Core Animation Reference Collection

Graphics & Imaging > Quartz

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Contents

Figures, Tables, and Listings

Core Animation Reference Collection

Framework	/System/Library/Frameworks/QuartzCore.frameworks
Header file directories	/System/Library/Frameworks/QuartzCore.frameworks/Headers
Companion guide	Core Animation Programming Guide
Declared in	CAAnimation.h CABase.h CACIFilterAdditions.h CAConstraintLayoutManager.h CALayer.h CAMediaTiming.h CAMediaTimingFunction.h CAOpenGLLayer.h CARenderer.h CAScrollLayer.h CATextLayer.h CATransaction.h CATransform3D.h QCCompositionLayer.h

This collection of documents provides the API reference for Core Animation. Core Animation provides animation and display hierarchy capabilities to applications. For more details, see *Core Animation Programming Guide*.

Classes

CAAnimation Class Reference

Inherits from	NSObject
Conforms to	NSCoding NSCopying CAAction CAMediaTiming NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAAnimation.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CAAnimation` is an abstract animation class. It provides the basic support for the `CAMediaTiming` and `CAAction` protocols.

Tasks

Archiving Properties

`– shouldArchiveValueForKey:` (page 19)
Specifies whether the value of the property for a given key is archived.

Providing Default Values for Properties

`+ defaultValueForKey:` (page 18)
Specifies the default value of the property with the specified key.

Creating an Animation

+ `animation` (page 17)
: Creates and returns a new `CAAnimation` instance.

Animation Attributes

`removedOnCompletion` (page 17) *property*
: Determines if the animation is removed from the target layer's animations upon completion.

- `isRemovedOnCompletion` (page 18)
: A synthesized accessor for the `removedOnCompletion` (page 17) property.

`timingFunction` (page 17) *property*
: An optional timing function defining the pacing of the animation.

Getting and Setting the Delegate

`delegate` (page 16) *property*
: Specifies the receiver's delegate object.

Animation Progress

- `animationDidStart:` (page 19) *delegate method*
: Called when the animation begins its active duration.

- `animationDidStop:finished:` (page 19) *delegate method*
: Called when the animation completes its active duration or is removed from the object it is attached to.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

delegate

Specifies the receiver's delegate object.

```
@property(retain) id delegate
```

Discussion
Defaults to `nil`.

Important: The `delegate` object is retained by the receiver. This is a rare exception to the memory management rules described in *Memory Management Programming Guide for Cocoa*.

An instance of `CAAnimation` should not be set as a delegate of itself. Doing so (outside of a garbage-collected environment) will cause retain cycles.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

removedOnCompletion

Determines if the animation is removed from the target layer's animations upon completion.

```
@property BOOL removedOnCompletion
```

Discussion
When `YES`, the animation is removed from the target layer's animations once its active duration has passed. Defaults to `YES`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

timingFunction

An optional timing function defining the pacing of the animation.

```
@property(retain) CAMediaTimingFunction *timingFunction
```

Discussion
Defaults to `nil`, indicating linear pacing.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

Class Methods

animation

Creates and returns a new `CAAnimation` instance.

```
+ (id)animation
```

Return Value
An `CAAnimation` object whose input values are initialized.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

defaultValueForKey:

Specifies the default value of the property with the specified key.

```
+ (id)defaultValueForKey:(NSString *)key
```

Parameters

`key`
The name of one of the receiver's properties.

Return Value
The default value for the named property. Returns `nil` if no default value has been set.

Discussion
If this method returns `nil` a suitable "zero" default value for the property is provided, based on the declared type of the `key`. For example, if *`key`* is a *`CGSize`* object, a size of (0.0,0.0) is returned. For a `CGRect` an empty rectangle is returned. For `CGAffineTransform` and `CATransform3D`, the appropriate identity matrix is returned.

Special Considerations

If *`key`* is not a known for property of the class, the result of the method is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

Instance Methods

isRemovedOnCompletion

A synthesized accessor for the `removedOnCompletion` (page 17) property.

```
- (BOOL)isRemovedOnCompletion
```

See Also
`@property removedOnCompletion` (page 17)

shouldArchiveValueForKey:

Specifies whether the value of the property for a given key is archived.

```
- (BOOL)shouldArchiveValueForKey:(NSString *)key
```

Parameters

key

The name of one of the receiver's properties.

Return Value

`YES` if the specified property should be archived, otherwise `NO`.

Discussion

Called by the object's implementation of `encodeWithCoder:`. The object must implement keyed archiving.

The default implementation returns `YES`.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAAnimation.h`

Delegate Methods

animationDidStart:

Called when the animation begins its active duration.

```
- (void)animationDidStart:(CAAnimation *)theAnimation
```

Parameters

theAnimation

The `CAAnimation` instance that started animating.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAAnimation.h`

animationDidStop:finished:

Called when the animation completes its active duration or is removed from the object it is attached to.

```
- (void)animationDidStop:(CAAnimation *)theAnimation
    finished:(BOOL)flag
```

Parameters

theAnimation

The `CAAnimation` instance that stopped animating.

`flag`

If `YES`, the animation reached the end of its active duration without being removed.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAAnimation.h`

CAAnimationGroup Class Reference

Inherits from	CAAnimation : NSObject
Conforms to	NSCoding (CAAnimation) NSCopying (CAAnimation) CAAction (CAAnimation) CAMediaTiming (CAAnimation) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAAnimation.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CAAnimationGroup` allows multiple animations to be grouped and run concurrently. The grouped animations run in the time space specified by the `CAAnimationGroup` instance.

The duration of the grouped animations are not scaled to the duration of their CAAnimationGroup. Instead, the animations are clipped to the duration of the animation group. For example, a 10 second animation grouped within an animation group with a duration of 5 seconds will only display the first 5 seconds of the animation.

Important: The `delegate` and `removedOnCompletion` properties of animations in the `animations` (page 22) array are currently ignored. The `CAAnimationGroup` delegate does receive these messages.

Note: The `delegate` and `removedOnCompletion` properties of animations in the `animations` (page 22) property are currently ignored.

Tasks

Grouped Animations

`animations` (page 22) *property*
An array of `CAAnimation` objects to be evaluated in the time space of the receiver.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

animations

An array of `CAAnimation` objects to be evaluated in the time space of the receiver.

```
@property(copy) NSArray *animations
```

Discussion
The animations run concurrently in the receiver's time space.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

CABasicAnimation Class Reference

Inherits from	CAPropertyAnimation : CAAnimation : NSObject
Conforms to	NSCoding (CAAnimation) NSCopying (CAAnimation) CAAction (CAAnimation) CAMediaTiming (CAAnimation) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAAnimation.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CABasicAnimation` provides basic, single-keyframe animation capabilities for a layer property. You create an instance of `CABasicAnimation` using the inherited `animationWithKeyPath:` (page 103) method, specifying the key path of the property to be animated in the render tree.

Setting Interpolation Values

The `fromValue` (page 24), `byValue` (page 24) and `toValue` (page 25) properties define the values being interpolated between. All are optional, and no more than two should be non-`nil`. The object type should match the type of the property being animated.

The interpolation values are used as follows:

- Both `fromValue` (page 24) and `toValue` (page 25) are non-`nil`. Interpolates between `fromValue` (page 24) and `toValue` (page 25).
- `fromValue` (page 24) and `byValue` (page 24) are non-`nil`. Interpolates between `fromValue` (page 24) and (`fromValue` (page 24) + `byValue` (page 24)).
- `byValue` (page 24) and `toValue` (page 25) are non-`nil`. Interpolates between (`toValue` (page 25) - `byValue` (page 24)) and `toValue` (page 25).
- `fromValue` (page 24) is non-`nil`. Interpolates between `fromValue` (page 24) and the current presentation value of the property.

- `toValue` (page 25) is non-`nil`. Interpolates between the current value of `keyPath` in the target layer's presentation layer and `toValue` (page 25).
- `byValue` (page 24) is non-`nil`. Interpolates between the current value of `keyPath` in the target layer's presentation layer and that value plus `byValue` (page 24).
- All properties are `nil`. Interpolates between the previous value of `keyPath` in the target layer's presentation layer and the current value of `keyPath` in the target layer's presentation layer.

Tasks

Interpolation Values

`fromValue` (page 24) *property*
Defines the value the receiver uses to start interpolation.

`toValue` (page 25) *property*
Defines the value the receiver uses to end interpolation.

`byValue` (page 24) *property*
Defines the value the receiver uses to perform relative interpolation.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

byValue

Defines the value the receiver uses to perform relative interpolation.

```
@property(retain) id byValue
```

Discussion
See "Setting Interpolation Values" (page 23) for details on how `byValue` interacts with the other interpolation values.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

fromValue

Defines the value the receiver uses to start interpolation.

```
@property(retain) id fromValue
```

Discussion
See "Setting Interpolation Values" (page 23) for details on how `fromValue` interacts with the other interpolation values.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

toValue

Defines the value the receiver uses to end interpolation.

```
@property(retain) id toValue
```

Discussion
See "Setting Interpolation Values" (page 23) for details on how `toValue` interacts with the other interpolation values.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

CAConstraint Class Reference

Inherits from	NSObject
Conforms to	NSCoding NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAConstraintLayoutManager.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CAConstraint` represents a single layout constraint between two layers. Each `CAConstraint` instance encapsulates one geometry relationship between two layers on the same axis.

Sibling layers are referenced by name, using the `name` property of each layer. The special name `superlayer` is used to refer to the layer's superlayer.

For example, to specify that a layer should be horizontally centered in its superview you would use the following:

```
theConstraint=[CAConstraint constraintWithAttribute:kCAConstraintMidX
                                       relativeTo:@"superlayer"
                                        attribute:kCAConstraintMidX];
```

A maximum of two relationships must be specified per axis. If you specify constraints for the left and right edges of a layer, the width will vary. If you specify constraints for the left edge and the width, the right edge of the layer will move relative to the superlayer's frame. Often you'll specify only a single edge constraint, the layer's size in the same axis will be used as the second relationship.

Important: It is possible to create constraints that result in circular references to the same attributes. In cases where the layout is unable to be computed the behavior is undefined.

Tasks

Create a New Constraint

`+ constraintWithAttribute:relativeTo:attribute:scale:offset:` (page 29)
Creates and returns an `CAConstraint` object with the specified parameters.

`+ constraintWithAttribute:relativeTo:attribute:offset:` (page 29)
Creates and returns an `CAConstraint` object with the specified parameters.

`+ constraintWithAttribute:relativeTo:attribute:` (page 28)
Creates and returns an `CAConstraint` object with the specified parameters.

`- initWithAttribute:relativeTo:attribute:scale:offset:` (page 30)
Returns an `CAConstraint` object with the specified parameters. Designated initializer.

Class Methods

constraintWithAttribute:relativeTo:attribute:

Creates and returns an `CAConstraint` object with the specified parameters.

```
+ (id)constraintWithAttribute:(CAConstraintAttribute)attr
    relativeTo:(NSString *)srcLayer
    attribute:(CAConstraintAttribute)srcAttr
```

Parameters

attr
The attribute of the layer for which to create a new constraint.

srcLayer
The name of the layer that this constraint is calculated relative to.

srcAttr
The attribute of *srcLayer* the constraint is calculated relative to.

Return Value
A new `CAConstraint` object with the specified parameters. The scale of the constraint is set to 1.0. The offset of the constraint is set to 0.0.

Discussion
The value for the constraint is calculated is *srcAttr*.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAConstraintLayoutManager.h`

constraintWithAttribute:relativeTo:attribute:offset:

Creates and returns an `CAConstraint` object with the specified parameters.

```
+ (id)constraintWithAttribute:(CAConstraintAttribute)attr
    relativeTo:(NSString *)srcLayer
    attribute:(CAConstraintAttribute)srcAttr
    offset:(CGFloat)offset
```

Parameters

`attr`
: The attribute of the layer for which to create a new constraint.

`srcLayer`
: The name of the layer that this constraint is calculated relative to.

`srcAttr`
: The attribute of *`srcLayer`* the constraint is calculated relative to.

`offset`
: The offset added to the value of `srcAttr`.

Return Value
A new `CAConstraint` object with the specified parameters. The scale of the constraint is set to 1.0.

Discussion
The value for the constraint is calculated as (*`srcAttr`* + *`offset`*).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAConstraintLayoutManager.h`

constraintWithAttribute:relativeTo:attribute:scale:offset:

Creates and returns an `CAConstraint` object with the specified parameters.

```
+ (id)constraintWithAttribute:(CAConstraintAttribute)attr
    relativeTo:(NSString *)srcLayer
    attribute:(CAConstraintAttribute)srcAttr
    scale:(CGFloat)scale
    offset:(CGFloat)offset
```

Parameters

`attr`
: The attribute of the layer for which to create a new constraint.

`srcLayer`
: The name of the layer that this constraint is calculated relative to.

`srcAttr`
: The attribute of *`srcLayer`* the constraint is calculated relative to.

scale
: The amount to scale the value of *srcAttr*.

offset
: The offset from the srcAttr.

Return Value
A new CAConstraint object with the specified parameters.

Discussion
The value for the constraint is calculated as (*srcAttr* * scale) + offset).

Availability
Available in Mac OS X v10.5 and later.

Declared In
CAConstraintLayoutManager.h

Instance Methods

initWithAttribute:relativeTo:attribute:scale:offset:

Returns an CAConstraint object with the specified parameters. Designated initializer.

```
- (id)initWithAttribute:(CAConstraintAttribute)attr
    relativeTo:(NSString *)srcLayer
    attribute:(CAConstraintAttribute)srcAttr
    scale:(CGFloat)scale
    offset:(CGFloat)offset
```

Parameters

attr
: The attribute of the layer for which to create a new constraint.

srcLayer
: The name of the layer that this constraint is calculated relative to.

srcAttr
: The attribute of *srcLayer* the constraint is calculated relative to.

scale
: The amount to scale the value of *srcAttr*.

offset
: The offset added to the value of srcAttr.

Return Value
An initialized constraint object using the specified parameters.

Discussion
The value for the constraint is calculated as (*srcAttr* * *scale*) + *offset*).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAConstraintLayoutManager.h`

Constants

CAConstraintAttribute

These constants represent the geometric edge or axis of a constraint.

```
enum _CAConstraintAttribute
{
 kCAConstraintMinX,
 kCAConstraintMidX,
 kCAConstraintMaxX,
 kCAConstraintWidth,
 kCAConstraintMinY,
 kCAConstraintMidY,
 kCAConstraintMaxY,
 kCAConstraintHeight,
};
```

Constants

`kCAConstraintMinX`

The left edge of a layer's frame.

Available in Mac OS X v10.5 and later.

Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintMidX`

The horizontal location of the center of a layer's frame.

Available in Mac OS X v10.5 and later.

Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintMaxX`

The right edge of a layer's frame.

Available in Mac OS X v10.5 and later.

Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintWidth`

The width of a layer.

Available in Mac OS X v10.5 and later.

Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintMinY`

The bottom edge of a layer's frame.

Available in Mac OS X v10.5 and later.

Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintMidY`

The vertical location of the center of a layer's frame.

Available in Mac OS X v10.5 and later.

Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintMaxY`
: The top edge of a layer's frame.

  Available in Mac OS X v10.5 and later.

  Declared in `CAConstraintLayoutManager.h`.

`kCAConstraintHeight`
: The height of a layer.

  Available in Mac OS X v10.5 and later.

  Declared in `CAConstraintLayoutManager.h`.

Declared In
`CAConstraint.h`

Constraint Attribute Type

The constraint attribute type.

```
typedef int CAConstraintAttribute;
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAConstraintLayoutManager.h`

CAConstraintLayoutManager Class Reference

Inherits from	NSObject
Conforms to	NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAConstraintLayoutManager.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook
Related sample code	Core Animation QuickTime Layer

Overview

`CAConstraintLayoutManager` provides a constraint-based layout manager.

Constraint-based layout allows you to describe the position and size of a layer by specifying relationships between a layer and its sibling layers or its superlayer. The relationships are represented by instances of the `CAConstraint` class that are stored in an array in the layer's `constraints` property. You add constraints for a layer using its `addConstraint:` (page 65) method. Each `CAConstraint` instance encapsulates one geometry relationship between two layers. Layout is then performed by fetching the constraints of each sublayer and solving the resulting system of constraints for the frame of each sublayer starting from the bounds of the containing layer.

Sibling layers are referenced by name, using the `name` property of each layer. The special name `superlayer` is used to refer to the layer's superlayer.

Important: It is possible to specify a set of constraints for a layer (for example, circular attribute dependencies) that will cause layout to fail. In that case the behavior is undefined.

Tasks

Creating the Layout Manager

`+ layoutManager` (page 34)
Creates and returns a new `CAConstraintLayoutManager` instance.

Class Methods

layoutManager

Creates and returns a new `CAConstraintLayoutManager` instance.

```
+ (id)layoutManager
```

Return Value
A new `CAConstraintLayoutManager` instance.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
Core Animation QuickTime Layer

Declared In
`CAConstraintLayoutManager.h`

CAKeyframeAnimation Class Reference

Inherits from	CAPropertyAnimation : CAAnimation : NSObject
Conforms to	NSCoding (CAAnimation) NSCopying (CAAnimation) CAAction (CAAnimation) CAMediaTiming (CAAnimation) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAAnimation.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CAKeyframeAnimation` provides generic keyframe animation capabilities for a layer property in the render tree. You create an `CAKeyframeAnimation` instance using the inherited `animationWithKeyPath:` (page 103) method, specifying the key path of the property updated in the render tree during the animation. The animation provides a series of keyframe values, either as an array or a series of points in a `CGPathRef`. While animating, it updates the value of the property in the render tree with values calculated using the specified interpolation calculation mode.

Tasks

Providing Keyframe Values

`path` (page 37) *property*
An optional `CGPathRef` that provides the keyframe values for the receiver.

`values` (page 38) *property*
An array of objects that provide the keyframe values for the receiver.

Keyframe Timing

`keyTimes` (page 36) *property*
An optional array of `NSNumber` objects that define the duration of each keyframe segment.

`timingFunctions` (page 38) *property*
An optional array of `CAMediaTimingFunction` instances that defines the pacing of the each keyframe segment.

`calculationMode` (page 36) *property*
Specifies how intermediate keyframe values are calculated by the receiver.

Rotation Mode

`rotationMode` (page 37) *property*
Determines whether objects animating along the path rotate to match the path tangent.

Properties

For more about Objective-C properties, see “Properties” in *The Objective-C 2.0 Programming Language*.

calculationMode

Specifies how intermediate keyframe values are calculated by the receiver.

```
@property(copy) NSString *calculationMode
```

Discussion
The possible values are described in “`Value calculation modes`” (page 39). The default is `kCAAnimationLinear` (page 39).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

keyTimes

An optional array of `NSNumber` objects that define the duration of each keyframe segment.

```
@property(copy) NSArray *keyTimes
```

Discussion
Each value in the array is a floating point number between 0.0 and 1.0 and corresponds to one element in the values array. Each element in the `keyTimes` array defines the duration of the corresponding keyframe value as a fraction of the total duration of the animation. Each element value must be greater than, or equal to, the previous value.

The appropriate values in the `keyTimes` array are dependent on the `calculationMode` (page 36) property.

- If the calculationMode is set to `kCAAnimationLinear`, the first value in the array must be 0.0 and the last value must be 1.0. Values are interpolated between the specified keytimes.
- If the calculationMode is set to `kCAAnimationDiscrete`, the first value in the array must be 0.0.
- If the calculationMode is set to `kCAAnimationPaced`, the `keyTimes` array is ignored.

If the values in the `keyTimes` array are invalid or inappropriate for the `calculationMode`, the `keyTimes` array is ignored.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

path

An optional `CGPathRef` that provides the keyframe values for the receiver.

```
@property CGPathRef path;
```

Discussion
Defaults to `nil`. Specifying a path overrides the `values` (page 38) property. Each point in the path, except for moveto points, defines a single keyframe segment for the purpose of timing and interpolation. For constant velocity animation along the path, `calculationMode` (page 36) should be set to `kCAAnimationPaced` (page 39).

Availability
Available in Mac OS X v10.5 and later.

See Also
`@property rotationMode` (page 37)

Declared In
`CAAnimation.h`

rotationMode

Determines whether objects animating along the path rotate to match the path tangent.

```
@property(copy) NSString *rotationMode
```

Discussion
Possible values are described in "`Rotation Mode Values`" (page 38). The default is `nil`, which indicates that objects should not rotate to follow the path.

The effect of setting this property to a non-`nil` value when no path object is supplied is undefined.

Availability
Available in Mac OS X v10.5 and later.

See Also
`@property path` (page 37)

Declared In
`CAAnimation.h`

timingFunctions

An optional array of `CAMediaTimingFunction` instances that defines the pacing of the each keyframe segment.

```
@property(copy) NSArray *timingFunctions
```

Discussion
If the receiver defines *n* keyframes, there must be *n*-1 objects in the `timingFunctions` array. Each timing function describes the pacing of one keyframe to keyframe segment.

Special Considerations
The inherited `timingFunction` value is always ignored.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

values

An array of objects that provide the keyframe values for the receiver.

```
@property(copy) NSArray *values
```

Discussion
The `values` property is ignored when the `path` (page 37) property is used.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

Constants

Rotation Mode Values

These constants are used by the `rotationMode` (page 37) property.

```
NSString * const kCAAnimationRotateAuto
NSString * const kCAAnimationRotateAutoReverse
```

Constants

`kCAAnimationRotateAuto`

The objects travel on a tangent to the path.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCAAnimationRotateAutoReverse`

The objects travel at a 180 degree tangent to the path.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

Declared In

`CAAnimation.h`

Value calculation modes

These constants are used by the `calculationMode` (page 36) property.

```
NSString * const kCAAnimationLinear;
NSString * const kCAAnimationDiscrete;
NSString * const kCAAnimationPaced;
```

Constants

`kCAAnimationLinear`

Simple linear calculation between keyframe values.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCAAnimationDiscrete`

Each keyframe value is used in turn, no interpolated values are calculated.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCAAnimationPaced`

Keyframe values are interpolated to produce an even pace throughout the animation. This mode is not currently implemented

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

Declared In

`CAAnimation.h`

CALayer Class Reference

Inherits from	NSObject
Conforms to	NSCoding CAMediaTiming NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAConstraintLayoutManager.h CALayer.h CAScrollLayer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook
Related sample code	CALayerEssentials Core Animation QuickTime Layer

Overview

`CALayer` is the model class for layer-tree objects. It encapsulates the position, size, and transform of a layer, which defines its coordinate system. It also encapsulates the duration and pacing of a layer and its animations by adopting the `CAMediaTiming` protocol, which defines a layer's time space.

Tasks

Creating a Layer

`+ layer` (page 63)
  Creates and returns an instance of `CALayer`.

`- init` (page 70)
  Returns an initialized `CALayer` object.

`- initWithLayer:` (page 71)
  Override to copy or initialize custom fields of the specified layer.

Accessing the Presentation Layer

`- presentationLayer` (page 74)
: Returns a copy of the layer containing all properties as they were at the start of the current transaction, with any active animations applied.

`- modelLayer` (page 74)
: Returns the model layer of the receiver, if it represents a current presentation layer.

Modifying the Layer Geometry

`frame` (page 54) *property*
: Specifies receiver's frame rectangle in the super-layer's coordinate space.

`bounds` (page 50) *property*
: Specifies the bounds rectangle of the receiver. Animatable.

`position` (page 58) *property*
: Specifies the receiver's position in the superlayer's coordinate system. Animatable.

`zPosition` (page 61) *property*
: Specifies the receiver's position on the z axis. Animatable.

`anchorPoint` (page 47) *property*
: Defines the anchor point of the layer's bounds rectangle. Animatable.

`- affineTransform` (page 65)
: Convenience method for getting the `transform` (page 61) property as an affine transform.

`- setAffineTransform:` (page 78)
: Convenience method for setting the `transform` (page 61) property as an affine transform.

`transform` (page 61) *property*
: Specifies the transform applied to the receiver, relative to the center of its bounds. Animatable.

`sublayerTransform` (page 60) *property*
: Specifies a transform applied to each sublayer when rendering. Animatable.

Providing Layer Content

`contents` (page 51) *property*
: An object that provides the contents of the layer. Animatable.

`contentsRect` (page 52) *property*
: A rectangle, in the unit coordinate space, defining the subrectangle of `contents` (page 51) that the receiver should draw. Animatable.

`- display` (page 69)
: Reload the content of this layer.

`- displayLayer:` (page 80) *delegate method*
: Allows the delegate to override the `display` (page 69) implementation.

`- drawInContext:` (page 70)
: Draws the receiver's content in the specified graphics context.

`- drawLayer:inContext:` (page 81) *delegate method*
: Allows the delegate to override the layer's `drawInContext:` implementation.

`opaque` (page 57) *property*
: Specifies a hint marking that the pixel data provided by the `contents` (page 51) property is completely opaque.

- `isOpaque` (page 73)
: A synthesized accessor for the `opaque` (page 57) property.

`edgeAntialiasingMask` (page 53) *property*
: A bitmask defining how the edges of the receiver are rasterized.

`minificationFilter` (page 56) *property*
: The filter used when reducing the size of the content.

`magnificationFilter` (page 55) *property*
: The filter used when increasing the size of the content.

Style Attributes

`contentsGravity` (page 51) *property*
: Determines how the receiver's contents are positioned within its bounds.

`opacity` (page 57) *property*
: Determines the opacity of the receiver. Animatable.

`hidden` (page 54) *property*
: Determines whether the receiver is displayed. Animatable.

- `isHidden` (page 73)
: A synthesized accessor for the `hidden` (page 54) property.

`masksToBounds` (page 56) *property*
: Determines if the sublayers are clipped to the receiver's bounds. Animatable.

`doubleSided` (page 53) *property*
: Determines whether the receiver is displayed when facing away from the viewer. Animatable.

- `isDoubleSided` (page 73)
: A synthesized accessor for the `doubleSided` (page 53) property.

`mask` (page 55) *property*
: An optional layer whose alpha channel is used as a mask to select between the layer's background and the result of compositing the layer's contents with its filtered background.

`cornerRadius` (page 52) *property*
: Specifies a radius used to draw the rounded corners of the receiver's background. Animatable.

`borderWidth` (page 49) *property*
: Specifies the width of the receiver's border. Animatable.

`borderColor` (page 49) *property*
: The color of the receiver's border. Animatable.

`backgroundColor` (page 48) *property*
: Specifies the background color of the receiver. Animatable.

`backgroundFilters` (page 48) *property*
: An optional array of CoreImage filters that are applied to the receiver's background. Animatable.

`shadowOpacity` (page 59) *property*
: Specifies the opacity of the receiver's shadow. Animatable.

`shadowRadius` (page 59) *property*
: Specifies the blur radius used to render the receiver's shadow. Animatable.

`shadowOffset` (page 59) *property*
: Specifies the offset of the receiver's shadow. Animatable.

`shadowColor` (page 58) *property*
: Specifies the color of the receiver's shadow. Animatable.

`filters` (page 53) *property*
: An array of CoreImage filters that are applied to the contents of the receiver and its sublayers. Animatable.

`compositingFilter` (page 50) *property*
: A CoreImage filter used to composite the receiver's contents with the background. Animatable.

`style` (page 59) *property*
: An optional dictionary referenced to find property values that aren't explicitly defined by the receiver.

Managing the Layer Hierarchy

`sublayers` (page 60) *property*
: An array containing the receiver's sublayers.

`superlayer` (page 61) *property*
: Specifies receiver's superlayer. (read-only)

`– addSublayer:` (page 65)
: Appends the layer to the receiver's `sublayers` (page 60) array.

`– removeFromSuperlayer` (page 75)
: Removes the layer from the `sublayers` (page 60) array or `mask` (page 55) property of the receiver's `superlayer` (page 61).

`– insertSublayer:atIndex:` (page 72)
: Inserts the layer as a sublayer of the receiver at the specified index.

`– insertSublayer:below:` (page 72)
: Inserts the layer into the receiver's sublayers array, below the specified sublayer.

`– insertSublayer:above:` (page 71)
: Inserts the layer into the receiver's sublayers array, above the specified sublayer.

`– replaceSublayer:with:` (page 76)
: Replaces the layer in the receiver's sublayers array with the specified new layer.

Updating Layer Display

`– setNeedsDisplay` (page 78)
: Marks the receiver as needing display before the content is next committed.

`needsDisplayOnBoundsChange` (page 57) *property*
: Returns whether the receiver must be redisplayed when the bounds rectangle is updated.

`– setNeedsDisplayInRect:` (page 79)
: Marks the region of the receiver within the specified rectangle as needing display.

Layer Animations

– `addAnimation:forKey:` (page 64)
Add an animation object to the receiver's render tree for the specified key.

– `animationForKey:` (page 66)
Returns the animation added to the receiver with the specified identifier.

– `removeAllAnimations` (page 75)
Remove all animations attached to the receiver.

– `removeAnimationForKey:` (page 75)
Remove the animation attached to the receiver with the specified key.

Managing Layer Resizing and Layout

`layoutManager` (page 55) *property*
Specifies the layout manager responsible for laying out the receiver's sublayers.

– `setNeedsLayout` (page 79)
Called when the preferred size of the receiver may have changed.

`constraints` (page 51) *property*
Specifies the constraints used to layout the receiver's sublayers when using an `CAConstraintManager` instance as the layout manager.

– `addConstraint:` (page 65)
Adds the constraint to the receiver's array of constraint objects.

`name` (page 56) *property*
The name of the receiver.

`autoresizingMask` (page 48) *property*
A bitmask defining how the layer is resized when the bounds of its superlayer changes.

– `resizeWithOldSuperlayerSize:` (page 77)
Informs the receiver that the bounds size of its superview has changed.

– `resizeSublayersWithOldSize:` (page 77)
Informs the receiver's sublayers that the receiver's bounds rectangle size has changed.

– `preferredFrameSize` (page 74)
Returns the preferred frame size of the layer in the coordinate space of the superlayer.

– `layoutIfNeeded` (page 73)
Recalculate the receiver's layout, if required.

– `layoutSublayers` (page 73)
Called when the layer requires layout.

Actions

`actions` (page 47) *property*
A dictionary mapping keys to objects that implement the `CAAction` protocol.

+ `defaultActionForKey:` (page 62)
Returns an object that implements the default action for the specified identifier.

– `actionForKey:` (page 63)
  Returns an object that implements the action for the specified identifier.

– `actionForLayer:forKey:` (page 80) *delegate method*
  Allows the delegate to customize the action for a layer.

Mapping Between Coordinate and Time Spaces

– `convertPoint:fromLayer:` (page 67)
  Converts the point from the specified layer's coordinate system to the receiver's coordinate system.

– `convertPoint:toLayer:` (page 67)
  Converts the point from the receiver's coordinate system to the specified layer's coordinate system.

– `convertRect:fromLayer:` (page 67)
  Converts the rectangle from the specified layer's coordinate system to the receiver's coordinate system.

– `convertRect:toLayer:` (page 68)
  Converts the rectangle from the receiver's coordinate system to the specified layer's coordinate system.

– `convertTime:fromLayer:` (page 68)
  Converts the time interval from the specified layer's time space to the receiver's time space.

– `convertTime:toLayer:` (page 69)
  Converts the time interval from the receiver's time space to the specified layer's time space

Hit Testing

– `hitTest:` (page 70)
  Returns the farthest descendant of the receiver in the layer hierarchy (including itself) that contains a specified point.

– `containsPoint:` (page 66)
  Returns whether the receiver contains a specified point.

Rendering

– `renderInContext:` (page 76)
  Renders the receiver and its sublayers into the specified context.

Scrolling

`visibleRect` (page 61) *property*
  Returns the visible region of the receiver, in its own coordinate space. (read-only)

– `scrollPoint:` (page 77)
  Scrolls the receiver's closest ancestor `CAScrollLayer` so that the specified point lies at the origin of the layer.

– `scrollRectToVisible:` (page 78)
  Scrolls the receiver's closest ancestor `CAScrollLayer` the minimum distance needed so that the specified rectangle becomes visible.

Modifying the Delegate

`delegate` (page 52) *property*
: Specifies the receiver's delegate object.

Key-Value Coding Extensions

`- shouldArchiveValueForKey:` (page 79)
: Specifies whether the value of the property for a given key is archived.

`+ defaultValueForKey:` (page 62)
: Specifies the default value of the property with the specified key.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

actions

A dictionary mapping keys to objects that implement the `CAAction` protocol.

