Integrating JavaScript into Native Applications

Session 615

Mark Hahnenberg
JavaScriptCore engineer

JavaScriptCore.framework

Mac

iOS

C API

?

JavaScriptCore.framework

Mac

iOS

C API	C API
Objective-C API	Objective-C API

Overview

API Goals

Automatic

Safety

Fidelity

Overview

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Safety

Fidelity

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API Goals

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What You Will Learn

What You Will Learn

- Objective-C → JavaScript

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- Objective-C → JavaScript
- JavaScript → Objective-C

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- Objective-C → JavaScript
- JavaScript → Objective-C
- Memory management

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- JavaScript → Objective-C
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- Threading

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- JavaScriptCore C API

What You Will Learn

- Objective-C → JavaScript
- JavaScript → Objective-C
- Memory management
- Threading
- JavaScriptCore C API
- JavaScriptCore with a WebView

Demo

ColorMyWords application

Objective-C → JavaScript

Evaluating JavaScript Code

```
#import <JavaScriptCore/JavaScriptCore.h>

int main () {
    JSContext *context = [[JSContext alloc] init];

    JSValue *result = [context evaluateScript:@"2 + 2"];
    NSLog(@"2 + 2 = %d", [result toInt32]);
    return 0;
}
```

Evaluating JavaScript Code

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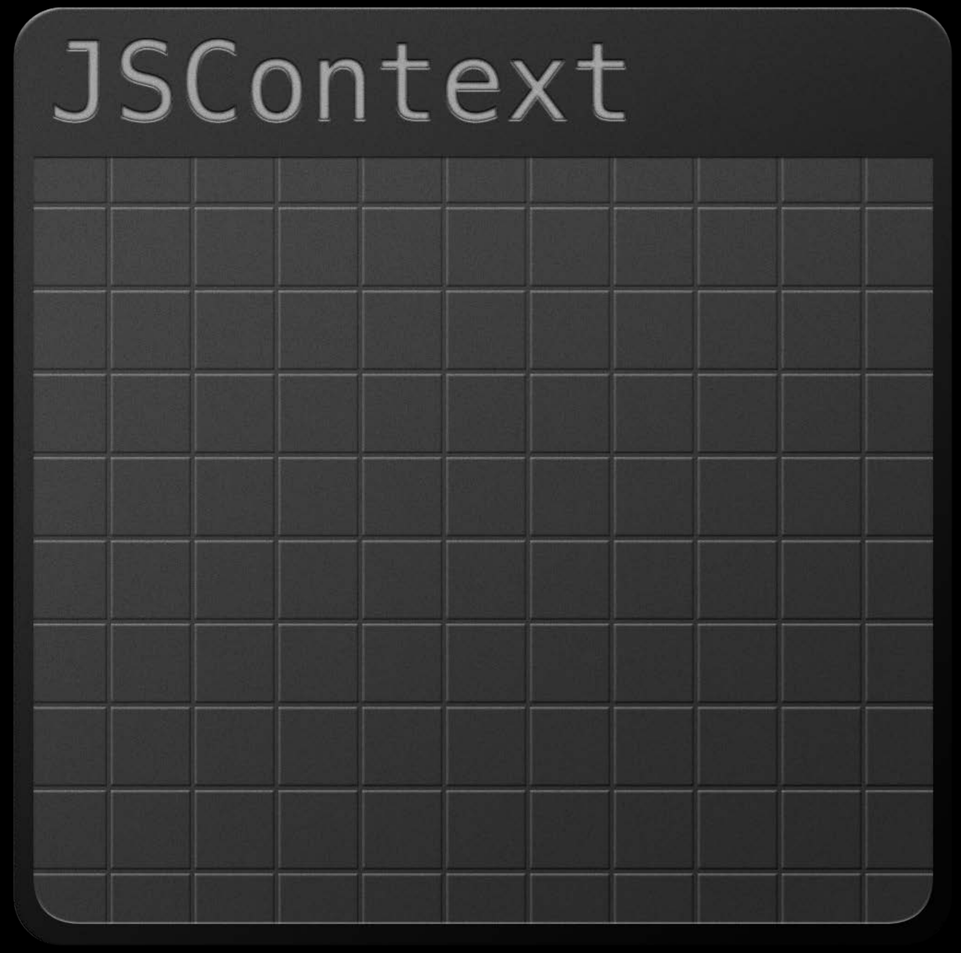
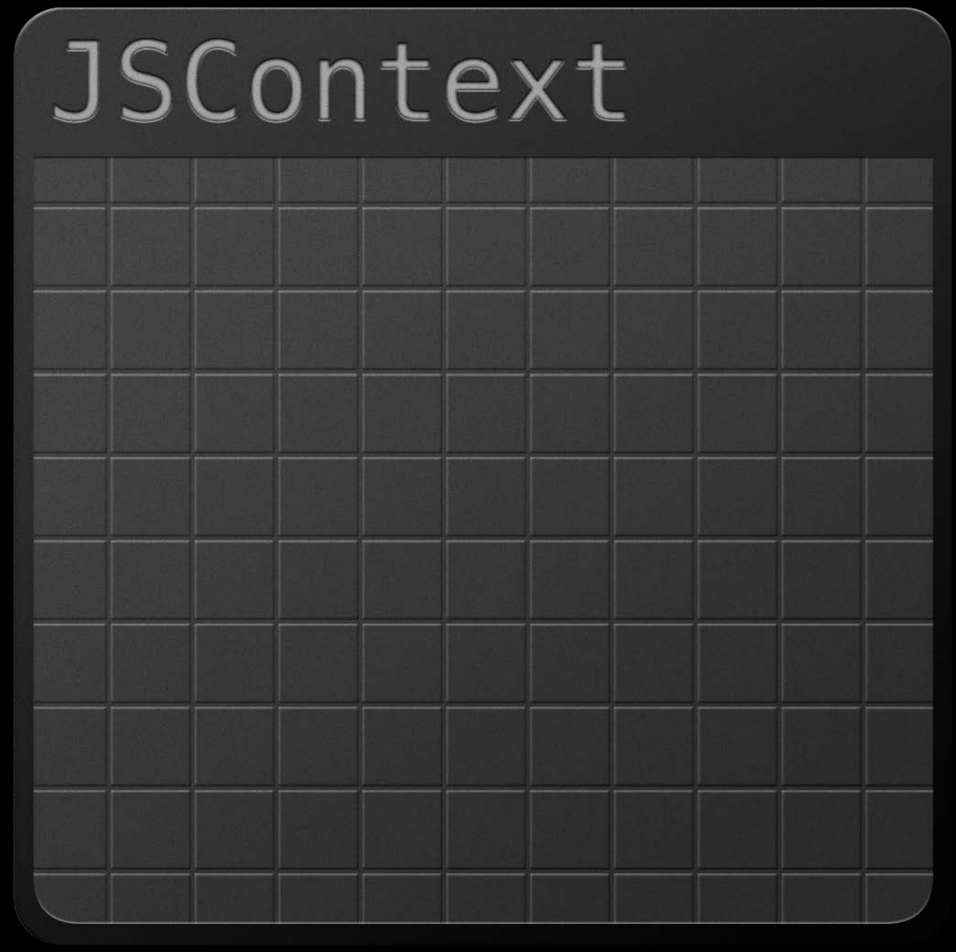
JSContext



