HIView Programming Guide

Carbon > User Experience

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Introduction to HIView Programming Guide

Note: This document was previously titled *Introducing HIView*.

HIView is an object-oriented view system for implementing Carbon user interface elements. *HIView Programming Guide* explains the concepts behind the HIView model, covering the view embedding hierarchy, composited drawing, and the new drawing coordinate system. This document also contains instructions and sample code for implementing common HIView tasks, such as creating and embedding views, automating view layout, drawing in views, implementing some new view-based controls, and subclassing views to create your own custom user interface elements.

HIView Programming Guide assumes you are familiar with the basics of creating and manipulating Carbon controls in Mac OS X. If you are not familiar with using Carbon controls, see the document *Handling Carbon Windows and Controls*.

Organization of This Document

This document contains two chapters:

- "HIView Concepts" (page 9) explains the concepts behind the HIView model.
- "HIView Tasks" (page 19) contains instructions and sample code for implementing common HIView tasks.

HIView Concepts

This chapter explains the concepts behind the HIView model, covering the view embedding hierarchy, composited drawing, and the new drawing coordinate system. It also describes how HIView relates to older controls and menus, and introduces some new HIView-only controls.

What Is HIView?

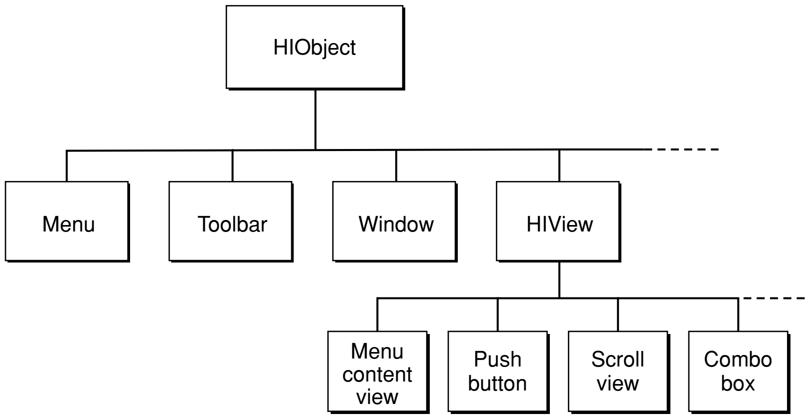
HIView is a new object-oriented view system available for implementing Carbon user interface elements. Beginning with Mac OS X v10.2, all of the standard controls can now be considered views. From Mac OS X v10.3 onwards, all standard menu content is also displayed using views. HIView also introduces several new view-based controls.

Advantages of HIView include the following:

- Quartz is the native drawing system, but you can still use QuickDraw if you want to.
- The modern coordinate system is not limited by the 16-bit space of QuickDraw. Floating-point coordinates are valid.
- There is a simplified coordinate system for view bounds and the position of a view within its parent.
- Views can be ordered within a hierarchy layer; that is, it is easy to place views behind or in front of other controls.
- Views can be easily attached and detached from windows. You can even retain a view separate from an owning window.
- The object-oriented nature of views makes it easy to subclass your own custom views.

HIView is a subclass of HIObject (also introduced in Mac OS X v10.2), which is the base class for all user interface objects in Carbon. Figure 1-1 shows how HIView fits into the HIObject class hierarchy.

Figure 1-1 The HIObject class hierarchy



HIView Versus the Control Manager

You can think of HIView as a more modern superset of the older Control Manager API. The HIView mechanism underlies all the workings of the current Control Manager, so just about all the standard controls can now be considered views.

HIView views use a special compositing procedure when drawing. Views are drawn from back to front, and your drawing routines have the opportunity to avoid redundant drawing when views overlap. You cannot gain the advantages of views unless you specify the compositing attribute when creating the window that contains them. Note that as compositing is enabled on a per-window basis, you can have both compositing and noncompositing windows in the same application.

Note: The following controls do not support compositing and therefore cannot not be used as views: the (non-Unicode) editable text control, the list box control, and the scrolling text field control. The data browser control supports compositing in Mac OS X v10.3 and later.

If you choose not to enable compositing, all the older Control Manager functions work as they did before.

If you enable compositing, all Control Manager controls (as defined in `ControlDefinitions.h`) gain the properties of views. For example, a checkbox created with `CreateCheckBoxControl` can be ordered in front or behind other views, may be detached from a window, and can be subclassed to create a custom checkbox. You can manipulate views using Control Manager functions or (if they exist) comparable HIView functions. For example, to get the bounds of a checkbox, you could call `GetControlBounds` or `HIViewGetFrame`. Functions that took a `ControlRef` parameter can now take either a `ControlRef` or an `HIViewRef` parameter. In addition, HIView functions that provide new functionality (such as `HIViewAdvanceFocus`) automatically work with the older controls.

Important: Certain Control Manager functions, such as `DrawControls`, `Draw1Control`, and `UpdateControls` are inappropriate for the HIView model and should not be used in compositing mode. See "Drawing in Views" (page 28) for more information.

HIView also introduces new view-only user interface elements as described in "New HIView User Interface Elements" (page 15). These new elements appear in `HIView.h`.

HIView Versus the Menu Manager

Technically, the actual menu (as defined by the menu reference) is an HIObject. However, what the user sees as a menu is a menu content view, which is embedded within a compositing window. The menu content view , which contains the individual menu items that the user can select, is essentially a view-based control, which means that you can manipulate it using Control Manager or HIView functions.

In Mac OS X v10.3 and later, all standard menu content is rendered using views. This translation occurs "under the hood," so you do not need to modify your existing menu code to adopt views. However, view-based menus are both simpler and more flexible than old-style menus, so if your code contains custom MDEF-based menus, you should consider re-implementing them as views.

Views Versus Controls and Menus

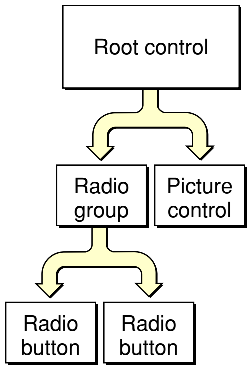
In the new HIView world, all controls are views and vice versa. In fact, the new `HIViewRef` type is exactly the same as the older `ControlRef` type. For the purposes of this document, the term *view* refers generically to any view object; that is, a new user interface element introduced with HIView or an older Control Manager control. The term *control* refers specifically to a Control Manager control.

As stated previously, the menu (as represented by the `MenuRef` type) is an HIObject but the Menu Manager displays its contents using a menu content view. For the purposes of this document, *menu* refers to the actual menu object, while *menu content view* or *menu view*, refers to the HIView used to display the menu content.

View Hierarchies

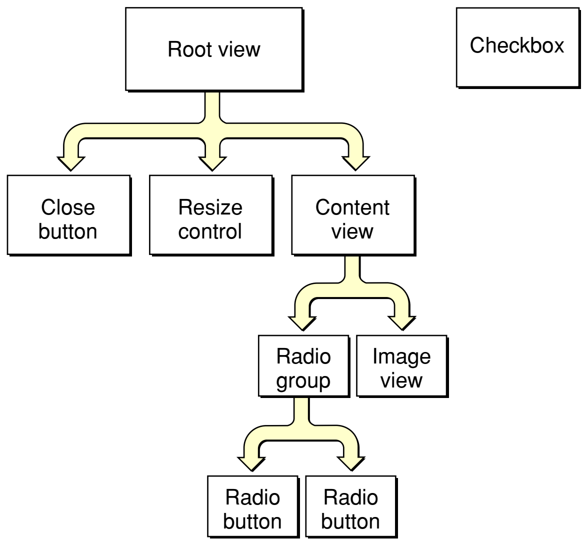
Both HIView and the Control Manager rely on a hierarchy of user interface elements. The two hierarchies are similar, but there are important differences. The old control hierarchy is shown in Figure 1-2.

Figure 1-2 An older control hierarchy



The control hierarchy dealt only with items in a window's content region. Items such as the close button and resize control were not contained in the hierarchy. However, in a view hierarchy, everything within a window is considered a view and is accessible to the application. Figure 1-3 shows a sample view hierarchy.

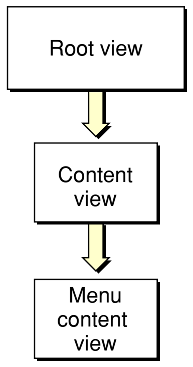
Figure 1-3 A view hierarchy for controls



The view hierarchy contains a content view which is equivalent to the root control in the old Control Manager control hierarchy. The content view contains all views that are visible in the window's content area.

The view hierarchy for menus is much simpler, as shown in Figure 1-4. Each menu content view is contained within a window, root view, and content view. The menu content view contains whatever is to be displayed in the menu, typically a list of menu items, although that is not a requirement. Note that a submenu is considered to be a separate menu and therefore belongs to its own window.

Figure 1-4 A view hierarchy for menus



A view can contain one or more **subviews**. The parent of a view is called the **superview**.

Note that Figure 1-3 (page 12) shows a checkbox appearing outside the hierarchy. While all controls must be associated with a window and must be contained within the control hierarchy, views can exist separate from an owning window. You can remove a view from a window, hold onto it for a while, and then embed it later (possibly within a different window). Views also don't require an owning window when you first create them.

The Root View

The root view is analogous to the Control Manager root control as it represents the top of the view hierarchy in a window. Like a root control, the root view is not visible, but merely acts as a receptacle for embedding other views.

The root view is actually a little higher in the hierarchy than the old Control Manager root control, as it contains all the standard window controls (close, minimize, and zoom buttons, resize control, and so on), not just what's in the content region. The root control is now equivalent to the content view (and calling `GetRootControl` in compositing mode returns the content view). Use the `HIViewGetRoot` function to obtain the true root view.

Calling the Control Manager function `CreateRootControl` while in compositing mode returns an error, `errRootAlreadyExists`.

Embedding and Ordering

HIView lets you embed views within other views, much like embedding controls. However, each of the views embedded within a superview can be ordered within the embedding layer. For example, say you have a content view that contains a picture view and a button. You can deliberately order the views in the content view to make sure that the picture is behind the button. See "Embedding Views" (page 20) and "Ordering Views" (page 26) for descriptions of the functions used for embedding and ordering views.

As stated earlier, views do not necessarily have to be in the embedding hierarchy; they can exist by themselves, and you can move them from window to window if desired.

The Drawing Model

HIView uses a special composited drawing method to minimize the amount of drawing that is necessary. Ideally, each opaque pixel is drawn only once, and only areas that are visible are drawn.

Views are drawn in order according to the view hierarchy and the order of the view within a hierarchy layer. At each level in the view hierarchy, an embedding view is drawn first, followed by its embedded views; the embedded views are drawn in bottom-up order. This drawing process means that embedded views are visible above the embedding view. It also means that a view ordered higher in the embedded view appears on top of those ordered below it. For example, for views in the window content area, the content view is drawn first, followed by the bottommost of the views embedded in the content view. If an opaque portion of a view overlaps a view beneath it, HIView informs the lower view, so it can avoid drawing into the overlapping area.

Note: The HIView compositor is not the same as the Quartz compositor. The Quartz compositor calculates pixel values of screen elements based on translucency and so on before rendering them onscreen.

Note that all drawing inside a compositing window must be done from within a view; that is, if you have custom content to display, you must create a custom view with a draw event handler to render your content. You cannot draw directly into a compositing window using classic event record–based update events or Carbon `kEventWindowUpdate` or `kEventWindowDraw` events; compositing windows do not receive these events.

The HIView drawing model does not support drawing to the screen outside of a `kEventControlDraw` event handler. If you want to redraw a view, you should mark areas as being invalid using the `HIViewSetNeedsDisplay`, `HIViewSetNeedsDisplayInRegion` or, in Mac OS X v10.4 and later, `HIViewSetNeedsDisplayInRect` and `HIViewSetNeedsDisplayInShape` functions. You draw only when the system tells you to do so by calling your `kEventControlDraw` handler.

This delayed drawing model is required to support correct compositing of overlapping views. Before your view draws itself, all views underneath it must have a chance to draw first, so that your view's drawing can be composited on top of views beneath it. Only by invalidating your view and allowing the Control Manager to manage the order of drawing can this compositing effect be achieved. Invalid views are automatically redrawn when your application allows the event loop to run; therefore, if you are updating the content of your view in response to user input, you should make sure to return to `RunApplicationEventLoop` or `WaitNextEvent` promptly after invalidating the view, so that the view hierarchy may be redrawn.