```
@property(copy) NSDictionary *actions
```

Discussion
The default value is `nil`. See `actionForKey:` (page 63) for a description of the action search pattern.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- actionForKey:` (page 63)
`- actionForLayer:forKey:` (page 80)
`+ defaultActionForKey:` (page 62)
`@property style` (page 59)

Declared In
`CALayer.h`

anchorPoint

Defines the anchor point of the layer's bounds rectangle. Animatable.

```
@property CGPoint anchorPoint
```

Discussion
Described in the unit coordinate space. Defaults to (0.5, 0.5), the center of the bounds rectangle.

See Layer Geometry and Transforms (page 173) in *Core Animation Programming Guide* for more information on the relationship between the `bounds` (page 50), `anchorPoint` (page 47) and `position` (page 58) properties.

Availability
Available in Mac OS X v10.5 and later.

See Also
`@property position` (page 58)

Declared In
`CALayer.h`

autoresizingMask

A bitmask defining how the layer is resized when the bounds of its superlayer changes.

```
@property unsigned int autoresizingMask
```

Discussion
See "`Autoresizing Mask`" (page 81) for possible values. Default value is `kCALayerNotSizable` (page 82).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

backgroundColor

Specifies the background color of the receiver. Animatable.

```
@property CGColorRef backgroundColor
```

Discussion
The default is `nil`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

backgroundFilters

An optional array of CoreImage filters that are applied to the receiver's background. Animatable.

```
@property(copy) NSArray *backgroundFilters
```

Discussion
Once an array of filters is set properties should be modified by invoking `setValue:forKeyPath:` using the appropriate key path. This requires that you set the name of the background filter to be modified. For example:

```
CIFilter *filter = ...;
CALayer *layer = ...;

filter.name = @"myFilter";
layer.filters = [NSArray arrayWithObject:filter];
[layer setValue:[NSNumber numberWithInt:1]
forKeyPath:@"filters.myFilter.inputScale"];
```

If the inputs of a background filter are directly modified after the filter is attached to a layer, the behavior is undefined.

Special Considerations

While the `CALayer` class exposes this property, Core Image is not available in iPhone OS. Currently the filters available for this property are undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

borderColor

The color of the receiver's border. Animatable.

```
@property CGColorRef borderColor
```

Discussion
Defaults to opaque black.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

borderWidth

Specifies the width of the receiver's border. Animatable.

```
@property CGFloat borderWidth
```

Discussion
The border is drawn inset from the receiver's bounds by `borderWidth`. It is composited above the receiver's `contents` (page 51) and `sublayers` (page 60) and includes the effects of the `cornerRadius` (page 52) property. The default is 0.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

bounds

Specifies the bounds rectangle of the receiver. Animatable.

```
@property CGRect bounds
```

Discussion
The default is an empty rectangle.

See Layer Geometry and Transforms (page 173) in *Core Animation Programming Guide* for more information on the relationship between the `bounds` (page 50), `anchorPoint` (page 47) and `position` (page 58) properties.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

compositingFilter

A CoreImage filter used to composite the receiver's contents with the background. Animatable.

```
@property(retain) CIFilter *compositingFilter
```

Discussion
If `nil`, the contents are composited using source-over. The default value is `nil`.

Once a filter is set its properties should be modified by invoking `setValue:forKeyPath:` using the appropriate key path. For example:

```
CIFilter *filter = ...;
CALayer *layer = ...;

layer.compositingFilter = filter;
[layer setValue:[NSNumber numberWithInt:1]
forKeyPath:@"compositingFilter.inputScale"];
```

If the inputs of the filter are modified directly after the filter is attached to a layer, the behavior is undefined.

Special Considerations

While the `CALayer` class exposes this property, Core Image is not available in iPhone OS. Currently the filters available for this property are undefined.

Availability
Available in Mac OS X v10.5 and later.

See Also

`@property backgroundFilters` (page 48)

Declared In

`CALayer.h`

constraints

Specifies the constraints used to layout the receiver's sublayers when using an `CAConstraintManager` instance as the layout manager.

```
@property NSArray *constraints
```

Discussion

See CAConstraintLayoutManager Class Reference (page 33) for more information.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAConstraintLayoutManager.h`

contents

An object that provides the contents of the layer. Animatable.

```
@property(retain) id contents
```

Discussion

A layer can set this property to a `CGImageRef` to display the image as its contents. The default value is `nil`.

Availability

Available in Mac OS X v10.5 and later.

See Also

`@property contentsRect` (page 52)

Declared In

`CALayer.h`

contentsGravity

Determines how the receiver's contents are positioned within its bounds.

```
@property(copy) NSString *contentsGravity
```

Discussion

The possible values for `contentsGravity` are shown in "`Contents Gravity Values`" (page 84). The default value is `kCAGravityResize` (page 85).

Availability

Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

contentsRect

A rectangle, in the unit coordinate space, defining the subrectangle of `contents` (page 51) that the receiver should draw. Animatable.

```
@property CGRect contentsRect
```

Discussion
Defaults to the unit rectangle (0.0,0.0,1.0,1.0).

If pixels outside the unit rectangles are requested, the edge pixels of the contents image will be extended outwards.

If an empty rectangle is provided, the results are undefined.

Availability
Available in Mac OS X v10.5 and later.

See Also
`@property contents` (page 51)

Declared In
`CALayer.h`

cornerRadius

Specifies a radius used to draw the rounded corners of the receiver's background. Animatable.

```
@property CGFloat cornerRadius
```

Discussion
If the radius is greater than 0 the background is drawn with rounded corners. The default value is 0.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

delegate

Specifies the receiver's delegate object.

```
@property(assign) id delegate
```

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CALayer.h`

doubleSided

Determines whether the receiver is displayed when facing away from the viewer. Animatable.

```
@property BOOL doubleSided
```

Discussion
If `NO`, the layer is hidden when facing away from the viewer. Defaults to `YES`.

Availability
Available in Mac OS X v10.5 and later.

See Also
`– isDoubleSided` (page 73)

Declared In
`CALayer.h`

edgeAntialiasingMask

A bitmask defining how the edges of the receiver are rasterized.

```
@property unsigned int edgeAntialiasingMask
```

Discussion
For each of the four edges (left, right, bottom, top) if the corresponding bit is set the edge will be antialiased.

Typically, this property is used to disable antialiasing for edges that abut edges of other layers, to eliminate the seams that would otherwise occur.

The mask values are defined in "Edge Antialiasing Mask" (page 83).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

filters

An array of CoreImage filters that are applied to the contents of the receiver and its sublayers. Animatable.

```
@property(copy) NSArray *filters
```

Discussion
Defaults to `nil`. Filter properties should be modified by calling `setValue:forKeyPath:` on each layer that the filter is attached to. If the inputs of the filter are modified directly after the filter is attached to a layer, the behavior is undefined.

Special Considerations

While the `CALayer` class exposes this property, Core Image is not available in iPhone OS. Currently the filters available for this property are undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

frame

Specifies receiver's frame rectangle in the super-layer's coordinate space.

```
@property CGRect frame
```

Discussion
The `value` of frame is derived from the `bounds` (page 50), `anchorPoint` (page 47) and `position` (page 58) properties. When the `frame` is set, the receiver's `position` (page 58) and the size of the receiver's `bounds` (page 50) are changed to match the new frame rectangle.

See Layer Geometry and Transforms (page 173) in *Core Animation Programming Guide* for more information on the relationship between the `bounds` (page 50), `anchorPoint` (page 47) and `position` (page 58) properties.

Note: The `frame` property is not directly animatable. Instead you should animate the appropriate combination of the `bounds` (page 50), `anchorPoint` (page 47) and `position` (page 58) properties to achieve the desired result.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CALayer.h`

hidden

Determines whether the receiver is displayed. Animatable.

```
@property BOOL hidden
```

Discussion
The default is `NO`.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- isHidden` (page 73)

Declared In
`CALayer.h`

layoutManager

Specifies the layout manager responsible for laying out the receiver’s sublayers.

```
@property(retain) id layoutManager
```

Discussion
The `layoutManager` must implement the `CALayoutManager` informal protocol. The default value is `nil`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

magnificationFilter

The filter used when increasing the size of the content.

```
@property(copy) NSString *magnificationFilter
```

Discussion
The possible values for `magnificationFilter` are shown in “`Scaling Filters`” (page 86). The default value is `kCAFilterLinear` (page 86).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

mask

An optional layer whose alpha channel is used as a mask to select between the layer's background and the result of compositing the layer's contents with its filtered background.

```
@property(retain) CALayer *mask
```

Discussion
Defaults to `nil`.

Special Considerations

When setting the `mask` to a new layer, the new layer's superlayer must first be set to `nil`, otherwise the behavior is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

masksToBounds

Determines if the sublayers are clipped to the receiver's bounds. Animatable.

```
@property BOOL masksToBounds
```

Discussion
If `YES`, an implicit mask matching the layer bounds is applied to the layer, including the effects of the `cornerRadius` (page 52) property. If `YES` and a `mask` (page 55) property is specified, the two masks are multiplied to get the actual mask values. Defaults to `NO`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

minificationFilter

The filter used when reducing the size of the content.

```
@property(copy) NSString *minificationFilter
```

Discussion
The possible values for `minifcationFilter` are shown in "`Scaling Filters`" (page 86). The default value is `kCAFilterLinear` (page 86).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

name

The name of the receiver.

```
@property(copy) NSString *name
```

Discussion
The layer name is used by some layout managers to identify a layer. Defaults to `nil`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

needsDisplayOnBoundsChange

Returns whether the receiver must be redisplayed when the bounds rectangle is updated.

```
@property BOOL needsDisplayOnBoundsChange
```

Discussion
When `YES`, `setNeedsDisplay` (page 78) is automatically invoked when the receiver's `bounds` (page 50) is changed. Default value is `NO`.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CALayer.h`

opacity

Determines the opacity of the receiver. Animatable.

```
@property float opacity
```

Discussion
Possible values are between 0.0 (transparent) and 1.0 (opaque). The default is 1.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

opaque

Specifies a hint marking that the pixel data provided by the `contents` (page 51) property is completely opaque.

```
@property BOOL opaque
```

Discussion
Defaults to `NO`.

Availability
Available in Mac OS X v10.5 and later.

See Also
`– isOpaque` (page 73)

Declared In
`CALayer.h`

position

Specifies the receiver's position in the superlayer's coordinate system. Animatable.

```
@property CGPoint position
```

Discussion
The position is relative to `anchorPoint` (page 47). The default is (0.0,0.0).

See Layer Geometry and Transforms (page 173) in *Core Animation Programming Guide* for more information on the relationship between the `bounds` (page 50), `anchorPoint` (page 47) and `position` (page 58) properties.

Availability
Available in Mac OS X v10.5 and later.

See Also
`@property anchorPoint` (page 47)

Declared In
`CALayer.h`

shadowColor

Specifies the color of the receiver's shadow. Animatable.

```
@property CGColorRef shadowColor
```

Discussion
The default is opaque black.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

shadowOffset

Specifies the offset of the receiver’s shadow. Animatable.

```
@property CGSize shadowOffset
```

Discussion
The default is (0.0,-3.0).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

shadowOpacity

Specifies the opacity of the receiver’s shadow. Animatable.

```
@property float shadowOpacity
```

Discussion
The default is 0.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

shadowRadius

Specifies the blur radius used to render the receiver’s shadow. Animatable.

```
@property CGFloat shadowRadius
```

Discussion
The default value is 3.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

style

An optional dictionary referenced to find property values that aren't explicitly defined by the receiver.

```
@property(copy) NSDictionary *style
```

Discussion
This dictionary may in turn have a `style` key, forming a hierarchy of default values. In the case of hierarchical style dictionaries the shallowest value for a property is used. For example, the value for "style.someValue" takes precedence over "style.style.someValue".

If the style dictionary doesn't define a value for an attribute, the receiver's `defaultValueForKey:` method is called. Defaults to `nil`.

The style dictionary is not consulted for the following keys: `bounds`, `frame`.

Warning: If the style dictionary or any of its ancestors are modified, the values of the layer's properties are undefined until the `style` property is reset.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

sublayers

An array containing the receiver's sublayers.

```
@property(copy) NSArray *sublayers
```

Discussion
The layers are listed in back to front order. Defaults to `nil`.

Special Considerations

When setting the `sublayers` property to an array populated with layer objects you must ensure that the layers have had their `superlayer` (page 61) set to `nil`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

sublayerTransform

Specifies a transform applied to each sublayer when rendering. Animatable.

```
@property CATransform3D sublayerTransform
```

Discussion
This property is typically used as the projection matrix to add perspective and other viewing effects to the receiver. Defaults to the identity transform.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CALayer.h`

superlayer

Specifies receiver's superlayer. (read-only)

```
@property(readonly) CALayer *superlayer
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

transform

Specifies the transform applied to the receiver, relative to the center of its bounds. Animatable.

```
@property CATransform3D transform
```

Discussion
Defaults to the identity transform.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

visibleRect

Returns the visible region of the receiver, in its own coordinate space. (read-only)

```
@property(readonly) CGRect visibleRect
```

Discussion
The visible region is the area not clipped by the containing scroll layer.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAScrollLayer.h`

zPosition

Specifies the receiver's position on the z axis. Animatable.

```
@property CGFloat zPosition
```

Discussion
Defaults to 0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

Class Methods

defaultActionForKey:

Returns an object that implements the default action for the specified identifier.

```
+ (id<CAAction>)defaultActionForKey:(NSString *)aKey
```

Parameters

aKey
The identifier of the action.

Return Value
Returns the object that provides the action for *aKey*. The object must implement the `CAAction` protocol.

Discussion
See `actionForKey:` (page 63) for a description of the action search pattern.

Availability
Available in Mac OS X v10.5 and later.

See Also
- `actionForKey:` (page 63)
- `actionForLayer:forKey:` (page 80)
`@property actions` (page 47)
`@property style` (page 59)

Declared In
`CALayer.h`

defaultValueForKey:

Specifies the default value of the property with the specified key.

```
+ (id)defaultValueForKey:(NSString *)key
```

Parameters

key
The name of one of the receiver's properties.

Return Value
The default value for the named property. Returns `nil` if no default value has been set.

Discussion
If this method returns `nil` a suitable "zero" default value for the property is provided, based on the declared type of the `key`. For example, if *`key`* is a *`CGSize`* object, a size of (0.0,0.0) is returned. For a `CGRect` an empty rectangle is returned. For `CGAffineTransform` and `CATransform3D`, the appropriate identity matrix is returned.

Special Considerations

If *`key`* is not a known for property of the class, the result of the method is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

layer

Creates and returns an instance of `CALayer`.

```
+ (id)layer
```

Return Value
The initialized `CALayer` object or `nil` if initialization is not successful.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials
Core Animation QuickTime Layer

Declared In
`CALayer.h`

Instance Methods

actionForKey:

Returns an object that implements the action for the specified identifier.

```
- (id<CAAction>)actionForKey:(NSString *)aKey
```

Parameters
`aKey`
The identifier of the action.

Return Value
Returns the object that provides the action for *`aKey`*. The object must implement the `CAAction` protocol.

Discussion
There are three types of actions: property changes, externally-defined events, and layer-defined events. Whenever a layer property is modified, the event with the same name as the property is triggered. External events are defined by the owner of the layer calling `actionForKey:` to lookup the action associated with the identifier and directly messaging the returned object (if non-`nil`.)

The default implementation searches for an action object as follows:

- If defined, return the object provided by the receiver's delegate method `actionForLayer:forKey:` (page 80).
- Return the object that corresponds to the identifier in the receiver's `actions` (page 47) dictionary property.
- Search the `style` (page 59) dictionary recursively for an actions dictionary that contains the identifier.
- Call the receiver's `defaultActionForKey:` (page 62) method and return the result.

If any of these steps results in a non-`nil` action object, the remaining steps are ignored and the action is returned. If a step returns an `NSNull` object, the remaining steps are ignored and `nil` is returned.

When an action object is invoked it receives three parameters: the name of the event, the object on which the event happened (the layer), and a dictionary of named arguments specific to each event kind.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- actionForLayer:forKey:` (page 80)
`@property actions` (page 47)
`+ defaultActionForKey:` (page 62)
`@property style` (page 59)

Declared In
`CALayer.h`

addAnimation:forKey:

Add an animation object to the receiver's render tree for the specified key.

```
- (void)addAnimation:(CAAnimation *)anim
    forKey:(NSString *)key
```

Parameters

anim
The animation to be added to the render tree. Note that the object is copied by the render tree, not referenced. Any subsequent modifications to the object will not be propagated into the render tree.

key
A string that specifies an identifier for the animation. Only one animation per unique key is added to the layer. The special key `kCATransition` (page 83) is automatically used for transition animations. The `nil` pointer is also a valid key.

Discussion
Typically this is implicitly invoked through an action that is an CAAnimation object. If the `duration` property of the animation is zero or negative it is given the default duration, either the current value of the `kCATransactionAnimationDuration` transaction property, otherwise .25 seconds

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

addConstraint:

Adds the constraint to the receiver's array of constraint objects.

```
- (void)addConstraint:(CAConstraint *)aConstraint
```

Parameters

aConstraint
The constraint object to add to the receiver’s array of constraint objects.

Discussion
See CAConstraintLayoutManager Class Reference (page 33) for more information.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAConstraintLayoutManager.h`

addSublayer:

Appends the layer to the receiver’s `sublayers` (page 60) array.

```
- (void)addSublayer:(CALayer *)aLayer
```

Parameters

aLayer
The layer to be added to the receiver’s `sublayers` (page 60) array.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CALayer.h`

affineTransform

Convenience method for getting the `transform` (page 61) property as an affine transform.

```
- (CGAffineTransform)affineTransform
```

Return Value
A `CGAffineTransform` instance that best represents the receiver's `transform` (page 61) property.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

animationForKey:

Returns the animation added to the receiver with the specified identifier.

```
- (CAAnimation *)animationForKey:(NSString *)key
```

Parameters

key

A string that specifies the identifier of the animation.

Return Value
The animation object matching the identifier, or `nil` if no such animation exists.

Discussion
Attempting to modify any properties of the returned object will result in undefined behavior.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

containsPoint:

Returns whether the receiver contains a specified point.

```
- (BOOL)containsPoint:(CGPoint)thePoint
```

Parameters

thePoint

A point in the receiver's coordinate system.

Return Value
`YES` if the bounds of the layer contains the point.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

convertPoint:fromLayer:

Converts the point from the specified layer's coordinate system to the receiver's coordinate system.

```
- (CGPoint)convertPoint:(CGPoint)aPoint
    fromLayer:(CALayer *)layer
```

Parameters

aPoint
: A point specifying a location in the coordinate system of *layer*.

layer
: The layer with *aPoint* in its coordinate system. The receiver and *layer* and must share a common parent layer.

Return Value
The point converted to the receiver's coordinate system.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

convertPoint:toLayer:

Converts the point from the receiver's coordinate system to the specified layer's coordinate system.

```
- (CGPoint)convertPoint:(CGPoint)aPoint
    toLayer:(CALayer *)layer
```

Parameters

aPoint
: A point specifying a location in the coordinate system of *layer*.

layer
: The layer into whose coordinate system *aPoint* is to be converted. The receiver and *layer* and must share a common parent layer.

Return Value
The point converted to the coordinate system of *layer*.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

convertRect:fromLayer:

Converts the rectangle from the specified layer's coordinate system to the receiver's coordinate system.

```
- (CGRect)convertRect:(CGRect)aRect
    fromLayer:(CALayer *)layer
```

Parameters

aRect
: A point specifying a location in the coordinate system of *layer*.

layer
: The layer with *arect* in its coordinate system. The receiver and *layer* and must share a common parent layer.

Return Value
The rectangle converted to the receiver's coordinate system.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

convertRect:toLayer:

Converts the rectangle from the receiver's coordinate system to the specified layer's coordinate system.

```
- (CGRect)convertRect:(CGRect)aRect
    toLayer:(CALayer *)layer
```

Parameters

aRect
: A point specifying a location in the coordinate system of *layer*.

layer
: The layer into whose coordinate system *aRect* is to be converted. The receiver and *layer* and must share a common parent layer.

Return Value
The rectangle converted to the coordinate system of *layer*.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

convertTime:fromLayer:

Converts the time interval from the specified layer's time space to the receiver's time space.

```
- (CFTimeInterval)convertTime:(CFTimeInterval)timeInterval
    fromLayer:(CALayer *)layer
```

Parameters

timeInterval
: A point specifying a location in the coordinate system of *layer*.

layer
: The layer with *timeInterval* in its time space. The receiver and *layer* and must share a common parent layer.

Return Value

The time interval converted to the receiver's time space.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

convertTime:toLayer:

Converts the time interval from the receiver's time space to the specified layer's time space

```
- (CFTimeInterval)convertTime:(CFTimeInterval)timeInterval
    toLayer:(CALayer *)layer
```

Parameters

timeInterval

A point specifying a location in the coordinate system of *layer*.

layer

The layer into whose time space *timeInterval* is to be converted. The receiver and *layer* and must share a common parent layer.

Return Value

The time interval converted to the time space of *layer*.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

display

Reload the content of this layer.

```
- (void)display
```

Discussion

Calls the `drawInContext:` (page 70) method, then updates the receiver's `contents` (page 51) property. You should not call this method directly.

Subclasses can override this method to set the `contents` (page 51) property to an appropriate `CGImageRef`.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

drawInContext:

Draws the receiver's content in the specified graphics context.

```
- (void)drawInContext:(CGContextRef)ctx
```

Parameters

ctx

The graphics context in which to draw the content.

Discussion

Default implementation does nothing. The context may be clipped to protect valid layer content. Subclasses that wish to find the actual region to draw can call `CGContextGetClipBoundingBox`. Called by the `display` (page 69) method when the `contents` (page 51) property is being updated.

Subclasses can override this method to draw the receiver's content.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

hitTest:

Returns the farthest descendant of the receiver in the layer hierarchy (including itself) that contains a specified point.

```
- (CALayer *)hitTest:(CGPoint)thePoint
```

Parameters

thePoint

A point in the coordinate system of the receiver's superlayer.

Return Value

The layer that contains *thePoint*, or `nil` if the point lies outside the receiver's bounds rectangle.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

init

Returns an initialized `CALayer` object.

```
- (id)init
```

Return Value

An initialized `CALayer` object.

Discussion

This is the designated initializer for `CALayer`.

Availability
Available in Mac OS X v10.5 and later.

See Also
`+ layer` (page 63)

Declared In
`CALayer.h`

initWithLayer:

Override to copy or initialize custom fields of the specified layer.

```
- (id)initWithLayer:(id)layer
```

Parameters

`layer`
The layer from which custom fields should be copied.

Return Value
A layer instance with any custom instance variables copied from *`layer`*.

Discussion
This initializer is used to create shadow copies of layers, for example, for the presentationLayer method.

Subclasses can optionally copy their instance variables into the new object.

Subclasses should always invoke the superclass implementation

Note: Invoking this method in any other situation will produce undefined behavior. Do not use this method to initialize a new layer with an existing layer's content.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

insertSublayer:above:

Inserts the layer into the receiver's sublayers array, above the specified sublayer.

```
- (void)insertSublayer:(CALayer *)aLayer
    above:(CALayer *)siblingLayer
```

Parameters

`aLayer`
The layer to be inserted to the receiver's sublayer array.

`sublayer`
An existing sublayer in the receiver to insert *`aLayer`* above.

Special Considerations

If *sublayer* is not in the receiver's sublayers (page 60) array, an exception is raised.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

insertSublayer:atIndex:

Inserts the layer as a sublayer of the receiver at the specified index.

```
- (void)insertSublayer:(CALayer *)aLayer
    atIndex:(unsigned)index
```

Parameters

aLayer

The layer to be inserted to the receiver's sublayer array.

index

The index in the receiver at which to insert *aLayer*. This value must not be greater than the count of elements in the sublayer array.

Availability

Available in Mac OS X v10.5 and later.

Related Sample Code

Core Animation QuickTime Layer

Declared In

`CALayer.h`

insertSublayer:below:

Inserts the layer into the receiver's sublayers array, below the specified sublayer.

```
- (void)insertSublayer:(CALayer *)aLayer
    below:(CALayer *)sublayer
```

Parameters

aLayer

The layer to be inserted to the receiver's sublayer array.

sublayer

An existing sublayer in the receiver to insert *aLayer* after.