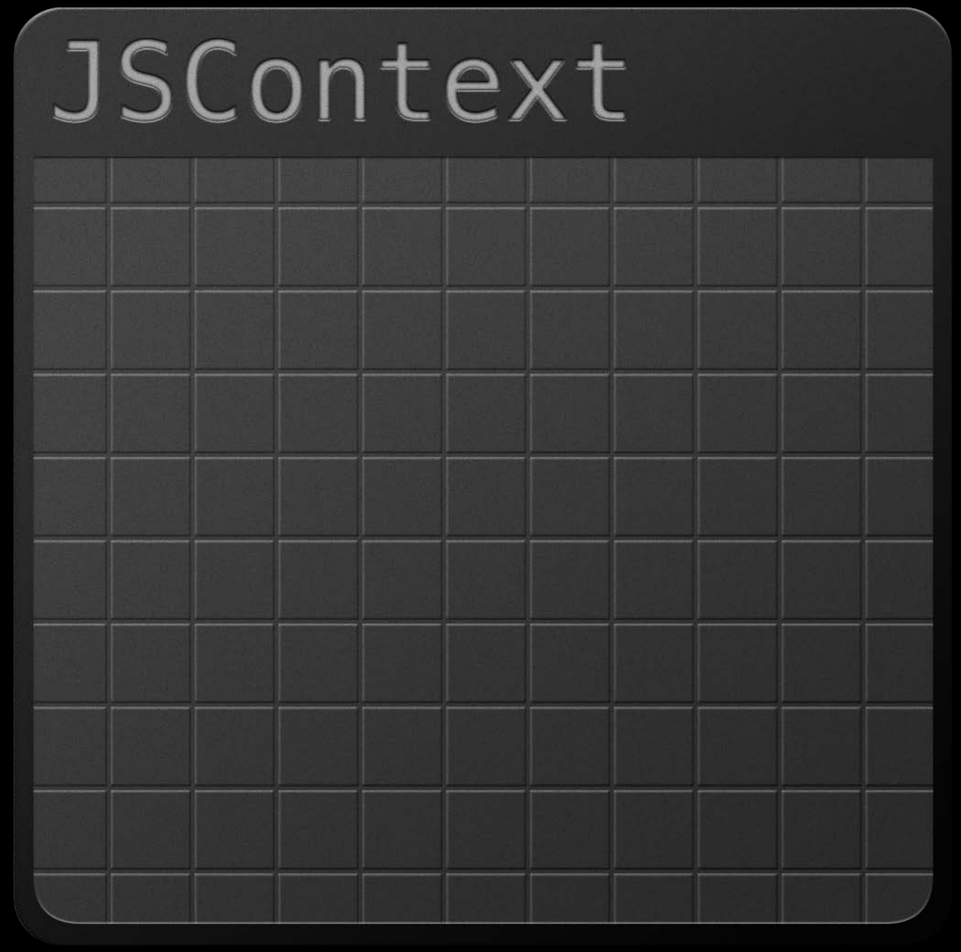
JSContext

- Context for evaluating code

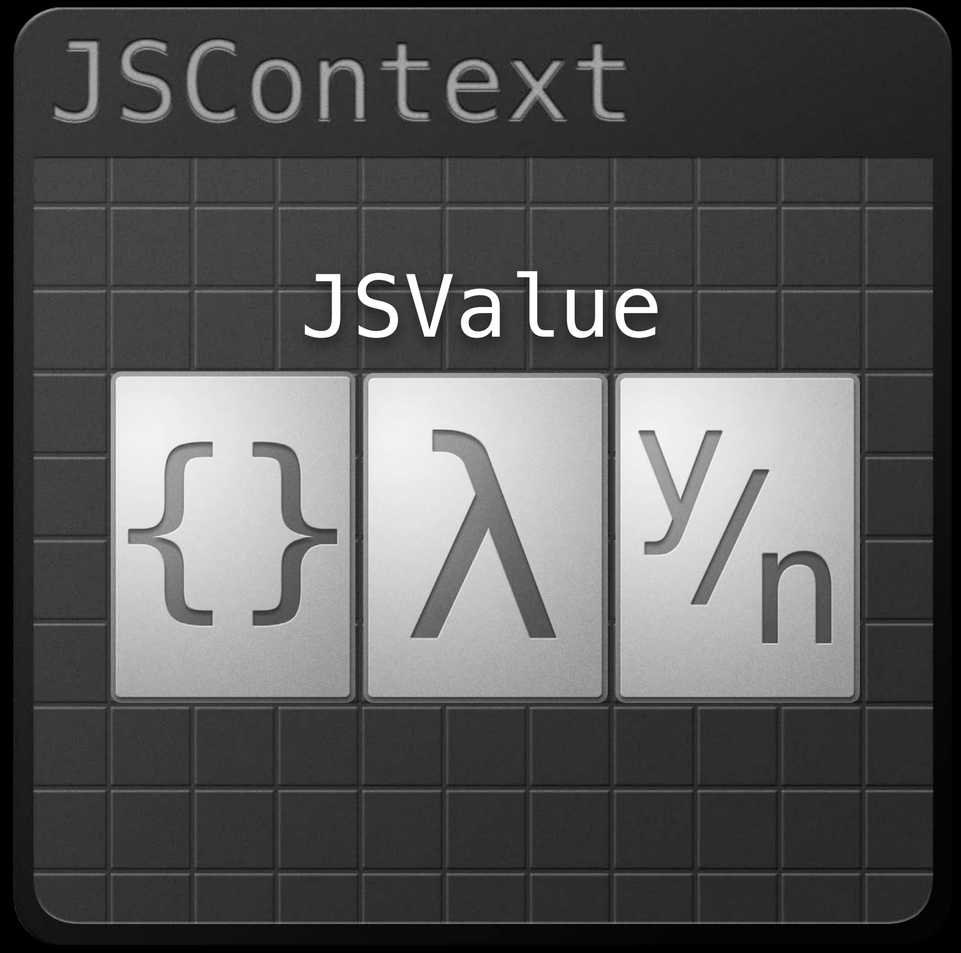


JSContext

- Context for evaluating code
- Global object

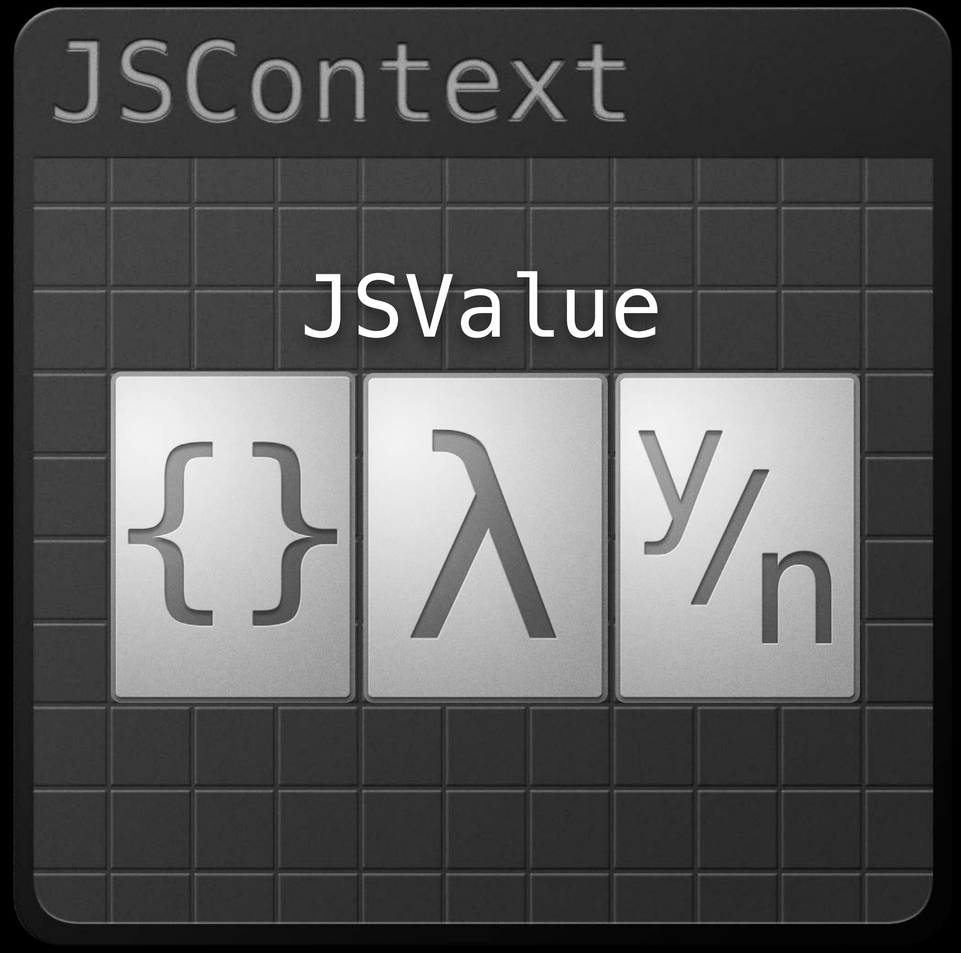


JSValue



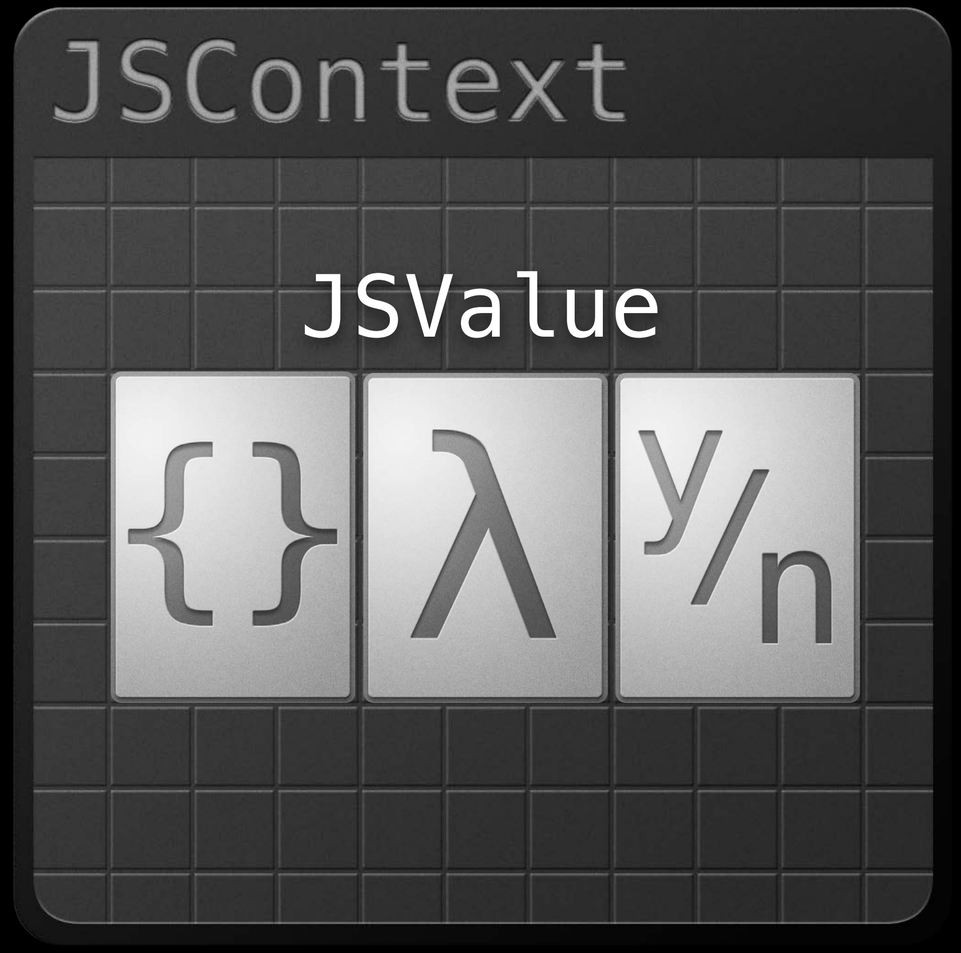
JSValue

- Reference to JavaScript value



JSValue

- Reference to JavaScript value
  - Strong reference



JSValue

- Reference to JavaScript value
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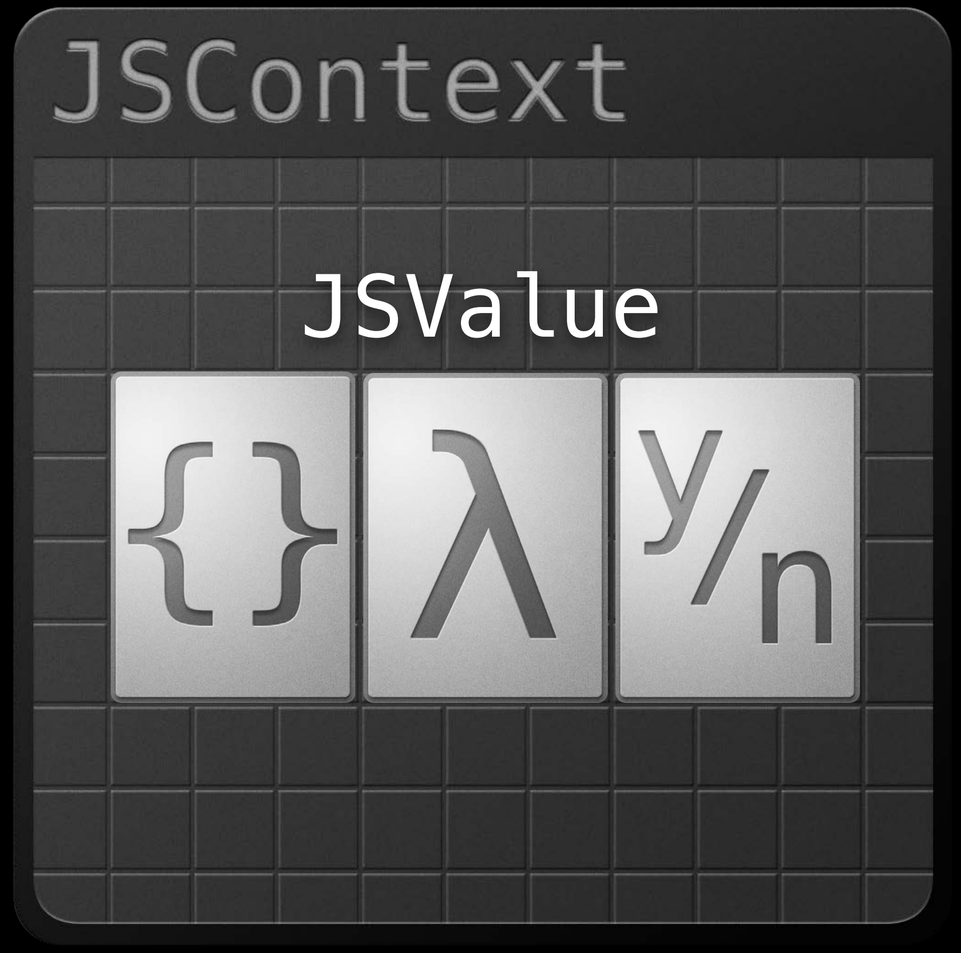

