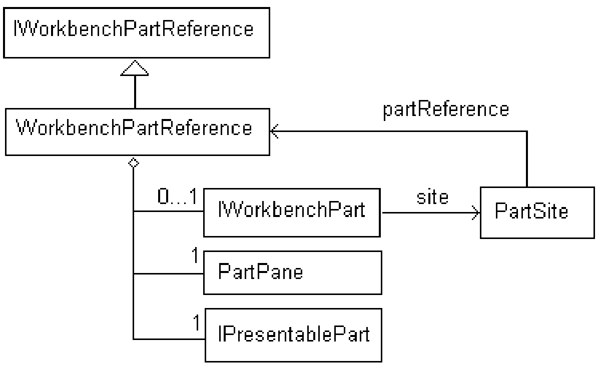
Not shown in figure 1 are the classes PerspectiveHelper and EditorAreaHelper. These classes exist largely for historic purposes, and in this article we will treat the former as though it were part of the Perspective class and the latter as part of the WorkbenchPage class.

Figure 2: Workbench objects and what they look like



2 Inside a part

Figure 3: Anatomy of a part



Internally, a part consists of several objects (Figure 3). WorkbenchPartReference is the topmost representation of the part. Depending on where it is used, the part reference is often exposed as IWorkbenchPartReference, IViewReference, IEditorRefenece, or IPresentablePart, or PartPane. These are essentially different interfaces to the same object. The I*Reference interfaces are implemented directly by WorkbenchPartReference and its subclasses. IPresentablePart is a simple adapter that redirects its methods directly to the part. PartPane implements the LayoutPart protocol which is needed to insert the part into the workbench layout. PartPane also manages the SWT resources (such as a top-level control) that are needed to include the control in the workbench layout.

The part implementation (the IEditorPart or IViewPart) is owned by the reference. When the implementation is created, it is given a PartSite. The PartSite (seen by client code as an IWorkbenchPartSite, IEditorSite, or IViewSite) allows the client code to communicate with the reference and manages services created for the implementation.

WorkbenchPartReferences allocates SWT resources lazily as needed. Once created, the part reference must be explicitly disposed. Disposing the reference cleans up all of its resources (including the part implementation itself) and guarantees that the reference will never allocate additional resources. The workbench page disposes the part reference once it is certain that it will never need to use that part again. Unlike SWT controls, it is valid to continue using the reference after it has been disposed. A disposed part reference is unlikely to do anything interesting besides returning its name and cannot be used with any methods in the workbench page. Since it is hard (or impossible) for clients to track the lifecycle of the reference, they are permitted to continue using its public interface after disposal.

2.1 Part Lifecycle

Figure 4: WorkbenchPartReference states

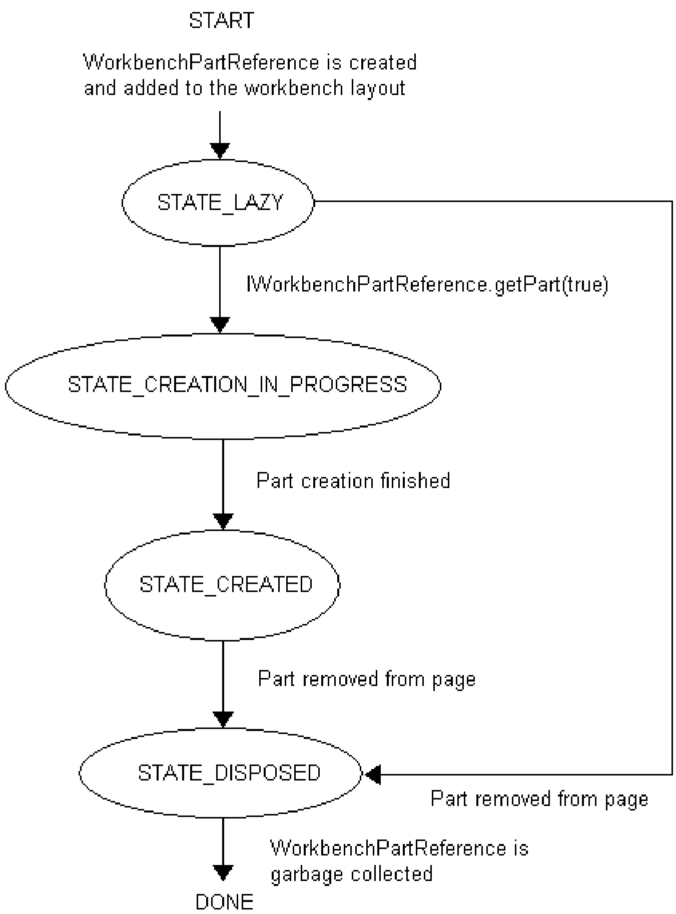


Figure 4 shows the part lifecycle as a state machine. The part reference stores its current state in the integer state field.

Notes:

- The part is in a distinct state while it is in the process of creating the implementation. It cannot be recursively re-created or disposed while it is in this state.
- The part implementation cannot be recreated once the reference has been disposed.
- Parts cannot return to the lazy state once they have been created. This is a limitation in the 3.1 implementation, not a functional requirement.
- It is valid to continue using the public interface of WorkbenchPartReference once it has been disposed, however a disposed reference cannot be passed to methods in workbench page (since it is, by definition, no longer part of any page).