Discussion

If *sublayer* is not in the receiver's `sublayers` (page 60) array, an exception is raised.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

isDoubleSided

A synthesized accessor for the `doubleSided` (page 53) property.

```
- (BOOL)isDoubleSided
```

See Also

`@property doubleSided` (page 53)

isHidden

A synthesized accessor for the `hidden` (page 54) property.

```
- (BOOL)isHidden
```

See Also

`@property hidden` (page 54)

isOpaque

A synthesized accessor for the `opaque` (page 57) property.

```
- (BOOL)isOpaque
```

See Also

`@property opaque` (page 57)

layoutIfNeeded

Recalculate the receiver's layout, if required.

```
- (void)layoutIfNeeded
```

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

layoutSublayers

Called when the layer requires layout.

```
- (void)layoutSublayers
```

Discussion

The default implementation invokes the layout manager method `layoutSublayersOfLayer:` (page 144), if a layout manager is specied and it implements that method. Subclasses can override this method to provide their own layout algorithm, which must set the frame of each sublayer.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

modelLayer

Returns the model layer of the receiver, if it represents a current presentation layer.

```
- (id)presentationLayer
```

Return Value
A layer instance representing the underlying model layer.

Discussion
The result of calling this method after the transaction that produced the presentation layer has completed is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

preferredFrameSize

Returns the preferred frame size of the layer in the coordinate space of the superlayer.

```
- (CGSize)preferredFrameSize
```

Return Value
Returns the receiver's preferred frame size.

Discussion
The default implementation calls the layout manager, if one exists and it implements the `preferredSizeOfLayer:` method. Otherwise, it returns the size of the receiver's `bounds` (page 50) rectangle mapped into coordinate space of the receiver's `superlayer` (page 61).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

presentationLayer

Returns a copy of the layer containing all properties as they were at the start of the current transaction, with any active animations applied.

```
- (id)presentationLayer
```

Return Value
A layer instance representing the current presentation layer.

Discussion
This method provides a close approximation to the version of the layer that is currently being displayed. The `sublayers` (page 60), `mask` (page 55), and `superlayer` (page 61) properties of the returned layer return the presentation versions of these properties. This pattern carries through to the read-only layer methods. For example, sending a `hitTest:` (page 70) message to the `presentationLayer` will query the presentation values of the layer tree.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

removeAllAnimations

Remove all animations attached to the receiver.

```
- (void)removeAllAnimations
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

removeAnimationForKey:

Remove the animation attached to the receiver with the specified key.

```
- (void)removeAnimationForKey:(NSString *)key
```

Parameters

key
The identifier of the animation to remove.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

removeFromSuperlayer

Removes the layer from the `sublayers` (page 60) array or `mask` (page 55) property of the receiver's `superlayer` (page 61).

```
- (void)removeFromSuperlayer
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

renderInContext:

Renders the receiver and its sublayers into the specified context.

```
- (void)renderInContext:(CGContextRef)ctx
```

Parameters

`ctx`
The graphics context that the content is rendered in to.

Discussion
This method renders directly from the layer tree, ignoring any animations added to the render tree. Renders in the coordinate space of the layer.

Important: The Mac OS X v10.5 implementation of this method does not support the entire Core Animation composition model. `QCCompositionLayer`, `CAOpenGLLayer`, and `QTMovieLayer` layers are not rendered. Additionally, layers that use 3D transforms are not rendered, nor are layers that specify `backgroundFilters` (page 48), `filters` (page 53), `compositingFilter` (page 50), or a `mask` (page 55) values. Future versions of Mac OS X may add support for rendering these layers and properties.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

replaceSublayer:with:

Replaces the layer in the receiver's sublayers array with the specified new layer.

```
- (void)replaceSublayer:(CALayer *)oldLayer
    with:(CALayer *)newLayer
```

Parameters

`oldLayer`
The layer to be replaced to the receiver's sublayer array.

`newLayer`
The layer with which to replace *`oldLayer`* in the receiver's sublayer array.

Discussion
If the receiver is not the superlayer of *`oldLayer`* the behavior is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

resizeSublayersWithOldSize:

Informs the receiver's sublayers that the receiver's bounds rectangle size has changed.

```
- (void)resizeSublayersWithOldSize:(CGSize)size
```

Parameters

`size`
The previous size of the receiver's bounds rectangle.

Discussion
This method is used when the autoresizingmask property is used for resizing. It is called when the receiver's `bounds` property is altered. It calls `resizeSublayersWithOldSize:` on each sublayer to resize the sublayer's frame to match the new superlayer bounds based on the sublayer's autoresizing mask.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

resizeWithOldSuperlayerSize:

Informs the receiver that the bounds size of its superview has changed.

```
- (void)resizeWithOldSuperlayerSize:(CGSize)size
```

Parameters

`size`
The previous size of the superlayer's bounds rectangle

Discussion
This method is used when the autoresizingmask property is used for resizing. It is called when the receiver's `bounds` property is altered. It calls `resizeWithOldSuperlayerSize:` on each sublayer to resize the sublayer's frame to match the new superlayer bounds based on the sublayer's autoresizing mask.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

scrollPoint:

Scrolls the receiver's closest ancestor `CAScrollLayer` so that the specified point lies at the origin of the layer.

```
- (void)scrollPoint:(CGPoint)thePoint
```

Parameters

thePoint
: The point in the receiver to scroll to.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAScrollLayer.h`

scrollRectToVisible:

Scrolls the receiver's closest ancestor `CAScrollLayer` the minimum distance needed so that the specified rectangle becomes visible.

```
- (void)scrollRectToVisible:(CGRect)theRect
```

Parameters

theRect
: The rectangle to be made visible.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAScrollLayer.h`

setAffineTransform:

Convenience method for setting the `transform` (page 61) property as an affine transform.

```
- (void)setAffineTransform:(CGAffineTransform)m
```

Parameters

m
: The affine transform to set as the `transform` (page 61) property.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

setNeedsDisplay

Marks the receiver as needing display before the content is next committed.

```
- (void)setNeedsDisplay
```

Discussion
Calling this method will cause the receiver to recache its content. This will result in the layer receiving a `drawInContext:` (page 70) which may result in the delegate receiving either a `displayLayer:` (page 80) or `drawLayer:inContext:` (page 81) message.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CALayer.h`

setNeedsDisplayInRect:

Marks the region of the receiver within the specified rectangle as needing display.

```
- (void)setNeedsDisplayInRect:(CGRect)theRect
```

Parameters

theRect
The rectangular region of the receiver to mark as invalid; it should be specified in the coordinate system of the receiver.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

setNeedsLayout

Called when the preferred size of the receiver may have changed.

```
- (void)setNeedsLayout
```

Discussion
This method is typically called when the receiver's sublayers have changed. It marks that the receiver sublayers must update their layout (by invoking `layoutSublayers` (page 73) on the receiver and all its superlayers). If the receiver's layout manager implements the `invalidateLayoutOfLayer:` (page 143) method it is called.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

shouldArchiveValueForKey:

Specifies whether the value of the property for a given key is archived.

```
- (BOOL)shouldArchiveValueForKey:(NSString *)key
```

Parameters

key
The name of one of the receiver's properties.

Return Value
`YES` if the specified property should be archived, otherwise `NO`.

Discussion
The default implementation returns `YES`. Called by the object's implementation of `encodeWithCoder:`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

Delegate Methods

actionForLayer:forKey:

Allows the delegate to customize the action for a layer.

```
- (id<CAAction>)actionForLayer:(CALayer *)layer
      forKey
    :(NSString *)key
```

Parameters

layer
  The layer that is the target of the action.

key
  The identifier of the action.

Return Value
Returns an object implementing the `CAAction` protocol. May return `nil` if the delegate doesn't specify a behavior for `key`.

Discussion
See `actionForKey:` (page 63) for a description of the action search pattern.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- actionForLayer:forKey:` (page 80)
`@property actions` (page 47)
`+ defaultActionForKey:` (page 62)
`@property style` (page 59)

Declared In
`CALayer.h`

displayLayer:

Allows the delegate to override the `display` (page 69) implementation.

```
- (void)displayLayer:(CALayer *)layer
```

Parameters

layer

The layer to display.

Discussion

If defined, called by the default implementation of `display`, in which case it should set the layer's contents property.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

drawLayer:inContext:

Allows the delegate to override the layer's `drawInContext:` implementation.

```
- (void)drawLayer:(CALayer *)layer
    inContext:(CGContextRef)ctx
```

Parameters

layer

The layer to draw the content of.

ctx

The graphics context to draw in to.

Discussion

If defined, called by the default implementation of `drawInContext:` (page 70).

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

Constants

Autoresizing Mask

These constants are used by the `autoresizingMask` (page 48) property.

```
enum CAAutoresizingMask
{
  kCALayerNotSizable    = 0,
  kCALayerMinXMargin    = 1U << 0,
  kCALayerWidthSizable    = 1U << 1,
  kCALayerMaxXMargin    = 1U << 2,
  kCALayerMinYMargin    = 1U << 3,
  kCALayerHeightSizable    = 1U << 4,
  kCALayerMaxYMargin    = 1U << 5
};
```

Constants

`kCALayerNotSizable`

The receiver cannot be resized.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerMinXMargin`

The left margin between the receiver and its superview is flexible.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerWidthSizable`

The receiver's width is flexible.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerMaxXMargin`

The right margin between the receiver and its superview is flexible.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerMinYMargin`

The bottom margin between the receiver and its superview is flexible.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerHeightSizable`

The receiver's height is flexible.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerMaxYMargin`

The top margin between the receiver and its superview is flexible.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

Declared In

`CALayer.h`

Action Identifiers

These constants are the predefined action identifiers used by `actionForKey:` (page 63), `addAnimation:forKey:` (page 64), `defaultActionForKey:` (page 62), `removeAnimationForKey:` (page 75), `actionForLayer:forKey:` (page 80), and the `CAAction` protocol method `runActionForKey:object:arguments:` (page 141).

```
NSString * const kCAOnOrderIn;
NSString * const kCAOnOrderOut;
NSString * const kCATransition;
```

Constants

`kCAOnOrderIn`

The identifier that represents the action taken when a layer becomes visible, either as a result being inserted into the visible layer hierarchy or the layer is no longer set as hidden.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCAOnOrderOut`

The identifier that represents the action taken when the layer is removed from the layer hierarchy or is hidden.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCATransition`

The identifier that represents a transition animation.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

Declared In

`CALayer.h`

Edge Antialiasing Mask

This mask is used by the `edgeAntialiasingMask` (page 53) property.

```
enum CAEdgeAntialiasingMask
{
  kCALayerLeftEdge    = 1U << 0,
  kCALayerRightEdge    = 1U << 1,
  kCALayerBottomEdge    = 1U << 2,
  kCALayerTopEdge    = 1U << 3,
};
```

Constants

`kCALayerLeftEdge`

Specifies that the left edge of the receiver's content should be antialiased.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCALayerRightEdge`
: Specifies that the right edge of the receiver's content should be antialiased.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCALayerBottomEdge`
: Specifies that the bottom edge of the receiver's content should be antialiased.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCALayerTopEdge`
: Specifies that the top edge of the receiver's content should be antialiased.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

Declared In
`CALayer.h`

Contents Gravity Values

The contents gravity constants specify the position of the content object when the layer bounds is larger than the bounds of the content object. The are used by the `contentsGravity` (page 51) property.

```
NSString * const kCAGravityCenter;
NSString * const kCAGravityTop;
NSString * const kCAGravityBottom;
NSString * const kCAGravityLeft;
NSString * const kCAGravityRight;
NSString * const kCAGravityTopLeft;
NSString * const kCAGravityTopRight;
NSString * const kCAGravityBottomLeft;
NSString * const kCAGravityBottomRight;
NSString * const kCAGravityResize;
NSString * const kCAGravityResizeAspect;
NSString * const kCAGravityResizeAspectFill;
```

Constants

`kCAGravityCenter`
: The content is horizontally and verticallycentered in the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityTop`
: The content is horizontally centered at the top-edge of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityBottom`
: The content is horizontally centered at the bottom-edge of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityLeft`
: The content is vertically centered at the left-edge of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityRight`
: The content is vertically centered at the right-edge of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityTopLeft`
: The content is positioned in the top-left corner of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityTopRight`
: The content is positioned in the top-right corner of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityBottomLeft`
: The content is positioned in the bottom-left corner of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityBottomRight`
: The content is positioned in the bottom-right corner of the bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityResize`
: The content is resized to fit the entire bounds rectangle.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityResizeAspect`
: The content is resized to fit the bounds rectangle, preserving the aspect of the content. If the content does not completely fill the bounds rectangle, the content is centered in the partial axis.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

`kCAGravityResizeAspectFill`
: The content is resized to completely fill the bounds rectangle, while still preserving the aspect of the content. The content is centered in the axis it exceeds.

  Available in Mac OS X v10.5 and later.

  Declared in `CALayer.h`.

Declared In

`CALayer.h`

Identity Transform

Defines the identity transform matrix used by Core Animation.

```
const CATransform3D CATransform3DIdentity
```

Constants

`CATransform3DIdentity`

The identity transform: [1 0 0 0; 0 1 0 0; 0 0 1 0; 0 0 0 1].

Available in Mac OS X v10.5 and later.

Declared in `CATransform3D.h`.

Declared In

`CATransform3D.h`

Scaling Filters

These constants specify the scaling filters used by `magnificationFilter` (page 55) and `minificationFilter` (page 56).

```
NSString * const kCAFilterLinear;
NSString * const kCAFilterNearest;
```

Constants

`kCAFilterLinear`

Linear interpolation filter.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

`kCAFilterNearest`

Nearest neighbor interpolation filter.

Available in Mac OS X v10.5 and later.

Declared in `CALayer.h`.

Declared In

`CALayer.h`

Transform

Defines the standard transform matrix used throughout Core Animation.

```
struct CATransform3D
{
  CGFloat m11, m12, m13, m14;
  CGFloat m21, m22, m23, m24;
  CGFloat m31, m32, m33, m34;
  CGFloat m41, m42, m43, m44;
};
typedef struct CATransform3D CATransform3D;
```

Fields

`m11`

The entry at position 1,1 in the matrix.

`m12`
: The entry at position 1,2 in the matrix.

`m13`
: The entry at position 1,3 in the matrix.

`m14`
: The entry at position 1,4 in the matrix.

`m21`
: The entry at position 2,1 in the matrix.

`m22`
: The entry at position 2,2 in the matrix.

`m23`
: The entry at position 2,3 in the matrix.

`m24`
: The entry at position 2,4 in the matrix.

`m31`
: The entry at position 3,1 in the matrix.

`m32`
: The entry at position 3,2 in the matrix.

`m33`
: The entry at position 3,3 in the matrix.

`m34`
: The entry at position 3,4 in the matrix.

`m41`
: The entry at position 4,1 in the matrix.

`m42`
: The entry at position 4,2 in the matrix.

`m43`
: The entry at position 4,3 in the matrix.

`m44`
: The entry at position 4,4 in the matrix.

Discussion
The transform matrix is used to rotate, scale, translate, skew, and project the layer content. Functions are provided for creating, concatenating, and modifying CATransform3D data.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CAMediaTimingFunction Class Reference

Inherits from	NSObject
Conforms to	NSCoding NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAMediaTimingFunction.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CAMediaTimingFunction` represents one segment of a function that defines the pacing of an animation as a timing curve. The function maps an input time normalized to the range [0,1] to an output time also in the range [0,1].

Tasks

Creating Timing Functions

`+ functionWithName:` (page 90)
Creates and returns a new instance of `CAMediaTimingFunction` configured with the predefined timing function specified by *`name`*.

`+ functionWithControlPoints::::` (page 90)
Creates and returns a new instance of `CAMediaTimingFunction` timing function modeled as a cubic bezier curve using the specified control points.

`- initWithControlPoints::::` (page 91)
Returns an initialized timing function modeled as a cubic bezier curve using the specified control points.

Accessing the Control Points

`- getControlPointAtIndex:values:` (page 91)
Returns the control point for the specified index.

Class Methods

functionWithControlPoints::::

Creates and returns a new instance of `CAMediaTimingFunction` timing function modeled as a cubic bezier curve using the specified control points.

```
+ (id)functionWithControlPoints:(float)c1x
    :(float)c1y
    :(float)c2x
    :(float)c2y
```

Parameters

c1x
A floating point number representing the x position of the c1 control point.

c1y
A floating point number representing the y position of the c1 control point.

c2x
A floating point number representing the x position of the c2 control point.

c2y
A floating point number representing the y position of the c2 control point.

Return Value
A new instance of `CAMediaTimingFunction` with the timing function specified by the provided control points.

Discussion
The end points of the bezier curve are automatically set to (0.0,0.0) and (1.0,1.0). The control points defining the bezier curve are: [(0.0,0.0), (*c1x*,*c1y*), (*c2x*,*c2y*), (1.0,1.0)].

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTimingFunction.h`

functionWithName:

Creates and returns a new instance of `CAMediaTimingFunction` configured with the predefined timing function specified by *name*.

```
+ (id)functionWithName:(NSString *)name
```

Parameters

name

The timing function to use as specified in "`Predefined timing functions`" (page 92).

Return Value

A new instance of `CAMediaTimingFunction` with the timing function specified by *name*.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAMediaTimingFunction.h`

Instance Methods

getControlPointAtIndex:values:

Returns the control point for the specified index.

```
- (void)getControlPointAtIndex:(size_t)index
    values:(float[2])ptr
```

Parameters

index

An integer specifying the index of the control point to return.

ptr

A pointer to an array that, upon return, will contain the x and y values of the specified point.

Discussion

The value of *index* must between 0 and 3.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAMediaTimingFunction.h`

initWithControlPoints::::

Returns an initialized timing function modeled as a cubic bezier curve using the specified control points.

```
- (id)initWithControlPoints:(float)c1x
    :(float)c1y
    :(float)c2x
    :(float)c2y
```

Parameters

c1x

A floating point number representing the x position of the c1 control point.

c1y

A floating point number representing the y position of the c1 control point.

c2x

A floating point number representing the x position of the c2 control point.

c2y

A floating point number representing the y position of the c2 control point.

Return Value

An instance of `CAMediaTimingFunction` with the timing function specified by the provided control points.

Discussion

The end points of the bezier curve are automatically set to (0.0,0.0) and (1.0,1.0). The control points defining the bezier curve are: [(0.0,0.0), (*c1x*,*c1y*), (*c2x*,*c2y*), (1.0,1.0)].

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAMediaTimingFunction.h`

Constants

Predefined timing functions

These constants are used to specify one of the predefined timing functions used by `functionWithName:` (page 90).

```
NSString * const kCAMediaTimingFunctionLinear;
NSString * const kCAMediaTimingFunctionEaseIn;
NSString * const kCAMediaTimingFunctionEaseOut;
NSString * const kCAMediaTimingFunctionEaseInEaseOut;
```

Constants

`kCAMediaTimingFunctionLinear`

Specifies linear pacing. A linear pacing causes an animation to occur evenly over its duration.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTimingFunction.h`.

`kCAMediaTimingFunctionEaseIn`

Specifies ease-in pacing. Ease-in pacing causes the animation to begin slowly, and then speed up as it progresses.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTimingFunction.h`.

`kCAMediaTimingFunctionEaseOut`

Specifies ease-out pacing. An ease-out pacing causes the animation to begin quickly, and then slow as it completes.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTimingFunction.h`.

`kCAMediaTimingFunctionEaseInEaseOut`

Specifies ease-in ease-out pacing. An ease-in ease-out animation begins slowly, accelerates through the middle of its duration, and then slows again before completing.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTimingFunction.h`.

Declared In

`CAMediaTimingFunction.h`

CAOpenGLLayer Class Reference

Inherits from	CALayer : NSObject
Conforms to	NSCoding (CALayer) CAMediaTiming (CALayer) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAOpenGLLayer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook
Related sample code	CALayerEssentials

Overview

`CAOpenGLLayer` provides a layer suitable for rendering OpenGL content.

To provide OpenGL content you subclass `CAOpenGLLayer` and override `drawInCGLContext:pixelFormat:forLayerTime:displayTime:` (page 98). You can specify that the OpenGL content is static by setting the `asynchronous` (page 96) property to `NO`.

Tasks

Drawing the Content

`asynchronous` (page 96) *property*
    Determines when the contents of the layer are updated.

– `isAsynchronous` (page 99)
    A synthesized accessor for the `asynchronous` (page 96) property.

– `canDrawInCGLContext:pixelFormat:forLayerTime:displayTime:` (page 97)
    Returns whether the receiver should draw OpenGL content for the specified time.

– `drawInCGLContext:pixelFormat:forLayerTime:displayTime:` (page 98)
    Draws the OpenGL content for the specified time.

Managing the Pixel Format

`- copyCGLPixelFormatForDisplayMask:` (page 98)
Returns the OpenGL pixel format suitable for rendering to the set of displays specified by the display mask.

`- releaseCGLPixelFormat:` (page 99)
Releases the specified OpenGL pixel format object.

Managing the Rendering Context

`- copyCGLContextForPixelFormat:` (page 97)
Returns the rendering context the receiver requires for the specified pixel format.

`- releaseCGLContext:` (page 99)
Releases the specified rendering context.

Properties

For more about Objective-C properties, see “Properties” in *The Objective-C 2.0 Programming Language*.

asynchronous

Determines when the contents of the layer are updated.

```
@property BOOL asynchronous
```

Discussion
If `NO`, the contents of the layer are updated only in response to receiving a `setNeedsDisplay` (page 78) message. When `YES`, the receiver’s `canDrawInCGLContext:pixelFormat:forLayerTime:displayTime:` (page 97) is called periodically to determine if the OpenGL content should be updated.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- isAsynchronous` (page 99)

Related Sample Code
CALayerEssentials

Declared In
`CAOpenGLLayer.h`

Instance Methods

canDrawInCGLContext:pixelFormat:forLayerTime:displayTime:

Returns whether the receiver should draw OpenGL content for the specified time.

```
- (BOOL)canDrawInCGLContext:(CGLContextObj)glContext
    pixelFormat:(CGLPixelFormatObj)pixelFormat
    forLayerTime:(CFTimeInterval)timeInterval
    displayTime:(const CVTimeStamp *)timeStamp
```

Parameters

glContext

The `CGLContextObj` in to which the OpenGL content would be drawn.

pixelFormat

The pixel format used when the *glContext* was created.

timeInterval

The current layer time.

timeStamp

The display timestamp associated with *timeInterval*. Can be `null`.

Return Value

`YES` if the receiver should render OpenGL content, `NO` otherwise.

Discussion

This method is called before attempting to render the frame for the layer time specified by `timeInterval`. If the method returns `NO`, the frame is skipped. The default implementation always returns `YES`.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CAOpenGLLayer.h`

copyCGLContextForPixelFormat:

Returns the rendering context the receiver requires for the specified pixel format.

```
- (CGLContextObj)copyCGLContextForPixelFormat:(CGLPixelFormatObj)pixelFormat
```

Parameters

pixelFormat

The pixel format for the rendering context.

Return Value

A new `CGLContext` with renderers for *pixelFormat*.

Discussion

This method is called when a rendering context is needed by the receiver. The default implementation allocates a new context with a null share context.

You should not call this method directly, it is intended to be overridden by subclasses.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAOpenGLLayer.h`

copyCGLPixelFormatForDisplayMask:

Returns the OpenGL pixel format suitable for rendering to the set of displays specified by the display mask.

```
- (CGLPixelFormatObj)copyCGLPixelFormatForDisplayMask:(uint32_t)mask
```

Parameters

`mask`
The display mask the OpenGL content will be rendered on.

Discussion
This method is called when a pixel format object is needed for the receiver. The default implementation returns a 32bpp fixed point pixelf format, with the `NoRecovery` and `Accelerated` flags set.

You should not call this method directly, it is intended to be overridden by subclasses.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAOpenGLLayer.h`

drawInCGLContext:pixelFormat:forLayerTime:displayTime:

Draws the OpenGL content for the specified time.

```
- (void)drawInCGLContext:(CGLContextObj)glContext
    pixelFormat:(CGLPixelFormatObj)pixelFormat
    forLayerTime:(CFTimeInterval)timeInterval
    displayTime:(const CVTimeStamp *)timeStamp
```

Parameters

`glContext`
The rendering context in to which the OpenGL content should be rendered.

`pixelFormat`
The pixel format used when the *`glContext`* was created.

`timeInterval`
The current layer time.

`timeStamp`
The display timestamp associated with *`timeInterval`*. Can be `null`.

Discussion
This method is called when a new frame needs to be generated for the layer time specified by *`timeInterval`*. The viewport of *`glContext`* is set correctly for the size of the layer. No other state is defined. If the method enables OpenGL features, it should disable them before returning.

The default implementation of the method flushes the context.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAOpenGLLayer.h`

isAsynchronous

A synthesized accessor for the `asynchronous` (page 96) property.

```
- (BOOL)isAsynchronous
```

See Also
  `@property asynchronous` (page 96)

releaseCGLContext:

Releases the specified rendering context.

```
- (void)releaseCGLContext:(CGLContextObj)glContext
```

Parameters

`glContext`
  The rendering context to release.

Discussion
This method is called when the OpenGL context that was previously returned by `copyCGLContextForPixelFormat:` (page 97) is no longer needed.

You should not call this method directly, it is intended to be overridden by subclasses.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAOpenGLLayer.h`

releaseCGLPixelFormat:

Releases the specified OpenGL pixel format object.

```
- (void)releaseCGLPixelFormat:(CGLPixelFormatObj)pixelFormat
```

Parameters

`pixelFormat`
  The pixel format object to release.

Discussion
This method is called when the OpenGL pixel format that was previously returned by `copyCGLContextForPixelFormat:` (page 97).

You should not call this method directly, it is intended to be overridden by subclasses.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAOpenGLLayer.h`

CAPropertyAnimation Class Reference

Inherits from	CAAnimation : NSObject
Conforms to	NSCoding (CAAnimation) NSCopying (CAAnimation) CAAction (CAAnimation) CAMediaTiming (CAAnimation) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAAnimation.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CAPropertyAnimation` is an abstract subclass of `CAAnimation` for creating animations that manipulate the value of layer properties. The property is specified using a key path that is relative to the layer using the animation.

Tasks

Animated Key Path

`keyPath` (page 103) *property*
Specifies the key path the receiver animates.

Property Value Calculation Behavior

`cumulative` (page 102) *property*
Determines if the value of the property is the value at the end of the previous repeat cycle, plus the value of the current repeat cycle.

– `isCumulative` (page 104)
A synthesized accessor for the `cumulative` (page 102) property.

`additive` (page 102) *property*
: Determines if the value specified by the animation is added to the current render tree value to produce the new render tree value.

`- isAdditive` (page 103)
: A synthesized accessor for the `additive` (page 102) property.

Creating an Animation

`+ animationWithKeyPath:` (page 103)
: Creates and returns an `CAPropertyAnimation` instance for the specified key path.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

additive

Determines if the value specified by the animation is added to the current render tree value to produce the new render tree value.

```
@property BOOL additive
```

Discussion
If `YES`, the value specified by the animation will be added to the current render tree value of the property to produce the new render tree value. The addition function is type-dependent, e.g. for affine transforms the two matrices are concatenated. The default is `NO`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

cumulative

Determines if the value of the property is the value at the end of the previous repeat cycle, plus the value of the current repeat cycle.

```
@property BOOL cumulative
```

Discussion
If `YES`, then the value of the property is the value at the end of the previous repeat cycle, plus the value of the current repeat cycle. If `NO`, the value of the property is simply the value calculated for the current repeat cycle. The default is `NO`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

keyPath

Specifies the key path the receiver animates.

```
@property(copy) NSString *keyPath
```

Discussion
The key path is relative to the layer the receiver is attached to.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

Class Methods

animationWithKeyPath:

Creates and returns an `CAPropertyAnimation` instance for the specified key path.

```
+ (id)animationWithKeyPath:(NSString *)keyPath
```

Parameters

`keyPath`
The key path of the property to be animated.

Return Value
A new instance of `CAPropertyAnimation` with the key path set to *`keyPath`*.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

Instance Methods

isAdditive

A synthesized accessor for the `additive` (page 102) property.

```
- (BOOL)isAdditive
```

See Also

`@property additive` (page 102)

isCumulative

A synthesized accessor for the `cumulative` (page 102) property.

```
- (BOOL)isCumulative
```

See Also

`@property cumulative` (page 102)

CARenderer Class Reference

Inherits from	NSObject
Conforms to	NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CARenderer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CARenderer` allows an application to render a layer tree into a CGL context. For real-time output you should use an instance of `NSView` to host the layer-tree.

