

# Integrating JavaScript into Native Applications

Session 615

**Mark Hahnenberg**

JavaScriptCore engineer

These are confidential sessions—please refrain from streaming, blogging, or taking pictures

# 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

## API Goals

Automatic

Safety

Fidelity

# Overview

## API Goals

Automatic

Safety

Fidelity

# Overview

## API Goals

Automatic

Safety

Fidelity

# What You Will Learn



# What You Will Learn

- Objective-C → JavaScript

# What You Will Learn

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

# What You Will Learn

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

# What You Will Learn

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

# What You Will Learn

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

```
#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

```
#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

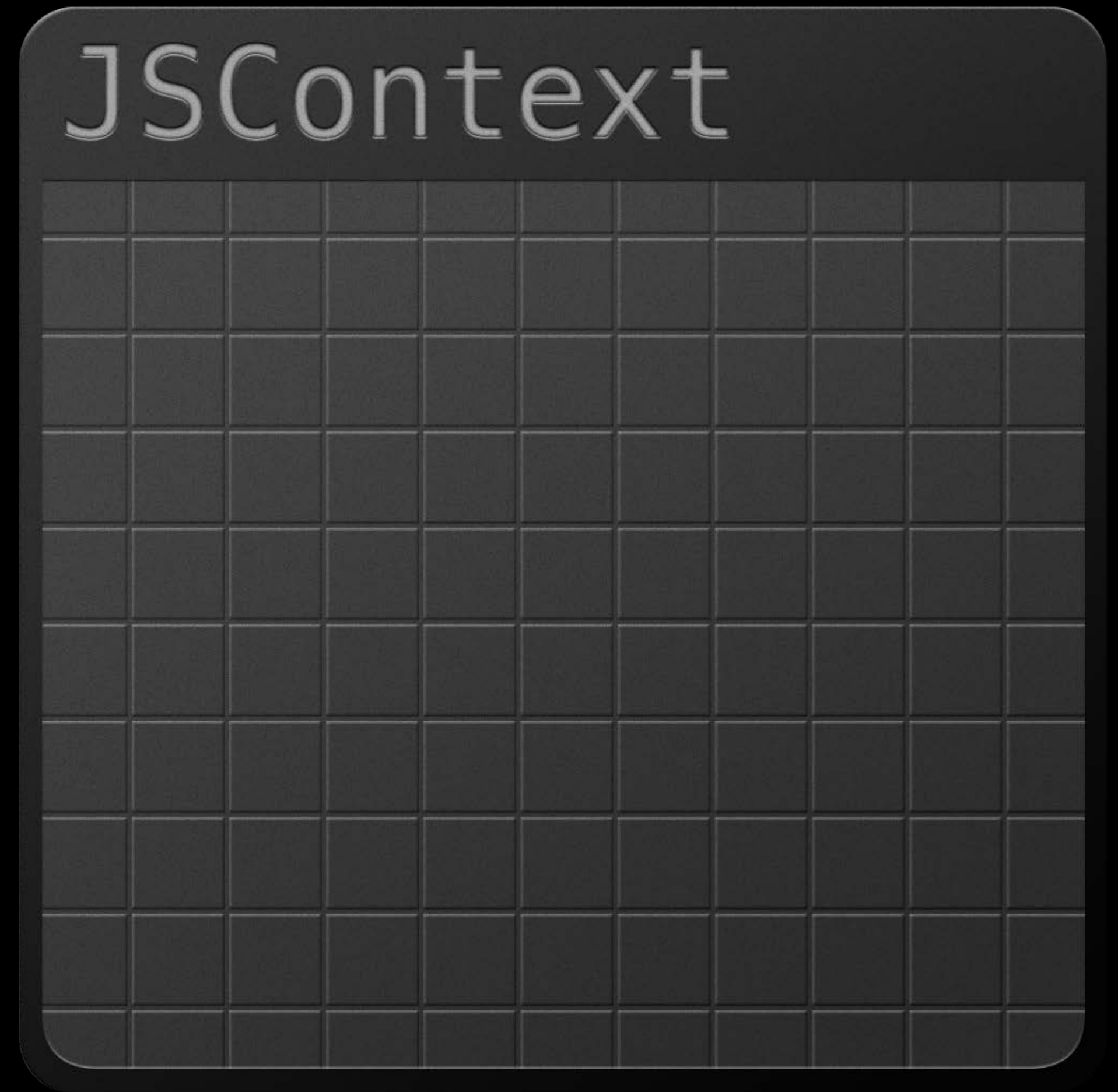
```
#import <JavaScriptCore/JavaScriptCore.h>

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

    JSValue *result = [context evaluateScript:@"2 + 2"];

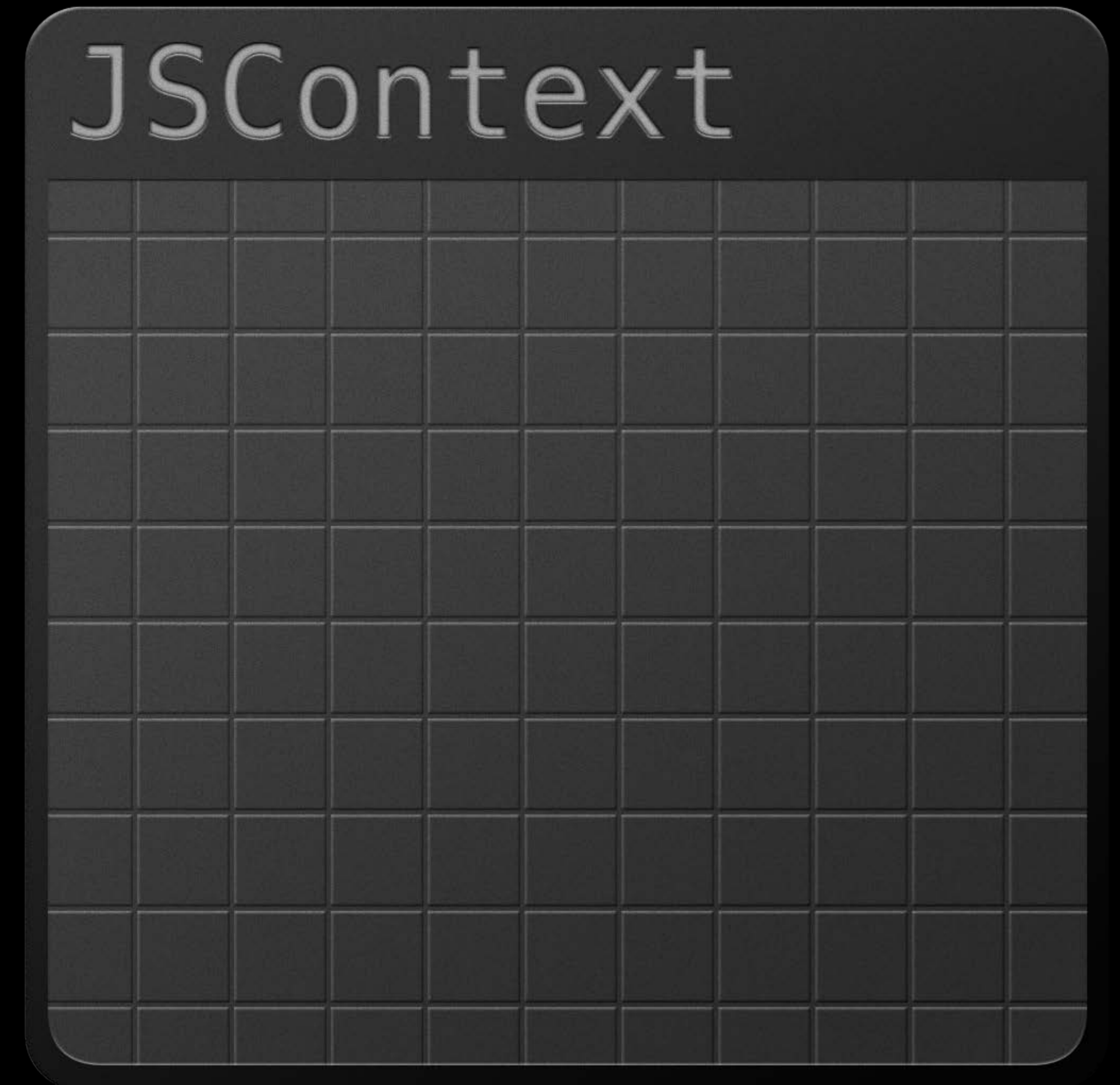
    NSLog(@"2 + 2 = %d", [result toInt32]);
    return 0;
}
```