2.2 Part Construction

Figure 5: Message sequence for creating a part

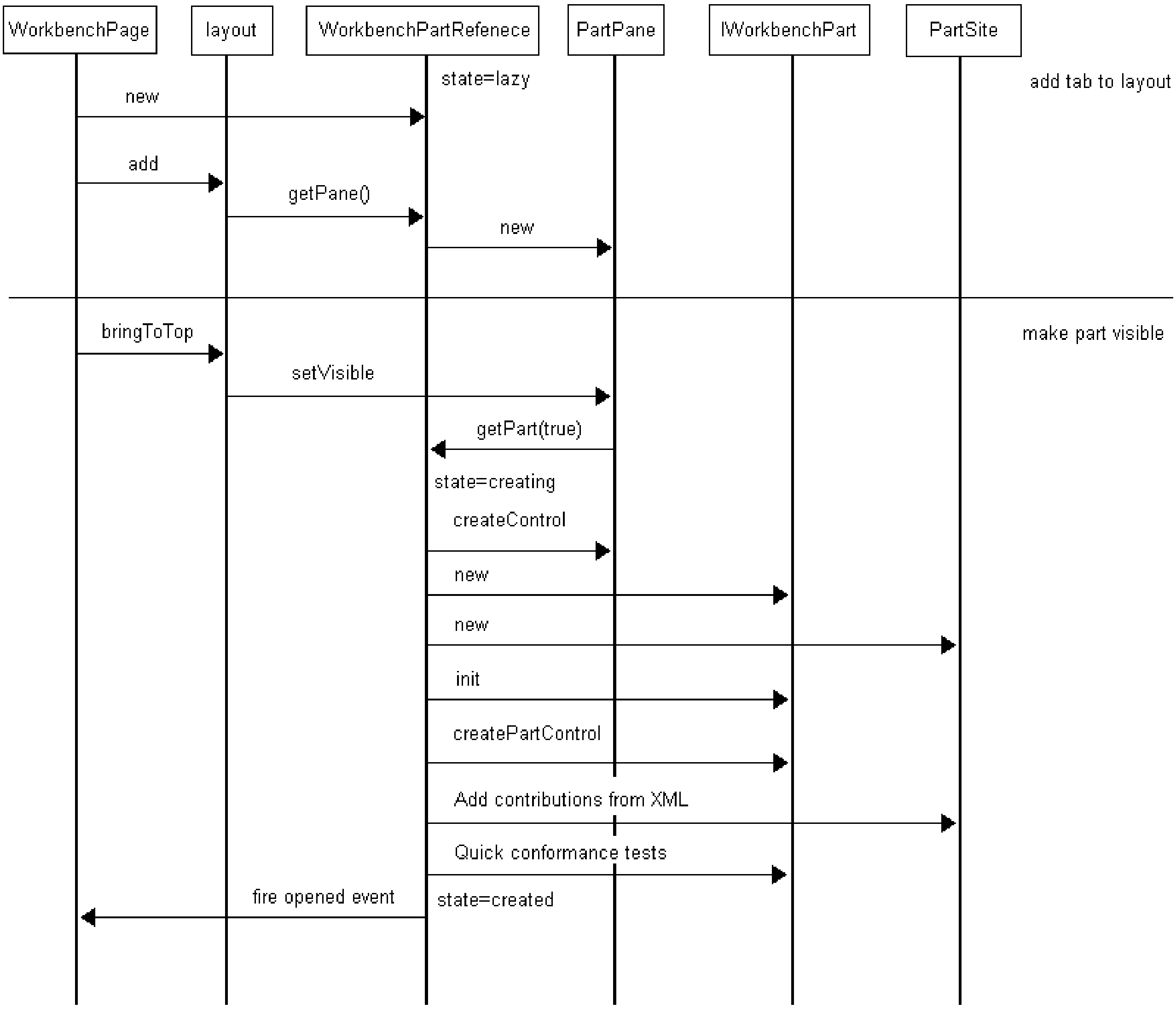
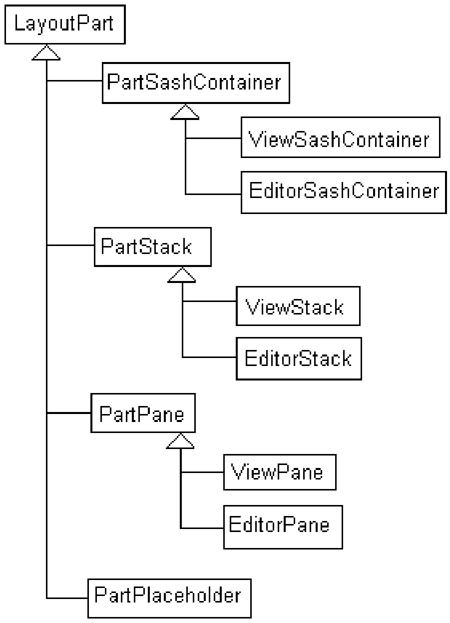


Figure 5 shows the process for creating a part. The horizontal line separates the two phases of creating a part. First the part is added to the layout, and then a real implementation is attached. These are two distinct operations, and the part can exist as a tab in the page with no implementation for some time before it becomes visible. This diagram focuses on the interactions with the part reference, and skips the details of adding the part to the presentation and creating the part site.

Suggestion: there are situations where it would be useful to only add the part to the layout if it can be created successfully (this would be necessary to pass a PartInitException thrown in the implementation's init method up through IWorkbenchPage.openEditor). In these situations, it would be possible to merge both operations into one atomic operation by creating the part before adding it to the layout. It is unknown if this would create event ordering bugs in client code.

3 Workbench Layout

Figure 6: LayoutPart hierarchy



The workbench layout provides supports arranging parts using drag & drop, resizing and detaching parts, fast views, etc. This section gives a quick overview of the layout mechanism.

Anything in the workbench layout is a LayoutPart. A LayoutPart manages a set of widgets in a rectangular region of the screen, can contain or arrange other layout parts, returns size constraints, responds to drag events, etc. To this extent, a LayoutPart is very similar to a custom SWT Control. However, LayoutPart differs from Control in several important ways.

- The LayoutPart hierarchy is not the same as the widget hierarchy. Even though one LayoutPart may contain another, their widgets may be peers. This allows drag and drop to work on platforms where SWT doesn't support reparenting, since a LayoutPart can be reparented without reparenting its widgets.
- LayoutParts mainly perform layout-related tasks, unlike Controls which also supply behavior and appearance. The behavior of a LayoutPart is supplied by the widgets it arranges.
- LayoutParts know about higher-level concepts like zoom, and can specify constraints about their own size.

Figure 6 shows the LayoutPart hierarchy. Notice the symmetry between the View* classes and the Editor* classes. These classes exist largely for historical reasons, and it should be possible to move all of the functionality into the Part* base classes or other objects in the system. Since all of the interesting behavior comes from the Part* classes, the remainder of this section will focus on them without describing the minor differences between views and editors.