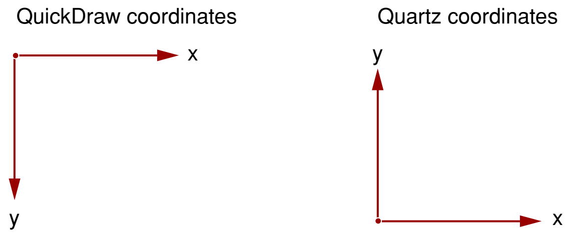
Note that you can force a redraw immediately by calling the `HIViewRender` function (available in Mac OS X v10.3 and later). However, you should not use this function indiscriminately, as it can cause performance issues.

The Coordinate System

HIView supports both Quartz and the older QuickDraw drawing systems. These drawing systems use different coordinate systems, as shown in Figure 1-5.

Note: The QuickDraw coordinate system is identical to the default drawing coordinate system on Windows.

Figure 1-5 The QuickDraw versus Quartz coordinate systems



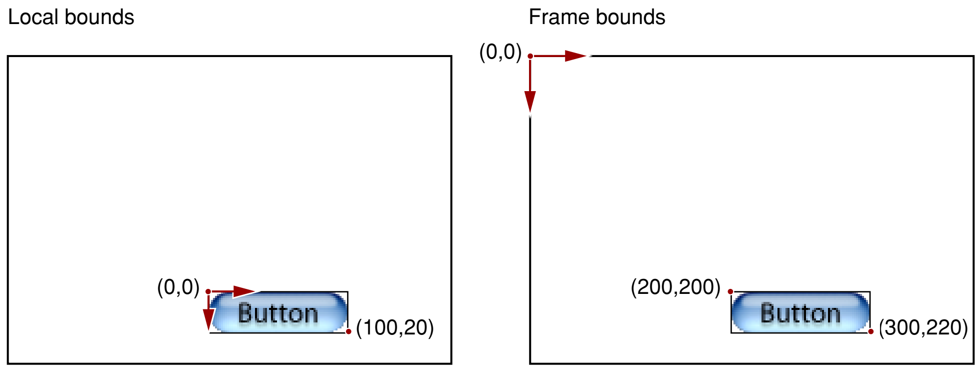
One drawback to the Quartz orientation is that the coordinates of objects within a window can change if the window is resized. To minimize confusion when drawing, HIView automatically transforms the Core Graphics context that it passes to your drawing routines, flipping the axis to match the QuickDraw coordinate system. This transformation means that you can do most of your Quartz drawing just as if you were drawing in a QuickDraw environment.

However, because the context is flipped, if you are drawing images using Quartz, the usual `CGContextDrawImage` function will draw upside down. To avoid having to translate your image bounds on-the-fly, you can call the utility function `HIViewDrawCGImage`. This function temporarily transforms the context back to the "normal" Quartz orientation before drawing the image.

HIView simplifies the process of placing items within a view by using a coordinate system that is always view-relative. For example, the placement of objects within a view (as well as any drawing or hit testing) is done relative to that view. That is, the origin is in the upper left corner of the view. The coordinates of items in the view won't change even if the view itself is moved. This relative coordinate system makes it much easier to calculate the position of views and the objects within them.

You can determine the bounds or position of a view in two different ways. The **local bounds** of a view refers to its bounds relative to its own coordinate system. The **frame bounds** of a view refers to its bounds relative to its parent view (or superview). Figure 1-6 shows the difference between the local and frame coordinate systems for a button embedded in a content view.

Figure 1-6 A button's local bounds versus its frame bounds



HIView also defines several new data types for positioning elements in its coordinate space:

- The type `HIPoint` defines a point in floating-point coordinates, and it replaces the QuickDraw-based `Point` in mouse events. Note that you do not need to update your QuickDraw-based mouse event code; if you attempt to obtain a mouse event parameter with the `typeQDPoint` type, the `HIPoint` is converted to a QuickDraw `Point` type. The `HIPoint` type is equivalent to a Core Graphics `CGPoint` type.
- The type `HISize` defines the dimensions of an element (but not its position) in floating point coordinates. It is equivalent to the Core Graphics `CGSize` type.
- The type `HIRect` is a structure that defines the size and position of a rectangle in floating point coordinates. Note that while it replaces the QuickDraw `Rect` type, the `HIRect` structure does not contain the same fields. The `HIRect` type is equivalent to a Core Graphics `CGRect`.

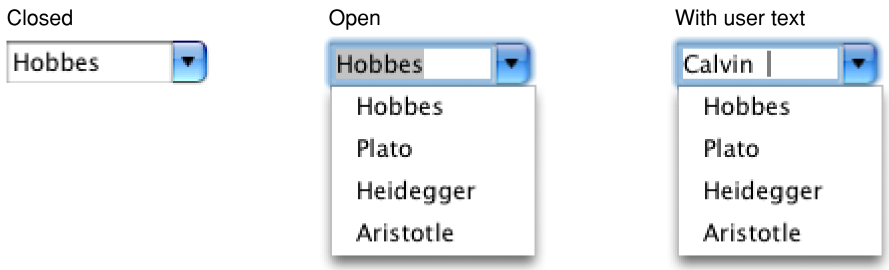
New HIView User Interface Elements

HIView introduces several new user interface elements that are specific to HIView. Moving forward, all new control-like elements will be based on HIView.

Combo Box

The combo box is a combination of an editable text field and a pop-up menu. The user can enter text into the field or choose a text item from the pop-up menu. Typically you use combo boxes if you have several preselected text options available but still want to give the user the option of entering other choices. Although you could build combo box functionality from several older Carbon controls, the HIView combo box provides a much simpler alternative. Figure 1-7 shows the combo box.

Figure 1-7 The combo box



Note that the combo box automatically turns into a scrolling list if you exceed a specified number of pop-up menu items (the default is six) or if the number of items exceeds the maximum specified pixel height for the box.

Image View

The image view is similar to the older Carbon picture control in that it simply holds an image. The advantage of having an image be a view is that you can rely on the system to redraw and update the image as necessary. You can also use the image view in conjunction with the new scroll view to make it easy to display images in a scrollable viewing area.

Scroll View

The scroll view control provides a simple way to display scrollable information. It provides a view into a "canvas," which is actually an embedded subview. For example, you can embed an image view within a scroll view and specify certain parameters such as the size of the viewing window and the offset of the view in relation to the total canvas. The scroll view automatically handles scrolling and live updating of the image. Again, while you can build similar functionality using older Carbon controls, the scroll view makes the process much simpler.

Search Field

A search field is a specialized text field that lets the user enter search information. This is the standard search field you see in Mail and Safari, for example. You can also specify a pop-up menu containing items to tune the search. In the HIView-based implementation, when the user enters text, the search field view sends that text to your application using a Carbon event so you can take any appropriate actions.

The search field is available in Mac OS X v10.3 and later.

Segmented View

A segmented view is partitioned control that operates as a group of buttons, each of which may be configured differently (with radio behavior, stickiness, and so on). The Finder uses a segmented view to allow switching between icon, list, and column views.

The segmented view is available in Mac OS X v10.3 and later.

Text View

The text view is a container for holding text. You can use text views whenever you need to handle or display text but don't want to use heavyweight text manipulation code. Text views use MLTE (Multilingual text engine) to display and manipulate text and, as such, supports Unicode, mixed style runs, copy-and-paste, drag-and-drop, and so on.

The text view is available in Mac OS X v10.3 and later.

Web View

The web view is simply a container (such as an image view) designed to hold web content. As with an image view, the system handles updates and redraws, requiring you to draw only when the web content actually changes.

Currently you must use Objective-C calls to load and manipulate web content within a web view. For more details, see the document *WebKit Objective-C Programming Guide*.

The Web view is available in Mac OS X v10.3 and later or when Safari 1.0 or later is installed.

HICocoaView

Cocoa provides views that are either not currently available in HIToolbox or are available without full support. These include views such as `WebView`, `PDFView`, `QTMovieView`, and `NSTokenField`. In addition, the Cocoa and Carbon control hierarchies are incompatible, so it has been difficult or impossible to have views from both frameworks embedded within the same window.

A new type of HIView called HICocoaView provides a general solution to these problems. You can embed a Cocoa view (any subclass of `NSView`) inside the HIView control hierarchy of a Carbon window. This is accomplished by associating the Cocoa view with a Carbon wrapper view called HICocoaView, a subclass of HIView. You can use standard HIView functions to manipulate the wrapper view, and you can use Cocoa methods to manipulate the associated Cocoa view. HICocoaView is supported only in compositing windows.

HICocoaView is available in Mac OS X v10.5 and later. For more information, see *Carbon-Cocoa Integration Guide*.

HIView Tasks

This chapter contains instructions and sample code for implementing common tasks involving HIView, such as creating and embedding views, automating view layout, drawing in views, and implementing some new view-based controls. It also contains information about subclassing views to create your own custom user interface elements.

Enabling Compositing in Windows

Windows that use HIView must have compositing turned on. Compositing means that HIView draws window content view by view, from back to front, allowing each view to draw only the portions of itself that are visible. That is, you don't have to worry about inefficient drawing resulting from drawing on top of existing pixels.

Turn on compositing by setting the compositing window attribute. You can do so in the Info window in Interface Builder or by adding `kWindowCompositingAttribute` to the attribute list when you call `CreateNewWindow`. Note that older window creation functions don't allow compositing.

Important: You must set the compositing attribute when you create the window; you cannot set the attribute later by calling `ChangeWindowAttributes`.

Unless you really need specialized event handling, you should also specify using the standard window event handler when creating windows for HIView.

If you are porting older control code to HIView, you should know that once compositing is on, your code must accommodate these changes:

- You should replace any calls that draw directly to the screen (`DrawControls`, `Draw1Control`) with the appropriate HIView invalidation call (`HIViewSetNeedsDisplay`).
- You no longer need to erase behind controls, as the compositor keeps track of the background layers and can redraw them as necessary.

Creating a View

Creating views is straightforward. If your view is an older control, just use the Control Manager creation function (for example, `CreateCheckBoxControl`). For new views, use the appropriate HIView creation function shown in Table 2-1.

Table 2-1 New view creation functions

View	Function
Combo box	`HIComboBoxCreate`
Image view	`HIImageViewCreate`
Scroll view	`HIScrollViewCreate`
Segmented View	`HISegmentedViewCreate`
Search field	`HISearchFieldCreate`
Text view	`HITextViewCreate`
Web view	`HIWebViewCreate`
HICocoaView	`HICocoaViewCreate`

Menus in Mac OS X v10.3 and later are automatically implemented as views, so you do not need to change your code to adopt view-based menus.

Note that when initially created, the new HIView views are not associated with a window, and some do not even have a physical size. To give the view physical dimensions, you must embed the view within a parent and then set its size and position by calling the function `HIViewSetFrame` or `HIViewPlaceInSuperviewAt`.

You can pass `NULL` for the window reference when calling older control creation functions if you want to create a control that is not initially associated with a window.

Views are invisible when first created. To make them visible, call `HIViewSetVisible` or the Control Manager function `ShowControl`.

Embedding Views

The HIView API provides a number of functions to add or remove views from a view hierarchy:

- To embed a view within another view, call the `HIViewAddSubview` function:

  ```
  OSStatus HIViewAddSubview (HIViewRef inParent, HIViewRef inChild);
  ```

  Note that this function merely adds the view to the hierarchy; it does not physically place the view within its parent. To position the view, you should call the `HIViewSetFrame` function or `HIViewPlaceInSuperviewAt`.