Tasks

Rendered Layer

`layer` (page 106) *property*
The root layer of the layer-tree the receiver should render.

Renderer Geometry

`bounds` (page 106) *property*
The bounds of the receiver.

Create a New Renderer

`+ rendererWithCGLContext:options:` (page 107)
Creates and returns a `CARenderer` instance with the render target specified by the Core OpenGL context.

Render a Frame

- `beginFrameAtTime:timeStamp:` (page 107)
  Begin rendering a frame at the specified time.
- `updateBounds` (page 109)
  Returns the bounds of the update region that contains all pixels that will be rendered by the current frame.
- `addUpdateRect:` (page 107)
  Adds the rectangle to the update region of the current frame.
- `render` (page 108)
  Render the update region of the current frame to the target context.
- `nextFrameTime` (page 108)
  Returns the time at which the next update should happen.
- `endFrame` (page 108)
  Release any data associated with the current frame.

Properties

For more about Objective-C properties, see “Properties” in *The Objective-C 2.0 Programming Language*.

bounds

The bounds of the receiver.

```
@property CGRect bounds
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

layer

The root layer of the layer-tree the receiver should render.

```
@property(retain) CALayer *layer
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

Class Methods

rendererWithCGLContext:options:

Creates and returns a `CARenderer` instance with the render target specified by the Core OpenGL context.

```
+ (CARenderer *)rendererWithCGLContext:(void *)ctx
    options:(NSDictionary *)dict
```

Parameters

ctx

A Core OpenGL render context that is used as the render target.

dict

A dictionary of optional parameters.

Return Value

A new instance of `CARenderer` that will use `ctx` as the render target.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CARenderer.h`

Instance Methods

addUpdateRect:

Adds the rectangle to the update region of the current frame.

```
- (void)addUpdateRect:(CGRect)aRect
```

Parameters

aRect

A rectangle defining the region to be added to the update region.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CARenderer.h`

beginFrameAtTime:timeStamp:

Begin rendering a frame at the specified time.

```
- (void)beginFrameAtTime:(CFTimeInterval)timeInterval
    timeStamp:(CVTimeStamp *)timeStamp
```

Parameters

timeInterval
: The layer time.

timeStamp
: The display timestamp associated with timeInterval. Can be null.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

endFrame

Release any data associated with the current frame.

```
- (void)endFrame
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

nextFrameTime

Returns the time at which the next update should happen.

```
- (CFTimeInterval)nextFrameTime
```

Return Value
The time at which the next update should happen.

Discussion
If infinite, no update needs to be scheduled yet. If `nextFrameTime` is the current frame time, a continuous animation is running and an update should be scheduled after an appropriate delay.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

render

Render the update region of the current frame to the target context.

```
- (void)render
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

updateBounds

Returns the bounds of the update region that contains all pixels that will be rendered by the current frame.

```
- (CGRect)updateBounds
```

Return Value
The bounds of the update region..

Discussion
Initially `updateBounds` will include all differences between the current frame and the previously rendered frame.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CARenderer.h`

CAScrollLayer Class Reference

Inherits from	CALayer : NSObject
Conforms to	NSCoding (CALayer) CAMediaTiming (CALayer) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAScrollLayer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook
Related sample code	CALayerEssentials

Overview

The `CAScrollLayer` class is a subclass of `CALayer` that simplifies displaying a portion of a layer. The extent of the scrollable area of the `CAScrollLayer` is defined by the layout of its sublayers. The visible portion of the layer content is set by specifying the origin as a point or a rectangular area of the contents to be displayed. `CAScrollLayer` does not provide keyboard or mouse event-handling, nor does it provide visible scrollers.

Tasks

Scrolling Constraints

`scrollMode` (page 112) *property*
Defines the axes in which the layer may be scrolled.

Scrolling the Layer

`– scrollToPoint:` (page 112)
Changes the origin of the receiver to the specified point.

`– scrollToRect:` (page 112)
Scroll the contents of the receiver to ensure that the rectangle is visible.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

scrollMode

Defines the axes in which the layer may be scrolled.

```
@property(copy) NSString *scrollMode
```

Discussion
The possible values are described in "`Scroll Modes`" (page 113). The default is `kCAScrollBoth`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAScrollLayer.h`

Instance Methods

scrollToPoint:

Changes the origin of the receiver to the specified point.

```
- (void)scrollToPoint:(CGPoint)thePoint
```

Parameters

`thePoint`
The new origin.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAScrollLayer.h`

scrollToRect:

Scroll the contents of the receiver to ensure that the rectangle is visible.

```
- (void)scrollToRect:(CGRect)theRect
```

Parameters

`theRect`
The rectangle that should be visible.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CAScrollLayer.h`

Constants

Scroll Modes

These constants describe the supported scroll modes used by the scrollMode (page 112) property.

```
NSString * const kCAScrollNone;
NSString * const kCAScrollVertically;
NSString * const kCAScrollHorizontally;
NSString * const kCAScrollBoth;
```

Constants

`kCAScrollNone`

The receiver is unable to scroll.

Available in Mac OS X v10.5 and later.

Declared in `CAScrollLayer.h`.

`kCAScrollVertically`

The receiver is able to scroll vertically.

Available in Mac OS X v10.5 and later.

Declared in `CAScrollLayer.h`.

`kCAScrollHorizontally`

The receiver is able to scroll horizontally.

Available in Mac OS X v10.5 and later.

Declared in `CAScrollLayer.h`.

`kCAScrollBoth`

The receiver is able to scroll both horizontally and vertically.

Available in Mac OS X v10.5 and later.

Declared in `CAScrollLayer.h`.

Declared In
`CAScrollLayer.h`

CATextLayer Class Reference

Inherits from	CALayer : NSObject
Conforms to	NSCoding (CALayer) CAMediaTiming (CALayer) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CATextLayer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook
Related sample code	CALayerEssentials

Overview

The `CATextLayer` provides simple text layout and rendering of plain or attributed strings. The first line is aligned to the top of the layer.

Note: CATextLayer disabled sub-pixel antialiasing when rendering text. Text can only be drawn using sub-pixel antialiasing when it is composited into an existing opaque background at the same time that it's rasterized. There is no way to draw subpixel-antialiased text by itself, whether into an image or a layer, separately in advance of having the background pixels to weave the text pixels into. Setting the `opacity` property of the layer to `YES` does not change the rendering mode.

Note: When a `CATextLayer` instance is positioned using the *CAConstraintLayoutManager Class Reference* the bounds of the layer is resized to fit the text content.

Tasks

Getting and Setting the Text

`string` (page 118) *property*
The text to be rendered by the receiver.

Text Visual Properties

`font` (page 116) *property*
  The font used to render the receiver's text.

`fontSize` (page 117) *property*
  The font size used to render the receiver's text.

`foregroundColor` (page 117) *property*
  The color used to render the receiver's text.

Text Alignment and Truncation

`wrapped` (page 118) *property*
  Determines whether the text is wrapped to fit within the receiver's bounds.

`– isWrapped` (page 119)
  A synthesized accessor for the `wrapped` (page 118) property.

`alignmentMode` (page 116) *property*
  Determines how individual lines of text are horizontally aligned within the receiver's bounds.

`truncationMode` (page 118) *property*
  Determines how the text is truncated to fit within the receiver's bounds.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

alignmentMode

Determines how individual lines of text are horizontally aligned within the receiver's bounds.

```
@property(copy) NSString *alignmentMode
```

Discussion
The possible values are described in "`Horizontal alignment modes`" (page 120). Defaults to `kCAAlignmentNatural` (page 120).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATextLayer.h`

font

The font used to render the receiver's text.

```
@property CFTypeRef font
```

Discussion
May be either a `CTFontRef`, a `CGFontRef`, an instance of `NSFont`, or a string naming the font. Defaults to Helvetica.

The `font` property is only used when the `string` (page 118) property is not an `NSAttributedString`.

Note: If the font property specifies a font size (if it is a `CTFontRef`, a `CGFontRef`, an instance of `NSFont`) the font size is ignored.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATextLayer.h`

fontSize

The font size used to render the receiver's text.

```
@property CGFloat fontSize
```

Discussion
Defaults to 36.0.

The `font` property is only used when the `string` (page 118) property is not an `NSAttributedString`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATextLayer.h`

foregroundColor

The color used to render the receiver's text.

```
@property CGColorRef foregroundColor
```

Discussion
Defaults to opaque white.

The `font` property is only used when the `string` (page 118) property is not an `NSAttributedString`.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CATextLayer.h`

string

The text to be rendered by the receiver.

```
@property(copy) id string
```

Discussion
The text must be an instance of `NSString` or `NSAttributedString`. Defaults to `nil`.

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Declared In
`CATextLayer.h`

truncationMode

Determines how the text is truncated to fit within the receiver's bounds.

```
@property(copy) NSString *truncationMode
```

Discussion
The possible values are described in "`Truncation modes`" (page 119). Defaults to `kCATruncationNone` (page 119).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATextLayer.h`

wrapped

Determines whether the text is wrapped to fit within the receiver's bounds.

```
@property BOOL wrapped
```

Discussion
Defaults to `NO`.

Availability
Available in Mac OS X v10.5 and later.

See Also
`– isWrapped` (page 119)

Declared In
`CATextLayer.h`

Instance Methods

isWrapped

A synthesized accessor for the `wrapped` (page 118) property.

```
- (BOOL)isWrapped
```

See Also

`@property wrapped` (page 118)

Constants

Truncation modes

These constants are used by the `truncationMode` (page 118) property.

```
NSString * const kCATruncationNone;
NSString * const kCATruncationStart;
NSString * const kCATruncationEnd;
NSString * const kCATruncationMiddle;
```

Constants

`kCATruncationNone`

If the `wrapped` (page 118) property is `YES`, the text is wrapped to the receiver's bounds, otherwise the text is clipped to the receiver's bounds.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCATruncationStart`

Each line is displayed so that the end fits in the container and the missing text is indicated by some kind of ellipsis glyph.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCATruncationEnd`

Each line is displayed so that the beginning fits in the container and the missing text is indicated by some kind of ellipsis glyph.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCATruncationMiddle`

Each line is displayed so that the beginning and end fit in the container and the missing text is indicated by some kind of ellipsis glyph in the middle.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

Declared In

`CATextLayer.h`

Horizontal alignment modes

These constants are used by the `alignmentMode` (page 116) property.

```
NSString * const kCAAlignmentNatural;
NSString * const kCAAlignmentLeft;
NSString * const kCAAlignmentRight;
NSString * const kCAAlignmentCenter;
NSString * const kCAAlignmentJustified;
```

Constants

`kCAAlignmentNatural`

Use the natural alignment of the text's script.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCAAlignmentLeft`

Text is visually left aligned.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCAAlignmentRight`

Text is visually right aligned.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCAAlignmentCenter`

Text is visually center aligned.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

`kCAAlignmentJustified`

Text is justified.

Available in Mac OS X v10.5 and later.

Declared in `CATextLayer.h`.

Declared In

`CATextLayer.h`

CATransaction Class Reference

Inherits from	NSObject
Conforms to	NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CATransaction.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CATransaction` is the Core Animation mechanism for batching multiple layer-tree operations into atomic updates to the render tree. Every modification to a layer tree must be part of a transaction Nested transactions are supported.

Core Animation supports two types of transactions: *implicit* transactions and *explicit* transactions. Implicit transactions are created automatically when the layer tree is modified by a thread without an active transaction and are committed automatically when the thread's run-loop next iterates. Explicit transactions occur when the the application sends the CATransaction class a `begin` (page 122) message before modifying the layer tree, and a `commit` (page 122) message afterwards.

In some circumstances (for example, if there is no run-loop, or the run-loop is blocked) it may be necessary to use explicit transactions to get timely render tree updates.

Tasks

Creating and Committing Transactions

`+ begin` (page 122)
Begin a new transaction for the current thread.

`+ commit` (page 122)
Commit all changes made during the current transaction.

`+ flush` (page 122)
Flushes any extant implicit transaction.

Getting and Setting Transaction Properties

`+ valueForKey:` (page 123)
: Returns the arbitrary keyed-data specified by the given key.

`+ setValue:forKey:` (page 123)
: Sets the arbitrary keyed-data for the specified key.

Class Methods

begin

Begin a new transaction for the current thread.

```
+ (void)begin
```

Discussion
The transaction is nested within the thread's current transaction, if there is one.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransaction.h`

commit

Commit all changes made during the current transaction.

```
+ (void)commit
```

Special Considerations

Raises an exception if no current transaction exists.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransaction.h`

flush

Flushes any extant implicit transaction.

```
+ (void)flush
```

Discussion
Delays the commit until any nested explicit transactions have completed.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransaction.h`

setValue:forKey:

Sets the arbitrary keyed-data for the specified key.

```
+ (void)setValue:(id)anObject
    forKey:(NSString *)key
```

Parameters

anObject
: The value for the key identified by *key*.

key
: The name of one of the receiver's properties.

Discussion
Nested transactions have nested data scope; setting a key always sets it in the innermost scope.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransaction.h`

valueForKey:

Returns the arbitrary keyed-data specified by the given key.

```
+ (id)valueForKey:(NSString *)key
```

Parameters

key
: The name of one of the receiver's properties.

Return Value
The value for the data specified by the key.

Discussion
Nested transactions have nested data scope. Requesting a value for a key first searches the innermost scope, then the enclosing transactions.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransaction.h`

Constants

Transaction properties

These constants define the property keys used by `valueForKey:` (page 123) and `setValue:forKey:` (page 123).

```
NSString * const kCATransactionAnimationDuration;
NSString * const kCATransactionDisableActions;
```

Constants

`kCATransactionAnimationDuration`

Default duration, in seconds, for animations added to layers. The value for this key must be an instance of `NSNumber`.

Available in Mac OS X v10.5 and later.

Declared in `CATransaction.h`.

`kCATransactionDisableActions`

If `YES`, implicit actions for property changes are suppressed. The value for this key must be an instance of `NSNumber`.

Available in Mac OS X v10.5 and later.

Declared in `CATransaction.h`.

Declared In

`CATransaction.h`

CATransition Class Reference

Inherits from	CAAnimation : NSObject
Conforms to	NSCoding (CAAnimation) NSCopying (CAAnimation) CAAction (CAAnimation) CAMediaTiming (CAAnimation) NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAAnimation.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

The `CATransition` class implements transition animations for a layer. You can specify the transition effect from a set of predefined transitions or by providing a custom `CIFilter` instance.

Tasks

Transition Start and End Point

`startProgress` (page 127) *property*
Indicates the start point of the receiver as a fraction of the entire transition.

`endProgress` (page 126) *property*
Indicates the end point of the receiver as a fraction of the entire transition.

Transition Properties

`type` (page 127) *property*
Specifies the predefined transition type.

`subtype` (page 127) *property*
Specifies an optional subtype that indicates the direction for the predefined motion-based transitions.

Custom Transition Filter

`filter` (page 126) *property*
An optional CoreImage filter object that provides the transition.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

endProgress

Indicates the end point of the receiver as a fraction of the entire transition.

```
@property float endProgress
```

Discussion
The value must be greater than or equal to `startProgress` (page 127), and not greater than 1.0. If `endProgress` is less than `startProgress` (page 127) the behavior is undefined. The default value is 1.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

filter

An optional CoreImage filter object that provides the transition.

```
@property(retain) CIFilter *filter
```

Discussion
If specified, the filter must support both `kCIInputImageKey` and `kCIInputTargetImageKey` input keys, and the `kCIOutputImageKey` output key. The filter may optionally support the `kCIInputExtentKey` input key, which is set to a rectangle describing the region in which the transition should run. If *`filter`* does not support the required input and output keys the behavior is undefined.

Defaults to `nil`. When a transition filter is specified the `type` (page 127) and `subtype` (page 127) properties are ignored.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

startProgress

Indicates the start point of the receiver as a fraction of the entire transition.

```
@property float startProgress
```

Discussion
Legal values are numbers between 0.0 and 1.0. For example, to start the transition half way through its progress set `startProgress` to 0.5. The default value is 0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

subtype

Specifies an optional subtype that indicates the direction for the predefined motion-based transitions.

```
@property(copy) NSString *subtype
```

Discussion
The possible values are shown in "`Common Transition Subtypes`" (page 128). The default is `nil`.

This property is ignored if a custom transition is specified in the `filter` (page 126) property.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

type

Specifies the predefined transition type.

```
@property(copy) NSString *type
```

Discussion
The possible values are shown in "`Common Transition Types`" (page 128). This property is ignored if a custom transition is specified in the `filter` (page 126) property. The default is `kCATransitionFade` (page 128).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAAnimation.h`

Constants

Common Transition Types

These constants specify the transition types that can be used with the `type` (page 127) property.

```
NSString * const kCATransitionFade;
NSString * const kCATransitionMoveIn;
NSString * const kCATransitionPush;
NSString * const kCATransitionReveal;
```

Constants

`kCATransitionFade`

The layer's content fades as it becomes visible or hidden.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCATransitionMoveIn`

The layer's content slides into place over any existing content. The "`Common Transition Subtypes`" (page 128) are used with this transition.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCATransitionPush`

The layer's content pushes any existing content as it slides into place. The "`Common Transition Subtypes`" (page 128) are used with this transition.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCATransitionReveal`

The layer's content is revealed gradually in the direction specified by the transition subtype. The "`Common Transition Subtypes`" (page 128) are used with this transition.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

Declared In

`CATransition.h`

Common Transition Subtypes

These constants specify the direction of motion-based transitions. They are used with the `subtype` (page 127) property.

```
NSString * const kCATransitionFromRight;
NSString * const kCATransitionFromLeft;
NSString * const kCATransitionFromTop;
NSString * const kCATransitionFromBottom;
```

Constants

`kCATransitionFromRight`

The transition begins at the right side of the layer.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCATransitionFromLeft`

The transition begins at the left side of the layer.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCATransitionFromTop`

The transition begins at the top of the layer.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

`kCATransitionFromBottom`

The transition begins at the bottom of the layer.

Available in Mac OS X v10.5 and later.

Declared in `CAAnimation.h`.

Declared In

`CATransition.h`

CIFilter Core Animation Additions

Inherits from	NSObject
Conforms to	NSCoding NSCopying NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Declared in	CACIFilterAdditions.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook Core Image Programming Guide

Overview

Core Animation adds two additional properties to the `CIFilter` class. These properties are accessible through key-value coding as well as the properties declared below.

Tasks

Naming Filter Instances

`name` (page 132) *property*
The name of the receiver.

Enabling Filter Instances

`enabled` (page 132) *property*
Determines if the receiver is enabled. Animatable.

`– isEnabled` (page 132)
A synthesized accessor for the `enabled` (page 132) property.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

enabled

Determines if the receiver is enabled. Animatable.

```
@property BOOL enabled
```

Discussion
The receiver is applied to its input when this property is set to `YES`. Default is `YES`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CACIFilterAdditions.h`

name

The name of the receiver.

```
@property(copy) NSString *name
```

Discussion
Default is `nil`. Each `CIFilter` instance can have an assigned name. The name is used to construct key paths to the filter's attributes. For example, if a `CIFilter` instance has the name "`myExposureFilter`", you refer to attributes of the filter using a key path such as "`filters.myExposureFilter.inputEV`". Layer animations may also access filter attributes via these key paths.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CACIFilterAdditions.h`

Instance Methods

isEnabled

A synthesized accessor for the `enabled` (page 132) property.

```
- (BOOL)isEnabled
```

See Also
`@property enabled` (page 132)

NSValue Core Animation Additions

Inherits from	NSObject
Conforms to	NSCoding NSCopying NSObject (NSObject)
Framework	/System/Library/Frameworks/QuartzCore.framework
Declared in	QuartzCore/CATransform3D.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

Core Animation adds two methods to the Foundation framework's `NSValue` class to support `CATransform3D` structure values.

Tasks

Creating an NSValue

`+ valueWithCATransform3D:` (page 133)
Creates and returns an NSValue object that contains a given `CATransform3D` structure.

Accessing Data

`- CATransform3DValue` (page 134)
Returns an `CATransform3D` structure representation of the receiver.

Class Methods

valueWithCATransform3D:

Creates and returns an NSValue object that contains a given `CATransform3D` structure.

```
+ (NSValue *)valueWithCATransform3D:(CATransform3D)aTransform
```

Parameters

aTransform

The value for the new object.

Return Value

A new `NSValue` object that contains the value of *aTransform*.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CATransform3D.h`

Instance Methods

CATransform3DValue

Returns an `CATransform3D` structure representation of the receiver.

```
- (CATransform3D)CATransform3DValue
```

Return Value

An `CATransform3D` structure representation of the receiver.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CATransform3D.h`

QCCompositionLayer Class Reference

Inherits from	CAOpenGLLayer : CALayer : NSObject
Conforms to	QCCompositionRenderer NSCoding (CALayer) CAMediaTiming (CALayer) NSObject (NSObject)
Framework	/System/Library/Frameworks/Quartz.framework/Frameworks/QuartzComposer.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	QuartzComposer/QCCompositionLayer.h
Companion guides	Core Animation Programming Guide Quartz Composer Programming Guide
Related sample code	CALayerEssentials

Overview

The `QCCompositionLayer` class loads, plays, and controls Quartz Composer compositions in a Core Animation layer hierarchy. The composition tracks the Core Animation layer time and is rendered directly at the current dimensions of the `QCCompositionLayer` object.

An archived `QCCompositionLayer` object saves the composition that's loaded at the time the layer is archived. It detects layer usage and pauses or resumes the composition appropriately. A `QCCompositionLayer` object starts rendering the composition automatically when the layer is placed in a visible layer hierarchy. The layer stops rendering when it is hidden or removed from the visible layer hierarchy.

You can pass data to the input ports, or retrieve data from the output ports, of the root patch of a composition by accessing the `patch` attribute of the `QCCompositionLayer` instance using methods provided by the `QCCompositionRenderer` protocol.

Note: You must not modify the `asynchronous` property of the superclass `CAOpenGLLayer`.

Tasks

Creating the Layer

`+ compositionLayerWithFile:` (page 137)
: Creates and returns an instance of a composition layer using the Quartz Composer composition in the specified file.

`+ compositionLayerWithComposition:` (page 136)
: Creates and returns an instance of a composition layer using the provided Quartz Composer composition.

`- initWithFile:` (page 138)
: Initializes and returns a composition layer using the Quartz Composer composition in the specified file.

`- initWithComposition:` (page 137)
: Initializes and returns a composition layer using the provided Quartz Composer composition.

Getting the Composition

`- composition` (page 137)
: Returns the composition associated with the layer.

Class Methods

compositionLayerWithComposition:

Creates and returns an instance of a composition layer using the provided Quartz Composer composition.

```
+ (QCCompositionLayer*)compositionLayerWithComposition:(QCComposition*)composition
```

Parameters

composition
: The Quartz Composer composition to use as content.

Return Value
An autoreleased, initialized `QCCompositionLayer` object or `nil` if initialization is not successful.

Availability
Available in Mac OS X v10.5 and later.

See Also
`+ compositionLayerWithFile:` (page 137)

Declared In
`QCCompositionLayer.h`

compositionLayerWithFile:

Creates and returns an instance of a composition layer using the Quartz Composer composition in the specified file.

```
+ (QCCompositionLayer*)compositionLayerWithFile:(NSString*)path
```

Parameters

`path`
A string that specifies the location of a Quartz Composer composition.

Return Value
An autoreleased, initialized `QCCompositionLayer` object or `nil` if initialization is not successful.

Availability
Available in Mac OS X v10.5 and later.

See Also
`+ compositionLayerWithComposition:` (page 136)

Related Sample Code
CALayerEssentials

Declared In
`QCCompositionLayer.h`

Instance Methods

composition

Returns the composition associated with the layer.

```
- (QCComposition*) composition
```

Return Value
The composition object associated with the layer or `nil` if there is none.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`QCCompositionLayer.h`

initWithComposition:

Initializes and returns a composition layer using the provided Quartz Composer composition.

```
- (id)initWithComposition:(QCComposition*)composition
```

Parameters

composition
: The Quartz Composer composition to use as content.

Return Value
The initialized `QCCompositionLayer` object or `nil` if initialization is not successful.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- initWithFile:` (page 138)

Declared In
`QCCompositionLayer.h`

initWithFile:

Initializes and returns a composition layer using the Quartz Composer composition in the specified file.

```
- (id)initWithFile:(NSString*)path
```

Parameters

path
: A string that specifies the location of a Quartz Composer composition.

Return Value
The initialized `QCCompositionLayer` object or `nil` if initialization is not successful.

Availability
Available in Mac OS X v10.5 and later.

See Also
`- initWithComposition:` (page 137)

Declared In
`QCCompositionLayer.h`

Protocols

CAAction Protocol Reference

Adopted by	CAAnimation
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CALayer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

The `CAAction` protocol provides an interface that allows an object to respond to an action triggered by an `CALayer`. When queried with an action identifier (a key path, an external action name, or a predefined action identifier) the layer returns the appropriate action object–which must implement the `CAAction` protocol–and sends it a `runActionForKey:object:arguments:` (page 141) message.

Tasks

Responding to an Action

– `runActionForKey:object:arguments:` (page 141)
    Called to trigger the action specified by the identifier.

Instance Methods

runActionForKey:object:arguments:

Called to trigger the action specified by the identifier.

```
- (void)runActionForKey:(NSString *)key
    object:(id)anObject
    arguments:(NSDictionary *)dict
```

Parameters

`key`

The identifier of the action. The identifier may be a key or key path relative to *`anObject`*, an arbitrary external action, or one of the action identifiers defined in *CALayer Class Reference*.

`anObject`

The layer on which the action should occur.

`dict`

A dictionary containing parameters associated with this event. May be `nil`.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

CALayoutManager Protocol Reference

Framework	/System/Library/Frameworks/QuartzCore.framework
Declared in	CALayer.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

`CALayoutManager` is an informal protocol implemented by Core Animation layout managers. If a layer's sublayers require custom layout you create a class that implements this protocol and set it as the layer's layout manager using the `CALayer` method `setLayoutManager:`. Your custom layout manager is then used when the layer invokes `setNeedsLayout` (page 79) or `layoutSublayers` (page 73).

Tasks

Layout Layers

`– invalidateLayoutOfLayer:` (page 143)
Invalidates the layout of the specified layer.

`– layoutSublayersOfLayer:` (page 144)
Layout each of the sublayers in the specified layer.

Calculate Layer Size

`– preferredSizeOfLayer:` (page 144)
Returns the preferred size of the specified layer in its coordinate system.

Instance Methods

invalidateLayoutOfLayer:

Invalidates the layout of the specified layer.

```
- (void)invalidateLayoutOfLayer:(CALayer *)layer
```

Parameters

layer

The layer that requires layout.

Discussion

This method is called when the preferred size of the specified layer may have changed. The receiver should invalidate any cached state.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

layoutSublayersOfLayer:

Layout each of the sublayers in the specified layer.

```
- (void)layoutSublayersOfLayer:(CALayer *)layer
```

Parameters

layer

The layer that requires layout of its sublayers.

Discussion

This method is called when the sublayers of the *layer* may need rearranging, and is typically called when a sublayer has changed its size. The receiver is responsible for changing the frame of each sublayer that requires layout.

Availability

Available in Mac OS X v10.5 and later.

Declared In

`CALayer.h`

preferredSizeOfLayer:

Returns the preferred size of the specified layer in its coordinate system.

```
- (CGSize)preferredSizeOfLayer:(CALayer *)layer
```

Parameters

layer

The layer that requires layout.

Return Value

The preferred size of the layer in the coordinate space of *layer*.

Discussion

This method is called when the preferred size of the specified layer may have changed. The receiver is responsible for recomputing the preferred size and returning it. If this method is not implemented the preferred size is assumed to be the size of the bounds of *layer*.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CALayer.h`

CAMediaTiming Protocol Reference

Adopted by	CAAnimation CALayer
Framework	/System/Library/Frameworks/QuartzCore.framework
Availability	Available in Mac OS X v10.5 and later.
Declared in	CAMediaTiming.h
Companion guides	Core Animation Programming Guide Core Animation Cookbook

Overview

The `CAMediaTiming` protocol models a hierarchical timing system, with each object describing the mapping of time values from the object's parent to local time.