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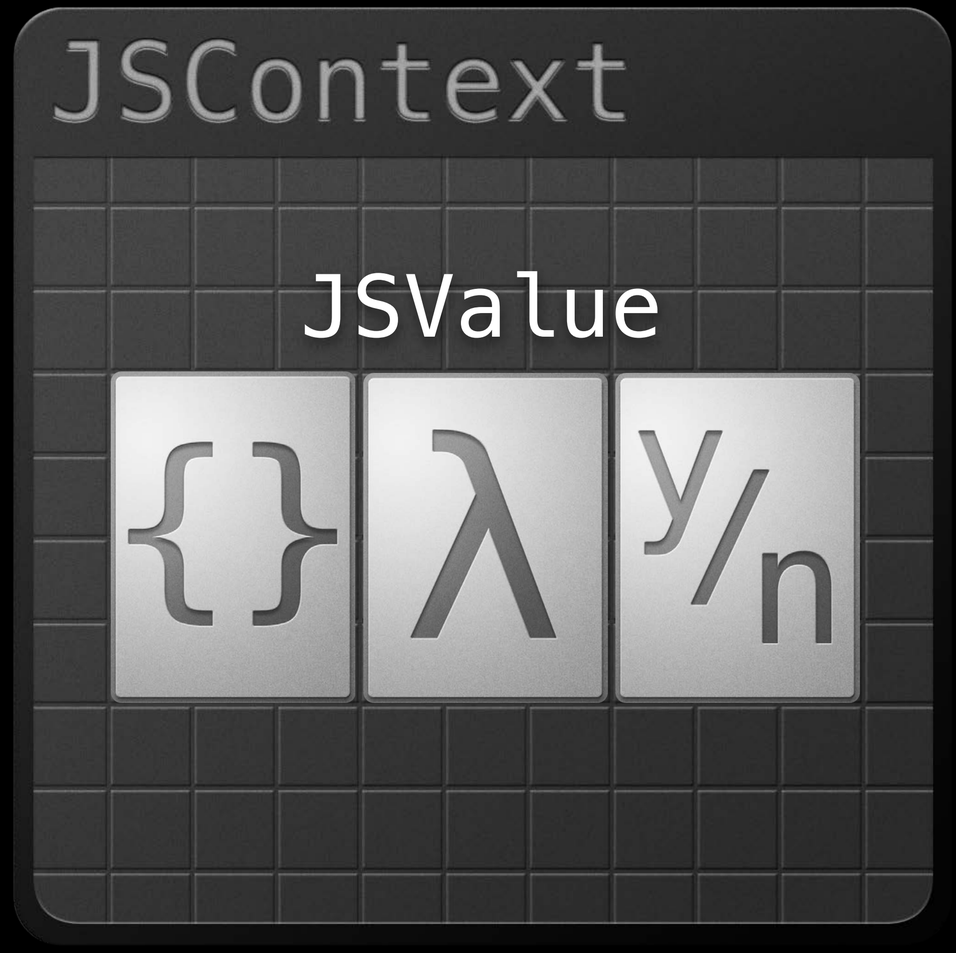

Creating JSValues

```
+ valueWithBool:(BOOL)value inContext:(JSContext *)context;
+ valueWithDouble:(double)value inContext:(JSContext *)context;
+ valueWithInt32:(int32_t)value inContext:(JSContext *)context;
+ valueWithUInt32:(uint32_t)value inContext:(JSContext *)context;
+ valueWithNullInContext:(JSContext *)context;
+ valueWithUndefinedInContext:(JSContext *)context;
+ valueWithNewObjectInContext:(JSContext *)context;
+ valueWithNewArrayInContext:(JSContext *)context;
+ valueWithNewRegularExpressionFromPattern:
    (NSString *)pattern
    flags:(NSString *)flags
    inContext:(JSContext *)context;
+ valueWithNewErrorFromMessage:
    (NSString *)message
    inContext:(JSContext *)context;
```

Creating JSValues

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    (NSString *)pattern
    flags:(NSString *)flags
    inContext:(JSContext *)context;
+ valueWithNewErrorFromMessage:
    (NSString *)message
    inContext:(JSContext *)context;
```

Creating JSValues

Bridging

```
+ valueWithObject:(id)value inContext:(JSContext *)context;
```

Accessing JavaScript Values

```
- (BOOL)toBool;
- (double)toDouble;
- (int32_t)toInt32;
- (uint32_t)toUInt32;
- (NSNumber *)toNumber;
- (NSString *)toString;
- (NSDate *)toDate;
- (NSArray *)toArray;
- (NSDictionary *)toDictionary;

- (id)toObject;
- (id)toObjectOfClass:(Class)expectedClass;
```

Calling JavaScript Functions

```
var factorial = function(n) {
     if (n < 0)
        return;
     if (n === 0)
        return 1;
     return n * factorial(n - 1)
};
```

Calling JavaScript Functions

```
NSString *factorialScript = loadFactorialScript();
[_context evaluateScript:factorialScript];

JSValue *function = _context[@"factorial"];

JSValue *result = [function callWithArguments:@[@5]];

NSLog(@"factorial(5) = %d", [result toInt32]);
```

Calling JavaScript Functions

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NSLog(@"factorial(5) = %d", [result toInt32]);
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Demo

ColorMyWords recap

JavaScript → Objective-C

JavaScript → Objective-C

JavaScript → Objective-C

- Two ways to interact with Objective-C from JavaScript

JavaScript → Objective-C

- Two ways to interact with Objective-C from JavaScript
  - Blocks

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- Two ways to interact with Objective-C from JavaScript
  - Blocks
    - JS functions

JavaScript → Objective-C

- Two ways to interact with Objective-C from JavaScript
  - Blocks
    - JS functions
  - JSExport protocol

JavaScript → Objective-C

- Two ways to interact with Objective-C from JavaScript
  - Blocks
    - JS functions
  - JSExport protocol
    - JS objects

Blocks

Blocks

Blocks

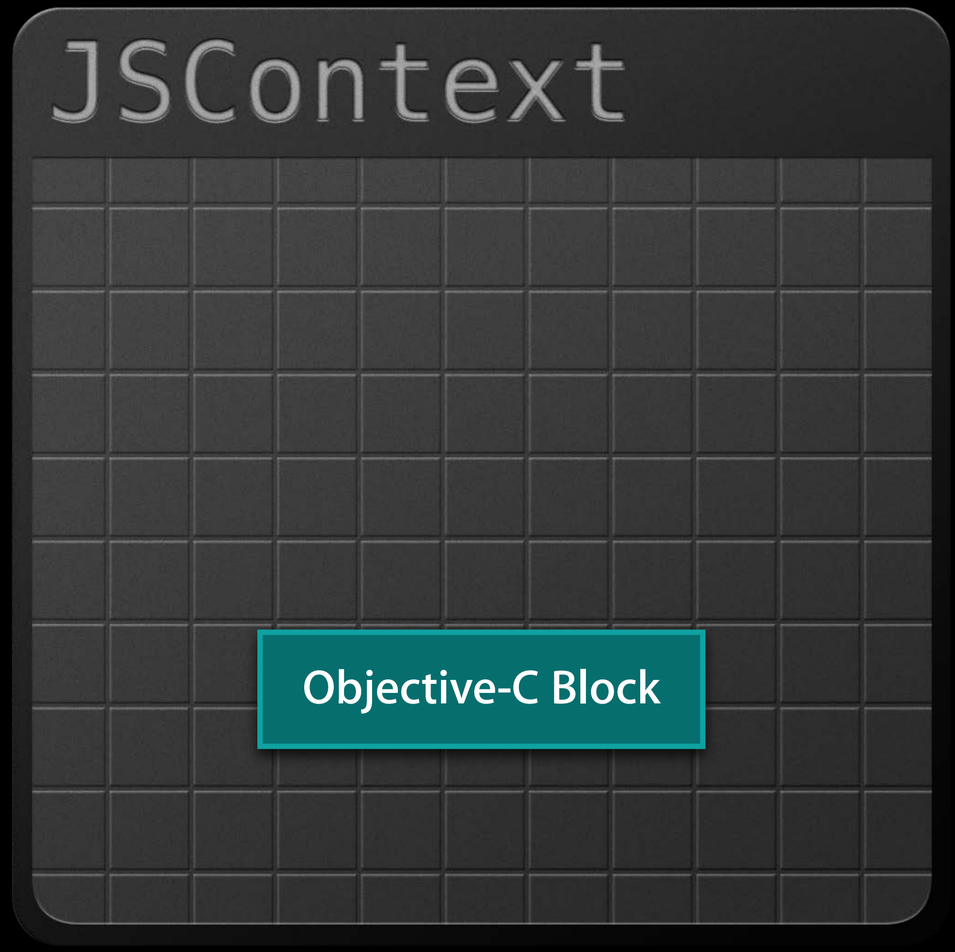
- Easy way to expose Objective-C code to JavaScript

Blocks

- Easy way to expose Objective-C code to JavaScript
- Automatically wraps Objective-C block inside callable JavaScript function

Blocks

```
context[@"makeNSColor"] = ^(NSDictionary *rgb){
    float r = [colors[@"red"] floatValue];
    float g = [colors[@"green"] floatValue];
    float b = [colors[@"blue"] floatValue];
    return [NSColor colorWithRed:(r / 255.0)
        green:(g / 255.0f)
        blue:(b / 255.0f)
        alpha:1.0];
};
```



Blocks

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context[@"makeNSColor"] = ^(NSDictionary *rgb){
    float r = [colors[@"red"] floatValue];
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    float b = [colors[@"blue"] floatValue];
    return [NSColor colorWithRed:(r / 255.0)
        green:(g / 255.0f)
        blue:(b / 255.0f)
        alpha:1.0];
};
```
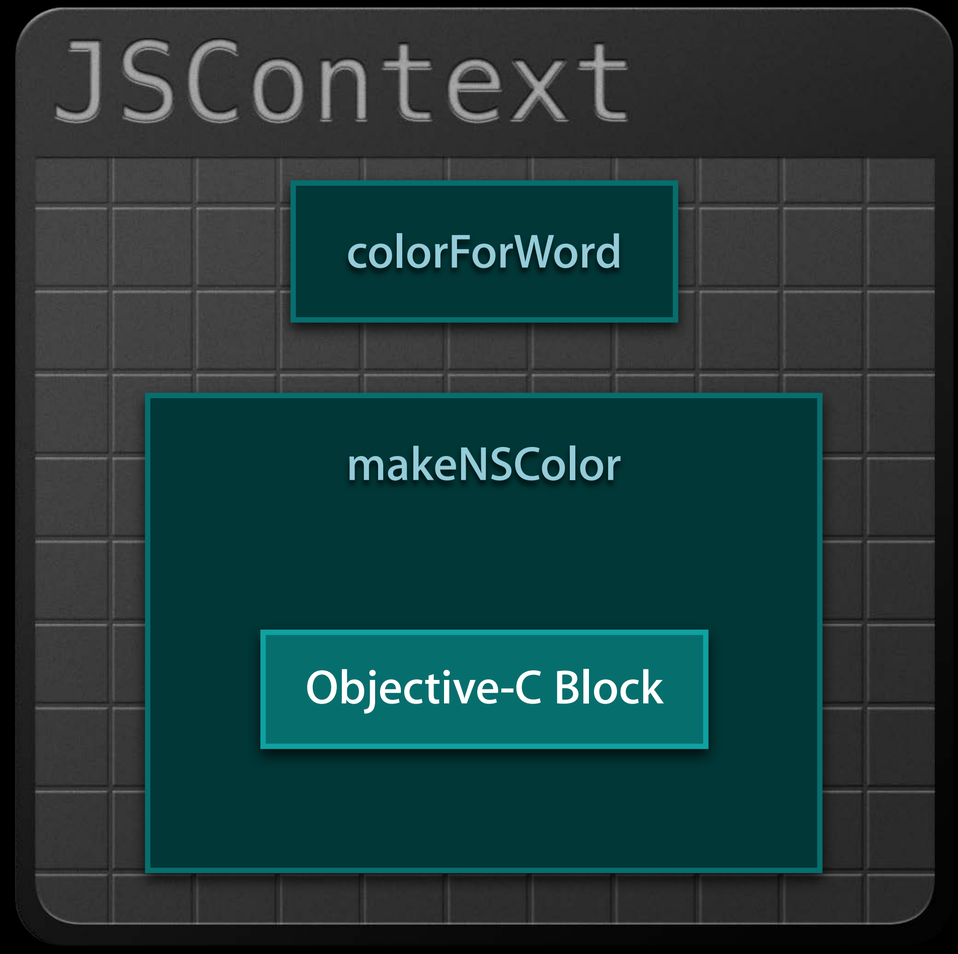

Blocks

```
var colorForWord = function(word) {
    if (!colorMap[word])
        return;
    return makeNSColor(colorMap[word]);
};
```