PartSashContainer arranges a set of child parts separated by a bunch of sashes. This is the object that implements the most visible aspects of the workbench layout. It arranges rectangular regions separated by sashes, and allows new regions to be created by splitting old ones. It also supports the size constraints that make minimized views possible, and determines what it means for one of these regions to be maximized. Typically, a PartSashContainer contains a bunch of PartStacks, although it is also possible for it to contain another PartSashContainer. The latter case occurs since the editor area and the perspective both use a PartSashContainer for their layout and one is embedded inside the other. PartSashContainer owns its stacks but does not own an embedded PartSashContainer. In a workbench window, there is one PartSashContainer for each perspective and one for the editor area itself.

PartStack arranges a stack of PartPanes. PartStack allows the presentation API to participate in the workbench layout. The code for creating the tabs and arranging parts is supplied by the active presentation.

PartPane allows views and editors to participate in the workbench layout. Although PartPanes are arranged by PartStacks they belong to part reference, not the stack. The same PartPane can exist in more than one PartStack at a time if that part appears in more that one perspective.

3.1 An example layout

LayoutParts are best explained through example. Imagine a WorkbenchWindow that contains custom Java and Java Browsing perspectives that look like Figure 7 and Figure 8 respectively.

Figure 7: Example Java Perspective

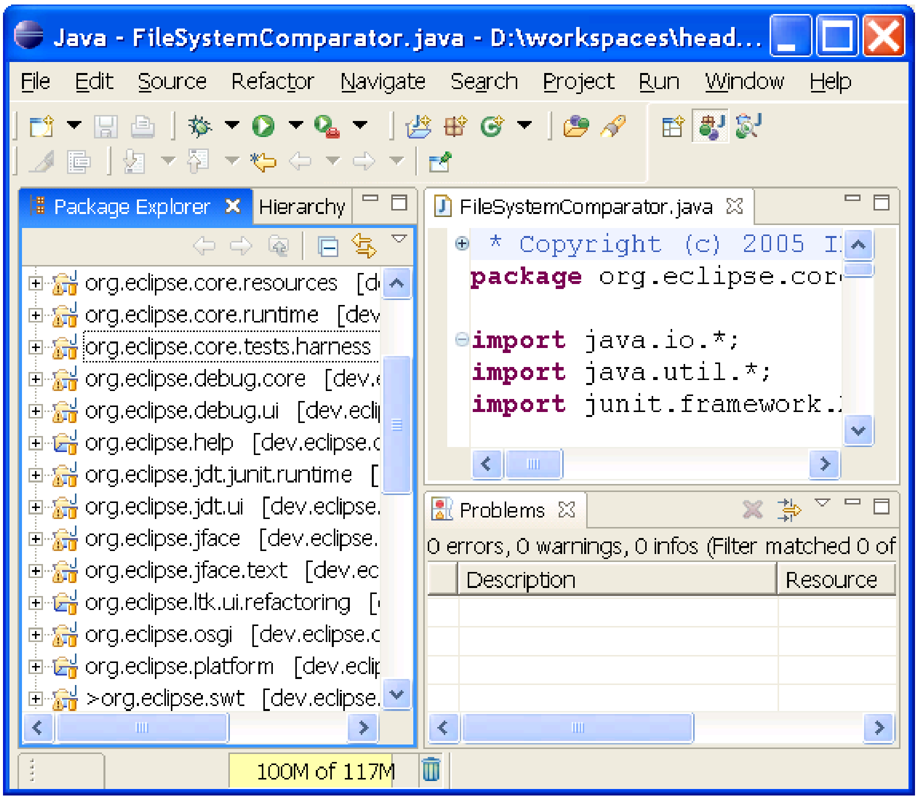
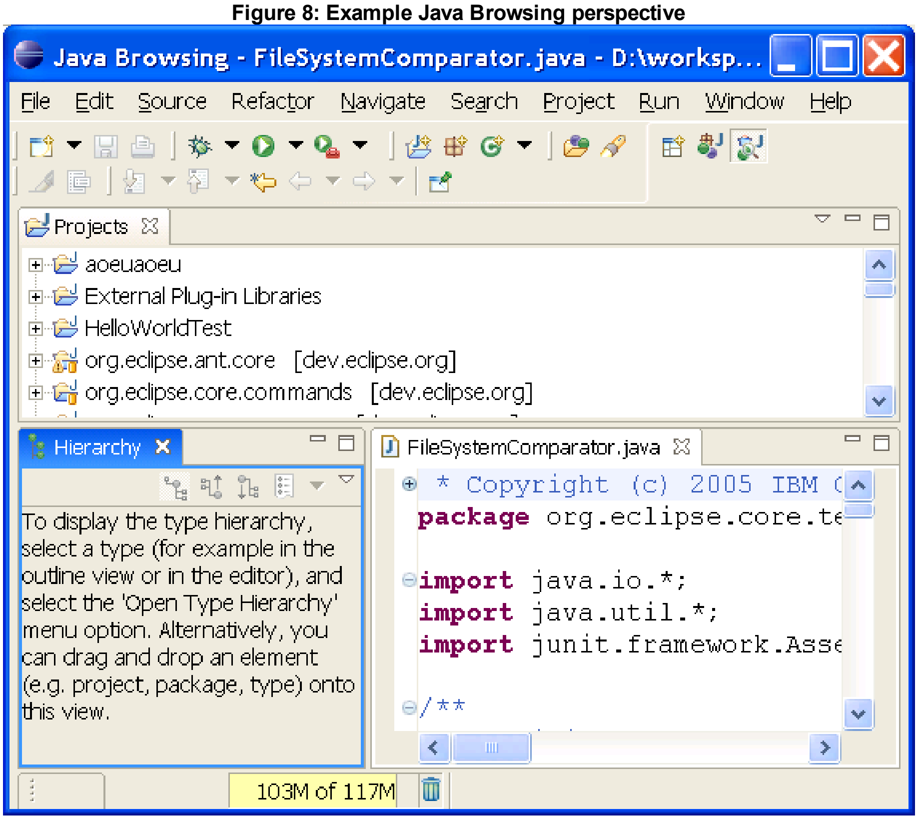
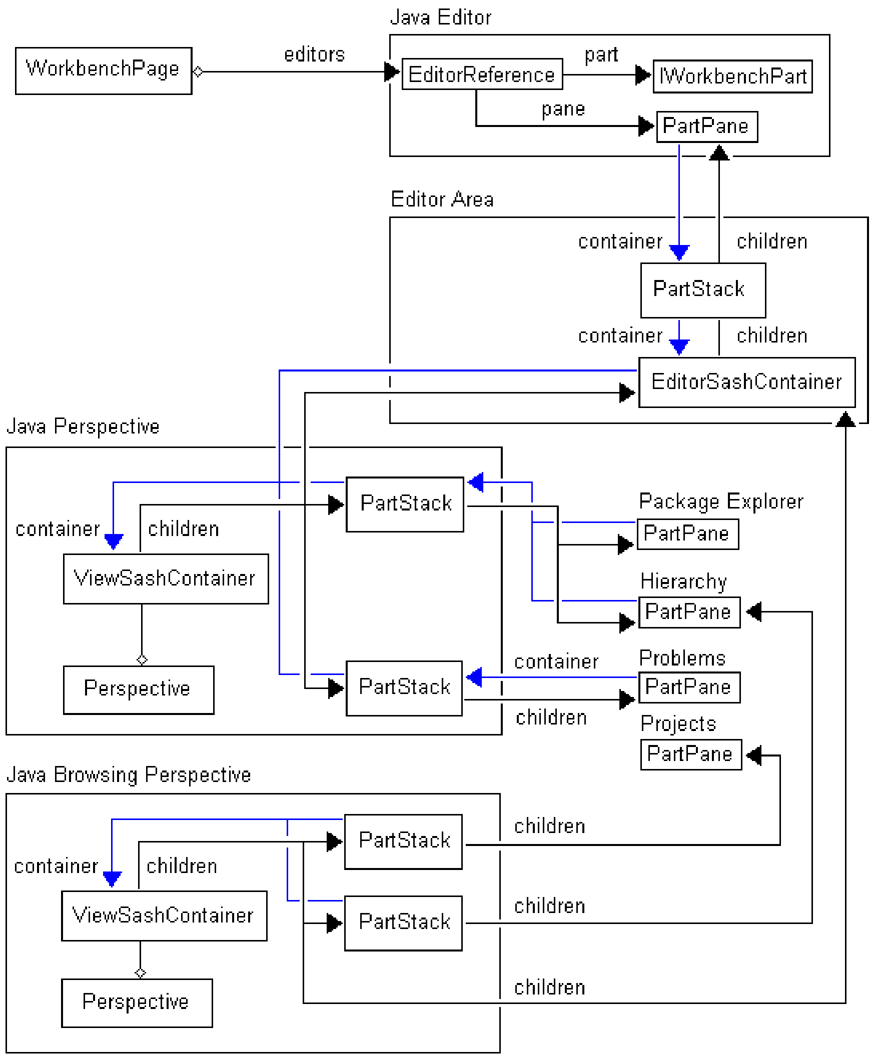