- To remove a view from its parent, call the `HIViewRemoveFromSuperview` function:

  ```
  OSStatus HIViewRemoveFromSuperview (HIViewRef inView);
  ```

- To determine the parent of a view, call the `HIViewGetSuperview` function:

  ```
  HIViewRef HIViewGetSuperview (HIViewRef inView);
  ```

- To obtain the root view for a window, call the `HIViewGetRoot` function:

  ```
  HIViewRef HIViewGetRoot (WindowRef inWindow);
  ```

Positioning Views

You use the following functions to set or obtain the position of a view within its parent:

- To obtain the local bounds of a view, call the `HIViewGetBounds` function:

  ```
  OSStatus HIViewGetBounds (HIViewRef inView, HIRect *outRect);
  ```

- To obtain the frame bounds of a view, call the `HIViewGetFrame` function:

  ```
  OSStatus HIViewGetFrame (HIViewRef inView, HIRect *outRect);
  ```

  This function is analogous to the older `GetControlBounds` function except that the coordinates are referenced to the view's parent, not the window's content region.

- To set the frame bounds of a view, call the `HIViewSetFrame` function.

  ```
  OSStatus HIViewSetFrame (HIViewRef inView, const HIRect *inRect);
  ```

  This function effectively moves the view within its parent. It also marks the view (as well anything that may have been exposed behind it) to be redrawn.

- To move a view a certain amount within its parent, call the `HIViewMoveBy` function:

  ```
  OSStatus HIViewMoveBy (HIViewRef inView, float inDX, float inDY);
  ```

- To place a view at a certain point within its parent, call the `HIViewPlaceInSuperviewAt` function:

  ```
  OSStatus HIViewPlaceInSuperviewAt (HIViewRef inView,
                                      float inX, float inY);
  ```

Automating View Layout

In Mac OS X v10.3 and later, you can use special layout functions to bind the size or position of one view to another view. For example, the layout APIs make it easy to do any of the following:

- Center views either horizontally or vertically (or both) in a window.
- Specify that an OK button always keep its proper pixel distance from the bottom right corner of the window (as per the Aqua guidelines) even if the window is resized.
- Create group boxes that automatically resize proportionally as the content view bounds change.

You can specify the following different layout options:

- *Bind* a view so that it maintains its relative position to one or more edges of another view. For example, if you bind a button to the top edge of a group box, the button maintains its relative position to that edge if the group box moves. (Note, however, that you can move the button's top edge independent of the group box.) See "The HIBinding Structure" (page 23) for more details.
- *Position* a view so that it is always aligned to the specified edge (or the center) of another view. For example, if you align a button's top edge to the top edge of a group box, those edges will always share the same y-coordinate. You can also specify an alignment offset if desired. See "The HIPositioning Structure" (page 24) for more details.
- *Scale* a view so that it maintains a particular size ratio with another view. For example, you can specify that a group box's width is always half that of the content view that contains it. See "The HIScaling Structure" (page 25) for more details.

Note that these layout constraints are "one-way"; for example, if button A is constrained to scale as the size of button B changes, that doesn't mean that button B will scale when button A changes size.

Important: Due to the flexibility of these layout constraints, it is possible to specify circular relationships that can hang your application. For example, you can use the layout APIs to set view A to be twice the size of view B and simultaneously set view B to be twice the size of view A. Your application is responsible for avoiding such circular relationships.

You specify a view's layout relationships by setting its `HILayoutInfo` structure:

```
struct HILayoutInfo {
    UInt32 version;
    HIBinding binding;
    HIScaling scale;
    HIPositioning position;
    };
```

The `version` field simply indicates the version of this data structure (in case it changes in the future); set this field to `kHILayoutInfoVersionZero`.

The `binding`, `scale`, and `position` fields each point to additional structures that indicate the specific layout constraints for this view.

You can use the view layout APIs to specify layout relationships between any two views (siblings, parents, and so on). The layouts are applied in the following order: binding, scaling, then positioning. Note that some layout information when applied may override previous constraints. For example, positioning constraints may override the bindings set in the `HIBinding` structure.

- To set layout constraints, you must first call the `HIViewGetLayoutInfo` function to obtain the layout structure:

  ```
  OSStatus HIViewGetLayoutInfo (HIViewRef inView,
                                  HILayoutInfo *outLayoutInfo);
  ```

  Important: Before calling `HIViewGetLayoutInfo`, you must set the version field of the `HILayoutInfo` structure. Doing so ensures that you will always receive a structure whose contents are compatible with your code. Currently the only value you can supply is `kHILayoutInfoVersionZero`.

  Then you can modify the fields of the structure to specify the layout constraints you want.

- To set the layout relationships for a view, you use the `HIViewSetLayoutInfo` function:

  ```
  OSStatus HIViewSetLayoutInfo (HIViewRef inView,
                                  const HILayoutInfo *inLayoutInfo);
  ```

- If you set a layout that constrains view A to view B, the layouts do not get implemented until either view B moves or resizes, or you call the `HIViewApplyLayout` function on view A:

  ```
  OSStatus HIViewApplyLayout (HIViewRef inView);
  ```

- Layouts are active by default. To temporarily disable the layout constraints, call `HIViewSuspendLayout`. To resume the layout, call `HIViewResumeLayout`:

  ```
  OSStatus HIViewSuspendLayout (HIViewRef inView);
  OSStatus HIViewResumeLayout (HIView inView);
  ```

- To determine if the layout is active or suspended, call the `HIViewIsLayoutActive` function:

  ```
  Boolean HIViewIsLayoutActive (HIViewRef inView);
  ```

The HIBinding Structure

The `HIBinding` structure specifies the layout bindings for all four sides of the view:

```
struct HIBinding {
    HISideBinding top;
    HISideBinding left;
    HISideBinding right;
    HISideBinding bottom;
    }
```

The `HISideBinding` structure indicates the binding constraints for a specific side:

```
struct HISideBinding {
    HIViewRef toView;
    HIBindingKind kind;
    };
```

The `toView` field indicates the view you want to bind to. The kind field specifies the side of the `inView` view to bind to. You can pass any of the following constants in the kind field: `kHILayoutBindLeft`, `kHILayoutBindRight`, `kHILayoutBindTop`, `kHILayoutBindBottom`.

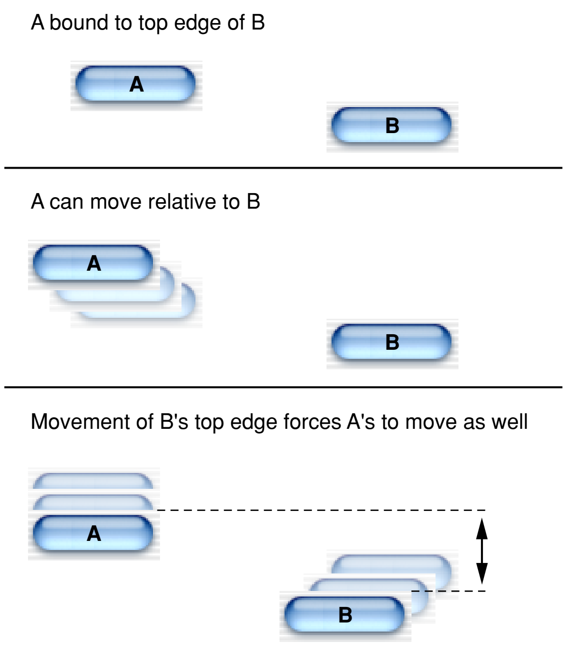
Note: The specified layout constants are actually abstracted from constants that assume axis information: `kHILayoutBindRight` and `kHILayoutBindBottom` map to `kHILayoutBindMax` and `kHILayoutBindLeft` and `kHILayoutBindTop` map to `kHILayoutBindMin`. Therefore, specifying seemingly nonsensical bindings is still valid. For example, if you attempt to bind the top of a view to another view using `kHILayoutBindLeft`, you are actually specifying `kHILayoutBindMin`, meaning, that the top of your view binds to the minimum y-axis value (that is, the top edge) of the specified view.

For example, say you bind the top edge of view A to the top edge of view B as in Figure 2-1.

You can move view A as you please, as binding seeks to preserve only the relative positioning between view A and B.

If view B moves (or resizes), view A must also move (or resize) to preserve the specified binding. In this case, that means to maintain the vertical distance between the top edges of view A and view B.

Figure 2-1 A binding example



You can bind all four edges of your view if you desire. Note that your view's bounds may change if that is required to maintain the specified bindings.

The HIPositioning Structure

The `HIPosition` structure specifies the position constraints for the view's axes:

```
struct HIPositioning {
    HIAxisPosition x;
    HIAxisPosition y;
    }
```

The `HIAxisPosition` structure contains the specific positioning constraints for each axis:

```
struct HIAxisPosition {
    HIViewRef toView;
    HIPositionKind kind;
    float offset;
    };
```

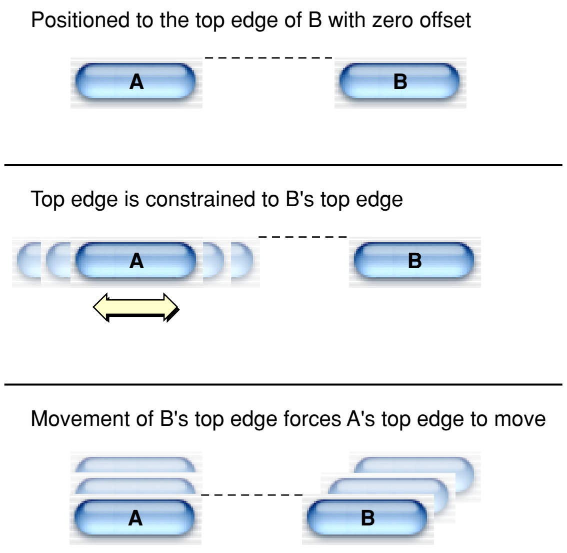
The `toView` field indicates the view that constrains your view. The kind field indicates along which line or side the two views are aligned. You can pass `kHILayoutPositionCenter`, `kHILayoutPositionLeft`, `kHILayoutPositionRight`, `kHILayoutPositionTop`, or `kHILayoutPositionBottom`. The offset field indicates any optional offset to include between `toView` and your view.

For example, say you position the y axis of view A to match the top edge of view B (that is, `positionKind` = `kHILayoutPositionTop`, `offset` = 0), as in Figure 2-2.

View A cannot move up or down, as it is position-constrained to match the top edge of view B.

If view B moves or resizes, view A must move or resize to match any change in view B's y coordinate.

Figure 2-2 A positioning example


Positioned to the top edge of B with zero offset
A
B
Top edge is constrained to B's top edge
A
B
Movement of B's top edge forces A's top edge to move
A
B

Note: Technically, you can move view A freely even when position-constrained to view B. However, the moment view B moves or resizes, or if you call `HIViewApplyLayout` on view A, view A automatically snaps to the constrained position specified by view B.

The HIScaling Structure

The `HIScaling` structure specifies the scaling constraints for both axes of the view:

```
struct HIScaling {
    HIAxisScale x;
    HIAxisScale y;
    };
```

The `HIAxisScale` structure indicates the scaling constraints for a specific axis:

```
struct HIAxisScale {
    HIViewRef toView;
    HIScaleKind kind;
    float ratio;
    };
```

The toView field indicates the view that will dictate the axial size of your view. The kind field specifies the type of scaling; currently you must pass kHILayoutScaleAbsolute. The ratio field specifies the scale ratio to maintain between your view and the constraining view. For example, if you want your view to always be half the width of toView, set ratio to 0.5.

Ordering Views

You can also set and manipulate the ordering of subviews within a parent view. This process is similar to ordering (sometimes called z-ordering) windows within an application, with views layered from top to bottom.

- To order a view in front of or behind a sibling view, call the HIViewSetZOrder function:

  ```
  OSStatus HIViewSetZOrder (HIViewRef inView, HIViewZOrderOp inOp,
                              HIViewRef inOther);
  ```

  The inOp parameter (possible values: kHIViewZOrderAbove or kHIViewZOrderBelow) determines the position of inView with respect to inOther.

- To obtain the first (that is, topmost) subview in a parent view, call the HIViewGetFirstSubview function:

  ```
  HIViewRef HIViewGetFirstSubview (HIViewRef inParentView);
  ```

- To obtain the last (bottommost) subview in a parent view, call the HIViewGetLastSubview function:

  ```
  HIViewRef HIViewGetLastSubview (HIViewRef inParentView);
  ```

- To obtain the next view after a specified one, call the HIViewGetNextView function:

  ```
  HIViewRef HIViewGetNextView (HIViewRef inView);
  ```

- To obtain the previous view before a specified one, call the HIViewGetPreviousView function:

  ```
  HIViewRef HIViewGetPreviousView (HIViewRef inView);
  ```

HIView Visibility

Just like controls, you can set or test for the visibility of views.