Blocks

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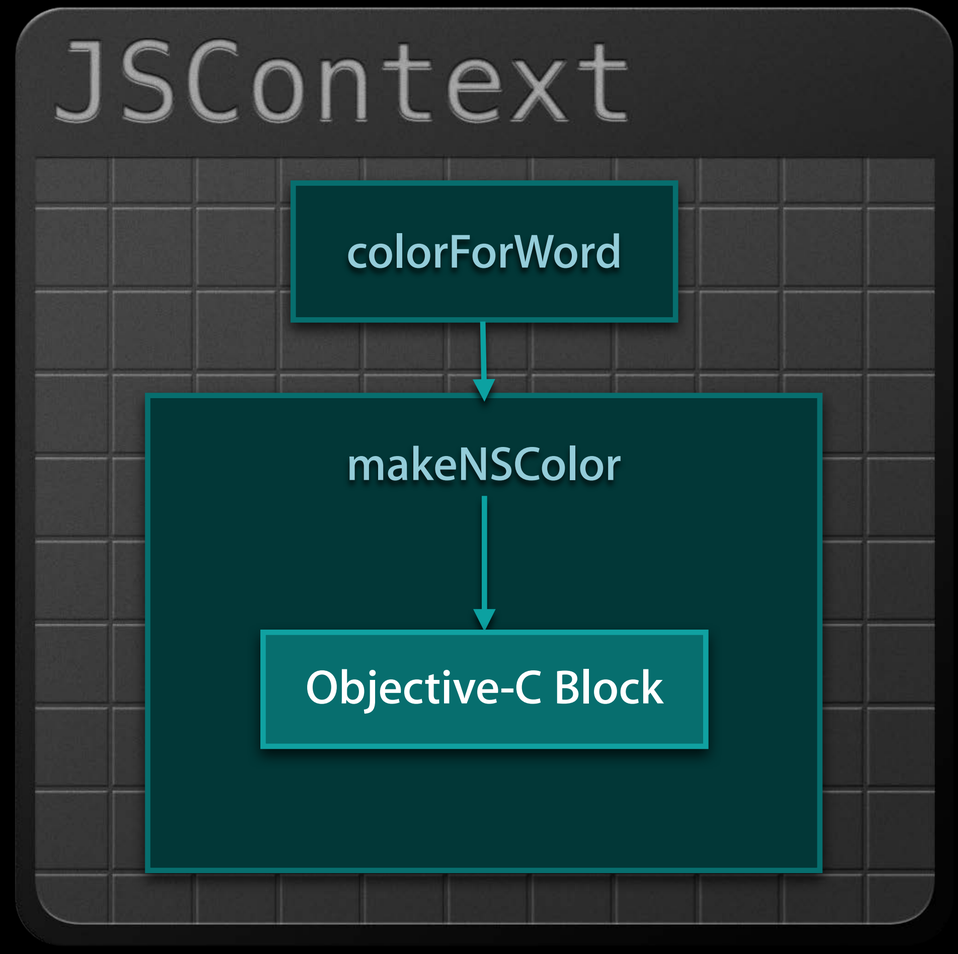

Blocks

Caveats

Blocks

Caveats

- Avoid capturing JSValues

Blocks

Caveats

- Avoid capturing JSValues
  - Prefer passing as arguments

Blocks

Caveats

- Avoid capturing JSValues
  - Prefer passing as arguments
- Avoid capturing JSContexts

Blocks

Caveats

- Avoid capturing JSValues
  - Prefer passing as arguments
- Avoid capturing JSContexts
  - Use + [JSContext currentContext]

Blocks

Bad

```
JSContext *context = [[JSContext alloc] init];

context[@"callback"] = ^{
     JSValue *object = [JSValue valueWithNewObjectInContext:context];
     object[@"x"] = 2;
     object[@"y"] = 3;
     return object;
};
```

Blocks

Good

```
JSContext *context = [[JSContext alloc] init];

context[@"callback"] = ^{
     JSValue *object = [JSValue valueWithNewObjectInContext:
        [JSContext currentContext]];
     object[@"x"] = 2;
     object[@"y"] = 3;
     return object;
};
```

JSExport

JSExport

- Easy way for JavaScript to interact with Objective-C objects

JSExport

Objective-C	JavaScript

`@interface MyPoint`
 	
`@property double x;`
`@property double y;`
 	
`- (NSString *)description;`
 	
`+ (MyPoint *)makePointWithX:(double)x`
`y:(double)y;`
 	
`@end`	

JSExport

Objective-C	JavaScript

`@interface MyPoint`
 	
`@property double x;`
`@property double y;`
 	
`- (NSString *)description;`
 	
`+ (MyPoint *)makePointWithX:(double)x`
`y:(double)y;`
 	
`@end`
	`point.x;`
	`point.x = 10;`

JSExport

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`@interface MyPoint`
 	
`@property double x;`
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	`point.description();`

JSExport

Objective-C	JavaScript

`@interface MyPoint`
 	
`@property double x;`
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`- (NSString *)description;`
 	
`+ (MyPoint *)makePointWithX:(double)x`
`y:(double)y;`
 	
`@end`
	`point.x;`
	`point.x = 10;`
	
	`point.description();`
	
	`MyPoint.makePointWithXY(0, 0);`

JSExport

Objective-C	JavaScript

`@protocol MyPointExports <JSExport>`
 	
`@property double x;`
`@property double y;`
 	
`- (NSString *)description;`
 	
`+ (MyPoint *)makePointWithX:(double)x`
`y:(double)y;`
 	
`@end`
	`point.x;`
	`point.x = 10;`
	
	`point.description();`
	
	`MyPoint.makePointWithXY(0, 0);`

JSExport

```
@interface MyPoint : NSObject <MyPointExports>

- (void)myPrivateMethod;  // Not visible to JavaScript code.

@end
```

```
@implementation MyPoint

...

@end
```

JSExport

JSExport

- Enumeration of methods and properties to export to JavaScript

JSExport

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- @property → JavaScript getter/setter

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JSExport

- Enumeration of methods and properties to export to JavaScript
- @property → JavaScript getter/setter
- Instance method → JavaScript function
- Class methods → JavaScript functions on global class object

JSExport

```
JSContext *context = [[JSContext alloc] init];
[context evaluateScript:geometryScript];

MyPoint *point1 = [[MyPoint alloc] initWithX:0.0 y:0.0];
MyPoint *point2 = [[MyPoint alloc] initWithX:1.0 y:1.0];

JSValue *function = context[@"euclideanDistance"];
JSValue *result = [function callWithArguments:@[point1, point2]];
```

JSExport

```
JSContext *context = [[JSContext alloc] init];
[context evaluateScript:geometryScript];

MyPoint *point1 = [[MyPoint alloc] initWithX:0.0 y:0.0];
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JSExport

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MyPoint *point1 = [[MyPoint alloc] initWithX:0.0 y:0.0];
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```

```
JSValue *function = context[@"euclideanDistance"];
JSValue *result = [function callWithArguments:@[point1, point2]];
```

JSExport

```
context[@"MyPoint"] = [MyPoint class];
```

```
JSValue *function = context[@"midpoint"];
JSValue *jsResult = [function callWithArguments:@[point1, point2]];
MyPoint *midpoint = [jsResult toObject];
```

JSExport

```
context[@"MyPoint"] = [MyPoint class];
```

```
JSValue *function = context[@"midpoint"];
JSValue *jsResult = [function callWithArguments:@[point1, point2]];
MyPoint *midpoint = [jsResult toObject];
```

JSExport

```
// geometry.js

var euclideanDistance = function(p1, p2) {
     var xDelta = p2.x - p1.x;
     var yDelta = p2.y - p1.y;
     return Math.sqrt(xDelta * xDelta + yDelta * yDelta);
};

var midpoint = function(p1, p2) {
     var xDelta = (p2.x - p1.x) / 2;
     var yDelta = (p2.y - p1.y) / 2;
     return MyPoint.makePointWithXY(p1.x + xDelta, p1.y + yDelta);
};
```

Advanced API Topics

Memory Management

Memory Management

Memory Management

- Objective-C uses ARC

Memory Management

- Objective-C uses ARC
- JavaScriptCore uses garbage collection

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Memory Management

- Objective-C uses ARC
- JavaScriptCore uses garbage collection
  - All references are strong
- API memory management is mostly automatic
- Two situations that require extra attention:
  - Storing JavaScript values in Objective-C objects
  - Adding JavaScript fields to Objective-C objects

Retain Cycles

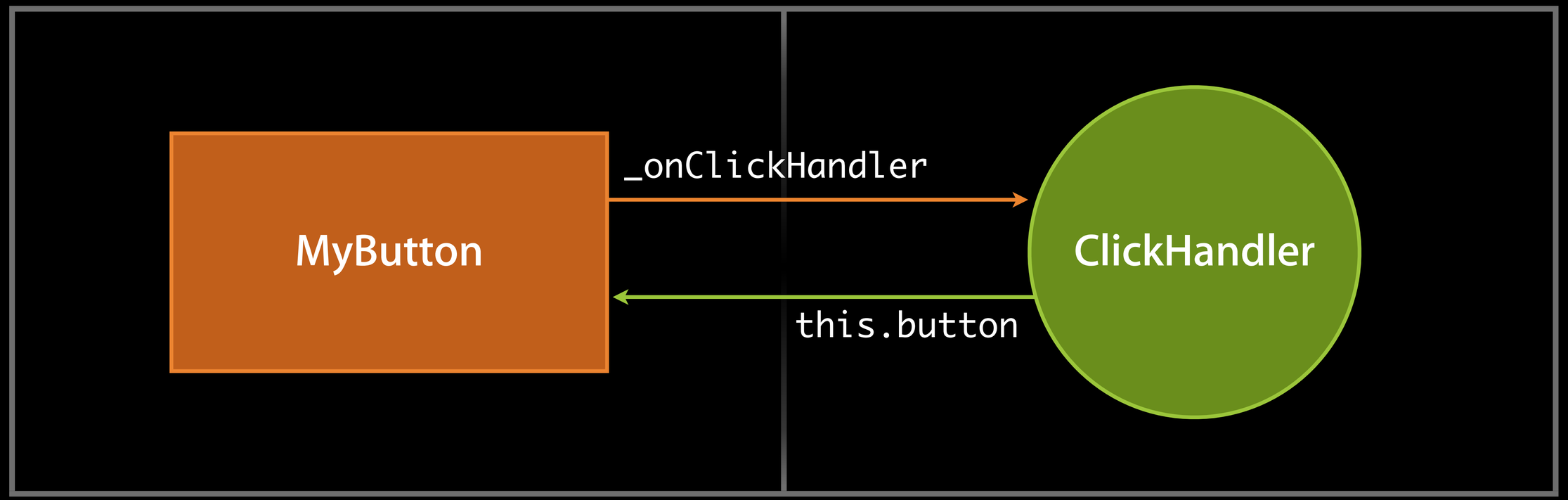
```
function ClickHandler(button, callback) {
     this.button = button;
     this.button.onClickHandler = this;
     this.handleEvent = callback;
};
```

JSManagedValue

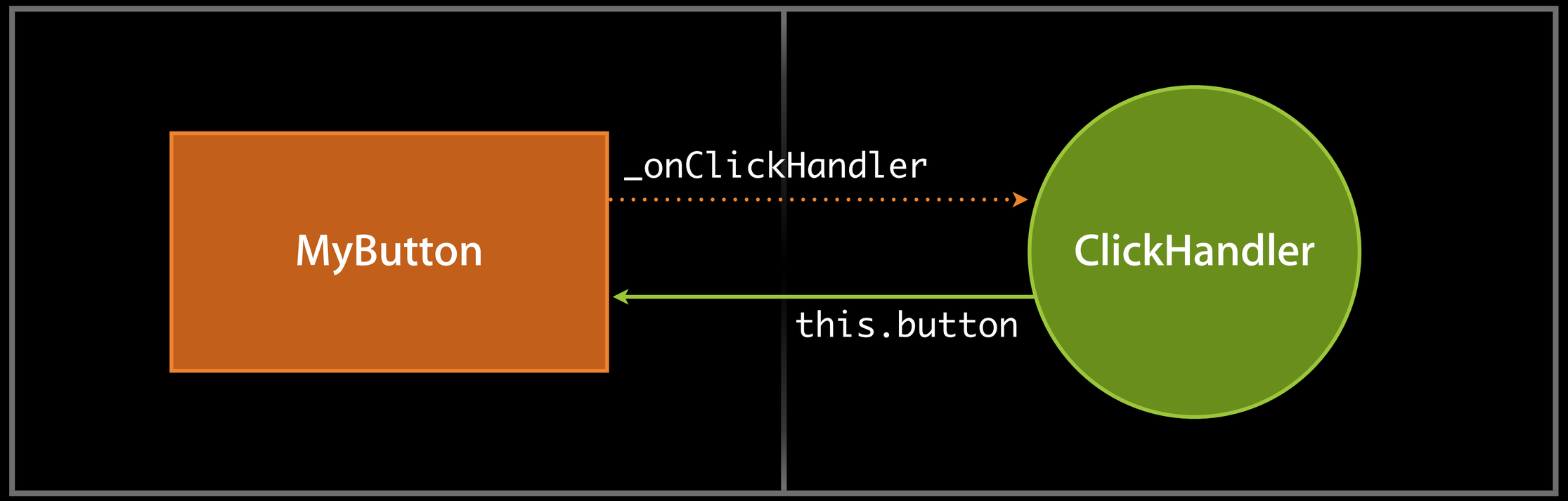
Bad