Absolute time is defined as mach time converted to seconds. The `CACurrentMediaTime` (page 156) function is provided as a convenience for getting the current absolute time.

The conversion from parent time to local time has two stages:

1. Conversion to "active local time". This includes the point at which the object appears in the parent object's timeline and how fast it plays relative to the parent.
2. Conversion from "active local time" to "basic local time". The timing model allows for objects to repeat their basic duration multiple times and, optionally, to play backwards before repeating.

Tasks

Animation Start Time

`beginTime` (page 148) *property*
Specifies the begin time of the receiver in relation to its parent object, if applicable.

`timeOffset` (page 150) *property*
Specifies an additional time offset in active local time.

Repeating Animations

`repeatCount` (page 149) *property*
  Determines the number of times the animation will repeat.

`repeatDuration` (page 150) *property*
  Determines how many seconds the animation will repeat for.

Duration and Speed

`duration` (page 149) *property*
  Specifies the basic duration of the animation, in seconds.

`speed` (page 150) *property*
  Specifies how time is mapped to receiver's time space from the parent time space.

Playback Modes

`autoreverses` (page 148) *property*
  Determines if the receiver plays in the reverse upon completion.

`fillMode` (page 149) *property*
  Determines if the receiver's presentation is frozen or removed once its active duration has completed.

Properties

For more about Objective-C properties, see "Properties" in *The Objective-C 2.0 Programming Language*.

autoreverses

Determines if the receiver plays in the reverse upon completion.

```
@property BOOL autoreverses
```

Discussion
When `YES`, the receiver plays backwards after playing forwards. Defaults to `NO`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

beginTime

Specifies the begin time of the receiver in relation to its parent object, if applicable.

```
@property CFTimeInterval beginTime
```

Discussion
Defaults to 0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

duration

Specifies the basic duration of the animation, in seconds.

```
@property CFTimeInterval duration
```

Discussion
Defaults to 0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

fillMode

Determines if the receiver's presentation is frozen or removed once its active duration has completed.

```
@property(copy) NSString *fillMode
```

Discussion
The possible values are described in "`Fill Modes`" (page 151). The default is `kCAFillModeRemoved` (page 151).

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

repeatCount

Determines the number of times the animation will repeat.

```
@property float repeatCount
```

Discussion
May be fractional. If the `repeatCount` is 0, it is ignored. Defaults to 0. If both `repeatDuration` (page 150) and `repeatCount` (page 149) are specified the behavior is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

repeatDuration

Determines how many seconds the animation will repeat for.

```
@property CFTimeInterval repeatDuration
```

Discussion
Defaults to 0. If the `repeatDuration` is 0, it is ignored. If both `repeatDuration` (page 150) and `repeatCount` (page 149) are specified the behavior is undefined.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

speed

Specifies how time is mapped to receiver's time space from the parent time space.

```
@property float speed
```

Discussion
For example, if `speed` is 2.0 local time progresses twice as fast as parent time. Defaults to 1.0.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

timeOffset

Specifies an additional time offset in active local time.

```
@property CFTimeInterval timeOffset
```

Discussion
Defaults to 0. .

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CAMediaTiming.h`

Constants

Fill Modes

These constants determine how the timed object behaves once its active duration has completed. They are used with the `fillMode` (page 149) property.

```
NSString * const kCAFillModeRemoved;
NSString * const kCAFillModeForwards;
NSString * const kCAFillModeBackwards;
NSString * const kCAFillModeBoth;
NSString * const kCAFillModeFrozen;
```

Constants

`kCAFillModeRemoved`

The receiver is removed from the presentation when the animation is completed.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTiming.h`.

`kCAFillModeForwards`

The receiver remains visible in its final state when the animation is completed.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTiming.h`.

`kCAFillModeBackwards`

The receiver clamps values before zero to zero when the animation is completed.

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTiming.h`.

`kCAFillModeBoth`

The receiver clamps values at both ends of the object's time space

Available in Mac OS X v10.5 and later.

Declared in `CAMediaTiming.h`.

`kCAFillModeFrozen`

The mode was deprecated before Mac OS X v10.5 shipped.

Deprecated in Mac OS X v10.5 and later.

Declared in `CAMediaTiming.h`.

Declared In

`CAMediaTiming.h`

Other References

Core Animation Function Reference

Framework:	QuartzCore/QuartzCore.h
Declared in	CABase.h CATransform3D.h

Overview

Functions by Task

Timing Functions

`CACurrentMediaTime` (page 156)
Returns the current absolute time, in seconds.

Transform Functions

`CATransform3DIsIdentity` (page 157)
Returns a Boolean value that indicates whether the transform is the identity transform.

`CATransform3DEqualToTransform` (page 156)
Returns a Boolean value that indicates whether the two transforms are exactly equal.

`CATransform3DMakeTranslation` (page 159)
Returns a transform that translates by '(tx, ty, tz)'. t' = [1 0 0 0; 0 1 0 0; 0 0 1 0; tx ty tz 1].

`CATransform3DMakeScale` (page 158)
Returns a transform that scales by `(sx, sy, sz)': * t' = [sx 0 0 0; 0 sy 0 0; 0 0 sz 0; 0 0 0 1].

`CATransform3DMakeRotation` (page 158)
Returns a transform that rotates by 'angle' radians about the vector '(x, y, z)'. If the vector has length zero the identity transform is returned.

`CATransform3DTranslate` (page 159)
Translate 't' by '(tx, ty, tz)' and return the result: * t' = translate(tx, ty, tz) * t.

`CATransform3DScale` (page 159)
Scale 't' by '(sx, sy, sz)' and return the result: * t' = scale(sx, sy, sz) * t.

`CATransform3DRotate` (page 159)
Rotate 't' by 'angle' radians about the vector '(x, y, z)' and return the result. If the vector has zero length the behavior is undefined: t' = rotation(angle, x, y, z) * t.

`CATransform3DConcat` (page 156)
: Concatenate 'b' to 'a' and return the result: t' = a * b.

`CATransform3DInvert` (page 157)
: Invert 't' and return the result. Returns the original matrix if 't' has no inverse.

`CATransform3DMakeAffineTransform` (page 158)
: Return a transform with the same effect as affine transform 'm'.

`CATransform3DIsAffine` (page 157)
: Returns true if 't' can be exactly represented by an affine transform.

`CATransform3DGetAffineTransform` (page 157)
: Returns the affine transform represented by 't'. If 't' can not be exactly represented as an affine transform the returned value is undefined.

Functions

CACurrentMediaTime

Returns the current absolute time, in seconds.

```
CFTimeInterval CACurrentMediaTime (void);
```

Return Value
A `CFTimeInterval` derived by calling `mach_absolute_time()` and converting the result to seconds.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CABase.h`

CATransform3DConcat

Concatenate 'b' to 'a' and return the result: t' = a * b.

```
CATransform3D CATransform3DConcat (CATransform3D a, CATransform3D b);
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DEqualToTransform

Returns a Boolean value that indicates whether the two transforms are exactly equal.

```
bool CATransform3DEqualToTransform (CATransform3D a, CATransform3D b);
```

Return Value
`YES` if *a* and *b* are exactly equal, otherwise `NO`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DGetAffineTransform

Returns the affine transform represented by 't'. If 't' can not be exactly represented as an affine transform the returned value is undefined.

```
CGAffineTransform CATransform3DGetAffineTransform (CATransform3D t);
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DInvert

Invert 't' and return the result. Returns the original matrix if 't' has no inverse.

```
CATransform3D CATransform3DInvert (CATransform3D t);
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DIsAffine

Returns true if 't' can be exactly represented by an affine transform.

```
bool CATransform3DIsAffine (CATransform3D t);
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DIsIdentity

Returns a Boolean value that indicates whether the transform is the identity transform.

```
bool CATransform3DIsIdentity (CATransform3D t);
```

Return Value
`YES` if *t* is the identity transform, otherwise `NO`.

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DMakeAffineTransform

Return a transform with the same effect as affine transform 'm'.

```
CATransform3D CATransform3DMakeAffineTransform (CGAffineTransform m)
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DMakeRotation

Returns a transform that rotates by 'angle' radians about the vector '(x, y, z)'. If the vector has length zero the identity transform is returned.

```
CATransform3D CATransform3DMakeRotation (CGFloat angle, CGFloat x, CGFloat y,
CGFloat z);
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DMakeScale

Returns a transform that scales by `(sx, sy, sz)': * t' = [sx 0 0 0; 0 sy 0 0; 0 0 sz 0; 0 0 0 1].

```
CATransform3D CATransform3DMakeScale (CGFloat sx, CGFloat sy,
    CGFloat sz);
```

Availability
Available in Mac OS X v10.5 and later.

Related Sample Code
CALayerEssentials

Core Animation QuickTime Layer

Declared In
`CATransform3D.h`

CATransform3DMakeTranslation

Returns a transform that translates by '(tx, ty, tz)'. t' = [1 0 0 0; 0 1 0 0; 0 0 1 0; tx ty tz 1].

```
CATransform3D CATransform3DMakeTranslation (CGFloat tx, CGFloat ty, CGFloat tz)
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DRotate

Rotate 't' by 'angle' radians about the vector '(x, y, z)' and return the result. If the vector has zero length the behavior is undefined: t' = rotation(angle, x, y, z) * t.

```
CATransform3D CATransform3DRotate (CATransform3D t, CGFloat angle, CGFloat x,
CGFloat y, CGFloat z)
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DScale

Scale 't' by '(sx, sy, sz)' and return the result: * t' = scale(sx, sy, sz) * t.

```
CATransform3D CATransform3DScale (CATransform3D t, CGFloat sx, CGFloat sy, CGFloat
 sz)
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

CATransform3DTranslate

Translate 't' by '(tx, ty, tz)' and return the result: * t' = translate(tx, ty, tz) * t.

```
CATransform3D CATransform3DTranslate (CATransform3D t, CGFloat tx, CGFloat ty,
CGFloat tz);
```

Availability
Available in Mac OS X v10.5 and later.

Declared In
`CATransform3D.h`

Drawing

This chapter discusses drawing issues when using Core Animation and other technologies.

Drawing Layer Content With Application Kit Classes

Core Animation `CALayer` class defines a delegate method, `drawLayer:inContext:`, that you can implement and draw your layer content using Quartz 2D drawing functions. However, Cocoa developers who have complete and working drawing solutions based on the Application Kit drawing classes may wish to continue using that code.

Listing 1 shows an implementation of the CALayer delegate method `drawLayer:inContext:` that creates an `NSGraphicsContext` from the `CGContextRef` passed as the *`inContext:`* parameter. Layer delegates can use this technique to display content created using `NSBezierPath`, `NSColor`, `NSImage` and other Application Kit classes.

Listing 1 Drawing into a layer using Application Kit classes

```
- (void)drawLayer:(CALayer *)layer inContext:(CGContextRef)ctx
{
   NSGraphicsContext *nsGraphicsContext;
   nsGraphicsContext = [NSGraphicsContext graphicsContextWithGraphicsPort:ctx
                                                                   flipped:NO];
   [NSGraphicsContext saveGraphicsState];
   [NSGraphicsContext setCurrentContext:nsGraphicsContext];

   // ...Draw content using NS APIs...
   NSRect aRect=NSMakeRect(10.0,10.0,30.0,30.0);
   NSBezierPath *thePath=[NSBezierPath bezierPathWithRect:aRect];
   [[NSColor redColor] set];
   [thePath fill];

   [NSGraphicsContext restoreGraphicsState];
}
```

What Is Core Animation?

Core Animation is a collection of Objective-C classes for graphics rendering, projection, and animation. It provides fluid animations using advanced compositing effects while retaining a hierarchical layer abstraction that is familiar to developers using the Application Kit and Cocoa Touch view architectures.

Dynamic, animated user interfaces are hard to create, but Core Animation makes creating these interfaces easier by providing:

- High performance compositing with a simple approachable programming model.
- A familiar view-like abstraction that allows you to create complex user interfaces using a hierarchy of layer objects.
- A lightweight data structure. You can display and animate hundreds of layers simultaneously.
- An abstract animation interface that allows animations to run on a separate thread, independent of your application's run loop. Once an animation is configured and starts, Core Animation assumes full responsibility for running it at frame rate.
- Improved application performance. Applications need only redraw content when it changes. Minimal application interaction is required for resizing and providing layout services layers. Core Animation also eliminates application code that runs at the animation frame-rate.
- A flexible layout manager model, including a manager that allows the position and size of a layer to be set relative to attributes of sibling layers.

Using Core Animation, developers can create dynamic user interfaces for their applications without having to use low-level graphics APIs such as OpenGL to get respectable animation performance.

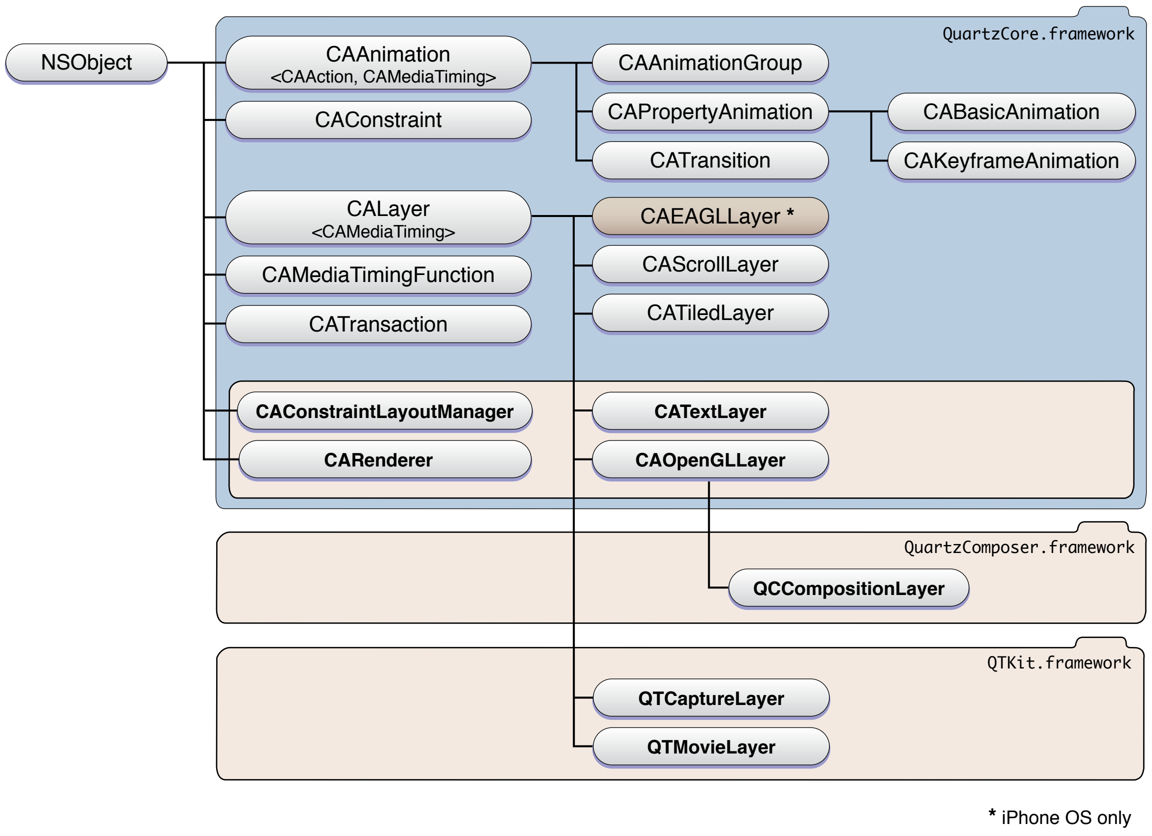
Core Animation Classes

Core Animation classes can be grouped into several categories:

- Layer classes that provide content for display
- Animation and timing classes
- Layout and constraint classes
- A transaction class that groups multiple layer changes into an atomic update

The basic Core Animation classes are contained in the Quartz Core framework, although additional layer classes can be defined in other frameworks. “Core Animation Classes” shows the class hierarchy of Core Animation.

Figure 1 Core Animation class hierarchy



Layer Classes

The layer classes are the foundation of Core Animation and provide an abstraction that should be familiar to developers who have used `NSView` or `UIView`. Basic layer functionality is provided by the `CALayer` class, which is the parent class for all types of Core Animation layers.

As with an instance of a view class, a `CALayer` instance has a single parent layer (the superlayer) and a collection of sublayers, creating a hierarchy of layers that is referred to as the layer tree. Layers are drawn from back to front just like views and specify their geometry relative to their superlayer, creating a local coordinate system. However, layers allow a more complex visual display by incorporating transform matrices that allow you to rotate, skew, scale, and project the layer content. "Layer Geometry and Transforms" (page 173) discusses layer geometry and transforms in more detail.

`CALayer` diverges from the Application Kit and Cocoa Touch view classes in that it is not necessary to subclass `CALayer` in order to display content. The content displayed by a `CALayer` instance can be provided by:

- Setting the layer's content property to a Core Graphics image representation directly, or through delegation.
- Providing a delegate that draws directly into a Core Graphics image context.
- Setting any of the number of visual style properties that all layer types have in common, for example, background colors, opacity, and masking. Mac OS X applications also have access to visual properties that make use of Core Image filters.

- Subclassing CALayer and implementing any of the above techniques in a more encapsulated manner.

"Providing Layer Content" describes the available techniques for providing the content for a layer. The visual style properties and the order in which they are applied to the content of a layer is discussed in "Layer Style Properties" (page 205).

In addition to the `CALayer` class, the Core Animation class collection provides additional classes that allow applications to display other types of content. The available classes differ slightly between Mac OS X and iPhone OS. The following classes are available on both Mac OS X and iPhone OS:

- `CAScrollLayer` class is a subclass of `CALayer` that simplifies displaying a portion of a layer. The extent of the scrollable area of a `CAScrollLayer` object is defined by the layout of its sublayers. `CAScrollLayer` does not provide keyboard or mouse event-handling, nor does it provide visible scrollers.
- `CATiledLayer` allows the display of large and complex images in incremental stages.

Mac OS X provides these additional classes:

- `CATextLayer` is a convenience class that creates a layer's content from a string or attributed string.
- `CAOpenGLLayer` provides an OpenGL rendering environment. You must subclass this class to provide content using OpenGL. The content can be static or can be updated over time.
- `QCCompositionLayer` (provided by the Quartz Composer framework) animates a Quartz Composer composition as its content.
- `QTMovieLayer` and `QTCaptureLayer` (provided by the QTKit framework) provides playback of QuickTime movies and live video.

iPhone OS adds the following class:

- `CAEAGLLayer` provides an OpenGLES rendering environment.

The `CALayer` class introduces the concept of a **key-value coding compliant container class**–that is, a class that can store arbitrary values, using key-value coding compliant methods, without having to create a subclass. `CALayer` also extends the `NSKeyValueCoding` informal protocol, adding support for default key values and automatic object wrapping for the additional structure types (`CGPoint`, `CGSize`, `CGRect`, `CGAffineTransform` and `CATransform3D`) and provides access to many of the fields of those structures by key path.

`CALayer` also manages the animations and actions that are associated with a layer. Layers receive action triggers in response to layers being inserted and removed from the layer tree, modifications being made to layer properties, or explicit developer requests. These actions typically result in an animation occurring. See "Animation" (page 185) and "Actions" (page 189) for more information.

Animation and Timing Classes

Many of the visual properties of a layer are implicitly animatable. By simply changing the value of an animatable property the layer will automatically animate from the current value to the new value. For example, setting a layer's hidden property to `YES` triggers an animation that causes the layer to gradually fade away. Most animatable properties have an associated default animation which you can easily customize and replace. A complete list of the animatable properties and their default animations are listed in "Animatable Properties".

Animatable properties can also be explicitly animated. To explicitly animate a property you create an instance of one of Core Animation's animation classes and specify the required visual effects. An explicit animation doesn't change the value of the property in the layer, it simply animates it in the display.

Core Animation provides animation classes that can animate the entire contents of a layer or selected attributes using both basic animation and key-frame animation. All Core Animation's animation classes descend from the abstract class `CAAnimation`. `CAAnimation` adopts the `CAMediaTiming` protocol which provides the simple duration, speed, and repeat count for an animation. `CAAnimation` also adopts the `CAAction` protocol. This protocol provides a standardized means for starting an animation in response to an action triggered by a layer.

The animation classes also define a timing function that describes the pacing of the animation as a simple Bezier curve. For example, a linear timing function specifies that the animation's pace is even across its duration, while an ease-in timing function causes an animation to slow down as it nears its duration.

Core Animation provides a number of additional abstract and concrete animation classes:

- `CATransition` provides a transition effect that affects the entire layer's content. It fades, pushes, or reveals layer content when animating. The stock transition effects can be extended by providing your own custom Core Image filters.
- `CAAnimation` allows an array of animation objects to be grouped together and run concurrently.
- `CAPropertyAnimation` is an abstract subclass that provides support for animating a layer property specified by a key path.
- `CABasicAnimation` provides simple interpolation for a layer property.
- `CAKeyframeAnimation` provides support for key frame animation. You specify the key path of the layer property to be animated, an array of values that represent the value at each stage of the animation, as well as arrays of key frame times and timing functions. As the animation runs, each value is set in turn using the specified interpolation.

These animation classes are used by both Core Animation and Cocoa Animation proxies. "Animation" (page 185) describes the classes as they pertain to Core Animation, *Animation Types and Timing Programming Guide* contains a more in-depth exploration of their capabilities.

Layout Manager Classes

Application Kit view classes provide the classic "struts and springs" model of positioning layers relative to their superlayer. While layers support this model, Core Animation on Mac OS X also provides a more flexible layout manager mechanism that allows developers to write their own layout managers.

Core Animation's `CAConstraint` class is a layout manager that arranges sublayers using a set of constraints that you specify. Each constraint (encapsulated by instances of the `CAConstraint` class) describes the relationship of one geometric attribute of a layer (the left, right, top, or bottom edge or the horizontal or vertical center) in relation to a geometric attribute of one of its sibling layers or its superlayer.

Layout managers in general, and the constraint layout manager are discussed in "Laying Out Core Animation Layers" (page 197)

Transaction Management Classes

Every modification to an animatable property of a layer must be part of a transaction. `CATransaction` is the Core Animation class responsible for batching multiple animation operations into atomic updates to the display. Nested transactions are supported.

Core Animation supports two types of transactions: implicit transactions and explicit transactions. Implicit transactions are created automatically when an animatable property of a layer is modified by a thread without an active transaction and are committed automatically when the thread's run-loop next iterates. Explicit transactions occur when the application sends the `CATransaction` class a begin message before modifying the layer, and a commit message afterwards.

Transaction management is discussed in "Transactions" (page 193).

Timing

This chapter discusses timing issues when using Core Animation.

Using a Single Timing Function For a Keyframe Animation

The `CAKeyframeAnimation` class provides a powerful means of animating layer properties. However, `CAKeyframeAnimation` does not allow you to specify a single animation timing function that is used for the entire path. Instead you are required to specify the timing using the `keyTimes` (page 36) property, or by specifying an array of timing functions in the `timingFunctions` (page 38) property.

You can provide a single timing function for the animation by grouping the keyframe animation in a `CAAnimationGroup`, and setting the group animation's timing function to the desired `CAMediaTimingFunction`. The animation group's timing function and duration take precedence over the keyframe animation's timing properties.

A code fragment that implements this strategy is shown in Listing 1.

Listing 1 Using a single timing function for a keyframe animation

```
// create the path for the keyframe animation
CGMutablePathRef thePath = CGPathCreateMutable();
CGPathMoveToPoint(thePath,NULL,15.0f,15.f);
CGPathAddCurveToPoint(thePath,NULL,
                      15.f,250.0f,
                      295.0f,250.0f,
                      295.0f,15.0f);

// create an explicit keyframe animation that
// animates the target layer's position property
// and set the animation's path property
CAKeyframeAnimation *theAnimation=[CAKeyframeAnimation

                                      animationWithKeyPath:@"position"];
theAnimation.path=thePath;

// create an animation group and add the keyframe animation
CAAnimationGroup *theGroup = [CAAnimationGroup animation];
theGroup.animations=[NSArray arrayWithObject:theAnimation];

// set the timing function for the group and the animation duration
theGroup.timingFunction=[CAMediaTimingFunction

                                functionWithName:kCAMediaTimingFunctionEaseIn];
theGroup.duration=15.0;
// release the path
CFRelease(thePath);
```