- To set the visibility of a view, call the HIViewSetVisible function:

  ```
  OSStatus HIViewSetVisible (HIViewRef inView, Boolean inVisible);
  ```

  This function is analogous to the older SetControlVisibility function. Hiding a view also hides any embedded subviews.

- To determine whether a view is visible, call the HIViewIsVisible function:

  ```
  Boolean HIViewIsVisible (HIViewRef inView);
  ```

Note that you can also use the Control Manager functions `SetControlVisibility` and `IsControlVisible` on views.

Changing Keyboard Focus

In Mac OS X v10.2 and later, most views can acquire keyboard focus. This feature allows a user to select a checkbox, enter text, or click a button entirely through the keyboard. The user presses the Tab key to advance the focus and Shift-Tab to move it backwards. Pressing the Space bar activates the view with focus.

Note: For menus, the user can also use the cursor (arrow) keys to switch focus between menus and menu items.

Your application should allow the user to advance focus and activate focused views. HIView provides several functions to change keyboard focus:

- To advance the focus to the next appropriate view, call the `HIViewAdvanceFocus` function:

  ```
  OSStatus HIViewAdvanceFocus (HIViewRef inRootForFocus,
                                  EventModifiers inModifiers);
  ```

  You pass in the root of the subtree in which to confine the focus. That is, if you pass in a content view as the root, the focus is confined to the subviews within the content view. You must also pass in the event modifiers parameter of the keyboard event that resulted in the call to `HIViewAdvanceFocus`.

  `HIViewAdvanceFocus` sends a `kEventControlSetFocusPart` event whenever a view is requested to gain, advance, or lose keyboard focus.

  Note that if your window uses the standard event handler, the basic focus-shifting work (acquiring the raw keyboard input, calling `HIViewAdvanceFocus` and so on) is handled for you, and the standard views support the `kEventControlSetFocusPart` event. However, if you are creating a custom view, you may need to handle the `kEventControlSetFocusPart` event yourself.

  Menus and menu items automatically gain keyboard focus support, independent of any standard event handlers.

- `HIViewAdvanceFocus` uses its own algorithm to determine the next view to acquire focus, generally attempting to move the focus from left to right, top to bottom, taking groups of views into account. However, if you want to explicitly specify which view should follow a given view in the focus chain, call the `HIViewSetNextFocus` function:

  ```
  OSStatus HIViewSetNextFocus (HIViewRef inView,
                                  HIViewRef inNextFocus);
  ```

Translating Coordinates

Although HIView simplifies most operations by adopting a view-relative coordinate system, at times you may need to know the coordinates of a object relative to a different view. The HIView API provides several functions to simplify these translations:

Note: These conversion functions assume that both views have a common parent (that is, they must both be associated with the same window).

- To translate the coordinates of a point from one view to another, call the `HIViewConvertPoint` function:

  ```
  OSStatus HIViewConvertPoint (HIPoint *inPoint, HIViewRef inSourceView,
                                  HIViewRef inDestView);
  ```

- To translate an `HIRect` structure from one view to another, call the `HIViewConvertRect` function:

  ```
  OSStatus HIViewConvertRect (HIRect *ioRect, HIViewRef inSourceView,
                                  HIViewRef inDestView);
  ```

- To translate a region from one view to another, call the `HIViewConvertRegion` function:

  ```
  OSStatus HIViewConvertRegion (RgnHandle ioRgn, HIViewRef inSourceView,
                                  HIViewRef inDestView);
  ```

Note: Note that with all three functions you can pass `NULL` for a view parameter to convert to or from window-relative coordinates. That is, the `NULL` parameter is equivalent to the `HIViewRef` of the root view.

For example, if you wanted to obtain the global coordinates of a point within a view, (to be used in, say, a call to `WaitMouseUp`), you can call `HIViewConvertPoint` to obtain the window-relative coordinates. You can then get to global coordinates by calling `GetWindowBounds`, specifying the structure region, and add the top left global point of the window to the window-relative point.

Drawing in Views

You can use any of the usual Quartz functions to draw in your views. However, because HIView flips the Core Graphics context it passes to you, you draw using the QuickDraw coordinate system by default. If you need to draw images, you can use the `HIViewDrawCGImage` function, which flips the Core Graphics context (`CGContext`) back to the Quartz coordinate system, draws the image, and then flips the context back:

```
OSStatus HIViewDrawCGImage (CGContextRef inContext,
                                const HIRect *inBounds,
                                CGImageRef inImage);
```

This function is essentially identical to the Quartz function `CGContextDrawImage` except that it reverses the direction of the y-coordinate axis.

Note: The HIView system still supports drawing using QuickDraw.

If you prefer to draw in your view using the Quartz coordinate system, you can translate the context you receive in your drawing handler

```
HIViewGetBounds (view, &bounds);
CGContextTranslateCTM (theContext, 0, bounds.size.height);
CGContextScaleCTM (theContext, 1.0, -1.0);
```

The CGContextTranslateCTM shifts the origin of the y-axis by the height of the view bounds, while the CGContextScaleCTM call invert the y-axis.

Note that unlike in older system software, you should never draw your views outside of a kEventControlDraw handler; do not use the Control Manager functions UpdateControls, DrawControls, or Draw1Control to draw to the screen. Instead, you must let the system know that a view, or a portion thereof, needs to be updated. This process is analogous to the older method of adding dirty areas to an update region.

To mark a view as dirty and needing to be redrawn, call the HIViewSetNeedsDisplay function:

```
OSStatus HIViewSetNeedsDisplay (HIViewRef inView,
                                    Boolean inNeedsDisplay);
```

Pass true for the inNeedsDisplay parameter if you want the view updated. You should make this call wherever you would have previously called DrawControls.

If you need to update only a portion of a view, you can call the HIViewSetNeedsDisplayInRegion function:

```
OSStatus HIViewSetNeedsDisplayInRegion (HIViewRef inView, RgnHandle inRgn,
                                            Boolean inNeedsDisplay);
```

In Mac OS X v10.4 and later you can also use the HIViewSetNeedsDisplayInRect and HIViewSetNeedsDisplayInShape functions:

```
OSStatus HIViewSetNeedsDisplayInRect( HIViewRef inView,
                const HIRect *  inRect, Boolean inNeedsDisplay);

OSStatus HIViewSetNeedsDisplayInShape( HIViewRef inView,
                HIShapeRef   inArea, Boolean inNeedsDisplay)
```

At the appropriate time, the system copies the updated regions to the screen (or calls your drawing routines).

In rare cases where you want to redraw your view immediately, you can call the HIViewRender function in Mac OS X v10.3 and later. Doing so allows you to bypass firing Carbon event timers or any other actions that may occur when cycling through the event loop.

Important: You should never pass false for the inNeedsDisplay parameter. If you do so, you may suppress updates for views or regions that intersect the area you specified.

You can turn off drawing related to a view by calling the HIViewSetDrawingEnabled function:

```
OSStatus HIViewSetDrawingEnabled (HIViewRef inView, Boolean inEnabled);
```

Turning off drawing in a view also affects any subviews embedded within it.

When drawing is turned off, the view is not drawn or updated (that is, calls to HIViewSetNeedsDisplay or even Draw1Control have no effect).

To determine whether drawing is allowed for a view, call the HIViewIsDrawingEnabled function:

```
Boolean HIViewIsDrawingEnabled (HIViewRef inView);
```

Manipulating Menu Views

Beginning in Mac OS X v10.3, all menus are implemented as views. This feature allows additional flexibility in creating or modifying menus. The actual menu content views are created lazily, as needed. That is, the Menu Manager does not create the menu content view, or even the owning window/root view/content view hierarchy that holds it, until the user first clicks on a menu title in the menu bar.

Listing 2-1 gives an example of how you can manipulate a menu as a view. This example allows you to install an event handler on the menu content view.

Listing 2-1 Creating a menu with an embedded image

```
IBNibRef nibRef;
MenuRef myMenuRef;
HIViewRef theView;
EventTypeSpec myEvent;
...
CreateMenuFromNib (nibRef, CFSTR ("myMenu"),&myMenuRef);
InsertMenu (myMenuRef, 0);

HIMenuGetContentView (myMenuRef, kThemeMenuTypePullDown, &theView);

myEvent.eventClass = kEventClassControl;
myEvent.eventKind = kEventControlOwningWindowChanged;

InstallControlEventHandler (theView, myPictureHandler, 2, &myEvent,0, NULL);
```

Here is how the code works:

1. First create the menu. The easiest way is to load it from a nib file, but you can use older Menu Manager functions to do so as well. After creating the menu, use `InsertMenu` to install it into the menu bar. At this point, none of the menu content views or owning windows have been created.
2. Call `HIMenuGetContentView` on your menu reference to obtain the menu content view associated with it. This is the view that displays the menu items. Note that making this call forces an instantiation of the menu content view before it actually needs to be displayed.
3. Install an event handler for the `kEventControlOwningWindowChanged` event on the menu content view. This event is sent when the menu content view is attached to a window content view for display (which occurs the first time the user clicks the menu title to display the menu).

Listing 2-2 shows a possible implementation for the event handler installed in Listing 2-1. This example installs an image view in your menu content view so that it appears behind the menu items.

Note: Placing an image behind a menu violates the Aqua human interface guidelines, so you should not actually do this in your application. This example is for illustrative purposes only.

Listing 2-2 Adding an image view to a menu

```
OSStatus PictureHandler( EventHandlerCallRef caller, EventRef event,
                            void* refcon )
{
    OSStatus    err = eventNotHandledErr;
    WindowRef   owner;

    GetEventParameter( event, kEventParamControlCurrentOwningWindow,
                 typeWindowRef, NULL, sizeof( owner ), NULL, &owner );

    if ( owner != NULL )
    {
        // find the content view
        HIViewRef content;
        HIViewFindByID( HIViewGetRoot( owner ), kHIViewWindowContentID,
                         &content );

        // create a data provider for our image
        CFURLRef url = CFBundleCopyResourceURL( CFBundleGetMainBundle(),
                            CFSTR("GoldenGate"), CFSTR("jpg"), NULL );
        CGDataProviderRef data = CGDataProviderCreateWithURL( url );
        CFRelease( url );

        // create our image
        CGImageRef image = CGImageCreateWithJPEGDataProvider( data, NULL,
                                     true, kCGRenderingIntentDefault );
        CFRelease( data );

        // create our image view
        HIViewRef imageView;
        HIImageViewCreate( image, &imageView );
        HIImageViewSetOpaque( imageView, false );
        HIImageViewSetAlpha( imageView, 0.3 );
        CFRelease( image );

        // position our image view below the content view's children
        HIViewAddSubview( content, imageView );
        HIViewSetZOrder( imageView, kHIViewZOrderBelow, NULL );
        HIViewSetVisible( imageView, true );

        // size our image view to match the content view
        HIRect bounds;
        HIViewGetBounds( content, &bounds );
        HIViewSetFrame( imageView, &bounds );
    }
    return err;
}
```

Here is how the code works:

1. Call `GetEventParameter` to obtain a reference to the window that owns this menu. Note that each menu has its own separate owning window (including submenus).

2. Call `HIViewFindByID` to obtain the content view for the window. This is the view that contains the menu content view, and also the one in which the image view will be embedded.

3. Create a data provider for the image you want to display. First, call the Core Foundation function `CFBundleCopyResourceURL` to get the URL to the image in the bundle, then call the Core Graphics function `CGDataProviderCreateWithURL` to obtain a data provider. After creating the data provider, you can release the URL by calling `CFRelease`.

4. Next, create a Core Graphics image from the data provider by calling `CGImageCreateWithJPEGDataProvider`. After creating the image, you can release the data provider.

5. Call `HIImageViewCreate` to create an image view from the Core Graphics image. After creating the image view, you can dispose of the Core Graphics image by calling `CFRelease`.

6. Passing `false` to `HIImageViewSetOpaque` specifies that the image view is not opaque.

7. Set the transparency of the image view by calling `HIViewSetAlpha`. Making the image translucent allows the background of the window content view (that is, the light gray striping) to show through. The alpha range can vary from 0 (transparent) to 1 (opaque).