Figure 8: Example Java Browsing perspective



Assume that the window resembles Figure 7. In this case, the Java perspective is active, the Java Browsing perspective is hidden, and the objects are connected as shown in Figure 9:

Figure 9: LayoutPart instances when two perspectives are open



All LayoutParts have a container pointer that points to the object that is currently managing their position. Since the same LayoutPart instance may exist in more than one perspective at once, this pointer points to the part's container in the currently-active perspective. In the case of the projects view, above, the part is not in the current perspective so its container pointer is null. When another perspective becomes active, all the container pointers move to the new perspective. For historical reasons, this is accomplished by setting and clearing the contianer pointer when the container becomes visible or invisible. This works since only one perspective is visible at a time, but it also means that perspectives cannot be manipulated when they are invisible.

The diagram shows the internal objects that make up the only editor. Although this detail has been omitted for the views, they would look similar. Each view's PartPane is owned by a part reference which may have an associated part implementation.

3.2 Zoom / Unzoom protocol

The notion of "zoom" is defined locally between a part and its immediate container. Zoom changes are triggered bottom-up. A part asks its parent to "zoom me", and the parent either does something with the request or forwards the request up to its parent. Each container determines what it means for a child to be zoomed. Once a part's zoom state changes, its parent notifies it by calling setZoomed. The part may in turn zoom or unzoom one or more of its children.

Anything that can contain LayoutParts must implement the following methods, to support zooming:

```
/**
 * Called by child parts to request a zoom in, given an immediate child
 *
 * @param toZoom part to zoom in on
 */
public void childRequestZoomIn(LayoutPart toZoom);

/**
 * Called by child parts to request a zoom out
 */
public void childRequestZoomOut();

/**
 * Returns true iff the given child is obscured due to the fact that the container is zoomed into
 * another part.
 *
```

```
     * @param toTest part to test
     * @return true iff the part is currently obscured
     */
    public boolean childObscuredByZoom(LayoutPart toTest);

    /**
     * Returns true iff we are zoomed into the given part, given an immediate child of this container.
     *
     * @param toTest part to test
     * @return true iff this contianer is currently zooming in on the given part
     */
    public boolean childIsZoomed(LayoutPart toTest);
```

Consider again Figure 7. If we were to double-click on the java editor to zoom it, the LayoutParts would send messages to one another in the following sequence. (In this diagram, each cell represents a method call. Each column is an object. The reciever's column shows the method name and the caller contains an arrow. Rows are in ascending order of time.)