```
// adding the animation to the target layer causes it
// to begin animating
[theLayer addAnimation:theGroup forKey:@"animatePosition"];
```

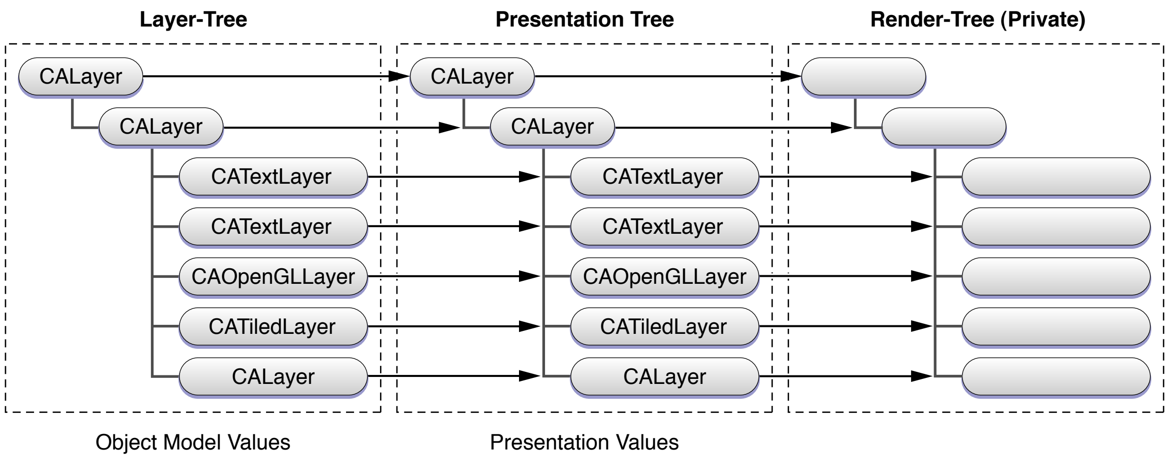
Core Animation Rendering Architecture

While there are obvious similarities between Core Animation layers and Cocoa views the biggest conceptual divergence is that layers do not render directly to the screen.

Where `NSView` and `UIView` are clearly view objects in the model-view-controller design pattern, Core Animation layers are actually model objects. They encapsulate geometry, timing and visual properties, and they provide the content that is displayed, but the actual display is not the layer's responsibility.

Each visible layer tree is backed by two corresponding trees: a presentation tree and a render tree. Figure 1 shows an example layer-tree using the Core Animation layer classes available in Mac OS X.

Figure 1 Core Animation Rendering Architecture



The layer tree contains the object model values for each layer. These are the values you set when you assign a value to a layer property.

The presentation tree contains the values that are currently being presented to the user as an animation takes place. For example, setting a new value for the `backgroundColor` of a layer immediately changes the value in the layer tree. However, the `backgroundColor` value in the corresponding layer in the presentation tree will be updated with the interpolated colors as they are displayed to the user.

The render-tree uses the value in the presentation-tree when rendering the layer. The render-tree is responsible for performing the compositing operations independent of application activity; rendering is done in a separate process or thread so that it has minimal impact on the application's run loop.

You can query an instance of `CALayer` for its corresponding presentation layer while an animation transaction is in process. This is most useful if you intend to change the current animation and want to begin the new animation from the currently displayed state.

Layer Geometry and Transforms

This chapter describes the components of a layer's geometry, how they interrelate, and how transform matrices can produce complex visual effects.

Layer Coordinate System

The layer's location and size are expressed using the same coordinate system that the Quartz graphics environment uses. By default, the graphics environment origin (0.0,0.0) is located in the lower left, and values are specified as floating-point numbers that increase up and to the right in coordinate system units. The coordinate system units, the unit square, is the size of a 1.0 by 1.0 rectangle.

Every layer instance defines and maintains its own coordinate system, and all sublayers are positioned, and drawing is done, relative to this coordinate system. Methods are provided to convert points, rectangles and sizes from one layer coordinate system to another. A layer's coordinate system should be considered the base coordinate system for all the content of the layer, including its sublayers.

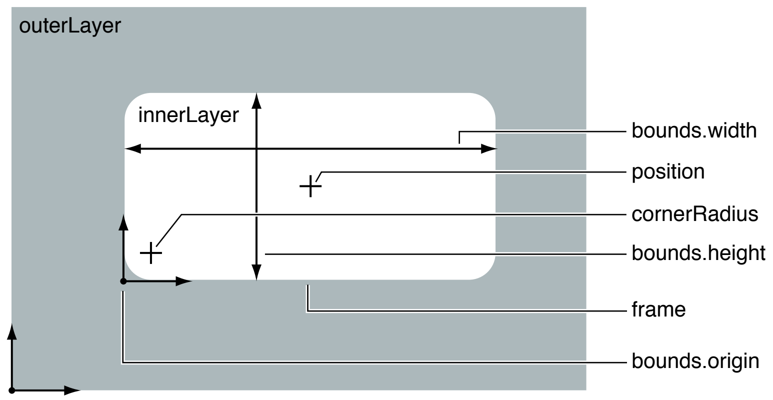
iPhone OS Note: The default root layer of a `UIView` instance uses a flipped coordinate system that matches the default coordinate system of a `UIView` instance–the origin is in the top-left and values increase down and to the right. Layers created by instantiating `CALayer` directly use the standard Core Animation coordinate system.

Specifying a Layer's Geometry

While layers and the layer-tree are analogous to Cocoa views and the view hierarchy in many ways, how a layer's geometry is specified is different, and often simpler, manner. All of a layer's geometric properties, including the layer's transform matrices, can be implicitly and explicitly animated.

Figure 1 shows the properties used to specify a layer's geometry in context.

Figure 1 CALayer geometry properties



The `position` property is a `CGPoint` that specifies the position of the layer relative to its superlayer, and is expressed in the superlayer's coordinate system.

The `bounds` property is a `CGRect` that provides the size of the layer (`bounds.size`) and the origin (`bounds.origin`). The bounds origin is used as the origin of the graphics context when you override a layer's drawing methods.

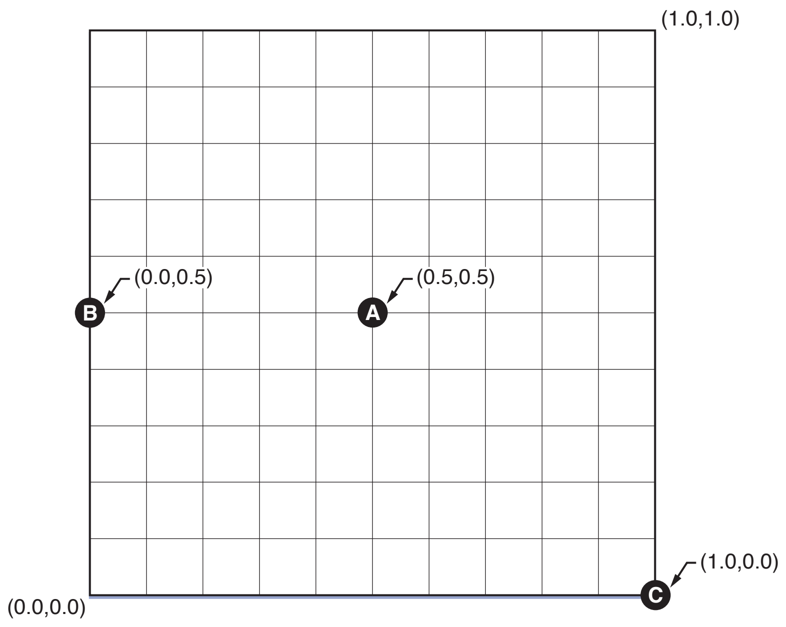
Layers have an implicit `frame` that is a function of the `position`, `bounds`, `anchorPoint`, and `transform` properties. Setting a new frame rectangle changes the layer's `position` and `bounds` properties appropriately, but the frame itself is not stored. When a new frame rectangle is specified the bounds origin is undisturbed, while the bounds size is set to the size of the frame. The layer's position is set to the proper location relative to the anchor point. When you get the `frame` property value, it is calculated relative to the `position`, `bounds`, and `anchorPoint` properties.

The `anchorPoint` property is a `CGPoint` that specifies a location within the bounds of a layer that corresponds with the position coordinate. The anchor point specifies how the bounds are positioned relative to the position property, as well as serving as the point that transforms are applied around. It is expressed in the unit coordinate system-the lower left of the layer bounds is 0.0,0.0, and the upper right is 1.0,1.0.

When you specify the frame of a layer, `position` is set relative to the anchor point. When you specify the position of the layer, `bounds` is set relative to the anchor point.

Figure 2 shows three example values for an anchor point.

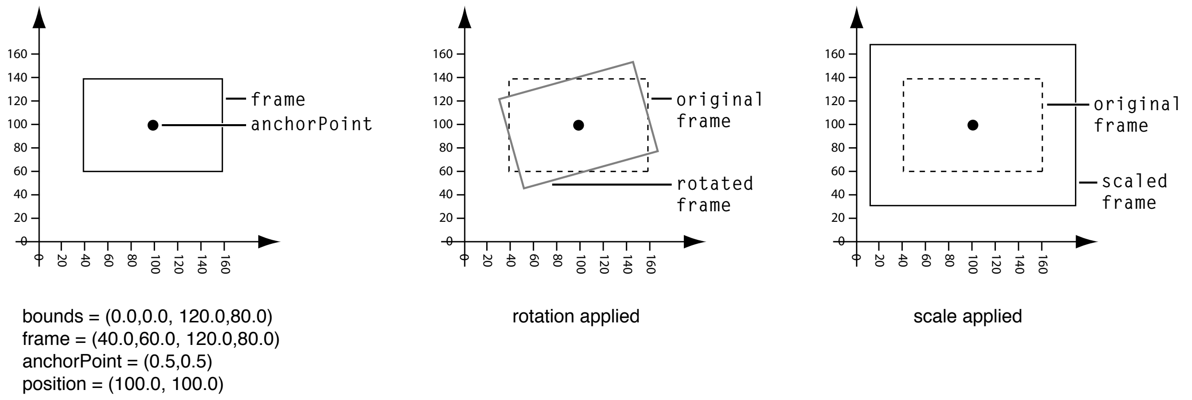
Figure 2 Three anchorPoint values



The default value for `anchorPoint` is (0.5,0.5) which corresponds to the center of the layer's bounds (shown as point A in Figure 2.) Point B shows the position of an anchor point set to (0.0,0.5). Finally, point C (1.0,0.0) causes specifies that the layer's `position` is set to the bottom right corner of the frame.

The relationship of the `frame`, `bounds`, `position`, and `anchorPoint` properties is shown in Figure 3.

Figure 3 Layer Origin of (0.5,0.5)

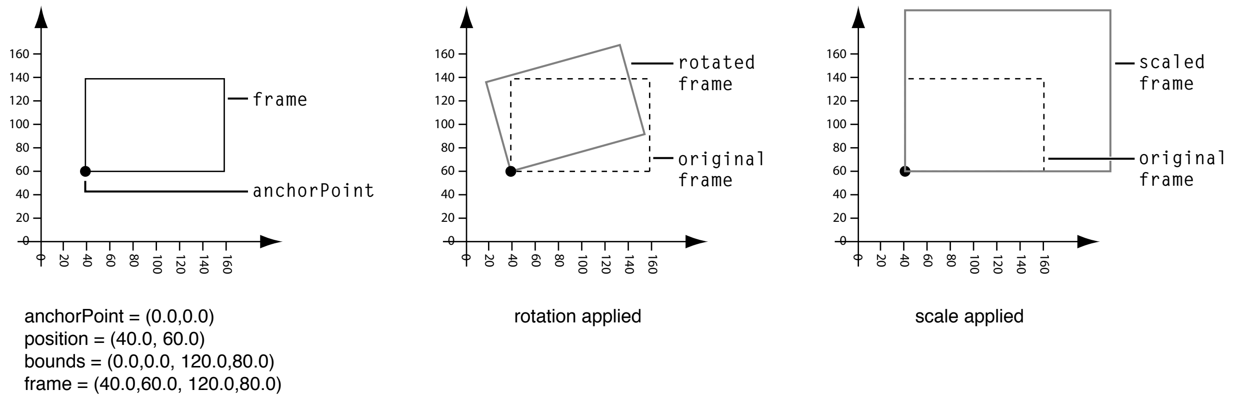


In this example the `anchorPoint` is set to the default value of (0.5,0.5), which corresponds to the center of the layer. The `position` of the layer is set to (100.0,100.0), and the `bounds` is set to the rectangle (0.0, 0.0, 120.0, 80.0). This causes the frame property to be calculated as (40.0, 60.0, 120.0, 80.0).

If you created a new layer, and set only the layer's frame property to (40.0, 60.0, 120.0, 80.0), the `position` property would be automatically set to (100.0,100.0), and the bounds property to (0.0, 0.0, 120.0, 80.0).

Figure 4 shows a layer with the same `frame` rectangle as the layer in Figure 3. However, in this case the `anchorPoint` of the layer is set to (0.0,0.0), which corresponds with the bottom left corner of the layer.

Figure 4 Layer Origin of (0.0,0.0)



With the frame set to (40.0, 60.0, 120.0, 80.0), the value of the `bounds` property is the same, but the value of the `position` property has changed.

Another aspect of layer geometry that differs from Cocoa views is that you can specify a radius that is used to round the corners of the layer. The `cornerRadius` property specifies a radius the layer uses when drawing content, clipping sublayers, and drawing the border and shadow.

The `zPosition` property specifies the z-axis component of the layer's position. The `zPosition` is intended to be used to set the visual position of the layer relative to its sibling layers. It should not be used to specify the order of layer siblings, instead reorder the layer in the sublayer array.

Transforming a Layer's Geometry

Once established, you can transform a layer's geometry using matrix transformations. The `Transform` (page 86) data structure defines a homogenous three-dimensional transform (a 4 by 4 matrix of `CGFloat` values) that is used to rotate, scale, offset, skew, and apply perspective transformations to a layer.

Two layer properties specify transform matrices: `transform` and `sublayerTransform`. The matrix specified by the `transform` property is applied to the layer and its sublayers relative to the layer's `anchorPoint`. Figure 3 shows how rotation and scaling transforms affect a layer when using an anchorPoint of (0.5,0.5), the default value. Figure 4 shows how the same transform matrices affect a layer when an anchorPoint of (0.0,0.0). The matrix specified by the `sublayerTransform` property is applied only to the layer's sublayers, rather than to the layer itself.

You create and modify `CATransform3D` data structures in one of the following ways:

- using the `CATransform3D` functions
- modifying the data structure members directly
- using key-value coding and key paths.

The constant `CATransform3DIdentity` is the identity matrix, a matrix that has no scale, rotation, skewing, or perspective applied. Applying the identity matrix to a layer causes it to be displayed with its default geometry.

Transform Functions

The transform functions available in Core Animation operate on matrices. You can use these functions (shown in Table 1) to construct a matrix that you later apply to a layer or its sublayers by modifying the transform or sublayerTransform properties respectively. The transform functions either operate on, or return, a `CATransform3D` data structure. This enables you to construct simple or complex transforms that you can readily reuse.

Table 1 CATransform3D transform functions for translation, rotation, and scaling

Function	Use
`CATransform3DMakeTranslation` (page 159)	Returns a transform that translates by '(tx, ty, tz)'. t' = [1 0 0 0; 0 1 0 0; 0 0 1 0; tx ty tz 1].
`CATransform3DTranslate` (page 159)	Translate 't' by '(tx, ty, tz)' and return the result: * t' = translate(tx, ty, tz) * t.
`CATransform3DMakeScale` (page 158)	Returns a transform that scales by `(sx, sy, sz)': * t' = [sx 0 0 0; 0 sy 0 0; 0 0 sz 0; 0 0 0 1].
`CATransform3DScale` (page 159)	Scale 't' by '(sx, sy, sz)' and return the result: * t' = scale(sx, sy, sz) * t.
`CATransform3DMakeRotation` (page 158)	Returns a transform that rotates by 'angle' radians about the vector '(x, y, z)'. If the vector has length zero the identity transform is returned.
`CATransform3DRotate` (page 159)	Rotate 't' by 'angle' radians about the vector '(x, y, z)' and return the result. t' = rotation(angle, x, y, z) * t.

The angles of rotation is specified in radians rather than degrees. The following functions allow you to convert between radians and degrees.

```
CGFloat DegreesToRadians(CGFloat degrees) {return degrees * M_PI / 180;};
CGFloat RadiansToDegrees(CGFloat radians) {return radians * 180 / M_PI;};
```

Core Animation provides a transform function that inverts a matrix, `CATransform3DInvert`. Inversion is generally used to provide reverse transformation of points within transformed objects. Inversion can be useful when you need to recover a value that has been transformed by a matrix: invert the matrix, and multiply the value by the inverted matrix, and the result is the original value.

Functions are also provided that allow you to convert a `CATransform3D` matrix to a `CGAffineTransform` matrix, if the `CATransform3D` matrix can be expressed as such.

Table 2 CATransform3D transform functions for CGAffineTransform conversion

Function	Use
`CATransform3DMakeAffineTransform` (page 158)	Returns a `CATransform3D` with the same effect as the passed affine transform.
`CATransform3DIsAffine` (page 157)	Returns `YES` if the passed `CATransform3D` can be exactly represented an affine transform.
`CATransform3DGetAffineTransform` (page 157)	Returns the affine transform represented by the passed `CATransform3D`.

Functions are provided for comparing transform matrices for equality with the identity matrix, or another transform matrix.

Table 3 CATransform3D transform functions for testing equality

Function	Use
`CATransform3DIsIdentity` (page 157)	Returns `YES` if the transform is the identity transform.
`CATransform3DEqualToTransform` (page 156)	Returns `YES` if the two transforms are exactly equal..

Modifying the Transform Data Structure

You can modify the value of any of the `CATransform3D` data structure members as you would any other data structure. Listing 1 contains the definition of the `CATransform3D` data structure, the structure members are shown in their corresponding matrix positions.

Listing 1 CATransform3D structure

```
struct CATransform3D
{
  CGFloat m11, m12, m13, m14;
  CGFloat m21, m22, m23, m24;
  CGFloat m31, m32, m33, m34;
  CGFloat m41, m42, m43, m44;
};

typedef struct CATransform3D CATransform3D;
```

The example in Listing 2 illustrates how to configure a `CATransform3D` as a perspective transform.

Listing 2 Modifying the CATransform3D data structure directly

```
 CATransform3D aTransform = CATransform3DIdentity;
// the value of zDistance affects the sharpness of the transform.
zDistance = 850;
aTransform.m34 = 1.0 / -zDistance;
```

Modifying a Transform Using Key Paths

Core Animation extends the key-value coding protocol to allow getting and setting of the commonly values of a layer's `CATransform3D` matrix through key paths. Table 4 describes the key paths for which a layer's `transform` and `sublayerTransform` properties are key-value coding and observing compliant.

Table 4 CATransform3D key paths

Field Key Path	Description
`rotation.x`	The rotation, in radians, in the x axis.
`rotation.y`	The rotation, in radians, in the y axis.
`rotation.z`	The rotation, in radians, in the z axis.
`rotation`	The rotation, in radians, in the z axis. This is identical to setting the `rotation.z` field.
`scale.x`	Scale factor for the x axis.
`scale.y`	Scale factor for the y axis.
`scale.z`	Scale factor for the z axis.
`scale`	Average of all three scale factors.
`translation.x`	Translate in the x axis.
`translation.y`	Translate in the y axis.
`translation.z`	Translate in the z axis.
`translation`	Translate in the x and y axis. Value is an NSSize or CGSize.

You can not specify a structure field key path using Objective-C 2.0 properties. This will not work:

```
myLayer.transform.rotation.x=0;
```

Instead you must use `setValue:forKeyPath:` or `valueForKeyPath:` as shown below:

```
[myLayer setValue:[NSNumber numberWithInt:0] forKeyPath:@"transform.rotation.x"];
```

Layer-Tree Hierarchy

Along with their own direct responsibilities for providing visual content and managing animations, layers also act as containers for other layers, creating a layer hierarchy.

This chapter describes the layer hierarchy and how you manipulate layers within that hierarchy.

What Is a Layer-Tree Hierarchy?

The layer-tree is the Core Animation equivalent of the Cocoa view hierarchy. Just as an instance of `NSView` or `UIView` has superview and subviews, a Core Animation layer has a superlayer and sublayers. The layer-tree provides many of the same benefits as the view hierarchy:

- Complex interfaces can be assembled using simpler layers, avoiding monolithic and complex subclassing. Layers are well suited to this type of 'stacking' due to their complex compositing capabilities.
- Each layer declares its own coordinate system relative to its superlayer's coordinate system. When a layer is transformed, its sublayers are transformed within it.
- A layer-tree is dynamic. It can be reconfigured as an application runs. Layers can be created, added as a sublayer first of one layer, then of another, and removed from the layer-tree.

Displaying Layers in Views

Core Animation doesn't provide a means for actually displaying layers in a window, they must be hosted by a view. When paired with a view, the view must provide event-handling for the underlying layers, while the layers provide display of the content.

The view system in iPhone OS is built directly on top of Core Animation layers. Every instance of UIView automatically creates an instance of a `CALayer` class and sets it as the value of the view's `layer` property. To display custom layer content in a UIView instance you simply add the layers as sublayers of the view's layer.

On Mac OS X you must configure an `NSView` instance in such a way that it can host a layer. To display the root layer of a layer tree, you set a view's layer and then configure the view to use layers as shown in Table 2.

Listing 1 Inserting a layer into a view

```
// theView is an existing view in a window
// theRootLayer is the root layer of a layer tree

[theView setLayer: theRootLayer];
[theView setWantsLayer:YES];
```

Adding and Removing Layers from a Hierarchy

Simply instantiating a layer instance doesn't insert it into a layer-tree. Instead you add, insert, replace, and remove layers from the layer-tree using the methods described in .Table 1.

Table 1 Layer-tree management methods.

Method	Result
`addSublayer:`	Appends the layer to the receiver's sublayers array.
`insertSublayer: atIndex:`	Inserts the layer as a sublayer of the receiver at the specified index.
`insertSublayer: below:`	Inserts the layer into the receiver's sublayers array, below the specified sublayer.
`insertSublayer: above:`	Inserts the layer into the receiver's sublayers array, above the specified sublayer.
`removeFromSuperlayer`	Removes the receiver from the sublayers array or mask property of the receiver's superlayer.
`replaceSublayer: with:`	Replaces the layer in the receiver's sublayers array with the specified new layer.

You can also set the sublayers of a layer using an array of layers, and setting the intended superlayer's sublayers property. When setting the sublayers property to an array populated with layer objects you must ensure that the layers have had their superlayer set to `nil`.

By default, inserting and removing layers from a visible layer-tree triggers an animation. When a layer is added as a sublayer the animation returned by the parent layer for the action identifier `kCAOnOrderIn` is triggered. When a layer is removed from a layer's sublayers the animation returned by the parent layer for the action identifier `kCAOnOrderOut` is triggered. Replacing a layer in a sublayer causes the animation returned by the parent layer for the action identifier `kCATransition` to be triggered. You can disable animation while manipulating the layer-tree, or alter the animation used for any of the action identifiers.

Repositioning and Resizing Layers

After a layer has been created, you can move and resize it programmatically simply by changing the value of the layer's geometry properties: `frame`, `bounds`, `position`, `anchorPoint`, or `zPosition`.

If a layer's `needsDisplayOnBoundsChange` property is YES, the layer's content is recached when the layer's bounds changes. By default the `needsDisplayOnBoundsChange` property is no.

By default, setting the `frame`, `bounds`, `position`, `anchorPoint`, and `zPosition` properties causes the layer to animate the new values.

Autoresizing Layers

`CALayer` provides a mechanism for automatically moving and resizing sublayers in response to their superlayer being moved or resized. In many cases simply configuring the autoresizing mask for a layer provides the appropriate behavior for an application.

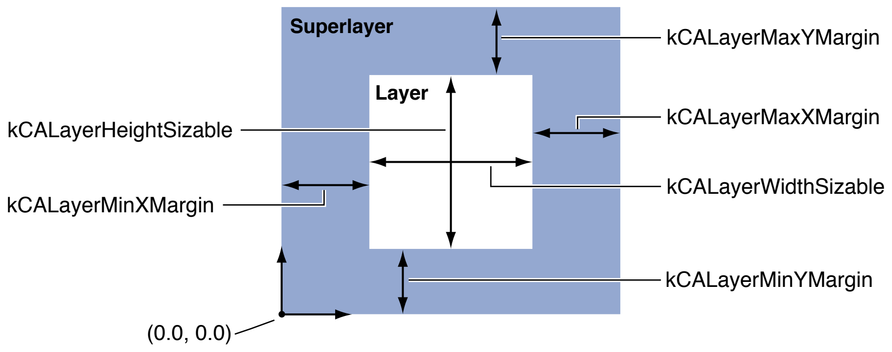
A layer's autoresizing mask is specified by combining the `CAAutoresizingMask` constants using the bitwise `OR` operator and the layer's `autoresizingMask` property to the resulting value. Table 2 shows each mask constant and how it effects the layer's resizing behavior.

Table 2 Autoresizing mask values and descriptions

Autoresizing Mask	Description
`kCALayerHeightSizable`	If set, the layer's height changes proportionally to the change in the superlayer's height. Otherwise, the layer's height does not change relative to the superlayer's height.
`kCALayerWidthSizable`	If set, the layer's width changes proportionally to the change in the superlayer's width. Otherwise, the layer's width does not change relative to the superlayer's width.
`kCALayerMinXMargin`	If set, the layer's left edge is repositioned proportionally to the change in the superlayer's width. Otherwise, the layer's left edge remains in the same position relative to the superlayer's left edge.
`kCALayerMaxXMargin`	If set, the layer's right edge is repositioned proportionally to the change in the superlayer's width. Otherwise, the layer's right edge remains in the same position relative to the superlayer.
`kCALayerMinYMargin`	If set, the layer's top edge is repositioned proportionally to the change in the superlayer's height. Otherwise, the layer's top edge remains in the same position relative to the superlayer.
`kCALayerMaxYMargin`	If set, the layer's bottom edge is repositioned proportional to the change in the superlayer's height. Otherwise, the layer's bottom edge remains in the same position relative to the superlayer.

For example, to keep a layer in the lower-left corner of its superlayer, you use the mask `kCALayerMaxXMargin | kCALayerMaxYMargin`. When more than one aspect along an axis is made flexible, the resize amount is distributed evenly among them. Figure 1 provides a graphical representation of the position of the constant values.

Figure 1 Layer autoresizing mask constants



When one of these constants is omitted, the layer's layout is fixed in that aspect; when a constant is included in the mask the layer's layout is flexible in that aspect.

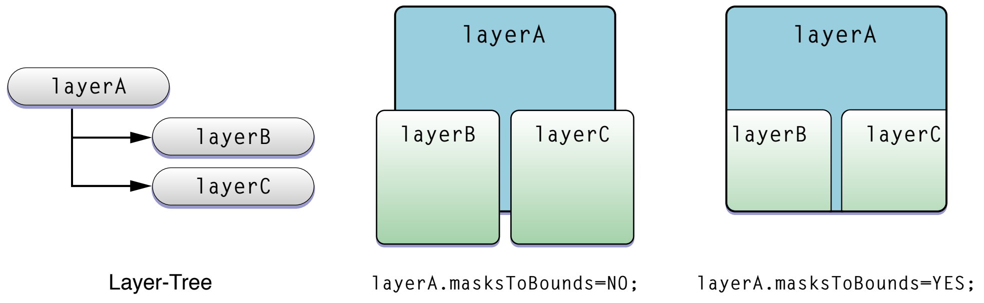
A subclass can override the `CALayer` methods `resizeSublayersWithOldSize:` and `resizeWithOldSuperlayerSize:` to customize the autoresizing behavior for a layer. A layers `resizeSublayersWithOldSize:` method is invoked automatically by a layer whenever bounds property changes, and sends a `resizeWithOldSuperlayerSize:` message to each sublayer. Each sublayer compares the old bounds size to the new size and adjusts its position and size according to its autoresize mask.

Clipping Sublayers

When subviews of a Cocoa view lie outside of the parent view's bounds, the views are clipped to the parent view. Layers remove this limitation, allowing sublayers to be displayed in their entirety, regardless of their position relative to the parent layer.

The value of a layer's `masksToBounds` property determines if sublayers are clipped to the parent. The default value of the `masksToBounds` property is `NO`, which prevents sublayers from being clipped to the parent. Figure 2 shows the results of setting the masksToBounds for `layerA` and how it will affect the display of `layerB` and `layerC`.

Figure 2 Example Values of the masksToBounds property



Animation

Animation is a key element of today's user interfaces. When using Core Animation animation is completely automatic. There are no animation loops or timers. Your application is not responsible for frame by frame drawing, or tracking the current state of your animation. The animation occurs automatically in a separate thread, without further interaction with your application.

This chapter provides an overview of the animation classes, and describes how to create both implicit and explicit animations.

Animation Classes and Timing

Core Animation provides an expressive set of animation classes you can use in your application:

- `CABasicAnimation` provides simple interpolation between values for a layer property.
- `CAKeyframeAnimation` provides support for key frame animation. You specify the key path of the layer property to be animated, an array of values that represent the value at each stage of the animation, as well as arrays of key frame times and timing functions. As the animation runs, each value is set in turn using the specified interpolation.
- `CATransition` provides a transition effect that affects the entire layer's content. It fades, pushes, or reveals layer content when animating. The stock transition effects can be extended by providing your own custom Core Image filters.
- `CAAnimationGroup` allows an array of animation objects to be grouped together and run concurrently.

In addition to specifying the type of animation to perform, you must also specify the duration of the animation, the pacing (how the interpolated values are distributed across the duration), if the animation is to repeat and how many times, whether it should automatically reverse when each cycle is completed, and its visual state when the animation is completed. The animation classes and the `CAMediaTiming` protocol provides all this functionality and more.

`CAAnimation` and its subclasses and the timing protocols are shared by both Core Animation and the Cocoa Animation Proxy functionality. The classes are described in detail in *Animation Types and Timing Programming Guide*.

Implicit Animation

Core Animation's implicit animation model assumes that all changes to animatable layer properties should be gradual and asynchronous. Dynamically animated scenes can be achieved without ever explicitly animating layers. Changing the value of an animatable layer property causes the layer to implicitly animate the change from the old value to the new value. While an animation is in-flight, setting a new target value causes the animation transition to the new target value from its current state.

Listing 1 shows how simple it is to trigger an implicit animation that animates a layer from its current position to a new position.

Listing 1 Implicitly animating a layer's position property

```
// assume that the layer is current positioned at (100.0,100.0)
theLayer.position=CGPointMake(500.0,500.0);
```

You can implicitly animate a single layer property at a time, or many. You can also implicitly animate several layers simultaneously. The code in Listing 2 causes four implicit animations to occur simultaneously.

Listing 2 Implicitly animating multiple properties of multiple layers

```
// animate theLayer's opacity to 0 while moving it
// further away in the layer
theLayer.opacity=0.0;
theLayer.zPosition=-100;

// animate anotherLayer's opacity to 1
//  while moving it closer in the layer
anotherLayer.opacity=1.0;
anotherLayer.zPosition=100.0;
```

Implicit animations use the duration specified in the default animation for the property, unless the duration has been overridden in an implicit or explicit transaction. See "Overriding the Duration of Implied Animations" (page 194) for more information.

Explicit Animation

Core Animation also supports an explicit animation model. The explicit animation model requires that you create an animation object, and set start and end values. An explicit animation won't start until you apply the animation to a layer. The code fragment in Listing 3 creates an explicit animation that transitions a layer's opacity from fully opaque to fully transparent, and back over a 3 second duration. The animation doesn't begin until it is added to the layer.

Listing 3 Explicit animation

```
CABasicAnimation *theAnimation;

theAnimation=[CABasicAnimation animationWithKeyPath:@"opacity"];
theAnimation.duration=3.0;
theAnimation.repeatCount=2;
theAnimation.autoreverses=YES;
theAnimation.fromValue=[NSNumber numberWithFloat:1.0];
theAnimation.toValue=[NSNumber numberWithFloat:0.0];
[theLayer addAnimation:theAnimation forKey:@"animateOpacity"];
```

Explicit animations are especially useful when creating animations that run continuously. Listing 4 shows how to create an explicit animation that applies a CoreImage bloom filter to a layer, animating its intensity. This causes the "selection layer" to pulse, drawing the user's attention.

Listing 4 Continuous explicit animation example