```
@implementation MyButton

- (void)setOnClickHandler:(JSValue *)handler
{
    _onClickHandler = handler; // Retain cycle
}

@end
```

Retain Cycles



Retain Cycles



JSManagedValue

Good

```
@implementation MyButton

- (void)setOnClickHandler:(JSValue *)handler
{
    _onClickHandler = [JSManagedValue managedValueWithValue:handler];
    [_context.virtualMachine addManagedReference:_onClickHandler
                                       withOwner:self]
}

@end
```

JSManagedValue

Good

```
@implementation MyButton

- (void)setOnClickHandler:(JSValue *)handler
{
    _onClickHandler = [JSManagedValue managedValueWithValue:handler];
    [_context.virtualMachine addManagedReference:_onClickHandler
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}

@end
```
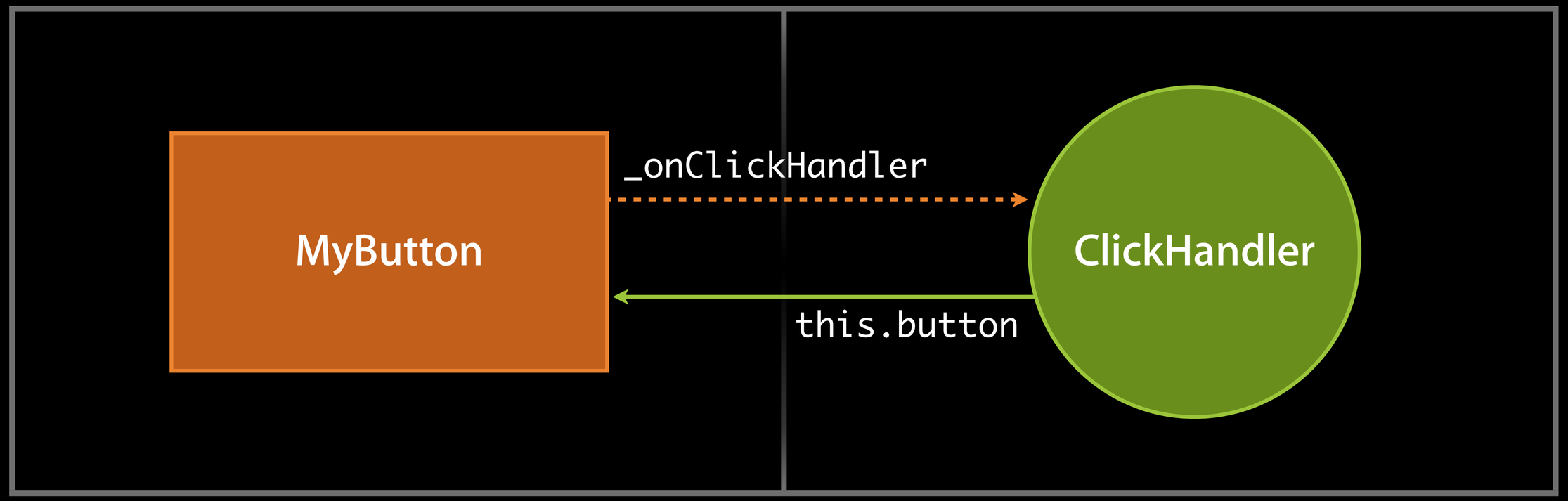

JSManagedValue