Java Editor (PartPane)	PartStack	editor area (EditorSashContainer)	ViewSashContainer
requestZoomIn			
⟶	childRequestZoomIn(java editor)		
	⟶	childRequestZoomIn(java editor's part stack)	
		if there were other editor stacks in the layout, we would call setVisible(false) on them here	
		remember the partStack as the zoomed part	
	setZoomed(true)	⟵	
setZoomed(true)	⟵		
		⟶	childRequestZoomIn(editor area)
			call setVisible(false) on all PartStacks for views in the perspective
			remember the editor area as the zoomed part
		setZoomed(true)	⟵
			trigger a layout
		setBounds(zoomed bounds)	⟵
	setBounds(zoomed bounds)	⟵	
setBounds(zoomed bounds)	⟵		
		trigger a layout (nothing to do)	

3.3 Layout protocol

Every LayoutPart can specify constraints on their size. Parts specify constraints by implementing the ISizeProvider interface. ISizeProvider serves a similar function as the computeSize method on an SWT control, in that the parent layout uses it to consult with the part when computing the part's size. ISizeProvider can provide a variety of constraints:

Constraint type	Meaning
Minimum size	Given the available space along one dimension, the part returns the minimum size that it can be compressed to along the other dimension. For example, a stack would typically set its minimum size to be large enough to fit its tabs. The information about available perpendicular space could allow a stack to have wrapping tabs and still reserve enough vertical space for the tabs once they are wrapped to fill the available horizontal space.
Maximum size	Given the available space along one dimension, the part returns the maximum size that it can utilize along the other dimension. For example, minimized stacks are implemented by setting their maximum size to the minimized size. Non-minimized stacks typically have an unbounded maximum size.

Preferred size	Given the availble space along one dimension and a preferred size, this returns the size closest to the preferred size at which the part would look best. Parts can use this to quantize their size. For example, a part can ensure that its size is always chosen such that it can be completely filled with toolbar icons leaving no space left over.

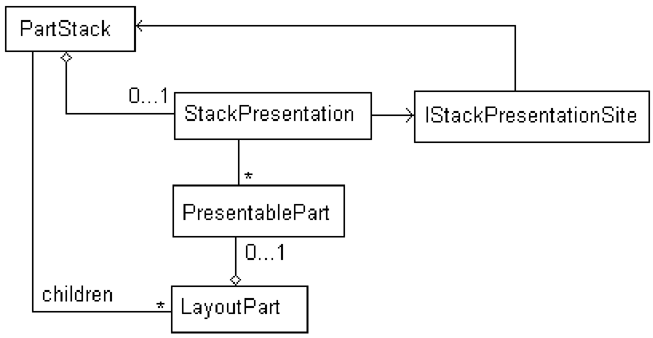
Although there are three kinds of constraints, they are all returned using a single method. See the JavaDoc on ISizeProvider for more information.

Whenever a size constraint changes, the part notifies its contianer by calling resizeChild(part). This tells the container to respond to the new constraints, and to resize the child if necessary (suggestion: if this is ever exposed as API, it would be better to separate the concerns of notifying the parent of changes and triggering a layout. In general, it may be possible for more than one part to change without requiring a layout between each change).

3.4 PartStack: Communicating with the Presentation API

PartStack allows presentation to participate in the workbench layout. As shown in Figure 10, it wraps a single instance of StackPresentation, and allows it the presentation to manipulate parts by converting each visible part into an IPresentablePart. The part stack outlives the StackPresentation. Whenever the part stack needs widgets, it creates the StackPresentation. If the widgets are no longer needed, it disposes the StackPresentation and remembers its persisted form. Whenever the PartStack persists its StackPresenation, it remembers the presentation ID so that it will not try to restore one StackPresentation from state saved by an incompatible presentation.

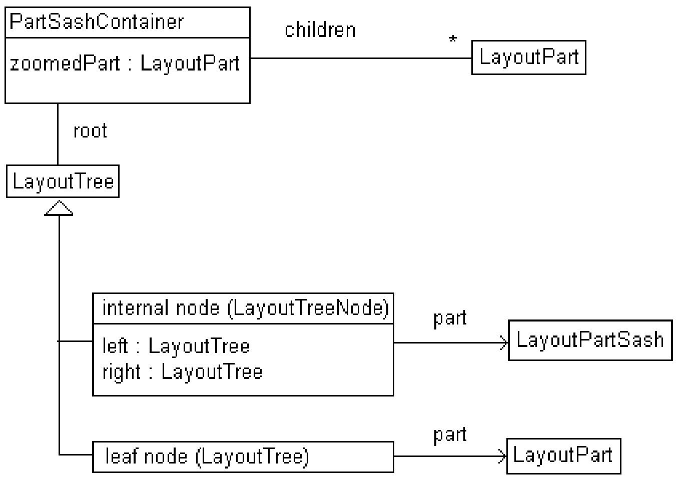
Figure 10: Anatomy of PartStack



Suggestion: it would be useful to update this document with a state diagram for PartStack, and message sequence charts for initializaiton and part activation.

3.5 PartSashContainer: The main workbench layout

Figure 11: PartSashContainer



PartSashContainer implements the main layout for a perspective and the editor area. As shown in Figure 11, PartSashContainer contains a list of children, a (possibly null) zoomed part, and a LayoutTree that manages the actual layout.

LayoutTree is a binary tree (technically, a KD tree). Each internal node is an instance of LayoutTreeNode. It contains a draggable sash (LayoutPartSash) that divides its area among its left and right children. LayoutTreeNodes can be horizontal or vertical based on the orientation of the sash. For horizontal nodes, the "left" child is on top and the "right" child is on the bottom. Leaf nodes are instances of LayoutTree (the base class), and they point to a LayoutPart that occupies that region of the screen. Normally, this is a PartStack, but in general it can be any LayoutPart.

Each LayoutTree occupies a recangular region of the screen that encompasses its children. Internal nodes keep track of an integer size for each child (implementation note: the sizes are stored in the associated LayoutPartSash, not the LayoutTreeNode itself). Normally, the left and right sizes are used as a ratio for dividing up the available space. However, when one child contains the editor area, the other becomes "non-compressible". If one side in non-compressible, the size value is interpreted as a fixed pixel size rather than a ratio. When the sash is moved, the size values are set to the current pixel sizes of the left and right children.

Figure 12 shows an example LayoutTree. If this tree were rendered in a workbench window, it would resemble Figure 3.5.3. The tall vertical sash separating the package explorer from the editor area is the root node. The left child is the leaf node holding the package explorer's stack. The right node is the horizontal sash separating the problems view from the editor area. The editor area itself is a PartSashContainer, which has its own LayoutTree. Note that the rounded rectangles in Figure 3.5.2 are LayoutParts. The upper portion of the rectangle is the part type and the lower portion is some text to help locate the part in the screenshot. In this example, every internal node has the editor area on one side of it, so all sizes are interpreted as pixel sizes and not ratios.