# JSContext



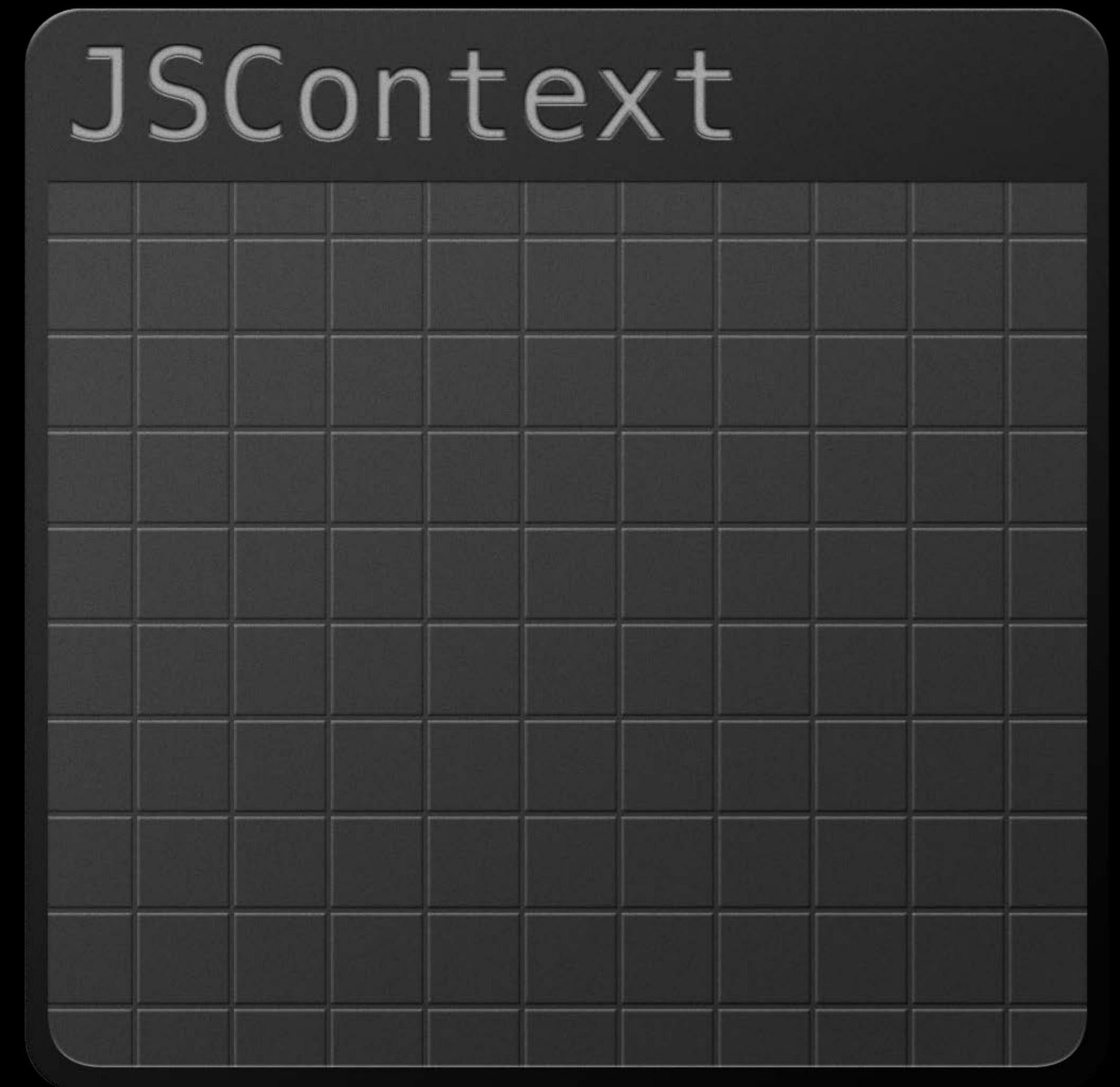
# JSContext

- Context for evaluating code