8. Call `HIViewAddSubview` to add the image view to the window content view.

9. Call `HIViewSetZOrder` to place the image view behind the menu content view.

10. Call `HIViewSetVisible` to make the image view visible.

11. Lastly, set the bounds of the image view to be the same as that of the window content view. Doing so ensures that the image covers the entire background of the menu. `HIViewGetBounds` obtains the bounds of the window content view, and `HIViewSetFrame` sets the bounds of the image view to match those of the content view.

View-based menus allow you even more flexibility when creating custom menu items. For example, you can draw into your menus using Quartz, embed controls within the menu, and so on. Instead of creating custom MDEFs for your menus, you simply create a custom view, and implement Carbon events to handle any required messaging. See "Creating Custom Menus" (page 45) for more information.

Creating a Scroll View

The HIView scroll view provides an easy way to display a scrollable image. For example, you can simply embed an image view within the scroll view and the scroll view automatically handles the scrolling of the image; you don't need to worry about installing live feedback handlers, adjusting scroller positions and sizes, or moving pixels.

Note: If you want to create custom views that can be embedded in scroll views, your view must support the `kEventClassScrollable` class of Carbon events.

Listing 2-3 shows a simple example of displaying a scrollable JPEG image in a document window. This example assumes that the image you want to display is a JPEG file installed in your application bundle (in the Resources folder).

Listing 2-3 Creating a scroll view with an embedded image

```
WindowRef scrollWindow;
Rect windowBounds = {100, 100, 500, 550};
HIRect myViewRect;
HIViewRef myImageView, myScrollView, myContentView;

CGImageRef myImage;
CGDataProviderRef myProvider;

CFBundleRef theAppBundle;
CFStringRef filename;
```

```
CFURLRef theURL;

CreateNewWindow (kDocumentWindowClass, kWindowStandardHandlerAttribute |
             kWindowCompositingAttribute, &windowBounds,&scrollWindow);

/* Get the JPEG image from a file. */
theAppBundle = CFBundleGetMainBundle();

filename = CFStringCreateWithCString(NULL, "CowPuppy.jpg",
                kCFStringEncodingASCII);

theURL = CFBundleCopyResourceURL (theAppBundle, filename, NULL, NULL);

/* Quartz stuff to put the JPEG image into an image view */
myProvider = CGDataProviderCreateWithURL(theURL);
myImage = CGImageCreateWithJPEGDataProvider (myProvider, NULL, false,
                                     kCGRenderingIntentDefault);

CGDataProviderRelease (myProvider);
CFRelease(filename);

/* Now create the scroll view and image view. */
HIScrollViewCreate (kHIScrollViewOptionsVertScroll |
                     kHIScrollViewOptionsHorizScroll, &myScrollView);

HIViewSetVisible (myScrollView, true);

HIViewFindByID(HIViewGetRoot(scrollWindow), kHIViewWindowContentID,
                 &myContentView);
HIViewAddSubview (myContentView, myScrollView);

myViewRect.origin.x = 50.0;
myViewRect.origin.y = 10.0;
myViewRect.size.width = 300.0;
myViewRect.size.height = 300.0;

HIViewSetFrame (myScrollView, &myViewRect);

HIImageViewCreate (myImage, &myImageView);
CGImageRelease (myImage);

HIViewSetVisible (myImageView, true);
HIViewAddSubview (myScrollView, myImageView);

ShowWindow (scrollWindow);
```

Here is how the code works:

1. Call `CreateNewWindow` to create a new document window. Note that you must set the `kWindowCompositingAttribute` attribute if you want to use HIView objects in the window. Use of the standard window handler is also highly recommended.

   If you are creating a window from a nib file, you must set the Compositing checkbox for the window from the Info window in Interface Builder.

2. Call the Core Foundation CFBundle function `CFBundleGetMainBundle` to find the main application bundle.

3. Create a CFString of the name of the image file using the Core Foundation function `CFStringCreateWithCString`.

4. Call the Core Foundation function `CFBundleCopyResourceURL` to build a URL path to the image file in the application bundle.

5. Use the Core Graphics function `CGDataProviderCreateWithURL` to create a data provider. In Quartz, you need to create data providers before creating a `CGImage` object.

6. Call the Core Graphics function `CGImageCreateWithJPEGDataProvider` to create a `CGImage` object from the JPEG file.

7. After creating the `CGImage` object, you can release the data provider and the `CFString` filename object by calling `CGDataProviderRelease` and `CFRelease` respectively.

8. To create the scroll view, call the `HIScrollViewCreate` function. This example passes in options specifying both horizontal and vertical scroll bars.

9. Call `HIViewSetVisible` to make the scroll view visible.

10. In order to embed the scroll view properly, you need to obtain the content view of the window. You do so by calling the `HIViewFindByID` function, specifying that you want to find the content view. Note that this function requires the root view as its first parameter. To obtain the root view for this window, you must call `HIViewGetRoot`.

    Note that to obtain the content view, you could also call the Control Manager function `GetRootControl`.

11. To embed the scroll view in the content view, call the `HIViewAddSubview` function. Note that at this point, although the scroll view is embedded in the content view, it has no bounds (that is, it has no physical location or size).

12. To set the bounds of the scroll view, you fill in an `HIRect` structure. Note that this structure has a format different from that of the QuickDraw `Rect` structure. This example creates a 300 pixel square scroll view located at (50,10) in the local coordinates of the content view.

13. Once you specify the bounds in `myViewRect`, you pass them into the `HIViewSetFrame` function to set the frame bounds of the scroll view (that is, the coordinates of the scroll view relative to the content view).

    If you want the scroll view to occupy the entire content view, you can call `HIViewGetBounds` (not `HIViewGetFrame`) on the content view and pass the resulting `HIRect` into `HIViewSetFrame` for the scroll view.

14. To create the image view, you call `HIImageViewCreate`, passing in the `CGImage` object you obtained from `CGImageCreateWithJPEGDataProvider`.

15. After creating the image view, you can dispose of the `CGImage` object by calling the Core Graphics function `CGImageRelease`.

16. Call `HIViewSetVisible` to make the image view visible.

17. Call `HIViewAddSubview` to embed the image view within the scroll view. The image view will appear with the top-left corner aligned with the scroll view's origin.

18. Call the Window Manager function `ShowWindow` to display the window with the scroll view.

If you create your scroll view to be resizable, by passing `true` to the `HIScrollViewSetScrollBarAutoHide` function, you can specify that the scroll bars be hidden if the scroll view is enlarged to the point that the entire image is visible.

Creating a Combo Box

HIView lets you create a combo box control using simple function calls. All of the basic pop-up behavior and item selection is handled for you automatically. In addition, HIView combo boxes also support the following optional features, which you set by specifying attributes during creation:

- auto-completion in the editable text field (`kHIComboBoxAutoCompletionAttribute`)
- automatic disclosure of list items when the user enters text (`kHIComboBoxAutoDisclosureAttribute`)
- alphabetical sorting of list items (`kHIComboBoxAutoSortAttribute`)
- automatic resizing of the list to conform to the Aqua human interface guidelines (`kHIComboBoxAutoSizeListAttribute`). Note that if you do not specify this attribute, you must size the list yourself using Control Manager `SetControlData` tags. Otherwise the size of the list is undefined. See `HIView.h` for a listing of available combo box data tags.

Listing 2-4 shows a code fragment that creates the simple combo box in Figure 1-7 (page 16).

Listing 2-4 Creating a simple combo box

```
WindowRef myPrefsWindow;
HIViewRef myCombo, myContentView;
HIRect hiRect;

Rect myBounds = {100, 100, 500, 500};
Rect ComboRect = {0, 0, 20, 100};

CreateNewWindow (kMovableModalWindowClass, kWindowStandardHandlerAttribute|
                kWindowCompositingAttribute, &myBounds,&myPrefsWindow);

hiRect.origin.x = ComboRect.left;
hiRect.origin.y = ComboRect.top;
hiRect.size.width = ComboRect.right-ComboRect.left;
hiRect.size.height = ComboRect.bottom-ComboRect.top;

HIComboBoxCreate (&hiRect, CFSTR ("Hobbes"), NULL, NULL,
                    kHIComboBoxStandardAttributes, &myCombo);

HIViewSetVisible (myCombo, true);

HIViewFindByID (HIViewGetRoot(myPrefsWindow),kHIViewWindowContentID,
                 &myContentView);
HIViewAddSubview (myContentView, myCombo);
HIViewPlaceInSuperviewAt (myCombo, 25.0, 25.0);

HIComboBoxAppendTextItem (myCombo, CFSTR ("Hobbes"), NULL);
HIComboBoxAppendTextItem (myCombo, CFSTR ("Plato"), NULL);
HIComboBoxAppendTextItem (myCombo, CFSTR ("Heidegger"), NULL);
HIComboBoxAppendTextItem (myCombo, CFSTR ("Aristotle"), NULL);
```

```
ShowWindow (myPrefsWindow);
```

Here is what the code does:

1. This example places the combo box in a movable modal window created using `CreateNewWindow`. Note that you must specify the `kWindowCompositingAttribute` attribute.

2. This example originally specifies the bounds of the combo box as a QuickDraw `Rect` structure and then translates those coordinates into a Quartz-compatible `HIRect` structure.

3. To create the combo box, call the `HIComboBoxCreate` function. You specify the following parameters:

   - The bounds of the combo box, as an `HIRect` structure.
   - The initial text in the editable text field as a Core Foundation `CFString`. This text could indicate the kind of item the user should enter, or the default item selection.
   - A pointer to a Control Manager `ControlFontStyleRec` structure indicating the font style to use for this combo box. Pass `NULL` (as in this example) if you want to use the default system font.
   - A Core Foundation `CFArray` containing the items you want to display in the item list. You can also pass `NULL` (as in this example) and add items on-the-fly later.
   - The attributes you want for this combo box. Specifying `kHIComboBoxStandardAttributes` gives you the automatic sizing, list disclosure, and text completion features.

   On return, `myCombo` contains the new combo box.

4. As usual, the new HIView is initially hidden, so call `HIViewSetVisible` to make it visible.

5. To embed the combo box in the movable modal window's content view, you can call `HIViewFindByID` and `HIViewAddSubview`, just as in Listing 2-3 (page 32). However, as an alternative to using `HIViewSetFrame` to position the combo box in the view, you can call the `HIViewPlaceInSuperviewAt` function. You can do this because the combo box already has a size; you now need to specify only a position. The coordinates you specify indicate the top-left corner of the view's bounds.

6. You can add items to the combo box list by simply calling the `HIComboBoxAppendTextItem` function. This example adds four items.

Creating Custom Views

One of the advantages of HIView is that you can subclass an existing view when creating a custom view. In object-oriented fashion, a view is essentially a class defined by Carbon event handlers (essentially methods) and instance data. To create a custom view, you must create a subclass of HIView and add your custom functionality by overriding event handlers.

Registering an HIObject Subclass

You register your subview much like you register a custom window or control when you call `RegisterToolboxObjectClass`, but there are some parameter differences.

```
OSStatus HIObjectRegisterSubclass (CFStringRef inClassID,
                                CFStringRef inBaseClassID,
                                OptionBits inOptions,
                                EventHandlerUPP inConstructProc,
                                UInt32 inNumEvents,
                                const EventTypeSpec *inEventList,
                                void* inConstructData,
                                HIObjectClassRef *outClassRef);
```

1. The `inClassID` parameter represents the ID of the class you want to register. This ID must be a Core Foundation string, preferably in the form *com.CompanyName.Application.ClassName*.
2. The `inBaseClassID` parameter represents the class you want to subclass. For the base HIView class, you pass the constant `kHIViewClassID`.
3. Pass any options in the `inOptions` parameter. Currently there are no options (pass `0`).
4. The `inConstructProc` is a universal procedure pointer (UPP) to the event handler for your view class.
5. The `inNumEvents` parameter indicates the number of events you want to register for this view class.
6. The `inEventList` array contains the events to register for this class. You define these just as you would for registering any Carbon Event handler.
7. The `inConstructData` parameter points to any initialization data (that is, constructor data) you want to pass to your class.
8. On return, `outClassRef` holds the class reference for your registered subclass. You pass this value to `HIObjectCreate` when creating an instance of your class.