Figure 12: Example LayoutTree

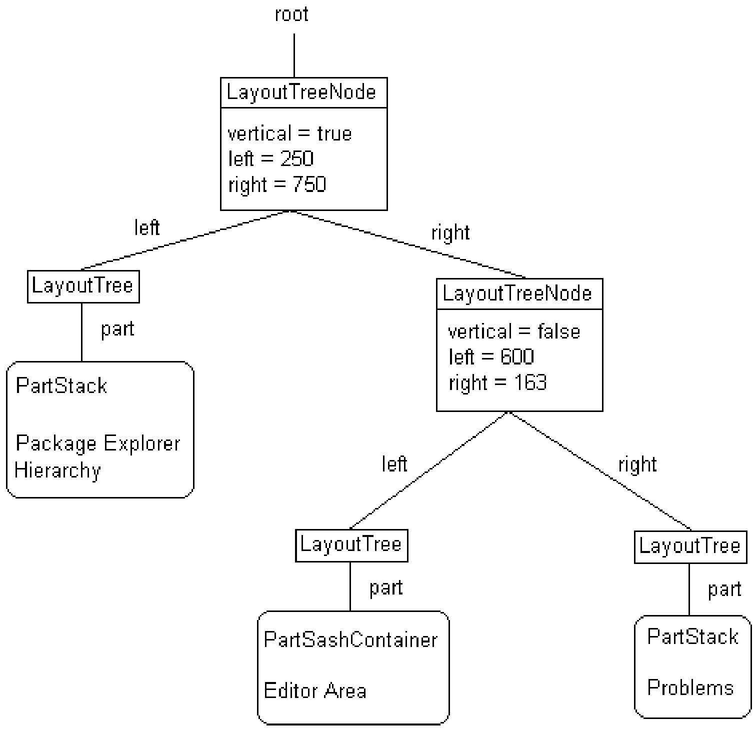
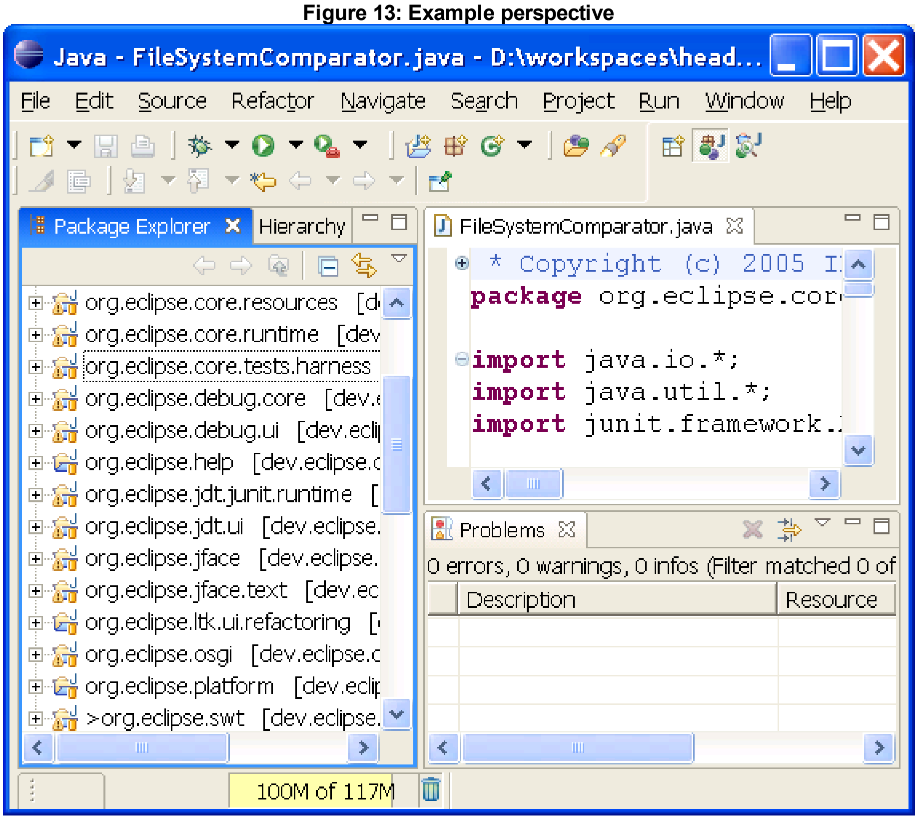


Figure 13: Example perspective



Like LayoutParts, LayoutTrees also implement ISizeProvider and support size constraints. For external nodes, the size constraints come directly from the LayoutPart. For internal nodes, the size constraints are computed from the child nodes as follows:

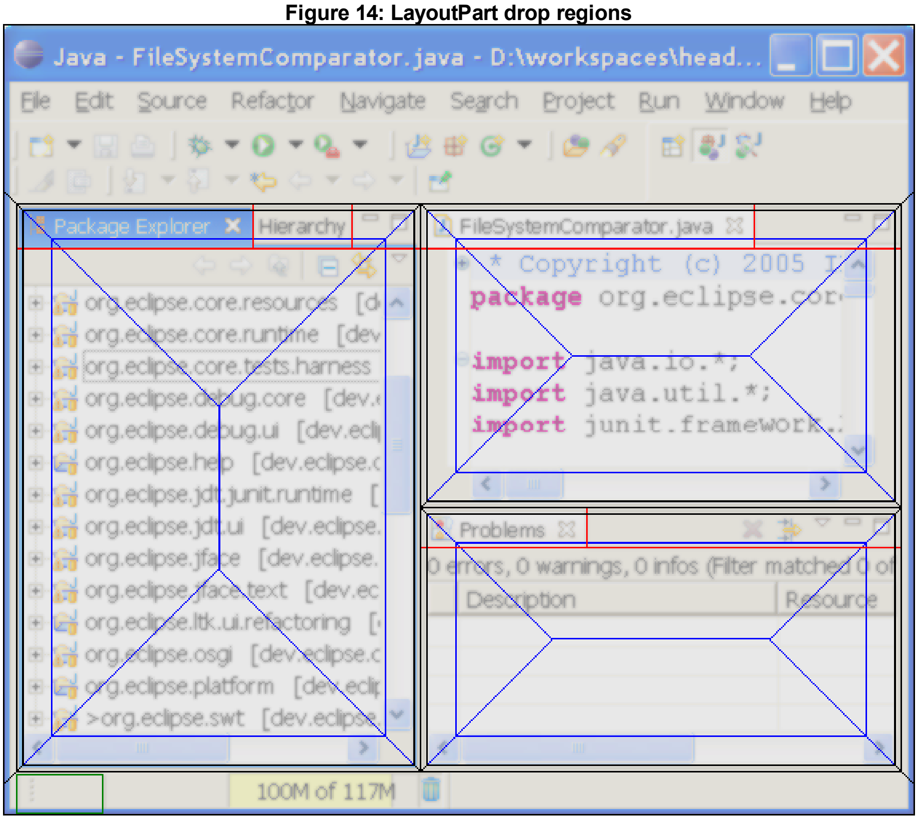
1. When computing a constraint perpendicular to the sash, the result is the sum of the constraints of the children plus the width of the sash.
2. When computing a constraint parallel to the sash, the result is the maximum of the constraints of the children

An example can help make this a little less abstract. Imagine we're computing the minimum width for the root node in Figure 12, which is a tall vertical sash. Width measurements are perpendicular to the sash, so we end up with case 1. The minimum width is the minimum width of the left stack plus the sash width plus the minimum width of the right child. This makes sense because if we made the root node any smaller, one of the three would need to be truncated or made smaller than their minimum size.

The "right child" mentioned above is the horizontal sash separating the problems view from the editor area. When computing its minimum width, we hit case 2: the minimum width of a horizantal sash is the maximum of the minimum widths of each child. Intuitively, this means that the child with the larger minimum size will be the first to reach its minimum when the layout gets small.

3.6 Drag / Drop

Figure 14: LayoutPart drop regions



Dragging a workbench part is triggered by calling DragUtil.performDrag. SWT controls can respond to drag / drop by registering an IDragOverListener with DragUtil .addDragTarget. If multiple drag listeners are registered for the same screen position, the one associated with the most specific control gets precidence.

Rather than register drag listeners directly, LayoutParts implement a getDropTarget method. When the window recieves a drag event, it delegates to the top-level LayoutPart's getDropTarget. Each part either delegates to one of its children or handles the drag event directly. If the part returns null from getDropTarget, this means that the part has no special preference for the drop event, and the parent may provide a default behavior. Unlike IDragOverListener, getDropTarget works top-down. The parent may overload any drag regions that are recognized by the child, or provide default behaviors for drag regions not recognized by the child.

Figure 14 shows regions of the workbench where LayoutParts can be dropped. The workbench checks these regions in the following order:

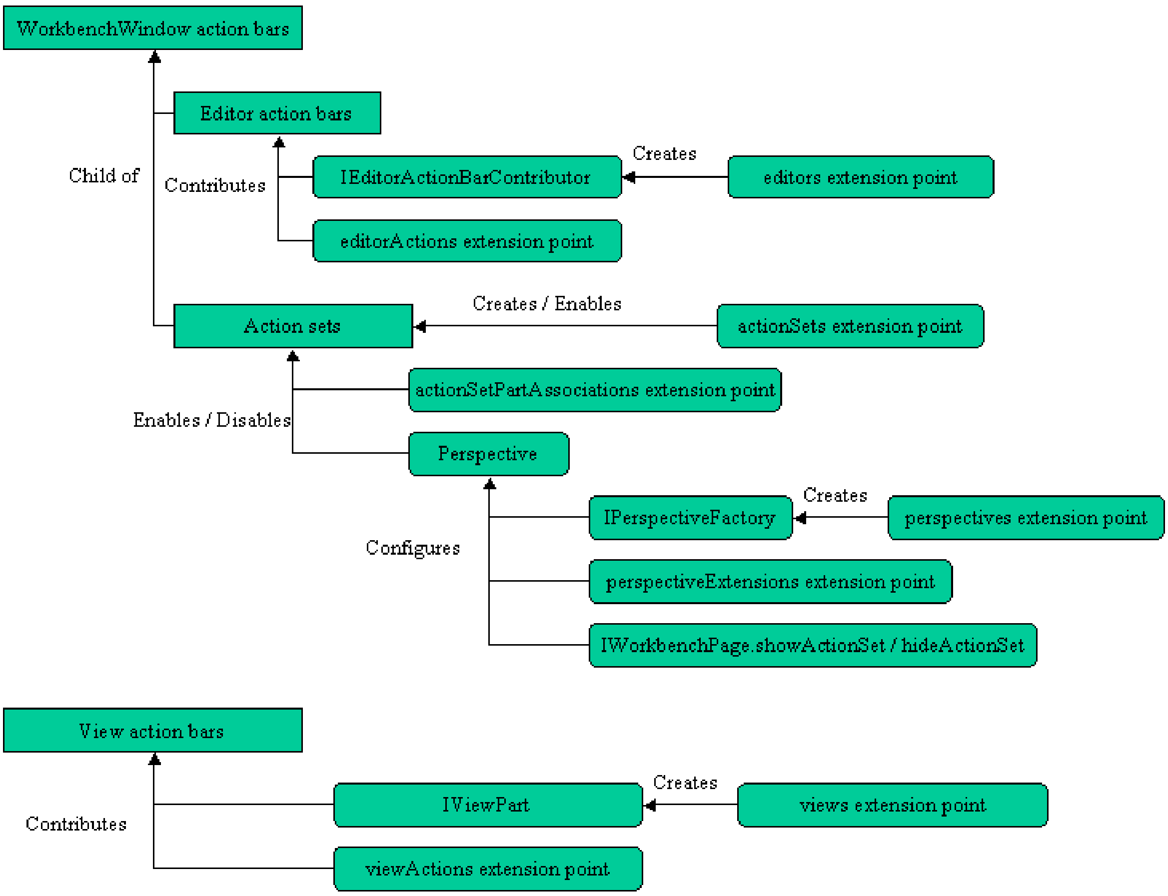
1. green region	The fast view bar registers a IDragOverListener that responds to views being dragged.
2. black regions	These areas are reserved by PartSashContainer.getDropTarget. When the user drags a part over this region, the PartSashContainer interprets this as a split and does not ask its child to participate in the drag. This ensures that it is never possible for the child to prevent splitting by reserving its entire area as a drop region. The region outside the PartSashContainer's client area is handled by an IDragOverListener registered with the shell. This allows parts to be attached to the edge of the layout by dragging over the window trim.
3. red regions	For most of the screen area, PartSashContainer delegates to its child (PartStack.getDropTarget). PartStack filters out objects that don't belong in the stack (no editors in view stacks, etc) and delegates to the presentation (StackPresentation.dragOver). The default presentation recognizes the tabs and title area as drop targets, but returns null everywhere else. This is the best practice for presentations and PartStack since it permits PartSashContainer to extend the split regions where possible.
4. blue regions	If the child doesn't have any particular use for the drop location, the PartSashContainer extends the split regions. If the child allows objects of this type to be added (determined by calling LayoutPart.allowsAdd), it uses the center of the rectangle for stacking. Otherwise, the entire region is used for splitting. The latter case occurs when dragging views over the editor area or when dragging over a standalone view.
5. outside the window (not shown)	The workbench page registers an IDragOverListener that responds to views being dragged outside the workbench window, and interprets this as a detach operation.