Strong

Weak

Garbage collected

Managed References

Managed References

- JSManagedValue by itself is a weak reference to a JavaScript value

Managed References

- JSManagedValue by itself is a weak reference to a JavaScript value
- `-addManagedReference:withOwner:` turns JSManagedValue into a "garbage collected" reference

Managed References

Managed References

- If JavaScript can find the Objective-C owner of a managed reference
  - Reference is kept alive

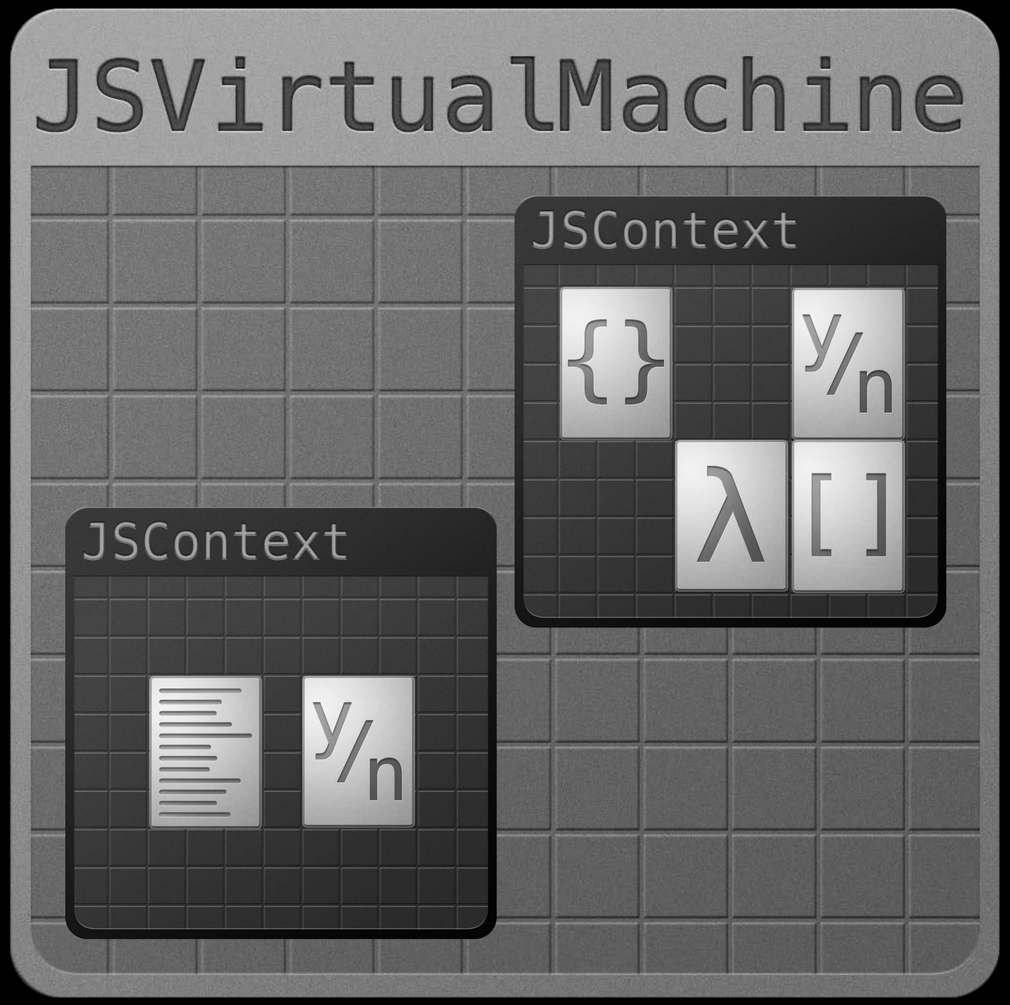
Managed References

- If JavaScript can find the Objective-C owner of a managed reference
  - Reference is kept alive
- Otherwise
  - Reference is released

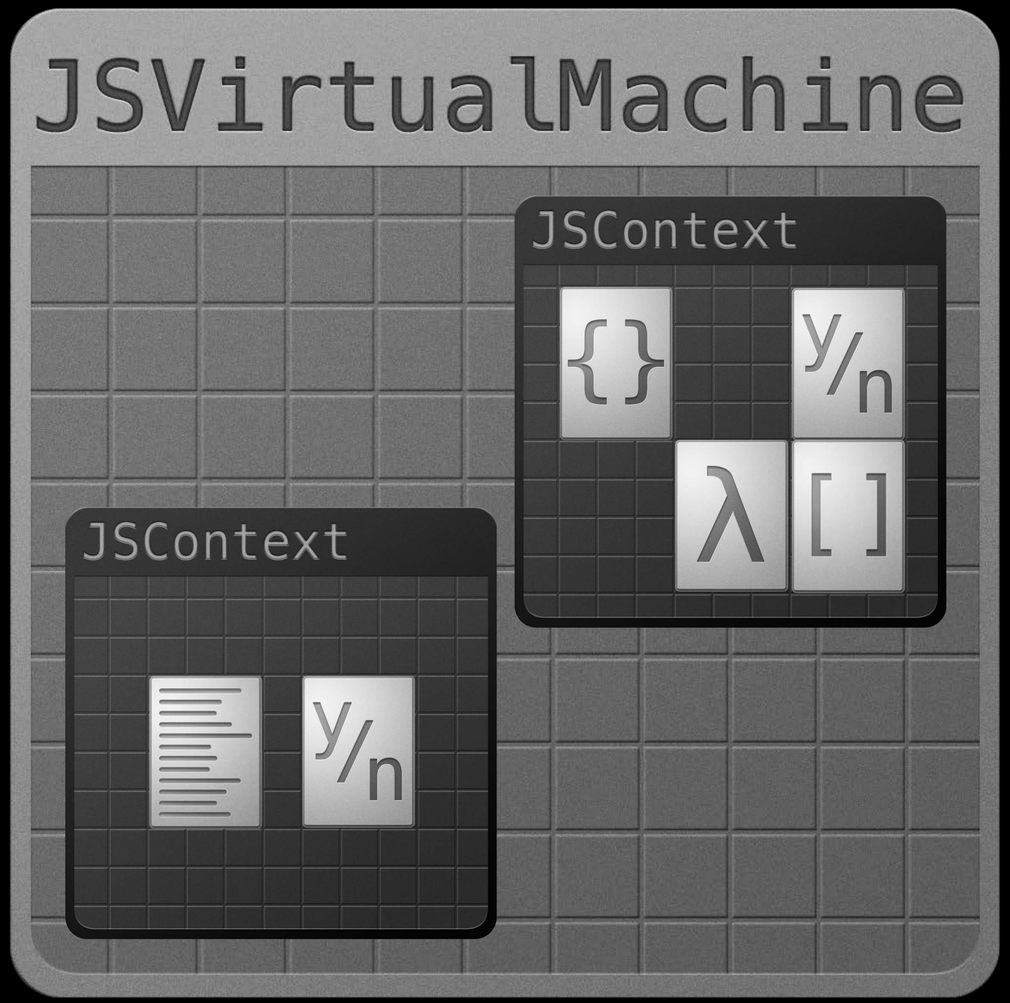
Threading

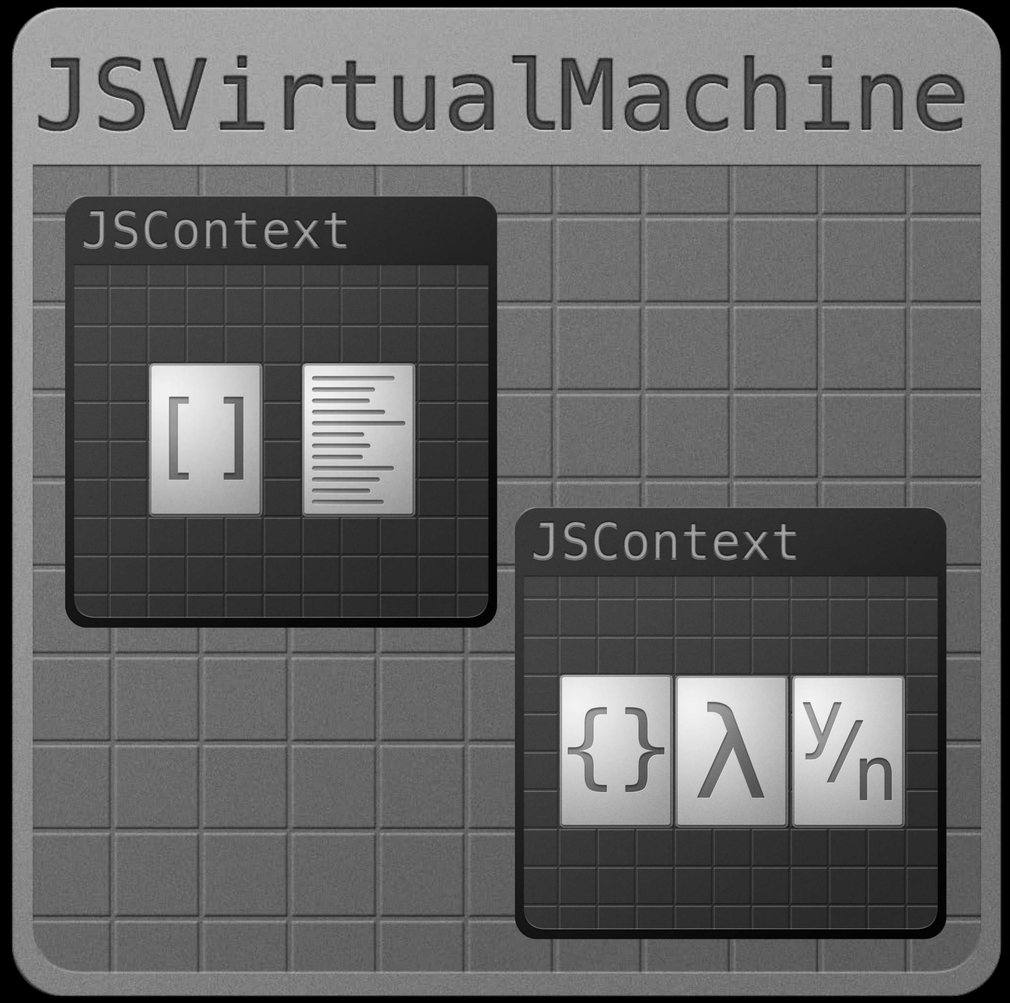
JSVirtualMachine

JSVirtualMachine



JSVirtualMachine