Listing 2-5 shows a function that registers a custom view.

Listing 2-5 Registering a custom view

```
#define kMyCustomViewClassID CFSTR("com.myCorp.myApp.myView")

OSStatus myCustomViewRegister()
{
    OSStatus                err = noErr;
    static HIObjectClassRef sMyViewClassRef = NULL;

    if ( sMyViewClassRef == NULL )
    {
        EventTypeSpec       eventList[] = {
            { kEventClassHIObject, kEventHIObjectConstruct },
            { kEventClassHIObject, kEventHIObjectInitialize },
            { kEventClassHIObject, kEventHIObjectDestruct },
            { kEventClassControl, kEventControlInitialize },
            { kEventClassControl, kEventControlDraw },
            { kEventClassControl, kEventControlHitTest },
            { kEventClassControl, kEventControlGetPartRegion } };

        err = HIObjectRegisterSubclass(
            kMyCustomViewClassID,       // class ID
            kHIViewClassID,             // base class ID
            NULL,                       // option bits
            myCustomViewHandler,        // construct proc
            GetEventTypeCount( eventList ),
            eventList,
            NULL,                       // construct data,
            &sMyViewClassRef );
    }

    return err;
}
```

This example stores the resulting `HIObjectClassRef` value as a static variable, so you can skip the registration call if your class has already been registered.

Handling View Events

You specify an event handler for your view when you call `HIObjectRegisterSubclass`, just as you would for any custom control. Listing 2-6 shows an event handler to correspond with the class registered in Listing 2-5.

Listing 2-6 A custom view event handler

```
OSStatus myCustomViewHandler(
    EventHandlerCallRef     inCallRef,
    EventRef                inEvent,
    void*                   inUserData )
{
    OSStatus                err = eventNotHandledErr;
    UInt32                  eventClass = GetEventClass( inEvent );
    UInt32                  eventKind = GetEventKind( inEvent );
    myCustomViewData*       data = (myCustomViewData*) inUserData;

    switch ( eventClass )
    {
        case kEventClassHIObject:
        {
            switch ( eventKind )
            {
                case kEventHIObjectConstruct:
                    err = myCustomViewConstruct( inEvent );
                    break;

                case kEventHIObjectInitialize:
                    err = myCustomViewInitialize( inCallRef, inEvent,
                                                      data );
                    break;

                case kEventHIObjectDestruct:
                    err = myCustomViewDestruct( inEvent, data );
                    break;
            }
        }
        break;

        case kEventClassControl:
        {
            switch ( eventKind )
            {
                case kEventControlInitialize:
                    err = noErr;
                    break;

                case kEventControlDraw:
                    err = myCustomViewDraw( inEvent, data );
                    break;

                case kEventControlHitTest:
                    err = myCustomViewHitTest( inEvent, data );
                    break;

                case kEventControlGetPartRegion:
                    err = myCustomViewGetRegion( inEvent, data );
                    break;
            }
        }
        break;
    }

    return err;
}
```

Note that this handler uses special HIObject class events. The sections that follow describe HIObject events, as well as other basic events your custom view may want to handle.

Handling HIObject Events

All custom views must support the following Carbon events of class `kEventClassHIObject` (as defined in `HIObject.h`). These events correspond to object-oriented constructor and destructor methods:

- `kEventHIObjectConstruct`: you use this event to allocate memory for your instance data. Typically you want to allocate enough space to store the `HIViewRef` (or `ControlRef`) as well as any other view-specific instance data. You must return a pointer to this allocated memory in the `kEventParamHIObjectInstance` parameter (type `typeVoidPtr`).
- `kEventHIObjectDestruct`: your view receives this event when its reference count has dropped to zero (that is, when the object should be destroyed). You should use this event to dispose of anything you may have allocated for your view.

Important: The HIObject constructor and destructor events are sent directly to your event handler, so there is no handler stack associated with the event. Therefore, your handler must not call any functions that assume the presence of an event handler stack (such as `CallNextEventHandler`).

Listing 2-7 shows a sample handler for the `kEventHIObjectConstruct` event.

Listing 2-7 A kEventHIObjectConstruct handler

```
typedef struct
{
    ControlRef control;
} myCustomViewData;
```

```
OSStatus myCustomViewConstruct (EventRef inEvent)
{
    OSStatus                err;
    myCustomViewData*       data;

    data = malloc( sizeof( myCustomViewData ) );
    require_action( data != NULL, CantMalloc, err = memFullErr );

    err = GetEventParameter( inEvent, kEventParamHIObjectInstance,
                            typeHIObjectRef, NULL, sizeof( HIObjectRef ),
                            NULL, (HIObjectRef*) &data->control );
    require_noerr( err, ParameterMissing );

    // Set the userData to be used with all subsequent eventHandler calls
    err = SetEventParameter( inEvent, kEventParamHIObjectInstance,
                            typeVoidPtr, sizeof( myCustomViewData* ),
                            &data );
ParameterMissing:
    if ( err != noErr )
        free( data );

CantMalloc:
    return err;
}
```

Here is what the code does:

1. The `myCustomViewData` structure defines the instance data to associated with the class. In this case, the only data required is the control reference. Note that you could also have defined this as an `HIViewRef` type or an `HIObjectRef` type, as they are identical.

2. Use `malloc` to allocate space for your instance data.

3. This code example and others in this section use Apple-defined error-checking macros. For more information about using these macros, see the header `AssertMacros.h`.

4. Use the Carbon Event Manager function `GetEventParameter` to obtain the default instance data for this class (which is just the `HIViewRef`). You store this data in the `control` field of your instance data.

5. Now, use `SetEventParameter` to set your instance data to be the instance data for this class. Because this example only has one field, you are passing back the same data that you received. However, this procedure allows you to specify additional instance data if you desire. The data you specify for the `kEventParamHIObjectInstance` parameter is then passed to your HIObject event handler in the `userData` parameter when subsequent events occur.

Your `kEventHIObjectDestruct` handler should dispose of anything allocated for your view (such as user data allocated during the initialize event and instance data) Do not dispose of the view reference. Listing 2-8 shows a very simple destruct handler that simply frees the instance data you allocated in the construct handler.

Listing 2-8 A kEventHIObjectDestruct handler

```
OSStatus myCustomViewDestruct (EventRef inEvent,
                                myCustomViewData* inData)
{
    free (inData);
    return noErr;
}
```

In addition, your view will usually want to support the `kEventHIObjectInitialize` event. This handler provides a simple mechanism to perform any needed initialization tasks. As a rule, your handler should first pass the event to its superclass by calling `CallNextEventHandler`. This gives the superclass the opportunity to perform any initializations.

You can also use this event to pass initialization data to your view when you call `HIObjectCreate`. For example, you may want to pass initial bounds (size and position) information to your view using this event.

Listing 2-9 shows an example of an initialization event handler.

Listing 2-9 A kEventHIObjectInitialize handler

```
OSStatus myCustomViewInitialize (EventHandlerCallRef inCallRef,
                            EventRef inEvent,
                            myCustomViewData* inData)
{
    OSStatus err;
    Rect bounds;

    // Let any parent classes have a chance at initialization
    err = CallNextEventHandler( inCallRef, inEvent );
    require_noerr( err, TroubleInSuperClass );

    // Extract the bounds from the initialization event
    err = GetEventParameter( inEvent, 'Boun', typeQDRectangle,
            NULL, sizeof( Rect ), NULL, &bounds );
    require_noerr( err, ParameterMissing );

    // Resize the view
    SetControlBounds( inData->control, &bounds );

ParameterMissing:
TroubleInSuperClass:
    return err;
}
```

Here is what the code does:

1. First, call the Carbon Event Manager function `CallNextEventHandler` to give the view’s superclasses a chance to perform any initialization.

2. Any further initialization is entirely up to the application. Note that before you call `HIObjectCreate`, you can store initialization data as parameters in the `kEventHIObjectInitialize` event. In this example, the initial bounds were stored in the event, so you call `GetEventParameter` to obtain it. The parameter identifier (`'Boun'` in this example) is entirely arbitrary (as long as it’s a four-character code), as it is used only in this event.

3. After obtaining the bounds of the view, you call the Control Manager function `SetControlBounds` to set them. Note that you could also have used the `HIViewSetFrame` function to set the bounds of the view, but you must make sure you passed an `HIRect` type in the initialize event.

Handling Hit-Test Events

When a hit-test event (`kEventControlHitTest`) occurs, your custom view must indicate what part of itself was hit. The system can then send draw events to your view if that is required for tracking or selecting.

Note that while the Control Manager defines several part codes, you are also free to define your own values within the range 1 through 127. All negative value part codes are defined by Apple; your application can respond to these negative values (for example, when asked to shift focus), but it should never return them from a `kEventControlHitTest` handler.

You can use `GetEventParameter` to obtain the mouse location parameter, and then use `SetEventParameter` to pass back the part code that was hit in the control part parameter.

Handling Draw Events

When the draw event (kEventControlDraw) occurs, you must draw your view or portion thereof.

If you are using Quartz, you must obtain the `kEventParamCGContextRef` parameter, which holds the Core Graphics context you should draw into. You must use the context that is passed to you rather than creating your own in the drawing handler. This context is already transformed, so you simply draw.

If you are using QuickDraw, you can obtain the current graphics port from the `kEventParamGrafPort` parameter.

In addition, whether you use QuickDraw or Quartz, the `kEventControlDraw` event also contains a `kEventParamRgnHandle` parameter. This region defines the visible portion of the view, and in most cases you should restrict your drawing to this area; any part of the view outside this area is presumably covered by another view and will be overwritten. The HIView compositor determines the size of this region.

Handling Region Calculation Events

At times the system may need to obtain region information about your view; it sends a `kEventControlGetPartRegion` event to do so. The most important regions are the structure region and the opaque region. The event reference indicates the desired region in the `kEventParamPartCode` parameter. You should use `SetEventParameter` to return the requested region handle in the `kEventParamControlRegion` parameter.

The structure region is essentially the area onscreen taken up by the view. In many cases this area is identical to the view's bounds, but not always. For example, focus rings are considered part of the structure region, even though they appear outside the view bounds. If you choose not to return a structure region (or you choose not to handle this event), the system assumes that the view's bounds are the structure region.

If your view's structure region changes, you should inform the system by calling the `HIViewReshapeStructure` function. Doing so lets the system recalculate visible areas and redraw as appropriate. For example, if your view gains or loses a focus ring, the structure changes size and you should inform the system.

The opaque region is the part of your view that is opaque. Knowledge of a view's opaque region simplifies drawing because the HIView compositor knows that it does not have to render anything underneath the opaque parts. If you do not return an opaque region (or if you don't handle this event) the compositor assumes the view is transparent.

Handling Drag and Drop Events

If your view supports drag and drop, you should support the following Carbon events:

- `kEventControlDragEnter`: sent when the drag item enters your view. Typically you should check to see if your view accepts the type of drag item, and if so, highlight the view. If your view accepts the drag item, you must return a Boolean parameter (`kEventParamControlLikesDrag`, `typeBoolean`) in the drag-enter event.
- `kEventControlDragWithin`: sent while the user drags within your view (but not within a subview).
- `kEventControlDragLeave`: sent when the drag item leaves your view.
- `kEventControlDragReceive`: sent when the user drops an item in your view. If your window accepts the item, it can take appropriate action (for example, paste dragged text into the window).

To enable drag-and-drop, your code should also take the following steps:

- Set the `kControlSupportsDragAndDrop` bit in the `kEventParamControlFeatures` parameter of the `kEventControlInitialize` event. You should set these bits before calling `CallNextEventHandler`.
- Call `SetControlDragTrackingEnabled` (with the Boolean parameter set to `True`) for the view.
- Turn on drag-tracking for the window using the `SetAutomaticControlDragTrackingEnabledForWindow` function.

To streamline the event handling, if your view does not handle the `kEventControlDragEnter` event, then it never receives any other drag events. If you think you may want the drag item, return `noErr` from your drag-entered handler.

Note that only views that can receive keyboard focus can receive drag-within or drag-received events.

For more detailed information about how your application should behave in response to drag-and-drop actions, see the document *Apple Human Interface Guidelines*.