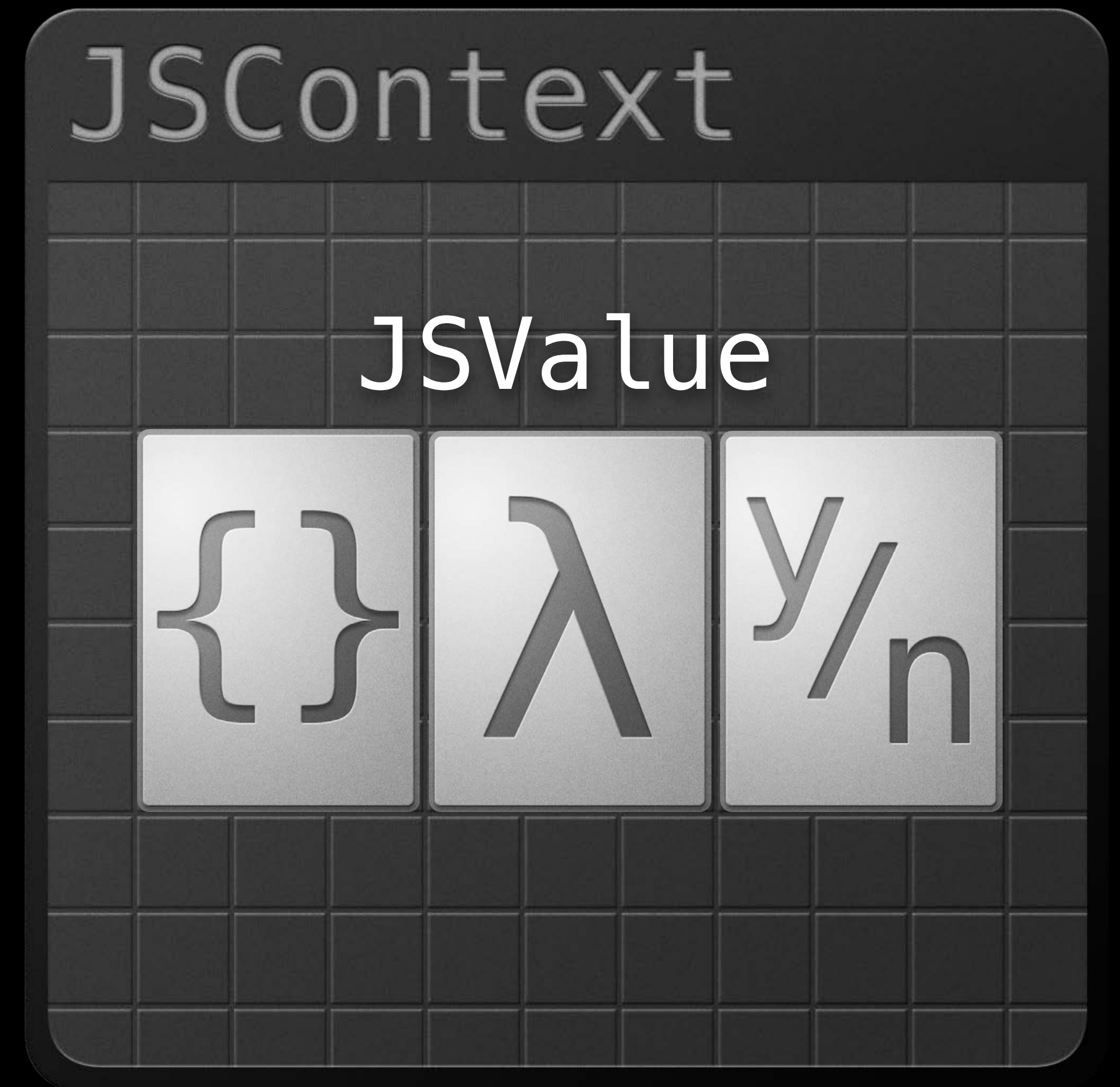


# JSContext

- Context for evaluating code