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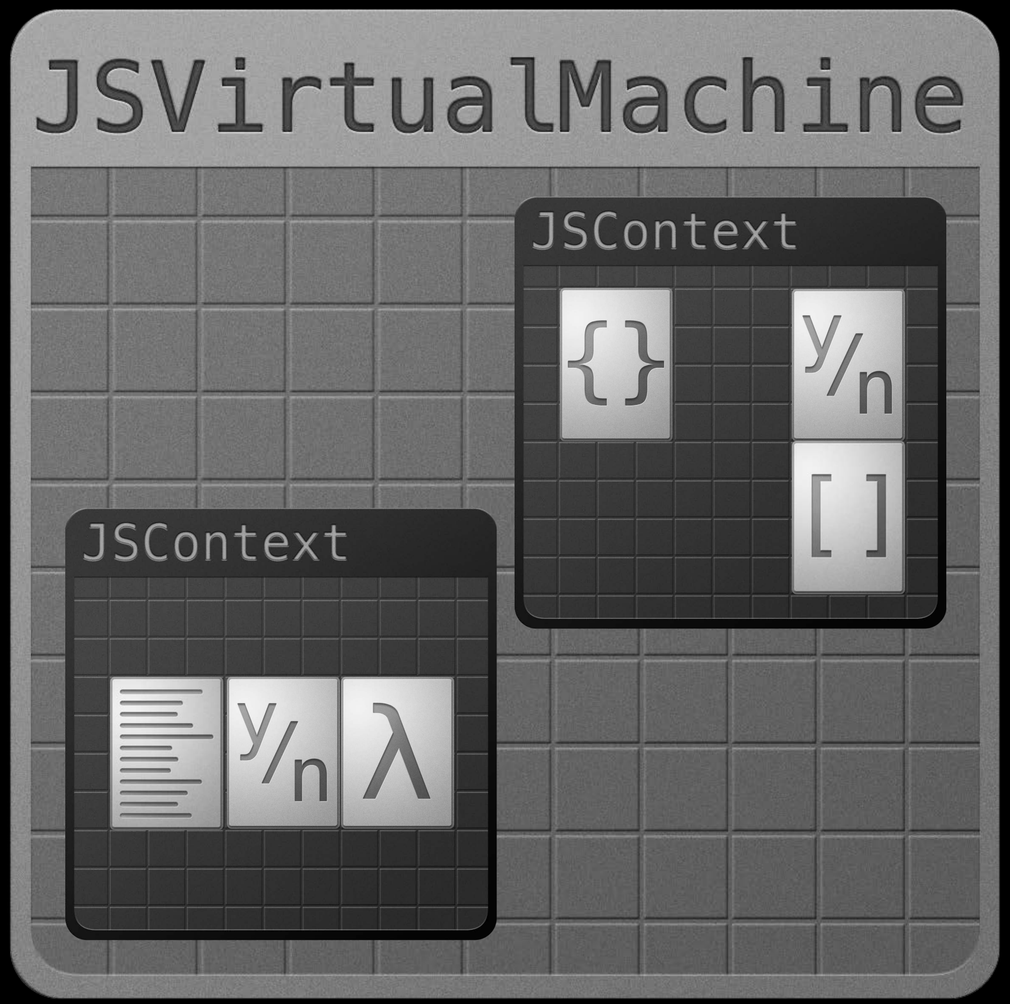
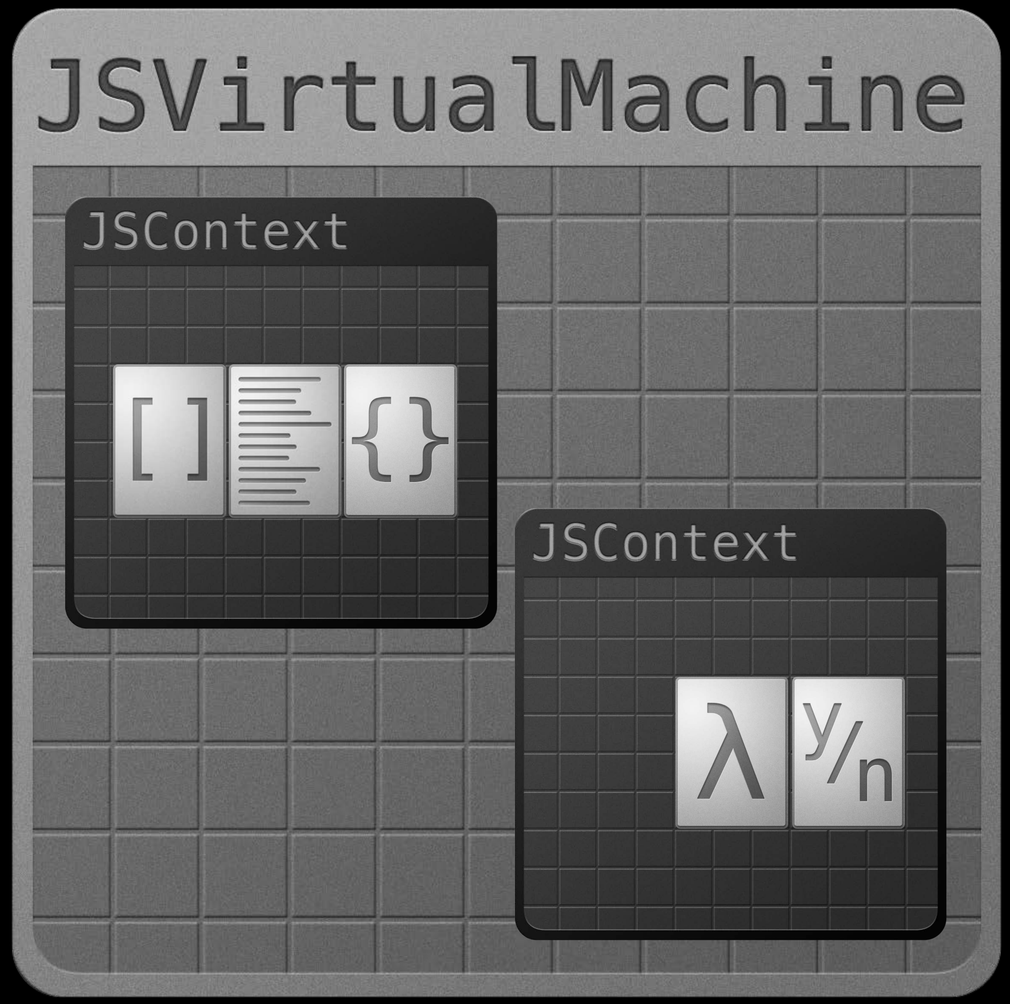
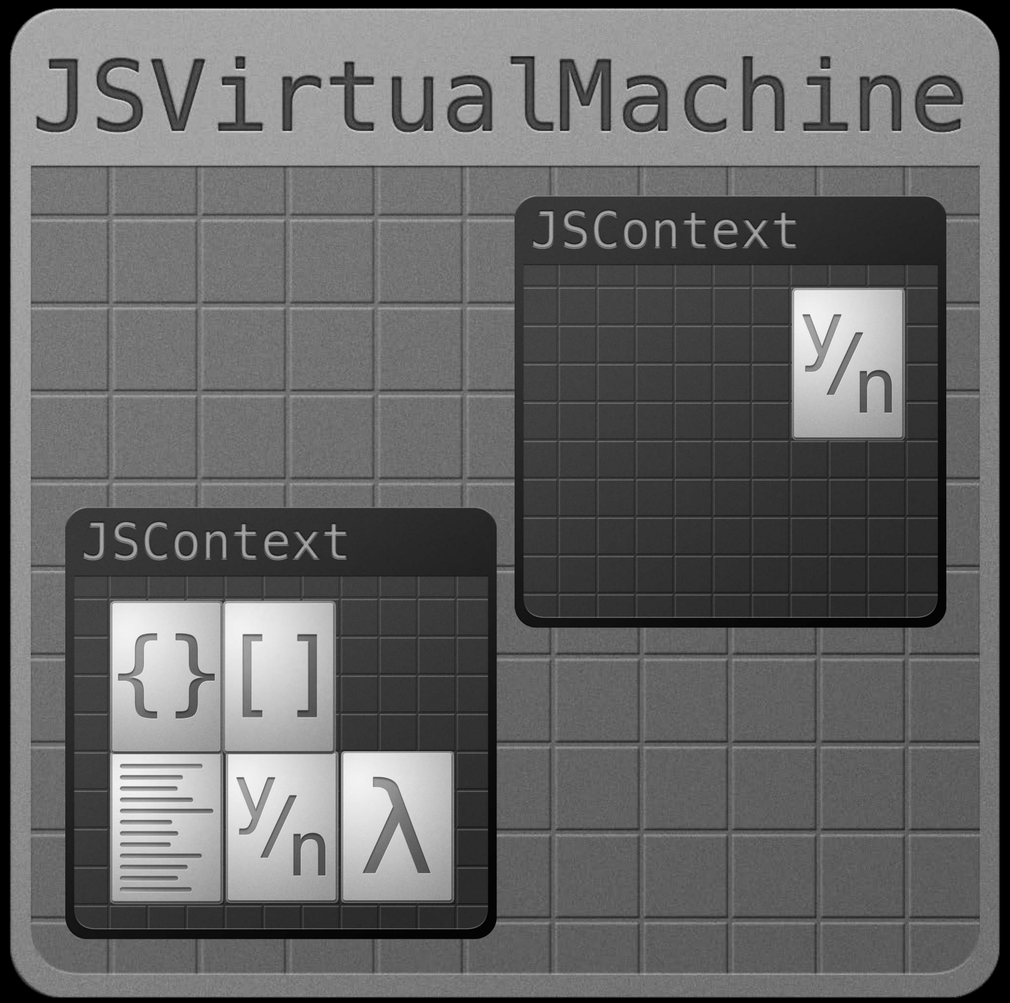
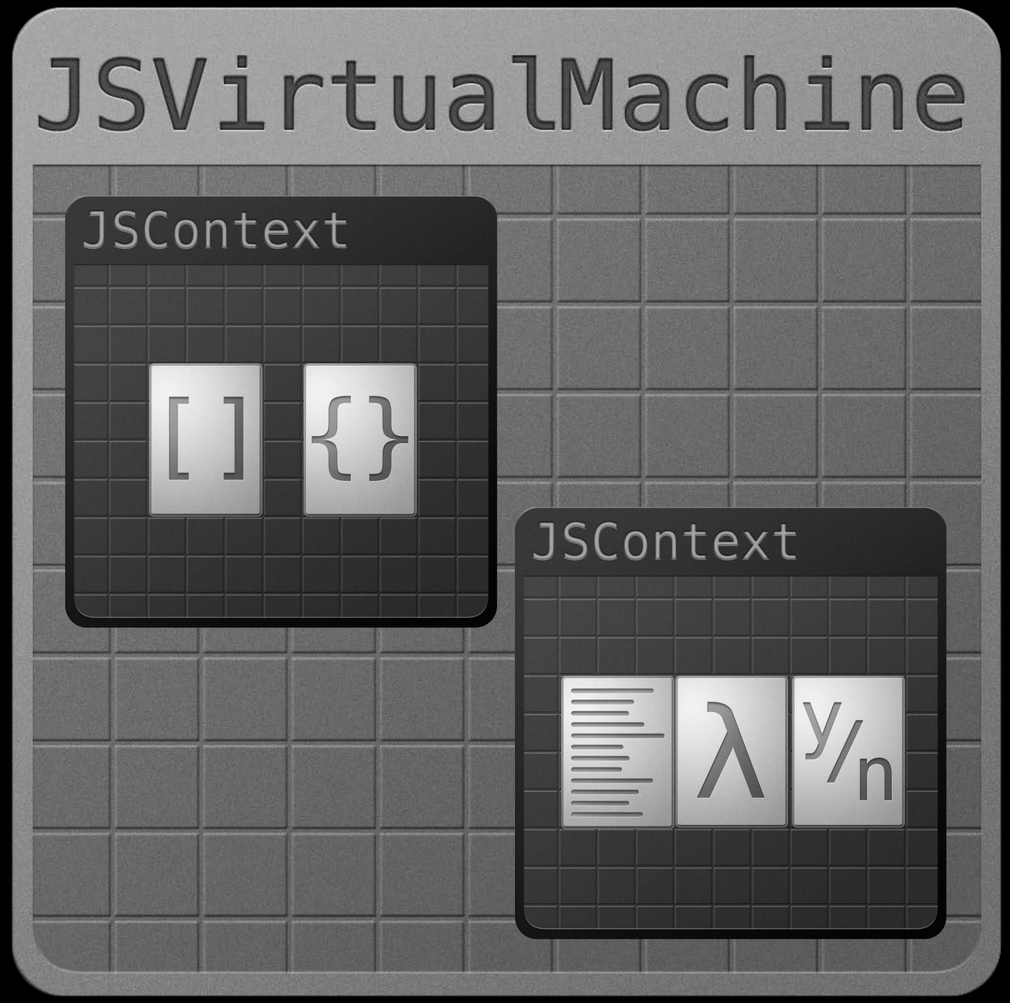


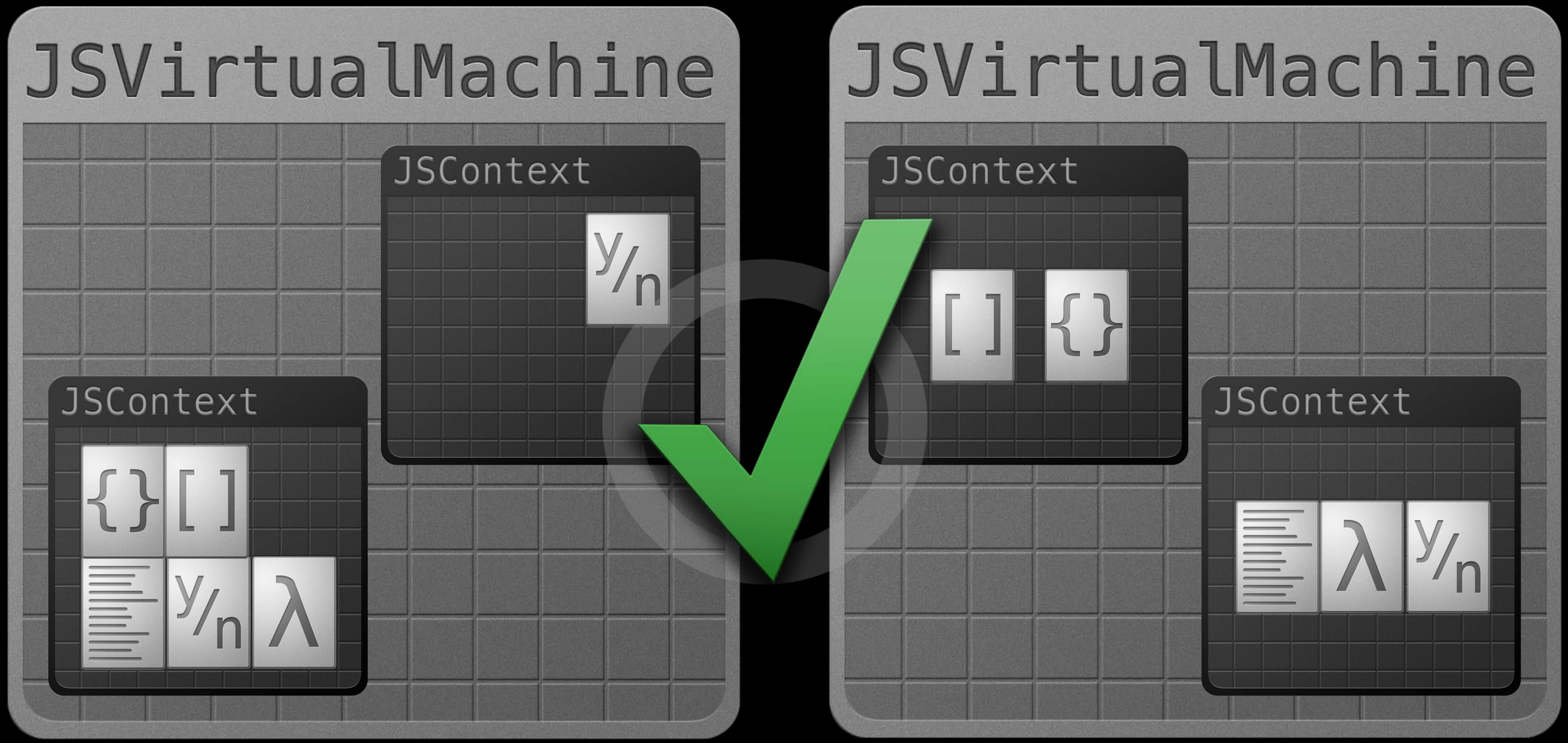


JSVirtualMachine

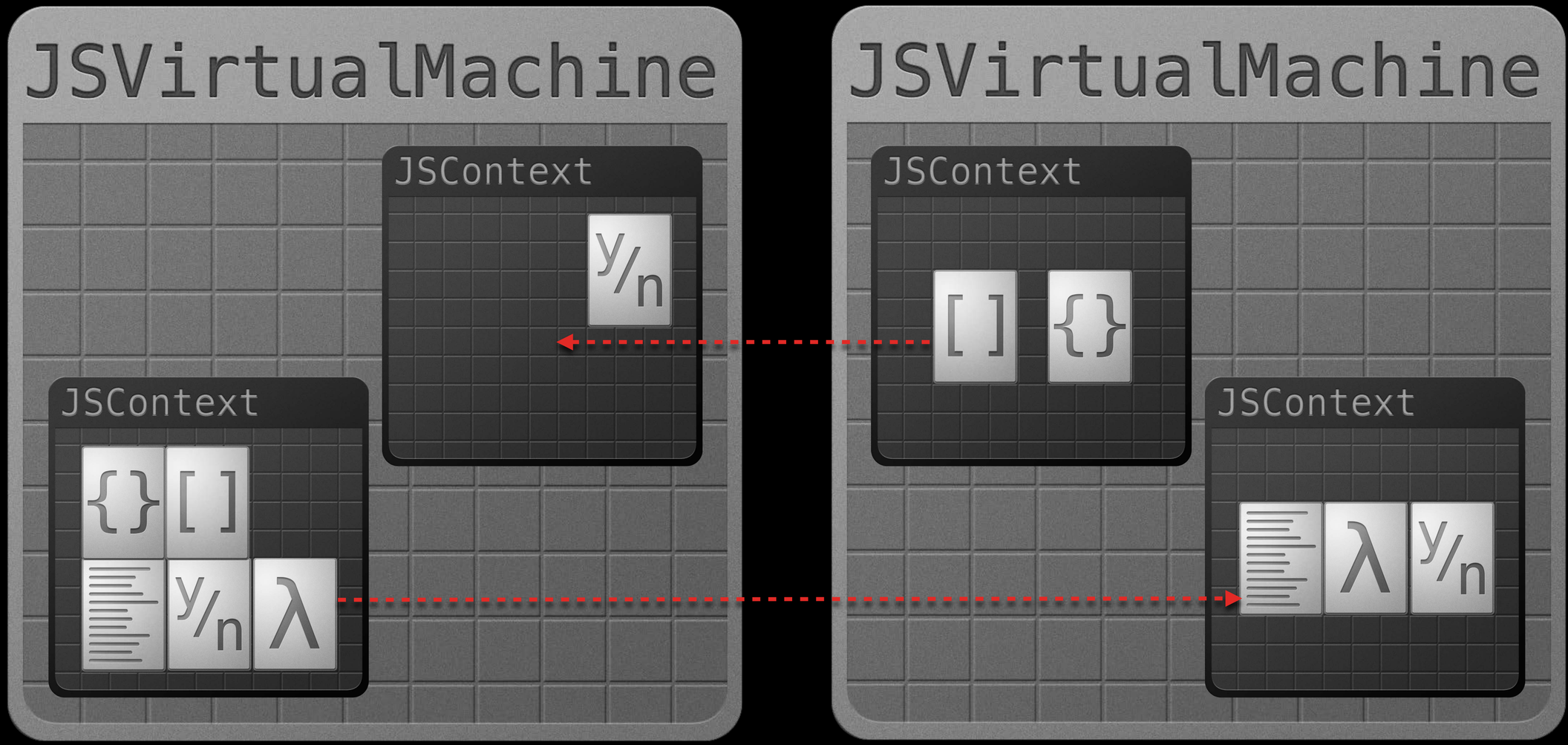




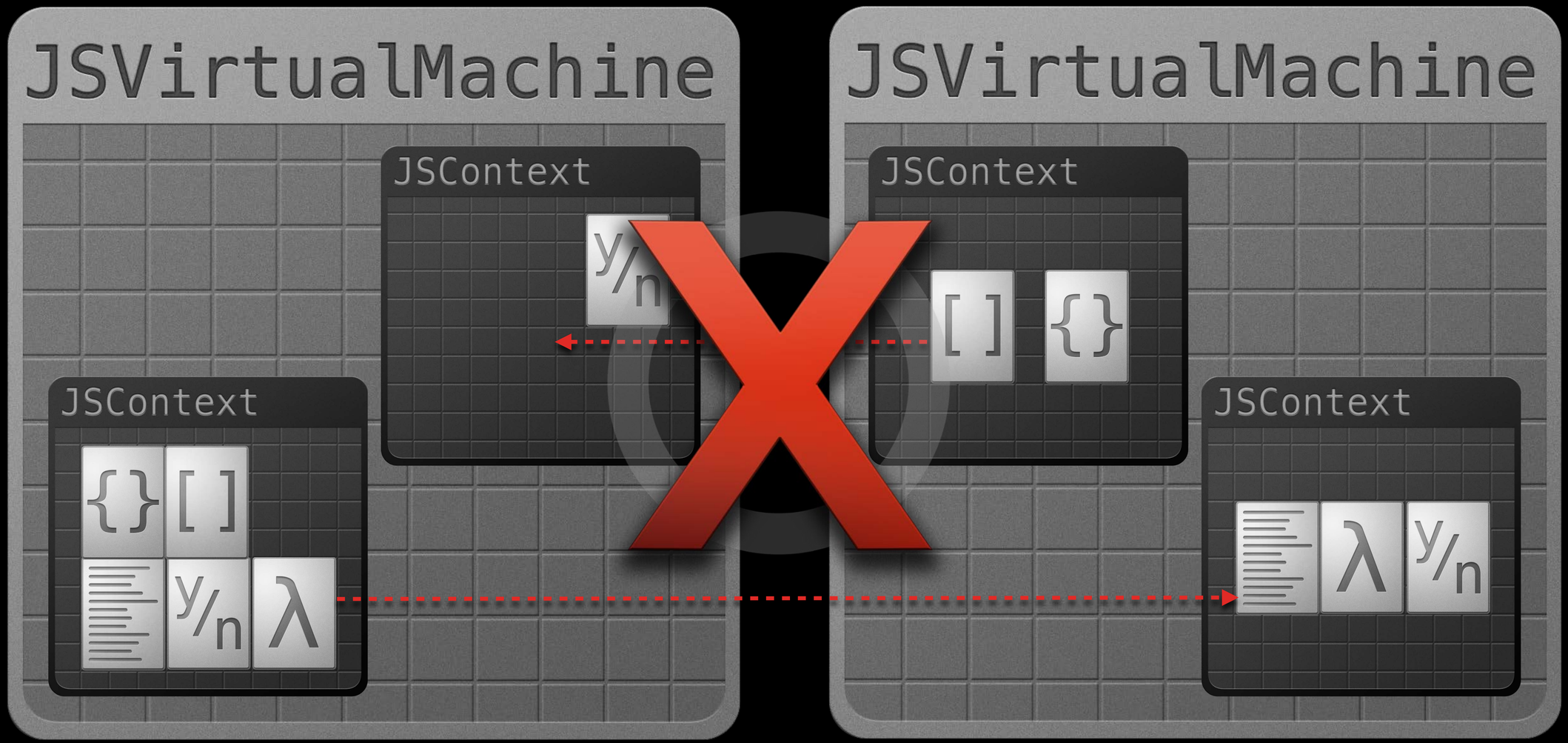
JSVirtualMachine



JSVirtualMachine



JSVirtualMachine



Threading

Threading

- API is thread safe

Threading

- API is thread safe
- Locking granularity is JSVirtualMachine

Threading

- API is thread safe
- Locking granularity is JSVirtualMachine
  - Use separate JSVirtualMachines for concurrency/parallelism

Interfacing with the JavaScriptCore C API

Interfacing with the C API

- JSValue ↔ JSValueRef
- JSContext ↔ JSGlobalContextRef

JSContext ↔ JSGlobalContextRef