By convention, all methods used for drag / drop work in display coordinates.

4 Action Bars

Parts contribute to menus, toolbars, coolbars, popup menus, etc. using action bars. Each action bar implements IActionBars. It is possible to create one action bar as a child of another. In this situation, the parent and child share the same widgets, but the child may be disabled independently of the parent. Figure 15 shows how the workbench action bars are constructed. The rectangles indicate instances of IActionBars, and the ovals indicate other entities that create or modify action bars.

Figure 15: Action bar information flow



The workbench window has a top level IActionBars instance that contributes to the main menubar, coolbar, etc. (this top-level object is returned by WorkbenchWindow.getActionBars()).

4.1 Editor Action Bars

Each type of editor gets a reference-counted IActionBars instance that is a child of the window's action bars. For example, if the workbench contains 10 java editors and 10 text editors, it will create one IActionBars to be shared among the Java editors and another IActionBars to be shared among the text editors. Editors can access this shared instance by calling getSite().getActionBars(). Editor action bars are initialized by an instance of IEditorActionBarContributor, and additional actions are added by the editorActions extension point.

The reference counted IEditorActionBars are managed by the EditorManager, along with the IActionBarContributor.

4.2 Action Sets

An action set is an action bar that is identified by ID. Action sets are contributed by the actionSets extension point, and their action bars are a child of the workbench window's root action bars. Visibility of action sets is controlled by the following function:

$$(P \cup A \cup E \cup D) \cap !N$$

Where:

P = set of actions enabled in the perspective. Returned by Perspective.getAlwaysOnActionSets(). Initialized by the perspective factory, perspective extensions extension point, and IWonkbenchPage.showActionSet.
A = action sets associated with the active part (associated by the actionSetPartAssociations extension point).
E = action sets associated with the active editor (associated by the actionSetPartAssociations extension point).
D = action sets that are enabled by default (a property of the actionSets extension markup).

N = action sets that are explicitly disabled in the current perspective. Initialized by IWorkbenchPage.hideActionSet.

The sets P and N are persisted with the current perspective between sessions. The sets A and E can change every time the active part or editor changes.

The workbench page uses the class ActionSetManager to compute action set enablement. This class keeps two reference counts for each action set:

- a "showCount" indicates how many of P, A, E, and D the action set appears in
- a "hideCount" indicates whether the action set appears in N

The action set is visible iff showCount is nonzero and hideCount is zero.

4.3 View Actions

Each view instance is given its own IActionBars instance. Unlike editor action bars, these are not shared and are not a child of the workbench window's root action bars. This means that view instances can programmatically add actions to their action bar. Additional actions are also added to a view's action bars through the viewActions extension point.

5 General Conventions

This section describes coding conventions that apply to the entire workbench.

5.1 Objects must not be returned through API until they are fully initialized

Some objects require several public methods to be called in a specific order before they are considered fully initialized. For example, to initialize an IViewPart, it is necessary to call the constructor, setInitializationData, init, and createPartControl before the part is considered initialized. Until *all* of the above have happened successfully, it must not be possible to reach the object through any API method.

Keep in mind that the object may trigger other client code during its own initialization, so it should not even be possible for an object to find itself during construction.

5.2 No method may open a modal dialog unless its JavaDoc says so

Any method that has the possibility of opening a modal (or of calling Display.readAndDispatch through any other means) needs to be clearly documented. All callers of that method must be prepared to handle background threads running arbitrary code in *syncExecs during the method call. It is always a bug to open a modal dialog when extending or overloading a method unless the JavaDoc in the base class says otherwise. Permitting opening of dialogs in a method that did not previously do so is a breaking change for all callers of that method.

Some common bugs:

- Views are never allowed to call MessageDialog.openError from their createPartControls method, especially when handling an exception.
- Parts can be closed in a *syncExec. If a part calls a method that opens dialogs, it might not still exist when the method returns. After calling the method, the part must check that it hasn't been disposed before using their widgets or accessing any members that would have been deallocated by the disposal.

5.3 Lazy creation should happen as late as possible

Part implementations should be created at the latest possible moment. The workbench's internal state should be restored as much as possible before the first object is created from an extension point. Parts should not be materialized until they are needed.

5.4 getters should not modify the thing they are supposed to measure

This applies to any situation where there is a getter and an associated listener that monitors changes in the getter's value. The getter should never cause such a property change to be fired while computing its return value.

For example, IWorkbenchPage.getActivePart() should never create the active part. Unless the active part already exists and a property change was fired to all IPartListeners, getActivePart must return null.

To discuss or report problems in this article see bug 103958.