- Global object



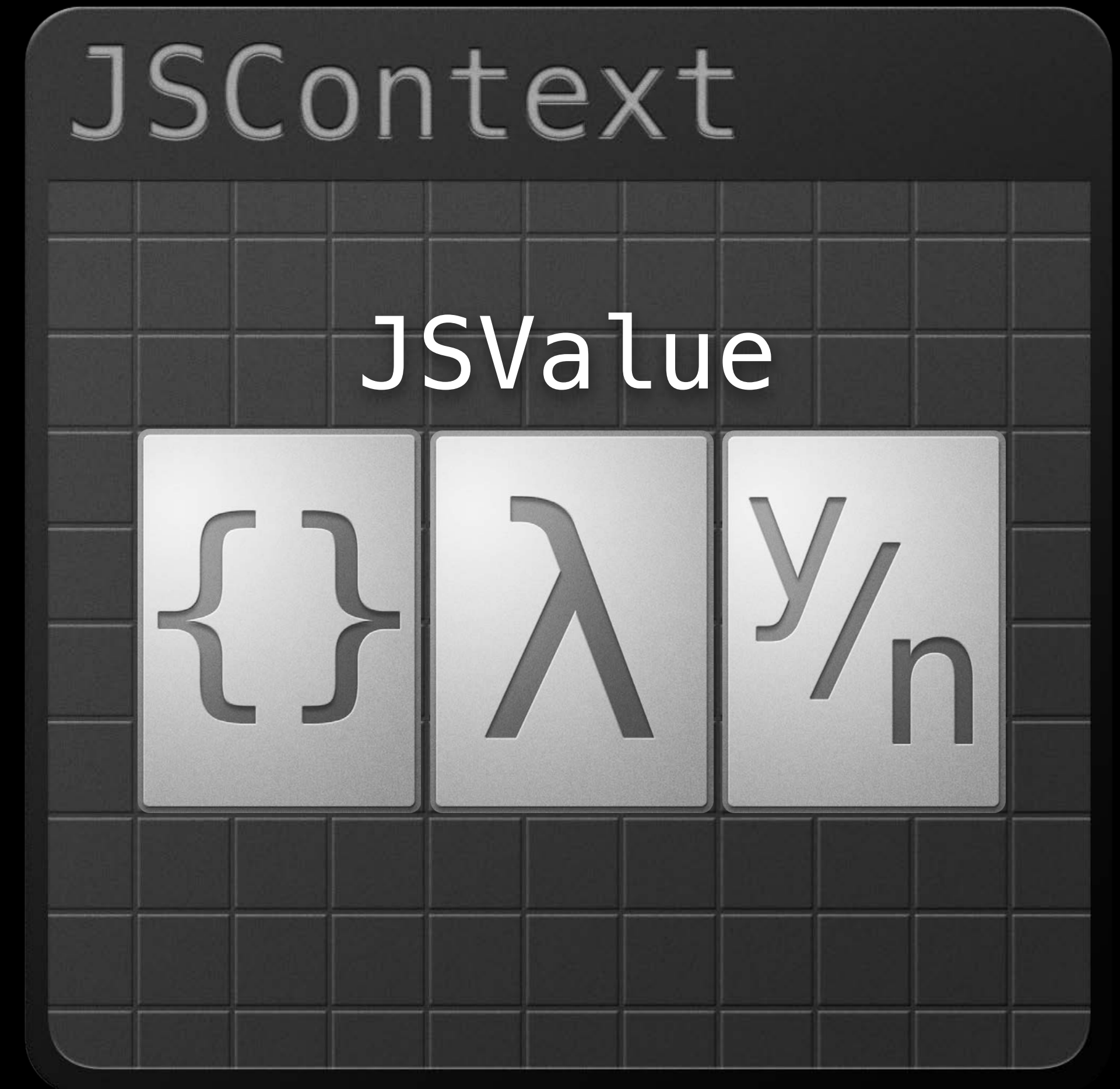
# JSValue