```
JSGlobalContextRef ctx = ...
JSContext *context = [JSContext contextWithJSGlobalContextRef:ctx];

JSContext *context = ...
JSGlobalContextRef ctx = [context JSGlobalContextRef];
```

JSValue ↔ JSValueRef

```
JSValueRef valueRef = ...
JSValue *value = [JSValue valueWithJSValueRef:valueRef inContext:context];

JSValue *value = ...
JSValueRef valueRef = [value JSValueRef];
```

Demo

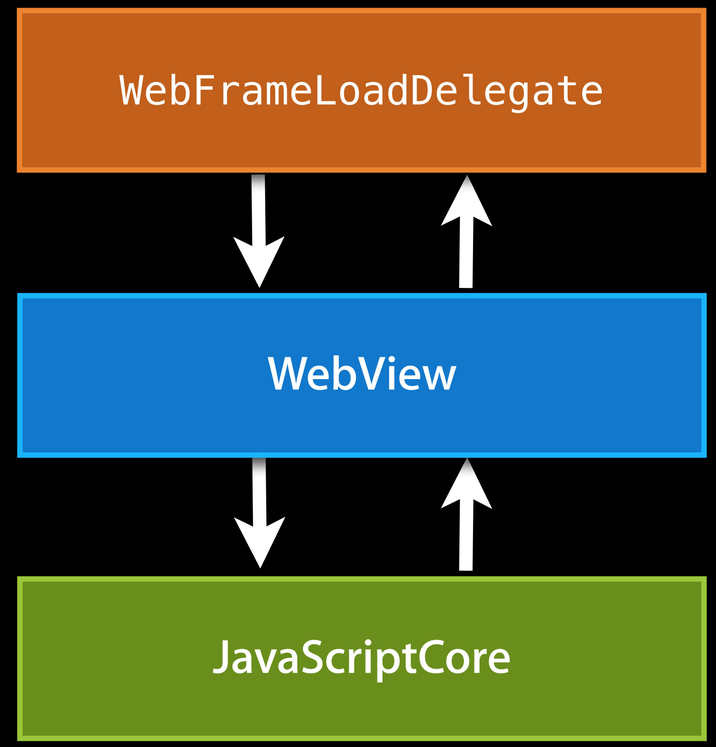
ColorMyCode

WebKit WebView

WebKit WebView (Mac)

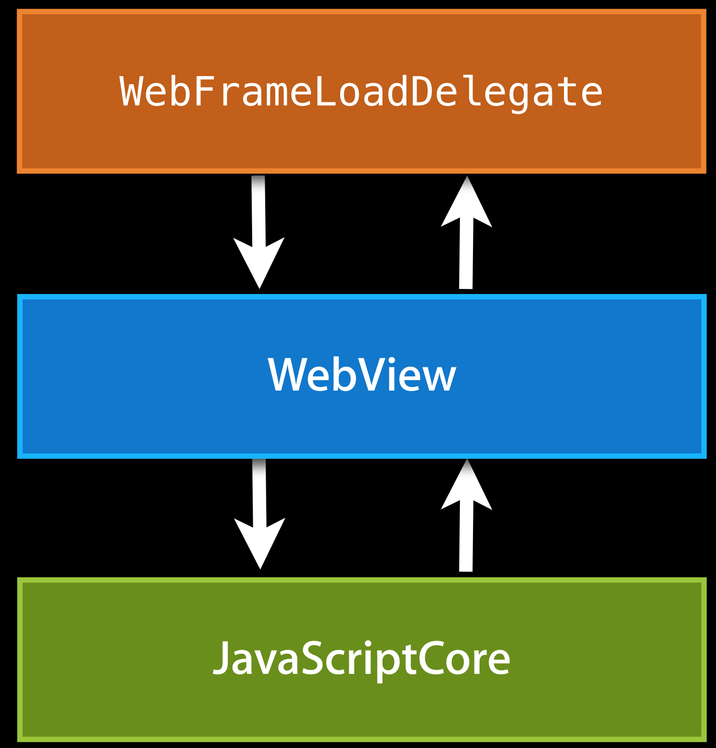
WebKit WebView (Mac)

- `-webView:didCreateJavaScriptContext:forFrame:`



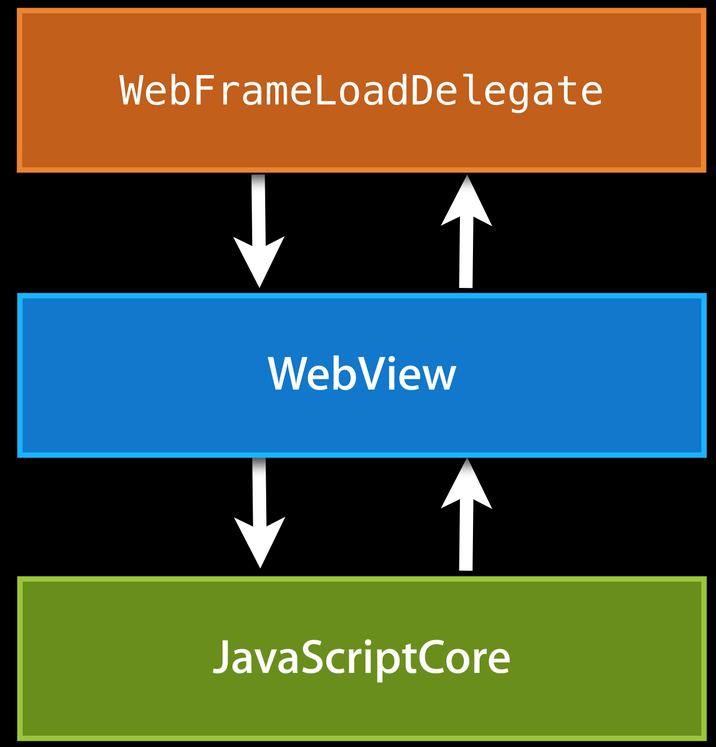
WebKit WebView (Mac)

- `-webView:didCreateJavaScriptContext:forFrame:`
- Install custom objects using context argument



WebKit WebView (Mac)

- `-webView:didCreateJavaScriptContext:forFrame:`
- Install custom objects using context argument
- Replaces old callbacks gracefully



WebKit WebView (Mac)

- `-webView:didCreateJavaScriptContext:forFrame:`
- Install custom objects using context argument
- Replaces old callbacks gracefully
- iTunes store uses WebView

WebKit WebView (Mac)

```
@implementation MyFrameLoadDelegate

- (void)webView:(WebView *)webView didCreateJavaScriptContext
(JSContext *)context forFrame:(WebFrame *)frame
{
    MyConsole *console = [[MyConsole alloc] init];
    context[@"myConsole"] = console;
}

@end
```

WebKit WebView (Mac)

```
<html>
     <head>
        <script>
        var onClickHandler = function() {
           myConsole.log("clicked!");
        };
        </script>
     </head>
     <body>
        <button onclick="onClickHandler()">Click Me!</button>
     </body>
</html>
```

Summary

What We've Covered

- Objective-C → JavaScript
- JavaScript → Objective-C
- Interfacing with the JavaScriptCore C API
- Reference counting vs. Garbage collection
- Threading
- Custom objects in WebKit WebViews

Call to Action

- Convert one bit of old code to use the new Objective-C API
- Add a small snippet of JavaScript to your app

More Information

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Documentation
JavaScriptCore.framework Headers
https://developer.apple.com/library/mac/#documentation/Carbon/Reference/WebKit_JavaScriptCore_Ref/

Apple Developer Forums
http://devforums.apple.com

Related Sessions

Getting to Know Web Inspector	Russian Hill Tuesday 10:15AM	
Getting the Most Out of Web Inspector	Russian Hill Tuesday 11:30AM	
Power and Performance: Optimizing Your Website for Great Battery Life and Responsive Scrolling	Russian Hill Wednesday 9:00AM	
Preparing and Presenting Media for Accessibility	Nob Hill Wednesday 10:15AM	
Implementing OS X Push Notifications for Websites	Marina Friday 9:00AM	
Integrating JavaScript into Native Apps	Marina Friday 10:15AM	

Labs

Integrating Web Technologies into Native Apps Lab	Media Lab A Friday 11:30 AM	
Safari and Web Tools Lab	Media Lab A Friday 2:00 PM	

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