```
// The selection layer will pulse continuously.
// This is accomplished by setting a bloom filter on the layer

// create the filter and set its default values
CIFilter *filter = [CIFilter filterWithName:@"CIBloom"];
[filter setDefaults];
[filter setValue:[NSNumber numberWithFloat:5.0] forKey:@"inputRadius"];

// name the filter so we can use the keypath to animate the inputIntensity
// attribute of the filter
[filter setName:@"pulseFilter"];

// set the filter to the selection layer's filters
[selectionLayer setFilters:[NSArray arrayWithObject:filter]];

// create the animation that will handle the pulsing.
CABasicAnimation* pulseAnimation = [CABasicAnimation animation];

// the attribute we want to animate is the inputIntensity
// of the pulseFilter
pulseAnimation.keyPath = @"filters.pulseFilter.inputIntensity";

// we want it to animate from the value 0 to 1
pulseAnimation.fromValue = [NSNumber numberWithFloat: 0.0];
pulseAnimation.toValue = [NSNumber numberWithFloat: 1.5];

// over a one second duration, and run an infinite
// number of times
pulseAnimation.duration = 1.0;
pulseAnimation.repeatCount = 1e100f;

// we want it to fade on, and fade off, so it needs to
// automatically autoreverse.. this causes the intensity
// input to go from 0 to 1 to 0
pulseAnimation.autoreverses = YES;

// use a timing curve of easy in, easy out..
pulseAnimation.timingFunction = [CAMediaTimingFunction functionWithName:
kCAMediaTimingFunctionEaseInEaseOut];

// add the animation to the selection layer. This causes
// it to begin animating. We'll use pulseAnimation as the
// animation key name
[selectionLayer addAnimation:pulseAnimation forKey:@"pulseAnimation"];
```

Starting and Stopping Explicit Animations

You start an explicit animation by sending a `addAnimation:forKey:` message to the target layer, passing the animation and an identifier as parameters. Once added to the target layer the explicit animation will run until the animation completes, or it is removed from the layer. The identifier used to add an animation to a layer is also used to stop it by invoking `removeAnimationForKey:`. You can stop all animations for a layer by sending the layer a `removeAllAnimations` message.

Actions

Layer actions are triggered in response to: layers being inserted and removed from the layer-tree, the value of layer properties being modified, or explicit application requests. Typically, action triggers result in an animation being displayed.

What are Actions?

An action object is an object that responds to an action identifier via the `CAAction` protocol. Action identifiers are named using standard dot-separated key paths. A layer is responsible for mapping action identifiers to the appropriate action object. When the action object for the identifier is located that object is sent the message defined by the `CAAction` protocol.

The `CALayer` class provides default action objects–instances of `CAAnimation`, a `CAAction` protocol compliant class–for all animatable layer properties. `CALayer` also defines the following action triggers that are not linked directly to properties, as well as the action identifiers in Table 1.

Table 1 Action triggers and their corresponding identifiers

Trigger	Action identifier
A layer is inserted into a visible layer-tree, or the `hidden` property is set to `NO`.	The action identifier constant `kCAOnOrderIn`.
A layer is removed from a visible layer-tree, or the `hidden` property is set to `YES`.	The action identifier constant `kCAOnOrderOut`.
A layer replaces an existing layer in a visible layer tree using `replaceSublayer: with:`.	The action identifier constant `kCATransition`.

Action Object Search Pattern

When an action trigger occurs, the layer's `actionForKey:` method is invoked. This method returns an action object that corresponds to the action identifier passed as the parameter, or `nil` if no action object exists.

When the `CALayer` implementation of `actionForKey:` is invoked for an identifier the following search pattern is used:

1. If the layer has a delegate, and it implements the method `actionForLayer:forKey:` it is invoked, passing the layer, and the action identifier as parameters. The delegate's `actionForLayer:forKey:` implementation should respond as follows:

   - Return an action object that corresponds to the action identifier.

- Return nil if it doesn't handle the action identifier.
- Return NSNull if it doesn't handle the action identifier and the search should be terminated.

2. The layer's actions dictionary is searched for an object that corresponds to the action identifier.
3. The layer's style property is searched for an actions dictionary that contains the identifier.
4. The layer's class is sent a defaultActionForKey: message. It will return an action object corresponding to the identifier, or nil if not found.

CAAction Protocol

The CAAction protocol defines how action objects are invoked. Classes that implement the CAAction protocol have a method with the signature runActionForKey:object:arguments:.

When the action object receives the runActionForKey:object:arguments: message it is passed the action identifier, the layer on which the action should occur, and an optional dictionary of parameters.

Typically, action objects are an instance of a CAAnimation subclass, which implements the CAAction protocol. You can, however, return an instance of any class that implements the protocol. When that instance receives the runActionForKey:object:arguments: message it should respond by performing its action.

When an instance of CAAnimation receives the runActionForKey:object:arguments: message it responds by adding itself to the layer's animations, causing the animation to run (see Listing 1 (page 190)).

Listing 1 runActionForKey:object:arguments: implementation that initiates an animation

```
- (void)runActionForKey:(NSString *)key
                 object:(id)anObject
              arguments:(NSDictionary *)dict
{
     [(CALayer *)anObject addAnimation:self forKey:key];
}
```

Overriding an Implied Animation

You can provide a different implied animation for an action identifier by inserting an instance of CAAnimation into the actions dictionary, into an actions dictionary in the style dictionary, by implementing the delegate method actionForLayer:forKey:, or subclassing a layer class, overriding defaultActionForKey: and returning the appropriate action object.

The example in Listing 2 replaces the default implied animation for the contents property using delegation.

Listing 2 Implied animation for the contents property

```
- (id<CAAction>)actionForLayer:(CALayer *)theLayer
```

```
                        forKey:(NSString *)theKey
{
    CATransition *theAnimation=nil;

    if ([theKey isEqualToString:@"contents"])
    {

        theAnimation = [[CATransition alloc] init];
        theAnimation.duration = 1.0;
        theAnimation.timingFunction = [CAMediaTimingFunction
functionWithName:kCAMediaTimingFunctionEaseIn];
        theAnimation.type = kCATransitionPush;
        theAnimation.subtype = kCATransitionFromRight;
    }

    return theAnimation;
}
```

The example in Listing 3 (page 191) disables the default animation for the `sublayers` property using the `actions` dictionary pattern.

Listing 3 Implied animation for the sublayers property

```
// get a mutable version of the current actions dictionary
NSMutableDictionary *customActions=[NSMutableDictionary
dictionaryWithDictionary:[theLayer actions]];

// add the new action for sublayers
[customActions setObject:[NSNull null] forKey:@"sublayers"];

// set theLayer actions to the updated dictionary
theLayer.actions=customActions;
```

Temporarily Disabling Actions

You can temporarily disable actions when modifying layer properties by using transactions. See "Temporarily Disabling Layer Actions" (page 193) for more information.

Transactions

Every modification to a layer is part of a transaction. `CATransaction` is the Core Animation class responsible for batching multiple layer-tree modifications into atomic updates to the render tree.

This chapter describes the two types of transactions Core Animation supports: implicit transactions and explicit transactions.

Implicit transactions

Implicit transactions are created automatically when the layer tree is modified by a thread without an active transaction, and are committed automatically when the thread's run-loop next iterates.

The example in Listing 1 modifies a layer's `opacity`, `zPosition`, and `position` properties, relying on the implicit transaction to ensure that the resulting animations occur at the same time.

Listing 1 Animation using an implicit transaction

```
theLayer.opacity=0.0;
theLayer.zPosition=-200;
thelayer.position=CGPointMake(0.0,0.0);
```

Important: When modifying layer properties from threads that don't have a runloop, you must use explicit transactions.

Explicit Transactions

You create an explicit transaction by sending the `CATransaction` class a `begin` message before modifying the layer tree, and a `commit` message afterwards. Explicit transactions are particularly useful when setting the properties of many layers at the same time (for example, while laying out multiple layer), temporarily disabling layer actions, or temporarily changing the duration of resulting implied animations.

Temporarily Disabling Layer Actions

You can temporarily disable layer actions when changing layer property values by setting the value of the transaction's `kCATransactionDisableActions` to true. Any changes made during the scope of that transaction will not resulting in an animation occuring. Listing 2 shows an example that disables the fade animation that occurs when removing `aLayer` from a visible layer-tree.

Listing 2 Temporarily disabling a layer's actions

```
[CATransaction begin];
[CATransaction setValue:(id)kCFBooleanTrue
                 forKey:kCATransactionDisableActions];
[aLayer removeFromSuperlayer];
[CATransaction commit];
```

Overriding the Duration of Implied Animations

You can temporarily alter the duration of animations that run in response to changing layer property values by setting the value of the transaction's `kCATransactionAnimationDuration` key to a new duration. Any resulting animations in that transaction scope will use that duration rather than their own. Listing 3 shows an example that causes an animation to occur over 10 seconds rather than the duration specified by the `zPosition` and `opacity` animations..

Listing 3 Overriding the animation duration

```
[CATransaction begin];
[CATransaction setValue:[NSNumber numberWithFloat:10.0f]
                 forKey:kCATransactionAnimationDuration];
theLayer.zPosition=200.0;
theLayer.opacity=0.0;
[CATransaction commit];
```

Although the above example shows the duration bracketed by an explicit transaction `begin` and `commit`, you could omit those and use the implicit transaction instead.

Nesting Transactions

Explicit transactions can be nested, allowing you to disable actions for one part of an animation, or using different durations for the implicit animations of properties that are modified. Only when the outer-most transaction is committed will the animations occur.

Listing 4 shows an example of nesting two transactions. The outer transaction sets the implied animation duration to 2 seconds and sets the layer's `position` property. The inner transaction sets the implied animation duration to 5 seconds and changes the layer's `opacity` and `zPosition`.

Listing 4 Nesting explicit transactions

```
[CATransaction begin]; // outer transaction

// change the animation duration to 2 seconds
[CATransaction setValue:[NSNumber numberWithFloat:2.0f]
                forKey:kCATransactionAnimationDuration];
// move the layer to a new position
theLayer.position = CGPointMake(0.0,0.0);

[CATransaction begin]; // inner transaction
// change the animation duration to 5 seconds
[CATransaction setValue:[NSNumber numberWithFloat:5.0f]
                 forKey:kCATransactionAnimationDuration];
```

```
// change the zPosition and opacity
theLayer.zPosition=200.0;
theLayer.opacity=0.0;

[CATransaction commit]; // inner transaction

[CATransaction commit]; // outer transaction
```

Laying Out Core Animation Layers

`NSView` provides the classic "struts and springs" model of repositioning views relative to their superlayer when it resizes. While layers support this model, Core Animation on Mac OS X provides a more general layout manager mechanism that allows developers to write their own layout managers. A custom layout manager (which implements the `CALayoutManager` protocol) can be specified for a layer, which then assumes responsibility for providing layout of the layer's sublayers.

This chapter describes the constraints layout manager and how to configure a set of constraints.

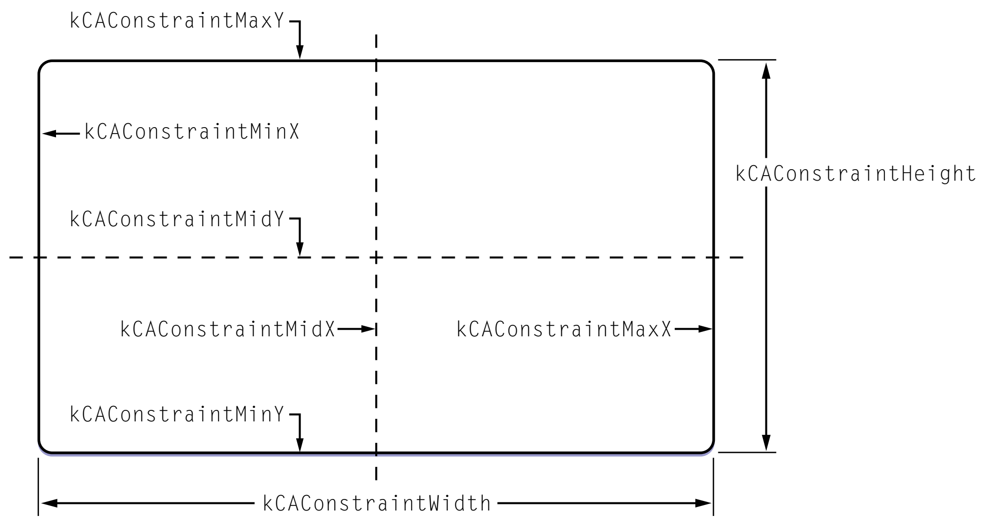
iPhone OS Note: The `CALayer` class in iPhone OS only supports the "struts and springs" positioning model, it does not provide custom layout managers.

Constraints Layout Manager

Constraint-based layout allows you to specify the position and size of a layer using relationships between itself its sibling layers or its superlayer. The relationships are represented by instances of the `CAConstraint` class that are stored in an array in the sublayers' `constraints` property.

Figure 1 shows the layout attributes you can use when specifying relationships.

Figure 1 Constraint layout manager attributes



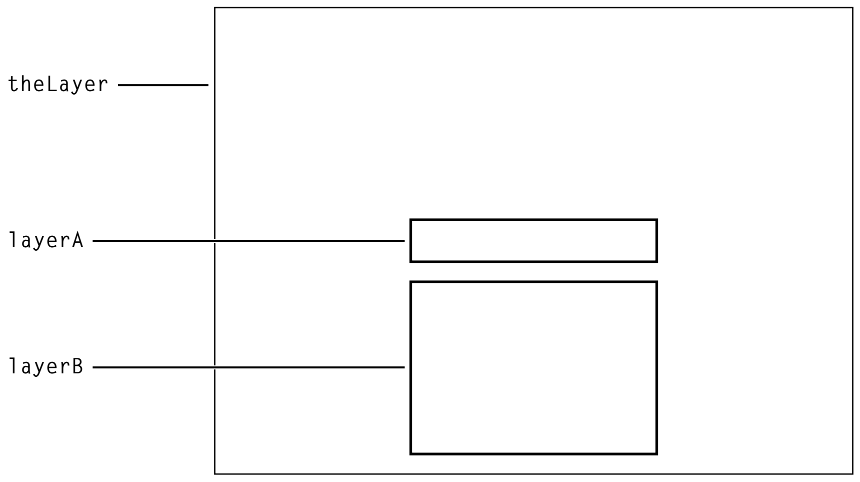
When using constraints layout you first create an instance of `CAConstraintsLayoutManager` and set it as the parent layer's layout manager. You then create constraints for the the sublayers by instantiating `CAConstraint` objects and adding them to the sublayer's constraints using `addConstraint:`. Each `CAConstraint` instance encapsulates one geometry relationship between two layers on the same axis.

Sibling layers are referenced by name, using the `name` property of a layer. The special name `superlayer` is used to refer to the layer's superlayer.

A maximum of two relationships must be specified per axis. If you specify constraints for the left and right edges of a layer, the width will vary. If you specify constraints for the left edge and the width, the right edge of the layer will move relative to the superlayer's frame. Often you'll specify only a single edge constraint, the layer's size in the same axis will be used as the second relationship.

The example code in Listing 1 creates a layer, and then adds sublayers that are positioned using constraints. Figure 2 shows the resulting layout.

Figure 2 Example constraints based layout



Listing 1 Configuring a layer's constraints

```
// create and set a constraint layout manager for theLayer
theLayer.layoutManager=[CAConstraintLayoutManager layoutManager];

CALayer *layerA = [CALayer layer];
layerA.name = @"layerA";

layerA.bounds = CGRectMake(0.0,0.0,100.0,25.0);
layerA.borderWidth = 2.0;

[layerA addConstraint:[CAConstraint constraintWithAttribute:kCAConstraintMidY
                                                 relativeTo:@"superlayer"
                                                  attribute:kCAConstraintMidY]];

[layerA addConstraint:[CAConstraint constraintWithAttribute:kCAConstraintMidX
                                                 relativeTo:@"superlayer"
                                                  attribute:kCAConstraintMidX]];

[theLayer addSublayer:layerA];
```

```
CALayer *layerB = [CALayer layer];
layerB.name = @"layerB";
layerB.borderWidth = 2.0;

[layerB addConstraint:[CAConstraint constraintWithAttribute:kCAConstraintWidth
                                                 relativeTo:@"layerA"
                                                attribute:kCAConstraintWidth]];

[layerB addConstraint:[CAConstraint constraintWithAttribute:kCAConstraintMidX
                                                 relativeTo:@"layerA"
                                                 attribute:kCAConstraintMidX]];


[layerB addConstraint:[CAConstraint constraintWithAttribute:kCAConstraintMaxY
                                                 relativeTo:@"layerA"
                                                  attribute:kCAConstraintMinY
                                                     offset:-10.0]];

[layerB addConstraint:[CAConstraint constraintWithAttribute:kCAConstraintMinY
                                                 relativeTo:@"superlayer"
                                                  attribute:kCAConstraintMinY
                                                     offset:+10.0]];

[theLayer addSublayer:layerB];
```

Here's what the code does:

1. Creates an instance of `CAConstraintsLayoutManager` and sets it as the `layoutManager` property of `theLayer`.
2. Creates an instance of `CALayer` (`layerA`) and sets the layer's `name` property to "layerA".
3. The bounds of `layerA` is set to a (0.0,0.0,100.0,25.0).
4. Creates a `CAConstraint` object, and adds it as a constraint of `layerA`.

   This constraint aligns the horizontal center of `layerA` with the horizontal center of the superlayer.
5. Creates a second `CAConstraint` object, and adds it as a constraint of `layerA`.

   This constraint aligns the vertical center of `layerA` with the vertical center of the superlayer.
6. Adds `layerA` as a sublayer of `theLayer`.
7. Creates an instance of `CALayer` (`layerB`) and sets the layer's `name` property to "layerB".
8. Creates a `CAConstraint` object, and adds it as a constraint of `layerA`.

   This constraint sets the width of `layerB` to the width of `layerA`.
9. Creates a second `CAConstraint` object, and adds it as a constraint of `layerB`.

   This constraint sets the horizontal center of `layerB` to be the same as the horizontal center of `layerA`.
10. Creates a third `CAConstraint` object, and adds it as a constraint of `layerB`.

    This constraint sets the top edge of `layerB` 10 points below the bottom edge of `layerA`.

11. Creates a fourth `CAConstraint` object, and adds it as a constraint of `layerB`.

    This constraint sets the bottom edge of `layerB` 10 points above the bottom edge of the superlayer.

Warning: It is possible to create constraints that result in circular references to the same attributes. In cases where the layout is unable to be computed, the behavior is undefined.

Core Animation Extensions To Key-Value Coding

The `CAAnimation` and `CALayer` classes extend the `NSKeyValueCoding` protocol adding default values for keys, expanded wrapping conventions, and key path support for `CGPoint`, `CGRect`, `CGSize`, and `CATransform3D`.

Key-Value Coding Compliant Container Classes

Both `CALayer` and `CAAnimation` are key-value coding compliant container classes, allowing you to set values for arbitrary keys. That is, while the key "foo" is not a declared property of the `CALayer` class, however you can still set a value for the key "foo" as follows:

```
[theLayer setValue:[NSNumber numberWithInteger:50] forKey:@"foo"];
```

You retrieve the value for the key "foo" using the following code:

```
fooValue=[theLayer valueForKey:@"foo"];
```

Mac OS X Note: On Mac OS X, the `CALayer` and `CAAnimation` classes support the `NSCoding` protocol and will automatically archive any additional keys that you set for an instance of those classes.

Default Value Support

Core Animation adds a new convention to key value coding that allows a class to provide a default value that is used when a class has no value set for that key. Both `CALayer` or `CAAnimation` support this convention using the class method `defaultValueForKey:`.

To provide a default value for a key you create a subclass of the class and override `defaultValueForKey:`. The subclass implementation examines the key parameter and then returns the appropriate default value. Listing 1 shows an example implementation of `defaultValueForKey:` that provides a new default value for the layer property `masksToBounds`.

Listing 1 Example implementation of defaultValueForKey:

```
+ (id)defaultValueForKey:(NSString *)key
{
    if ([key isEqualToString:@"masksToBounds"])
         return [NSNumber numberWithBool:YES];

    return [super defaultValueForKey:key];
}
```

Wrapping Conventions

When using the key-value coding methods to access properties whose values are not objects the standard key-value coding wrapping conventions support, the following wrapping conventions are used:

C Type	Class
CGPoint	NSValue
CGSize	NSValue
CGRect	NSValue
CGAffineTransform	NSAffineTransform
CATransform3D	NSValue

Key Path Support for Structure Fields

`CAAnimation` provides support for accessing the fields of selected structures using key paths. This is useful for specifying these structure fields as the key paths for animations, as well as setting and getting values using `setValue:forKeyPath:` and `valueForKeyPath:`.

`CATransform3D` exposes the following fields:

Structure Field	Description
`rotation.x`	The rotation, in radians, in the x axis.
`rotation.y`	The rotation, in radians, in the y axis.
`rotation.z`	The rotation, in radians, in the z axis.
`rotation`	The rotation, in radians, in the z axis. This is identical to setting the `rotation.z` field.
`scale.x`	Scale factor for the x axis.
`scale.y`	Scale factor for the y axis.
`scale.z`	Scale factor for the z axis.
`scale`	Average of all three scale factors.
`translation.x`	Translate in the x axis.
`translation.y`	Translate in the y axis.
`translation.z`	Translate in the z axis.
`translation`	Translate in the x and y axis. Value is an NSSize or CGSize.

`CGPoint` exposes the following fields:

Structure Field	Description
`x`	The x component of the point.
`y`	The y component of the point.

`CGSize` exposes the following fields:

Structure Field	Description
`width`	The width component of the size.
`height`	The height component of the size.

`CGRect` exposes the following fields:

Structure Field	Description
`origin`	The origin of the rectangle as a `CGPoint`.
`origin.x`	The x component of the rectangle origin.
`origin.y`	The y component of the rectangle origin.
`size`	The size of the rectangle as a `CGSize`.
`size.width`	The width component of the rectangle size.
`size.height`	The height component of the rectangle size.

You can not specify a structure field key path using Objective-C 2.0 properties. This will not work:

```
    myLayer.transform.rotation.x=0;
```

Instead you must use `setValue:forKeyPath:` or `valueForKeyPath:` as shown below:

```
    [myLayer setValue:[NSNumber numberWithInt:0]
forKeyPath:@"transform.rotation.x"];
```

Layer Style Properties

Regardless of the type of media a layer displays, a layer's style properties are applied by the render-tree as it composites layers.

This chapter describes the layer style properties and provides examples of their effect on an example layer.

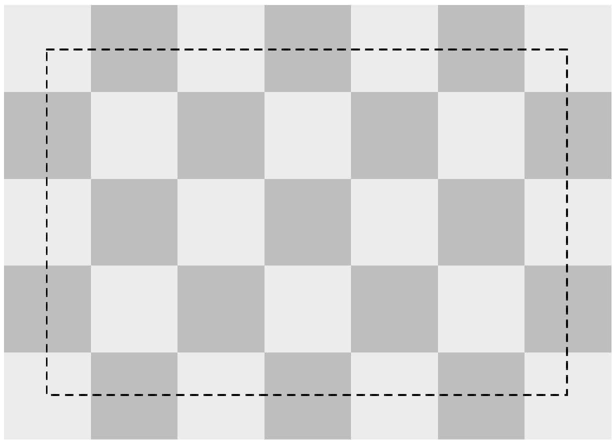
Note: The layer style properties available on Mac OS X and iPhone OS differ and are noted below.

Geometry Properties

A layer's geometry properties specify how it is displayed relative to its parent layer. The geometry also specifies the radius used to round the layer corners (available only on Mac OS X) and a transform that is applied to the layer and its sublayers.

Figure 1 shows the geometry of the example layer.

Figure 1 Layer geometry



The following `CALayer` properties specify a layer's geometry:

- `frame` (page 54)
- `bounds` (page 50)
- `position` (page 58)
- `anchorPoint` (page 47)
- `cornerRadius` (page 52)

- `transform` (page 61)
- `zPosition`

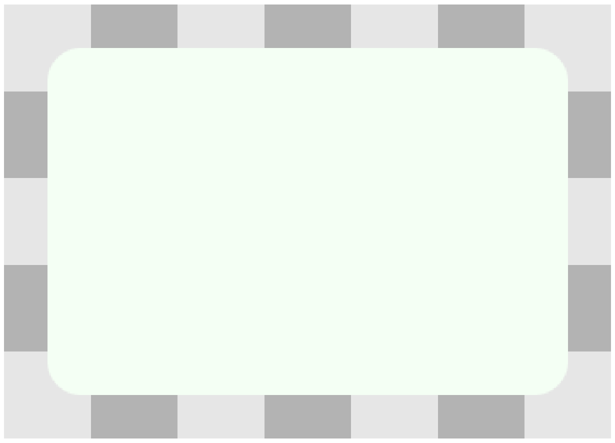
iPhone OS Note: iPhone OS does not support the `cornerRadius` property. To simulate the visual effect of a corner radius you can draw the content using the appropriate clipping regions. You can override the hit testing behavior of a layer and exclude touches as appropriate to emulate a geometry with a corner radius, although this is rarely necessary in a touch-based user interface.

Background Properties

Next, the layer renders its background. You can define a color for the background as well as a Core Image filter.

Figure 2 illustrates the sample layer with its `backgroundColor` set.

Figure 2 Layer with background color



The background filter is applied to the content behind the layer. For example, you may wish to apply a blur filter as a background filter to make the layer content stand out better.

The following `CALayer` properties affect the display of a layer's background:

- `backgroundColor` (page 48)
- `backgroundFilters` (page 48)

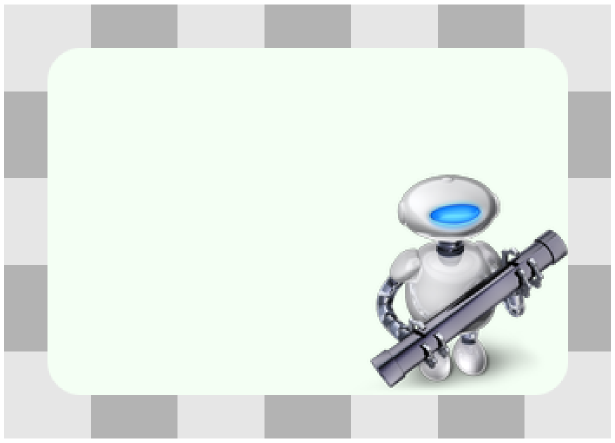
iPhone OS Note: While the `CALayer` class in iPhone OS exposes the `backgroundFilters` property, Core Image is not available. The filters available for this property are currently undefined.

Layer Content

Next, if set, the content of the layer is rendered. The layer content can be created using the Quartz graphics environment, OpenGL, QuickTime, or Quartz Composer.

Figure 4 shows the example layer with its content composited.

Figure 3 Layer displaying a content image



By default, the content of a layer is not clipped to its bounds and corner radius. The `masksToBounds` property can be set to `true` to clip the layer content to those values.

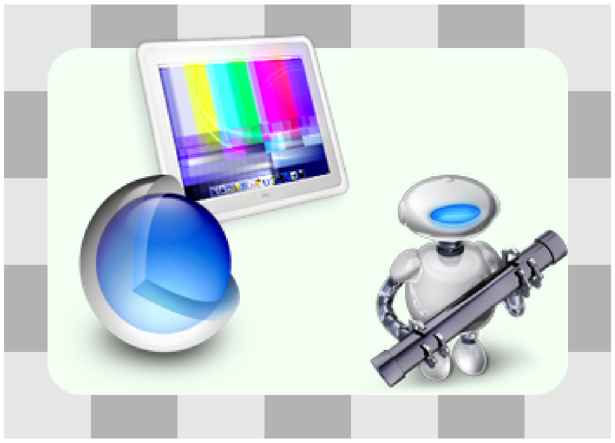
The following `CALayer` properties affect the display of a layer's content:

- `contents` (page 51)
- `contentsGravity` (page 51)

Sublayers Content

It is typical that a layer will have a hierarchy of child layers, its sublayers. These sublayers are rendered recursively, relative to the parent layer's geometry. The parent layer's `sublayerTransform` is applied to each sublayer, relative to the parent layer's anchor point.

Figure 4 Layer displaying the sublayers content



By default, a layer's sublayers are not clipped to the layer's bounds and corner radius. The `masksToBounds` property can be set to `true` to clip the layer content to those values. The example layer's `maskToBounds` property is `false`; notice that the sublayer displaying the monitor and test pattern is partially outside of its parent layer's bounds.

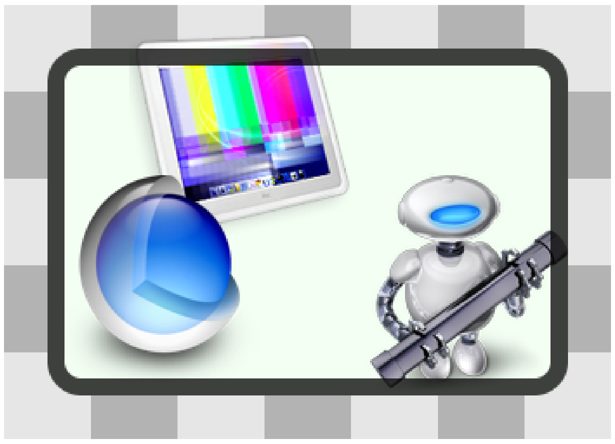
The following `CALayer` properties affect the display of a layer's sublayers:

- `sublayers` (page 60)
- `masksToBounds` (page 56)
- `sublayerTransform` (page 60)

Border Attributes

A layer can display an optional border using a specified color and width. Figure 5 shows the example layer after applying a border.

Figure 5 Layer displaying the border attributes content



The following `CALayer` properties affect the display of a layer's borders:

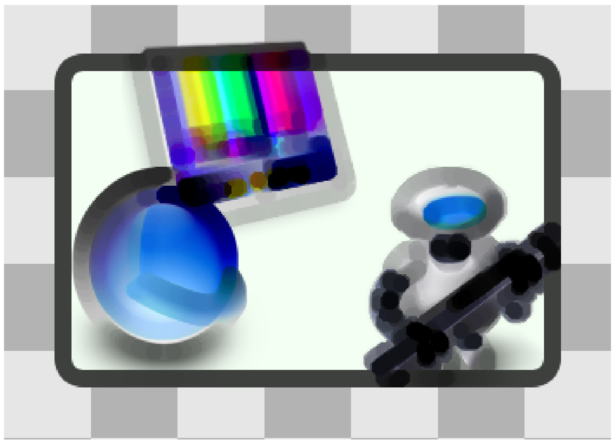
- `borderColor` (page 49)
- `borderWidth` (page 49)

iPhone OS Note: As a performance consideration, iPhone OS does not support the `borderColor` and `borderWidth` properties. Drawing a border for layer content is the responsibility of the developer.

Filters Property

An array of Core Image filters can be applied to the layer. These filters affect the layer's border, content, and background. Figure 6 shows the example layer with the Core Image posterize filter applied.

Figure 6 Layer displaying the filters properties



The following `CALayer` property specifies a layers content filters:

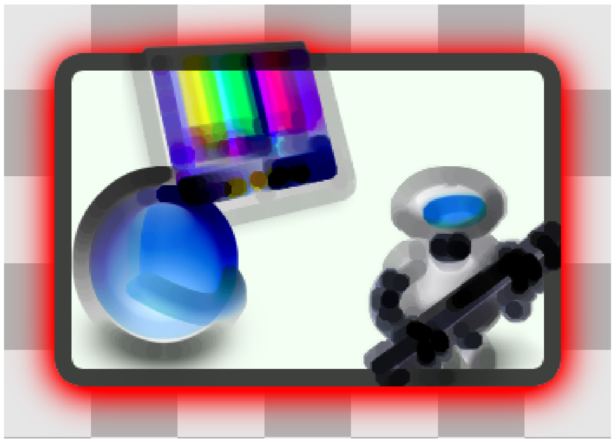
- `filters` (page 53)

iPhone OS Note: While the `CALayer` class in iPhone OS exposes the `filters` property, Core Image is not available. Currently the filters available for this property are undefined.

Shadow Properties

Optionally, a layer can display a shadow, specifying its opacity, color, offset, and blur radius. Figure 7 shows the example layer with a red shadow applied.

Figure 7 Layer displaying the shadow properties



The following `CALayer` properties affect the display of a layer's shadow:

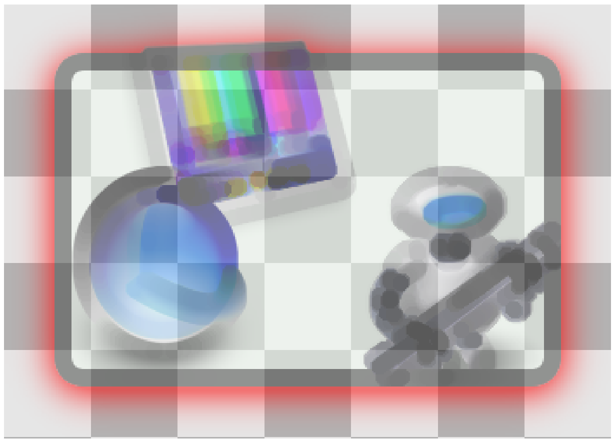
- `shadowColor` (page 58)
- `shadowOffset` (page 59)
- `shadowOpacity` (page 59)
- `shadowRadius` (page 59)

iPhone OS Note: As a performance consideration, iPhone OS does not support the `shadowColor`, `shadowOffset`, `shadowOpacity`, and `shadowRadius` properties.

Opacity Property

By setting the opacity of a layer, you can control the layer's transparency. Figure 8 shows the example layer with an opacity of 0.5.

Figure 8 Layer including the opacity property



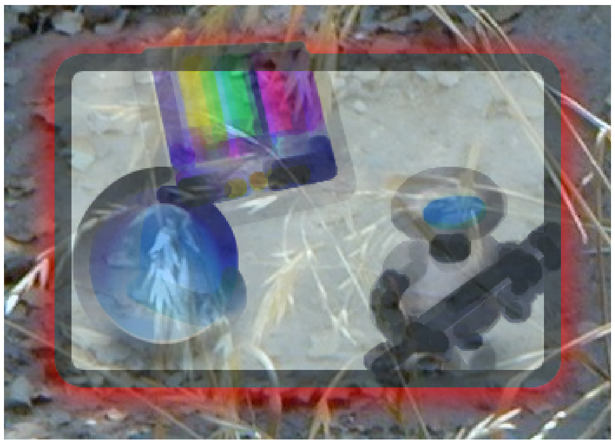
The following `CALayer` property specifies the opacity of a layer:

- `opacity` (page 57)

Composite Property

A layer's compositing filter is used to combine the layer content with the layers behind it. By default, a layer is composited using source-over. Figure 9 shows the example layer with a compositing filter applied.

Figure 9 Layer composited using the compositingFilter property



The following `CALayer` property specifies the composting filter for a layer:

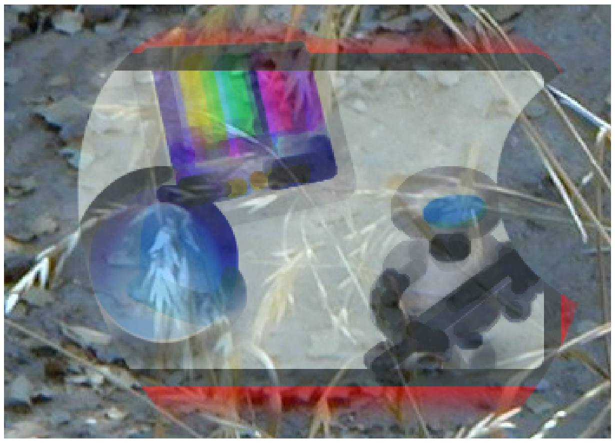
- `compositingFilter` (page 50)

iPhone OS Note: While the `CALayer` class in iPhone OS exposes the `compositingFilter` property, Core Image is not available. Currently the filters available for this property are undefined.

Mask Properties

Finally, you can specify a layer that will serve as a mask, further modifying how the rendered layer appears. The opacity of the mask layer determines masking when the layer is composited. Figure 10 shows the example layer composited with a mask layer.

Figure 10 Layer composited with the mask property



The following `CALayer` property specifies the mask for a layer:

- `mask` (page 55)

> **iPhone OS Note:** As a performance consideration, iPhone OS does not support the `mask` property.

Example: Core Animation Menu Application

The Core Animation Menu example displays a simple selection example using Core Animation layers to generate and animate the user interface. In less than 100 lines of code, it demonstrates the following capabilities and design patterns:

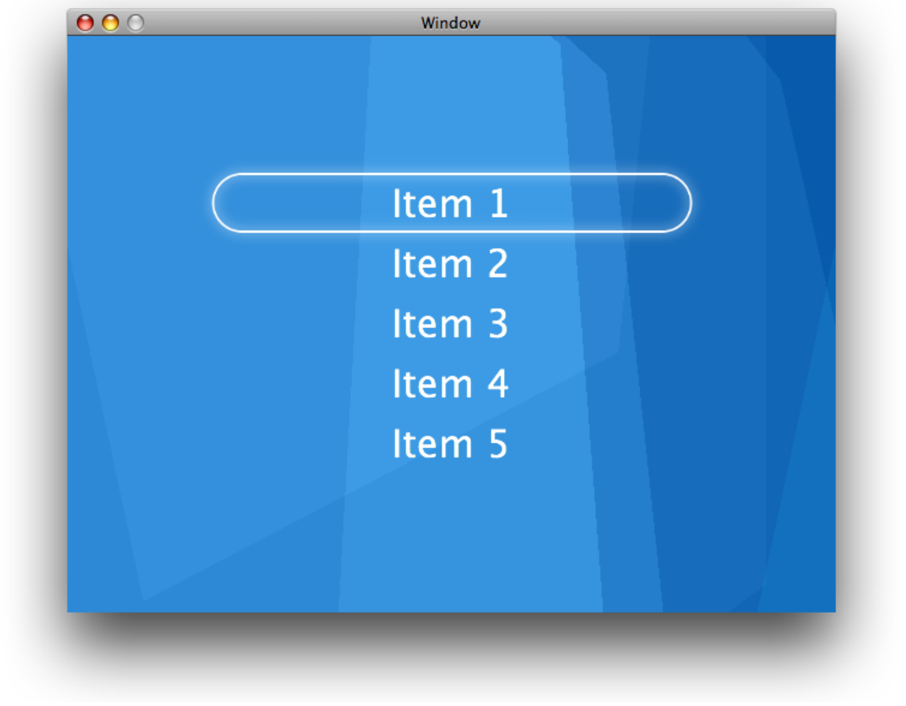
- Hosting the root-layer of a layer hierarchy in a view.
- Creating and inserting layers into a layer hierarchy.
- Using a `QCCompositionLayer` to display Quartz Composer compositions as layer content.
- Using an explicit animation that runs continuously.
- Animating Core Image Filter inputs.
- Implicitly animating the position of the selection item.
- Handling key events through the MenuView instance that hosts the view.

This application makes heavy use of Core Image filters and Quartz Composer compositions and, as a result, runs only on Mac OS X. The techniques illustrated for managing the layer hierarchy, implicit and explicit animation, and event handling are common to both platforms.

The User Interface

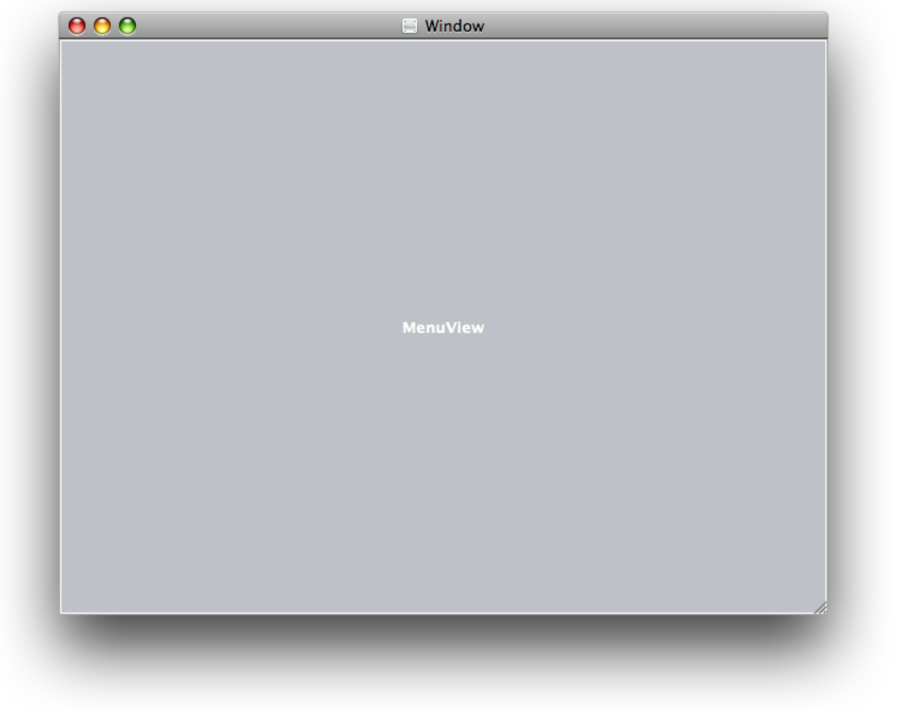
The Core Animation Menu application provides a very basic user interface; the user can select a single item in a menu. The user navigates the menu using the up and down arrows on the keyboard. As the selection changes the selection indicator (the rounded white rectangle) animates smoothly to its new location. A continuously animating bloom filter is set for the selection indicator causing it to subtly catch your attention. The background is a Quartz Composer animation that runs continuously. Figure 1 shows the application's interface.

Figure 1 Core Animation Menu Interface



Examining the Nib File

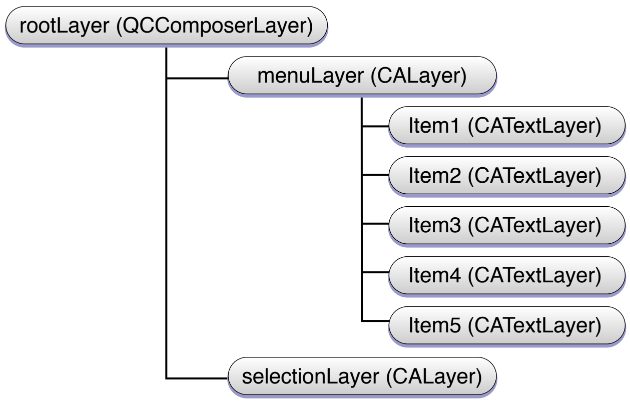
`Menu.nib` is very straightforward. An instance of `CustomView` is dragged from the Interface Builder palette and positioned in the window. It is resized such that it fills the entire window. The `MenuView.h` file is imported into Interface Builder by dragging it to the Menu.nib window. The `CustomView` is then selected, and the object type is changed to `MenuView`.



No other connections need to be made. When the nib file is loaded the window is unarchived and the `MenuView` is as well. The `MenuView` class gets an `awakeFromNib` message and the layers are configured there.

The Layer Hierarchy

The layer hierarchy, also referred to as the layer tree, of the Menu application is shown below.



The `rootLayer` is an instance of `QCComposerLayer`. As the root-layer this layer is the same size as the `MenuView` instance, and remains that way as the window is resized.

The menusLayer is a sublayer of the rootLayer. It is an empty layer; it does not have anything set as its contents property and none of its style properties are set. The menusLayer is simply used as a container for the menu item layers. This approach allows the application to easily access a menu item sublayer by its position in the menusLayers.sublayers array. The menusLayer is the same size as, and overlaps, the rootLayer. This was done intentionally so that there was no need to convert between coordinate systems when positioning the selectionLayer relative to the current menu item.

The Code

Having looked at the application's nib file and the overall design, you can now begin examining the implementation of the MenuView class..

Examining MenuView.h

The MenuView class is a subclass of NSView and it declares four instance variables:

NSIndex selectedIndex — tracks the index that is currently selected.

CALayer *menusLayer —the Core Animation layer that contains the menus items as its sublayers.

CALayer *selectionLayer — the Core Animation layer that displays the selection indicator

NSArray *name — an array of names displayed as menu items

Note: Notice that Quartz/CoreAnimation.h is imported. The QuartzCore.framework must be added to any project that uses Core Animation. Because this example uses Quartz Composer the MenuView implementation also imports Quartz/Quartz.h, and the Quartz.framework is added to the project.

Listing 1 MenuView.h listing

```
#import <Cocoa/Cocoa.h>
#import <QuartzCore/CoreAnimation.h>


// the MenuView class is the view subclass that is inserted into
// the window.  It hosts the rootLayer, and responds to events
@interface MenuView : NSView {

    // contains the selected menu item index
     NSInteger selectedIndex;

    // the layer that contains the menu item layers
    CALayer *menusLayer;

    // the layer that is used for the selection display
    CALayer *selectionLayer;

    // the array of menu item names
    NSArray *names;

}
```

```
-(void)awakeFromNib;
-(void)setupLayers;
-(void)changeSelectedIndex:(NSInteger)theSelectedIndex;
-(void)moveUp:(id)sender;
-(void)moveDown:(id)sender;
-(void)dealloc;
```

Examining MenuView.m

The `MenuView` class is the workhorse of this application. It responds when the view is loaded by the nib, sets up the layers to be displayed, creates the animations, and handles the keys that move the selection.

The examination of the `MenuView.m` is split as follows:

- Setting Up the `MenuView`
- Setting Up the Layers
- Animating the Selection Layer Movement
- Responding to Key Events
- Cleaning Up

Setting Up the MenuView

The `awakeFromNib` method is called when `Menu.nib` is loaded and unarchived. The view is expected to complete its setup in `awakeFromNib`.

The `MenuView` implementation of `awakeFromNib` creates an array of strings, names, that are used to display the menu items. It then calls the `setupLayers` method to setup the layers for the view.

```
- (void)awakeFromNib
{
    names=[[NSArray arrayWithObjects:@"Item 1",@"Item 2",
                                     @"Item 3",@"Item 4",@"Item 5",
                                     nil] retain];

    [self setupLayers];
}
```

Setting Up the Layers

The majority of the code in the Menu example resides in the `setupLayers` method. This method is responsible for the following:

- Creating and initializing `rootLayer`
- Setting `rootLayer` as the hosted layer of the view
- Creating and initializing the `menusLayer`
- Creating and initializing the menu item layers
- Adding the menu item positioning constraints

- Layout the `menusLayer`
- Creating the `selectionLayer`
- Configuring the continuous animation of `selectionLayer`
- Adding it to the layer tree of `rootLayer`
- Setting the initial value of `selectedIndex`

First, the constants used to position and space the layers are defined.

```
-(void)setupLayers;
{
    CGFloat width=400.0;
    CGFloat height=50.0;
    CGFloat spacing=20.0;
    CGFloat fontSize=32.0;
    CGFloat initialOffset=100.0;
```

The view must be set as the first responder to allow it to initially handle the up and down arrow events.

```
[[self window] makeFirstResponder:self];
```

Create the `rootLayer`, The `rootlayer` is an instance of `QCCompositionLayer` that displays the `Background.qtz` file which is located within the application bundle.

```
QCCompositionLayer* rootLayer;
rootLayer=[QCCompositionLayer compositionLayerWithFile:
           [[NSBundle mainBundle] pathForResource:@"Background"
                                           ofType:@"qtz"]];
```

The instance of `MenuView` is set as the layer-hosting view of `rootLayer`. The order of these two calls is important. By first setting the layer to `rootLayer` and then setting `setWantsLayer:` to `YES` our layer is used rather than the one that the view would create. This is the key difference between layer-hosting views and layer-backed views.

```
[self setLayer:rootLayer];
[self setWantsLayer:YES];
```

Create the `menusLayer`, and set its bounds to those of `rootLayer`. Again, this is done to allow us to use the same coordinate system for both the `menusLayer` sublayers and the `selectedLayer`. The menusLayer is also retained, `MenuView` requires it when positioning the `selectedLayer`.

```
menusLayer=[[CALayer layer] retain];
menusLayer.frame=rootLayer.frame;
```

Specify that the sublayers of `menusLayer` will be laid out using the `CAConstraintLayoutManager`. Constraints layout allows you to specify the location and size of layers relative to their sibling layers and superlayer. The superlayer is configured to use the constraints manager, and individual `CAContraint` instances are created and attached to each of the sublayers.

```
menusLayer.layoutManager=[CAConstraintLayoutManager layoutManager];
```

Add the `menusLayer` as a sublayer of the `rootLayer`.

```
[rootLayer addSublayer:menusLayer];
```

The next code fragment iterates over the items in the names array, creating a new `CATextLayer` for each name and defines its position using constraints.

```
NSInteger i;
for (i=0;i<[names count];i++) {
```

Get the name at the index of the current iteration.

```
NSString *name=[names objectAtIndex:i];
```

Create a new `CATextLayer` instance called `menuItemLayer`. Set its string to the name of the menu item, and specify that it should be displayed in white 32 point Lucida-Grande.

```
CATextLayer *menuItemLayer=[CATextLayer layer];
menuItemLayer.string=name;
menuItemLayer.font=@"Lucida-Grande";
menuItemLayer.fontSize=fontSize;
menuItemLayer.foregroundColor=CGColorCreateGenericRGB(1.0,1.0,1.0,1.0);
```

Note that the bounds of the `menuItemLayer` is never specified. When using `CATextLayer` instances the constraints manager takes responsibility for setting the bounds and height of the layer.

The next step is to specify the constraints for the layout. First the vertical constraint is set relative to the top edge of the superlayer. The top edge of `menuItemLayer` is offset by the `initialOffset` (defined earlier) and by the spacing between items (also specified earlier) and the height (again specified earlier) is multiplied by the index of the name. The final value is inverted because the layer coordinate system uses the bottom left as its origin.

```
[menuItemLayer addConstraint:[CAConstraint
              constraintWithAttribute:kCAConstraintMaxY
                           relativeTo:@"superlayer"
                            attribute:kCAConstraintMaxY
                               offset:-(i*height+spacing+initialOffset)]];
```

The second constraint simply causes the `menuItemLayer` object to be centered horizontally, relative to the center of its superlayer.

```
[menuItemLayer addConstraint:[CAConstraint
                              constraintWithAttribute:kCAConstraintMidX
                                           relativeTo:@"superlayer"
                                            attribute:kCAConstraintMidX]];
```

Each `menuItemLayer` is added to the menusLayer layer as a sublayer.

```
[menusLayer addSublayer:menuItemLayer];
} // end of for loop
```

Having configured all the menu item layers you must now force them to be laid out immediately. This is necessary to ensure that the first placement of the `selectionLayer` is correct.

```
[menusLayer layoutIfNeeded];
```

Now the `CALayer` that is used as the `selectionlayer` is created and configured. The `bounds` is set to be the width and height defined earlier. The layer is retained because we rely on it being available to `MenuView` after the layer is added to the layer tree.

```
selectionLayer=[[CALayer layer] retain];
selectionLayer.bounds=CGRectMake(0.0,0.0,width,height);
```

The `selectionLayer` depends on the `borderWidth`, `borderColor`, and `cornerRadius` style properties to provide its visual components. They are set to 2 points wide, a color of white, and a corner radius that ensures that the ends of the selectionLayer are rounded completely.

```
selectionLayer.borderWidth=2.0;
selectionLayer.borderColor=CGColorCreateGenericRGB(1.0f,1.0f,1.0f,1.0f);
selectionLayer.cornerRadius=height/2;
```

As the `selectionLayer` is displayed it softly pulses every second. This is done using a CIBloom filter and animating its inputIntensity between 0 (no intensity) and 1.5 (somewhat intense).

Create the filter, set its default values, and then specify the inputRadius is 5.0.

```
CIFilter *filter = [CIFilter filterWithName:@"CIBloom"];
[filter setDefaults];
[filter setValue:[NSNumber numberWithFloat:5.0] forKey:@"inputRadius"];
```

Core Animation extends the `CIFilter` class by adding the `name` property. The `name` property allows the inputs of filters in the layer's filters array to be animated using a key path.

```
[filter setName:@"pulseFilter"];
```

Set the `selectionLayer` filters array so that it contains filter.

```
[selectionLayer setFilters:[NSArray arrayWithObject:filter]];
```

The pulse animation is an explicit animation that runs continuously. It is a subclass of `CABasicAnimation` and, as such, must specify values for a `keyPath`, `toValue`, and `fromValue`.

```
CABasicAnimation* pulseAnimation = [CABasicAnimation animation];
```

Set the key path to be animated to `filters.pulseFilter.inputIntensity`. This is where the filter's name property is used.

```
pulseAnimation.keyPath = @"filters.pulseFilter.inputIntensity";
```

Set the `fromValue` and `toValue` to 0 and 1.0 respectively. This gives a nice pulse effect.

```
pulseAnimation.fromValue = [NSNumber numberWithFloat: 0.0];
pulseAnimation.toValue = [NSNumber numberWithFloat: 1.0];
```

The animation is 1 second long, and it repeats indefinitely. When the animation reaches 1.5, it cycles back to 0, and so on. The following code sets that up.

```
pulseAnimation.duration = 1.0;
pulseAnimation.repeatCount = 1e100f;
pulseAnimation.autoreverses = YES;
```

The `timingFunction` of an animation controls how the animation values are distributed over the course of the animation duration. In this case we'll use an easeIn-easeOut animation. This causes the animation to begin slowly, ramp up to speed, and then slow again before completing.

```
pulseAnimation.timingFunction = [CAMediaTimingFunction functionWithName:
                                     kCAMediaTimingFunctionEaseInEaseOut];
```

For an explicit animation to begin you must add it to the layer's animation collection. This is done using `addAnimation:forKey:`. The key itself is used as an identifier for removing the animation later, if necessary.

```
[selectionLayer addAnimation:pulseAnimation forKey:@"pulseAnimation"];
```

Finally, now that setup is complete add the `selectionLayer` to the `rootLayer`.

```
[rootLayer addSublayer:selectionLayer];
```

Set the initial position of the `selectionLayer` and the initial `selectedIndex` to 0.

```
[self changeSelectedIndex:0];
// end of setupLayers
```

The `setupLayers` method is by far the longest and most complex in this application. However, by breaking it down into the setup for each layer, it becomes much easier to understand.

Animating the Selection Layer Movement

The method `changeSelectedIndex:` is responsible for: setting selectedIndex to the new value, ensuring that the new value of selectedIndex is within the range of the number of items in the menu items, and positioning the selection layer relative to the `menusLayer` sublayer at the `selectedIndex`. This causes the selection layer to animate to show that the new item is selected.

```
-(void)changeSelectedIndex:(NSInteger)theSelectedIndex
{
    selectedIndex=theSelectedIndex;

    if (selectedIndex == [names count]) selectedIndex=[names count]-1;
    if (selectedIndex < 0) selectedIndex=0;

    CALayer *theSelectedLayer=[[menusLayer sublayers]
objectAtIndex:selectedIndex];
    selectionLayer.position=theSelectedLayer.position;
};
```

Notice that all that is required to animate the `selectionLayer` is to simply assign a new value to its `position` property. This is an example of implicit animation

Responding to Key Events

Because layers do not take part in the responder chain, or accept events, the MenuView that acts as the layer-host for the layer tree must assume that role. The `moveUp:` and `moveDown:` messages are provided by `NSResponder`, of which `MenuView` is a descendent. The `moveUp:` and `moveDown:` messages are invoked when the up arrow and down arrows are pressed respectively. Using these methods allows the application to respect any remapped arrow key functionally specified by the user. (And it's easier than implementing `keyDown:`).

When the up arrow is pressed the `selectedIndex` value is de-incremented and updated by calling `changeSelectedIndex:`.

```
-(void)moveUp:(id)sender
{
    [self changeSelectedIndex:selectedIndex-1];
}
```

When the down arrow is pressed the `selectedIndex` value is incremented and updated by calling `changeSelectedIndex:`.

```
-(void)moveDown:(id)sender
{
    [self changeSelectedIndex:selectedIndex+1];

}
```

Cleaning Up

When the `MenuView` is released, we are responsible for cleaning up our instance variables. The `menusLayer`, `selectionLayer`, and `names` are autoreleased in the `dealloc` implementation.

```
-(void)dealloc
{
    [menusLayer autorelease];
    [selectionLayer autorelease];
    [names autorelease];
    [super dealloc];
}
```

Document Revision History

This table describes the changes to *Core Animation Reference Collection*.

Date	Notes
2008-06-26	Updated for iPhone OS.
2007-10-31	Reordered companion guides to indicate prerequisites.
2007-07-24	New document that describes the Objective-C API for Core Animation .

Index