Creating a View Instance

To create an instance of a view, you call the `HIObjectCreate` function.

Listing 2-10 gives an example of a function to create a view instance.

Listing 2-10 A view instance creation function

```
OSStatus CreateMyCustomView ( WindowRef inWindow, const Rect*inBounds,
                                ControlRef* outControl )
{
    OSStatus            err;
    ControlRef          root;
    EventRef            event;

    // Register this class
    err = myCustomViewRegister();
    require_noerr( err, CantRegister );
    // Make an initialization event
    err = CreateEvent( NULL, kEventClassHIObject, kEventHIObjectInitialize,
                      GetCurrentEventTime(), 0, &event );
    require_noerr( err, CantCreateEvent );

    // If bounds were specified, push the them into the initialization event
    // so that they can be used in the initialization handler.
    if ( inBounds != NULL )
    {
        err = SetEventParameter( event, 'Boun', typeQDRectangle,
                sizeof( Rect ), inBounds );
        require_noerr( err, CantSetParameter );
    }

    err = HIObjectCreate( kMyCustomViewClassID, event, (HIObjectRef*)
                        outControl );
    require_noerr( err, CantCreate );

    // If a parent window was specified, place the new view into the
    // parent window.
    if ( inWindow != NULL )
    {
        err = GetRootControl( inWindow, &root );
        require_noerr( err, CantGetRootControl );

        err = HIViewAddSubview( root, *outControl );
    }

CantCreate:
CantGetRootControl:
CantSetParameter:
CantCreateEvent:
    ReleaseEvent( event );

CantRegister:
    return err;
}
```

Here is what the code does:

1. The `CreateMyCustomView` function mimics an older Control Manager creation function in that you can specify the desired bounds of the view as well as the owning window in its input parameters.

2. Register your custom class if you have not already done so. Note that you can register your subclass multiple times with no adverse effects.

3. As mentioned in "Handling HIObject Events" (page 39), the `HIObjectCreate` function requires you to pass it a `kEventHIObjectInitialize` event. You must create this event by calling the Carbon Event Manager function `CreateEvent`, specifying the event class and kind.

4. If the `CreateMyCustomView` function received a valid bounds parameter, you should attach it to the initialization event by calling `SetEventParameter`. The parameter name is four-character code that can be completely arbitrary as long as your initialization event handler recognizes it.

5. To create the instance, call `HIObjectCreate`, passing the class of view to create and the initialization event. On return, `outControl` contains a reference to the new view.

6. If the `CreateMyCustomView` function received a valid owning window reference, you can add it to the window's view hierarchy by calling `HIViewAddSubview`. This example adds the view to the content view (by calling the Control Manager function `GetRootControl`), but you can add it to the root view or any other arbitrary view if you desire.

Creating Custom Menus

In Mac OS X v10.3 and later, if you want to create a custom menu, you should create one as an HIView subclass rather than using an old-style menu definition `MDEF`. Doing so generally requires less work on your part, as you can inherit a lot of functionality from the menu content view class.

Note: If you have an existing MDEF, you can convert it to a view-based menu definition by translating the MDEF messages to specific Carbon events. See "Menu Definition Events Versus Older MDEF Messages" (page 48) for details.

A custom menu is a view typically subclassed from the `HIMenuView` or `HIStandardMenuView` classes.

- `HIMenuView` is the base class for menu views. It sets or implements the following functionality:
    - The view is marked to be ignored for accessibility, so assistive applications do not think it is a standard window/view hierarchy.
    - Sets the `kHIViewDoesNotUseSpecialParts` and `kHIViewAllowsSubviews` feature bits.
    - Implements default handlers for `kEventMenuCreateFrameView`, `kEventMenuGetFrameBounds`, `kEventControlSetFocusPart`, `kEventMenuBecomeScrollable`, `kEventMenuCeaseToBeScrollablekEventScrollableScrollTo` and `kEventControlSimulateHit`. See "Optional Menu Definition Events" (page 47) for more details.
    - Handles `kEventControlClick` by returning `paramErr`. Doing so prevents clicks in the menu view from invoking the Control Manager's default tracking. The Menu Manager handles all menu tracking instead.
    - Handles `kEventControlHit` by returning `paramErr`. Doing so prevents `kEventControlHit` events generated by clicks in the menu from being sent to the application.

  You should subclass from the base class if your menu contains unusual items (such as buttons, sliders, and so on) or requires specialized tracking.

- `HIStandardMenuView` is the class for the standard Aqua-compliant menu. That is, it assumes that you are displaying conventional menu items. It provides handlers for standard menu display, tracking, and selection.

Use the `HIObjectRegisterSubclass` function to register your custom subclasses.

You create your custom menus by calling `CreateCustomMenu`, just as if you were creating an MDEF-based menu. However, instead of providing a pointer to your menu definition, you must specify a class ID and an (optional) initialization event for your custom menu in the menu definition specification.

```
enum {kMenuDefClassID = 1};
struct MenuDefSpec
{
    MenuDefType defType;
union
{
    MenuDefUPP defProc;
    struct
    {
        CFStringRef classID;
        EventRef initEvent;
        }view;
    }u;
}
```

When it comes time to display the menu, the system calls `HIObjectCreate`, passing in the class ID and the initialization event you specified in the menu definition specification.

As with any custom view, you must register your view subclass before use, assigning it a unique class ID and specifying the events that your view will handle.

Required Menu Definition Events

All view-based menus must handle a number of different events. Note, however, that the hit-test, draw, and get part events may be handled by views embedded within the menu content view rather than the view itself.

kEventControlGetOptimalBounds

The Menu Manager sends this event to determine the size of your menu content view. Your view should return its dimensions in the `kEventParamControlOptimalBounds` parameter. Note that the optimal bounds may differ from the view bounds you receive from `HIViewGetBounds`. The latter may display only part of the complete menu, requiring the user to scroll up or down to view all the contents. For efficiency, you may want to store this size in the view's instance data so it can quickly respond to other queries (such as `kEventScrollableGetInfo`).

kEventScrollableGetInfo

Your menu should return the following information:

- The total image size of the menu, as determined in response to the `kEventControlGetOptimalBounds` event.
- The menu's view size, which is the bounds returned by `HIViewGetBounds`. You can think of this as the visible part of the total menu. If the entire menu cannot fit onscreen, the user must scroll to see the rest of it.
- Its scrolling line size, which should be the size of an individual menu item.
- Its bounds origin, which you can determine from `HIViewGetBounds`.

kEventControlDraw

Your menu should draw its menu items when receiving this event. The event supplies a Core Graphics context (`CGContext`) in which to draw, as well as an invalid region, which you should use to determine what parts need to be redrawn.

kEventControlHitTest

The Menu Manager sends this event during menu tracking to determine which item is currently underneath the mouse cursor. Your menu should return the index of the menu item under the specified point in the part code parameter. If no menu item is underneath the point, return 0.

kEventControlGetPartRegion

The Menu Manager sends this event to determine the bounds of a menu item. Your menu should update the region parameter to include the bounds of the menu item specified by the part code parameter.

Optional Menu Definition Events

If you subclass your custom menu from the HIMenuView class, you do not need to implement these events unless you want to override the default behavior.

kEventMenuCreateFrameView

The Menu Manager sends this event when it needs to create a menu (typically just before it is shown for the first time). You should return the HIView reference of the window that is to contain the menu content view. Note that your window must also contain a content view within which the Menu Manager will embed the menu content view.

The default handler returns the HIView reference for a standard window frame view for menus.

kEventMenuGetFrameBounds

The Menu Manager sends this event when it is ready to display the menu. you should calculate the appropriate bounds for your menu and return it in the `kEventParamBounds` parameter.

The default handler calculates and returns an appropriate bounding rectangle based on the menu bounds, the available screen space, and the frame metrics of the menu window’s content view.

kEventMenuBecomeScrollable

The Menu Manager sends this event to the most recently-opened menu in the menu hierarchy to indicate that this menu should become scrollable. You should install the appropriate event handlers on the menu content view, content view, or frame view, to implement scrolling support.

The default handler installs event handlers to provide automatic scrolling for view-based menus.

kEventMenuCeaseToBeScrollable

The Menu Manager sends this event when a menu is no longer the most recently-opened menu, and therefore should not allow scrolling. This occurs when a menu is closed, or if the user selects a submenu of the menu. You should remove whatever handlers you installed to enable scrolling for that menu.

The default handler removes the event handlers that implement automatic scrolling for view-based menus.

kEventScrollableScrollTo

The Menu Manager sends this event to indicate that the menu needs to be scrolled. You should implement any customized scrolling. Note that you can also use this event if you need to keep track of the origin of the view bounds.

The default handler changes the origin of the view bounds and then invalidates the entire menu content view.

kEventControlSetFocusPart

The Menu Manager sends this event during menu tracking to highlight a menu item as the mouse enters its bounds and unhighlight it as it leaves. Your handler should determine the area of the part gaining or losing focus (that is, the invalid region). Then the handler should call `HIViewSetNeedsDisplayInRegion`, passing the invalid region. The Control Manager then sends a `kEventControlDraw` event to your view with the invalid region stored in the `kEventParamRgnHandle` parameter. Your drawing handler can then update the focus area appropriately.

The default handler calls `GetControlRegion` to determine the region of the item gaining or losing focus, and then calls `HIViewSetNeedsDisplayInRegion` with the total invalid region.

kEventControlSimulateHit

The Menu Manager sends this event when the user selects a menu item. Your handler should display some sort of feedback to acknowledge the selection.

The default handler flashes the selected menu item off and on.

Menu Definition Events Versus Older MDEF Messages

If you have older custom menu code that uses MDEF messages, you should convert them to use Carbon events instead. Table 2-2 shows the correspondence between MDEF messages and their Carbon event equivalents.

Table 2-2 Carbon events versus MDEF messages

MDEF Message	Carbon Event
`kMenuInitMsg`	`kEventControlInitialize`
`kMenuDisposeMsg`	`kEventControlDispose`
`kMenuFindItemMsg`	`kEventControlHitTest`
`kMenuHiliteItemMsg`	`kEventControlSetFocusPart`
`kMenuDrawItemsMsg`	`kEventControlDraw`
`kMenuDrawMsg`	`kEventControlDraw`
`kMenuSizeMsg`	`kEventControlGetOptimalBounds`, `kEventScrollableGetInfo`
`kMenuPopUpMsg`	`kEventMenuGetFrameBounds`

MDEF Message	Carbon Event
`kMenuCalcItemMsg`	`kEventControlGetPartRegion`
`kMenuThemeSavvyMsg`	No equivalent

A Custom Menu View Example

As custom menu view is an HIView, you can conceivably put anything into the menu that you could put into a window content view, even standard controls. This example creates a menu view that contains a standard push button.

Note: Placing controls in menus violates the current Aqua human interface guidelines; this example is for illustrative purposes only. You should consult the Aqua guidelines before adding any custom user interface elements to your application.

Listing 2-11 shows the event handers that make up the menu definition.

Listing 2-11 Menu view event handlers

```
typedef struct
{
    HIViewRef           view;
    HIViewRef           button;
}
MyMenuData;

static const EventTypeSpec  kMyMenuEvents[] =
{
    { kEventClassHIObject, kEventHIObjectConstruct },
    { kEventClassHIObject, kEventHIObjectDestruct },
    { kEventClassControl, kEventControlInitialize },
    { kEventClassControl, kEventControlBoundsChanged },
    { kEventClassControl, kEventControlGetOptimalBounds },
    { kEventClassScrollable, kEventScrollableGetInfo }
};

static pascal OSStatus MyMenuHandler( EventHandlerCallRef inCaller,
                        EventRef inEvent, void* inRefcon )
{
    OSStatus    err = eventNotHandledErr;
    MyMenuData* data = (MyMenuData*) inRefcon;

    switch ( GetEventClass( inEvent ) )
    {
        case kEventClassHIObject:
            switch ( GetEventKind( inEvent ) )
            {
                case kEventHIObjectConstruct:
                {
                    data = (MyMenuData*) calloc( 1, sizeof( MyMenuData ) );
                    require_action( data != NULL, CouldntAllocData,
                                    err = memFullErr );
                    GetEventParameter(inEvent,kEventParamHIObjectInstance,
                            typeHIObjectRef, NULL, sizeof( data->view ),
                            NULL, &data->view );
                    SetEventParameter(inEvent,kEventParamHIObjectInstance,
                             typeVoidPtr, sizeof( data ), &data );
                    err = noErr;
                    break;
                }

                case kEventHIObjectDestruct:
                    free( (void*) data );
                    err = noErr;
                    break;
            }
            break;

        case kEventClassControl:
            switch ( GetEventKind( inEvent ) )
            {
                case kEventControlInitialize:
                {
                    Rect        bounds = { 0, 0, 0, 0 };

                    err = CreatePushButtonControl( NULL, &bounds,
                                     CFSTR("Beep!"), &data->button );
                    require_noerr( err, CouldntCreateButton );

                    HIViewAddSubview( data->view, data->button);
                    break;
                }

                case kEventControlGetOptimalBounds:
                {
                    HIRect bounds = { { 0, 0 }, { 90, 100} };
                    SetEventParameter( inEvent,
                                 kEventParamControlOptimalBounds,
                                 typeHIRect, sizeof( bounds ), &bounds );
                    err = noErr;
                    break;
                }

                case kEventControlBoundsChanged:
                {
                    HIRect bounds;
                    HIViewGetBounds( data->view, &bounds );

                    HIRect frame;

                    frame.origin.x = 10;
                    frame.origin.y = bounds.size.height/2 - 10;

                    frame.size.height = 20;
                    frame.size.width = bounds.size.width - 20;

                    HIViewSetFrame( data->button, &frame );
                    err = noErr;
                    break;
                }
            }
            break;

        case kEventClassScrollable:
            switch ( GetEventKind( inEvent ) )
            {
                case kEventScrollableGetInfo:
                {
                    HIRect bounds;
                    HIPoint origin = { 0, 0 };
                    HIViewGetBounds( data->view, &bounds );
                    SetEventParameter( inEvent, kEventParamImageSize,
                         typeHISize, sizeof( bounds.size ), &bounds.size );
                    SetEventParameter( inEvent, kEventParamViewSize,
                         typeHISize, sizeof( bounds.size ), &bounds.size );

                    bounds.size.height = 20;    // arbitrary
                    SetEventParameter( inEvent, kEventParamLineSize,
                         typeHISize, sizeof( bounds.size ), &bounds.size );

                    SetEventParameter( inEvent, kEventParamOrigin,
                         typeHIPoint, sizeof( origin ), &origin );
                    err = noErr;
                    break;
                }
            }
            break;
    }

CouldntCreateButton:
CouldntAllocData:
    return err;
}
```

Here is how the code works:

1. The custom menu code must define its instance data in a structure. In this example, the only instance data that we need to store are the HIView references for the custom menu and the button embedded within it.
2. This custom menu event handler handles the usual HIObject construct and destruct events as well as most of the events required for view-based menus. Note that it does not implement handlers for `kEventControlDraw`, `kEventControlHitTest`, or `kEventControlGetPartRegion`, as these events are handled by the push button control's handlers.
3. The instance data is passed to your handler in the `refCon` parameter.
4. The construct event allocates enough memory to hold the menu's instance data. As is typical, you call `GetEventParameter` to obtain the default instance data for the HIObject, which you store in the view field of your actual instance data. Then call `SetEventParameter` to set the instance data to be the entire data structure you allocated. This data is passed to your event handler for subsequent events.
5. The destruct event handler simply frees the instance data associated with the custom menu. You do not need to dispose of the actual views, as this occurs automatically when the view hierarchy is released.

6. When it comes time to create the custom menu view, you can choose to add additional initialization steps by creating a `kEventControlInitialize` handler. The control in this case is the menu content view. This example creates a push button control to embed in the menu content view. The HIView reference of the button is stored as part of the custom menu's instance data. The `HIViewAddSubview` function does the actual embedding.

   Note that at this point, neither the menu content view nor the button have size or relative position (that is, bounds). The menu content view's bounds are set when the Menu Manager is ready to display it.

   Instead of using `kEventControlInitialize`, you could also handle this initialization in a `kEventHIObjectInitialize` event.

7. When the Menu Manager is ready to display the custom menu, it sends the `kEventControlGetOptimalBounds` event to the menu content view to determine its proper size. The event handler uses `SetEventParameter` to return the bounds in the `kEventParamControlOptimalBounds` parameter. Note that these bounds are of type `HIRect`, which uses different fields than the older `Rect` type.

   Note that the baseline offset, which you can also return for this event, does not apply for menus.

8. When the bounds change in response to what is returned for the `kEventControlGetOptimalBounds` event, the Menu Manager sends the `kEventControlBoundsChanged` event to the menu content view. You can use this event to position any additional views that are embedded within the content view. This example calls `HIViewGetBounds` to obtain the bounds of the menu content view. It uses these bounds to calculate a position and width for the embedded push button (centered within the menu and sized to leave 10 pixel borders to either side of the button). Calling `HIViewSetFrame` sets the frame coordinates for the button.

9. The Menu Manager sends the `kEventScrollableGetInfo` event when it needs to lay out a menu or scroll an existing one. This example sets the following values:

   - The image size is the total size of the menu, set in the `kEventParamImageSize` parameter.
   - The view size is the bounds of the currently visible portion of the menu, set in the `kEventParamViewSize` parameter. Because this menu is not designed to be scrollable, the view bounds and the image bounds are identical.
   - The line size is the size of an individual menu item, set in the `kEventParamLineSize` parameter. Because this menu doesn't have individual menu items, the line size doesn't matter.
   - The origin, set in the `kEventParamOrigin` parameter. Because the image size and the view size are identical, the origin for this menu content view is always at 0,0. If the image and view sizes were different (that is, the menu can be scrolled) then the origin reflects the frame coordinates of the top left corner of the currently visible portion of the menu).

   Note that the size values passed are of type `HISize`, not `HIRect`.

You could use the function in Listing 2-12 to register, instantiate, and insert your custom menu:

Listing 2-12 Creating a custom menu

```
#define kMyCustomMenuViewClassID CFSTR("com.apple.sample.kMyCustomMenuClassID")

OSStatus MyCreateCustomMenu (MenuID theID)
{
    MenuDefSpec     defSpec;
    MenuRef         theMenu;

    HIObjectClassRef theClassIDRef;

    OSStatus        err;

    HIObjectRegisterSubclass( kMyCustomMenuViewClassID,
                        kHIMenuViewClassID, kNilOptions, MyMenuHandler,
                        GetEventTypeCount( kMyMenuEvents ), kMyMenuEvents,
                        NULL, &theClassIDRef );

    defSpec.defType = kMenuDefClassID;
    defSpec.u.view.classID = kMyCustomMenuViewClassID;
    defSpec.u.view.initEvent = NULL;
    err = CreateCustomMenu( &defSpec, 0, 0, &theMenu );
    if ( err == noErr ) {
        SetMenuTitleWithCFString( theMenu, CFSTR("Button") );
        InsertMenu( theMenu, theID );
    }
    return err;
}
```

Here is how the code works:

1. The class ID of your custom menu must be a unique CFString.

2. Call `HIObjectRegisterSubclass` to register your custom menu, just as you would for any HIObject. This custom menu is subclassed from the base HIMenuView class (`kHIMenuViewClassID`). The event handler is the function described in Listing 2-11 (page 49).

3. Specify `kMenuDefClassID` in the menu definition specification structure to indicate that this is an HIObject-based custom menu.

4. `kMyCustomMenuViewClassID`, the class of menu to instantiate, is the class registered in step 2.

5. This custom menu has no HIObject initialization event, so set this field in the menu definition specification to `NULL`.

6. Create an instance of the custom menu by calling `CreateCustomMenu` with the specified menu definition specification.

7. Call `SetMenuTitleWithCFString` to assign a title to the menu. If you don't assign a title, the corresponding space in the menu bar appears blank (although clicking in the appropriate region still activates the menu).

8. Call `InsertMenu` to insert the custom menu into the current menu list.

Document Revision History

This table describes the changes to *HIView Programming Guide*.

Date	Notes
2007-10-31	Added information about HICocoaView.
2007-04-03	Made minor technical and editorial corrections.
2005-04-29	Changed the title from *Introducing HIView*.
2003-10-15	Clarified that menus are HIObjects, but they are displayed using menu content views.
	Added binding and positioning illustrations.
	In "Creating Custom Menus" (page 45), changed feature bit `kControlDoesNotUseSpecialParts` to `kHIViewDoesNotUseSpecialParts`.
	Updated information under "kEventControlSetFocusPart" (page 48), indicating that the handler must call `HIViewSetNeedsDisplayInRegion`.
2003-09-16	Updated conceptual information to include menu content views.
	Specified that the combo box turns into a scrolling list if you exceed a certain number of menu items.
	Added information about new views, "Text View" (page 17) and "Web View" (page 17).
	Added new section about automating view layout.
	Added new section about manipulating menu views.
	Clarified in "Handling HIObject Events" (page 39) that when setting the `kEventParamHIObjectInstance` parameter for the construct event, the type should be `typeVoidPtr`, not `typeHIObjectRef`.
	Clarified in "Handling HIObject Events" (page 39) that the instance data you set in the `kEventHIObjectConstruct` handler is then passed to your event handler in the `userData` parameter.
	Added simple destruct handler, Listing 2-8 (page 40).
	Added additional requirements for enabling drag-and-drop in "Handling Drag and Drop Events" (page 43).
	Added new section, "Creating Custom Menus" (page 45).

Date	Notes
2002-09-28	Added additional drawing details to "The Drawing Model" (page 13).
	Indicated in "Translating Coordinates" (page 27) that you can pass null for a view parameter to convert to or from window-relative coordinates.
	Added information to "Drawing in Views" (page 28) about how to transform a context if you want to draw using Quartz coordinates.
	Qualified in "Creating a Combo Box" (page 35) that if you do not specify the `kHIComboBoxAutoSizeListAttribute` attribute when creating the combo box, you must size it yourself using the appropriate `SetControlData` tags.
	Correction in "Handling HIObject Events" (page 39): you *should* dispose of instance data in your `kEventHIObjectDestruct` handler.
	Qualified info about part codes in "Handling Hit-Test Events" (page 42): custom part codes should be in the range 1-127. Your application can respond to negative part code values, but it should never return them from a `kEventControlHitTest` handler.
2002-09-23	Cleaned up usage of "control" and "view" throughout the document to conform to the standard defined in "Views Versus Controls and Menus" (page 11).
	Removed mention of the toolbar control, as it is not a view, and cannot be directly accessed by the developer. Revised Figure 1-1 (page 10) to reflect this change.
	Corrected text throughout the document to remove mention of the Quartz compositor and discuss the HIView compositor instead.
	Revised "The Coordinate System" (page 14) to correctly describe the HIView coordinate system. The HIView coordinate axis is identical to the QuickDraw axis.
	Added information about `HIPoint`, `HISize`, and `HIRect` to "The Coordinate System" (page 14).
	Updated combo box screen shots in Figure 1-7 (page 16).
	Added information about how much work is done by the standard event handler in "Changing Keyboard Focus" (page 27).
	Added example to "Translating Coordinates" (page 27).
	Added warning to "Drawing in Views" (page 28) indicating that you should not pass `false` to the `HIViewSetNeedsDisplay` or `HIViewSetNeedsDisplayInRegion` functions, as this may unintentionally suppress updates in other intersecting views.
	Added note to "Creating a Scroll View" (page 32), indicating that if you want to embed custom views in a scroll view, they must support the `kEventClassScrollable` events.

Date	Notes
	Added attribute constant names for optional features in "Creating a Combo Box" (page 35).
	Changed "Calvin" to "Hobbes" in Listing 2-4 (page 35) to match the combo box in Figure 1-7 (page 16).
	Greatly expanded "Creating Custom Views" (page 36), adding sample code and more descriptions.
	Clarified in "Handling Draw Events" (page 42) that the `kEventControlDraw` event passes a region handle to you that you can use to constrain drawing to the visible parts of your view.
	Added info to "Handling Drag and Drop Events" (page 43) indicating that you must return a `kEventParamControlLikesDrag` Boolean parameter when responding to the the `kEventControlDragEntered` event.
2002-09-02	Preliminary review draft.