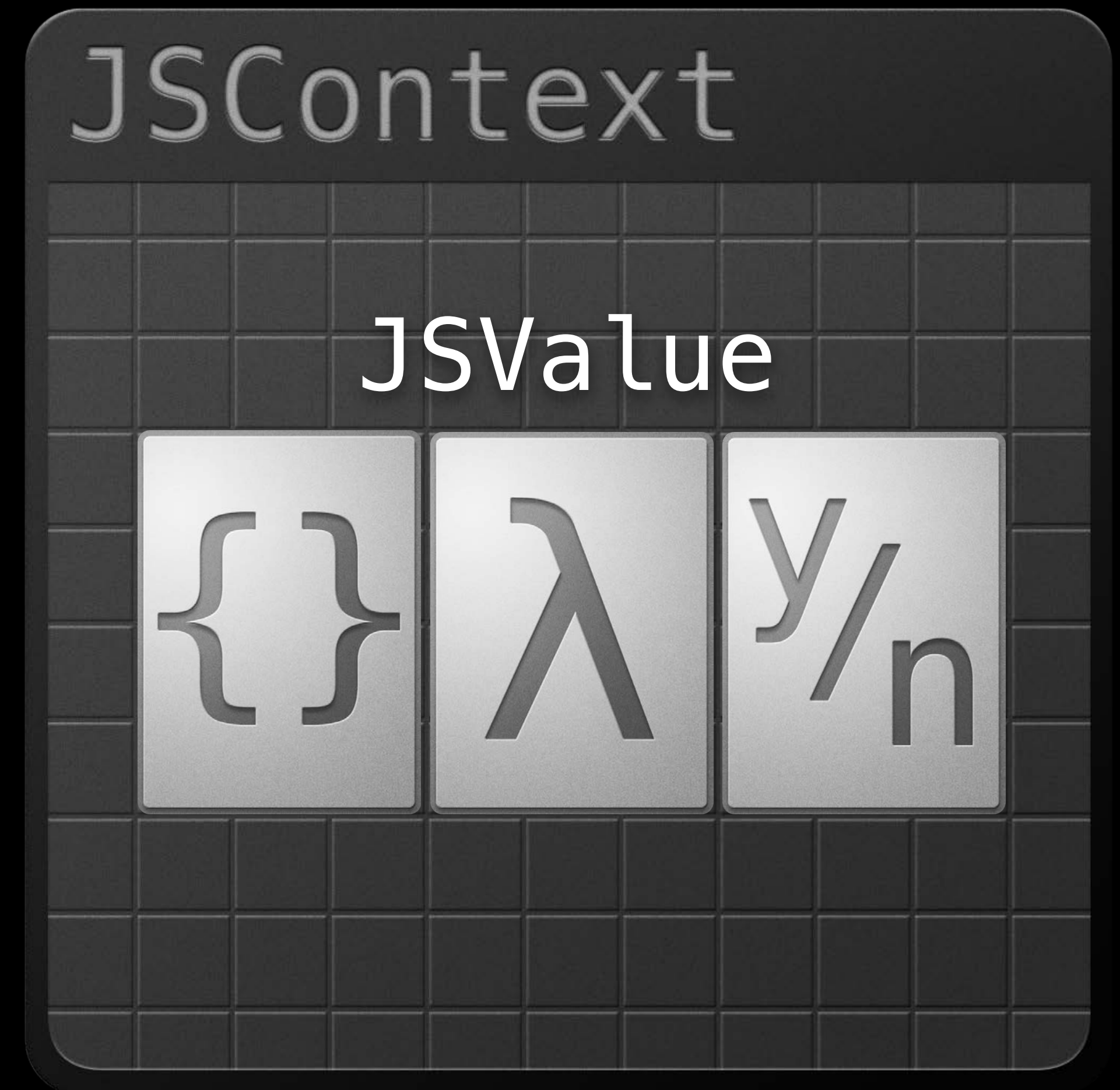
# JSValue

- Reference to JavaScript value



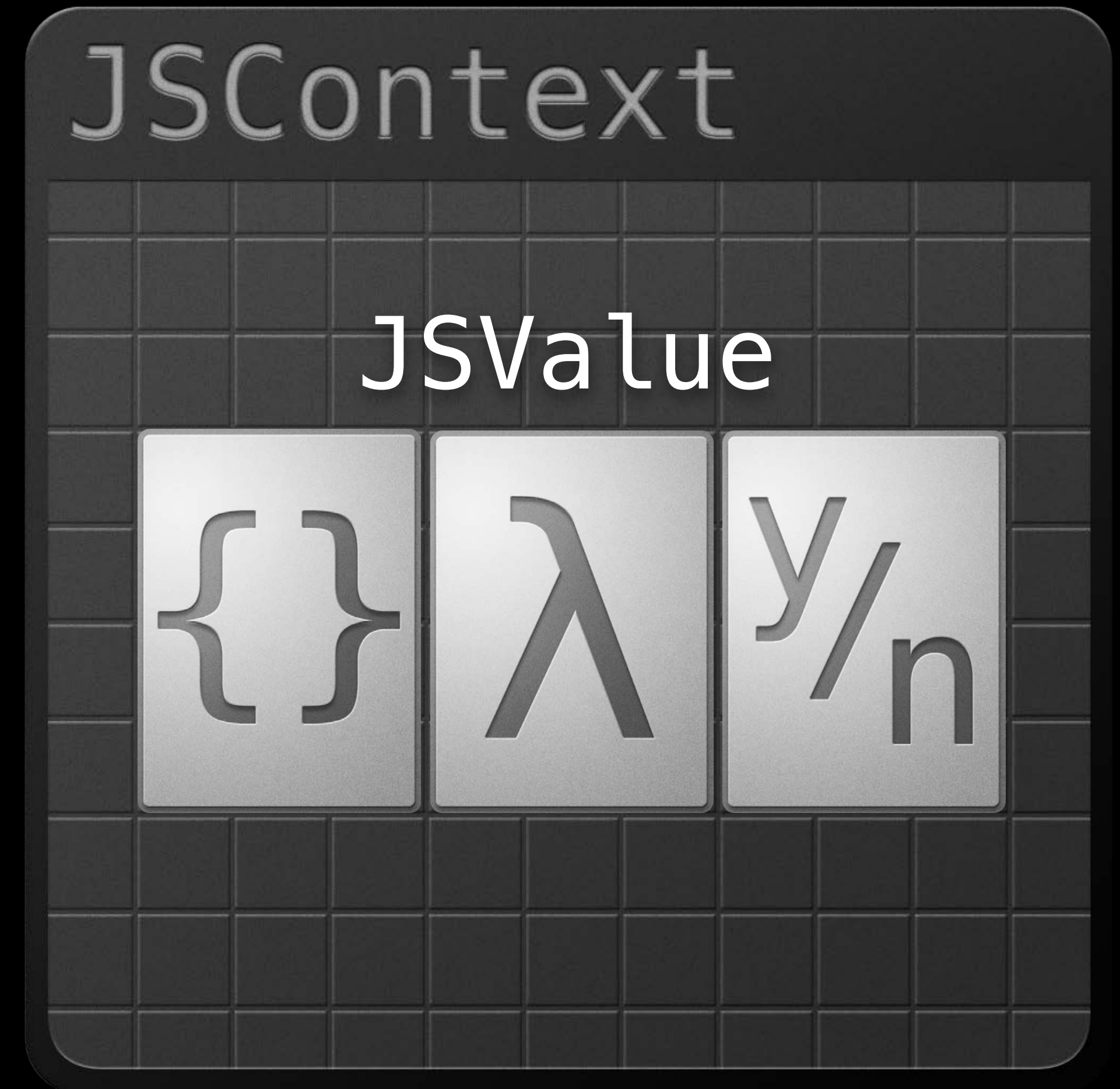
# JSValue

- Reference to JavaScript value
  - Strong reference



# JSValue

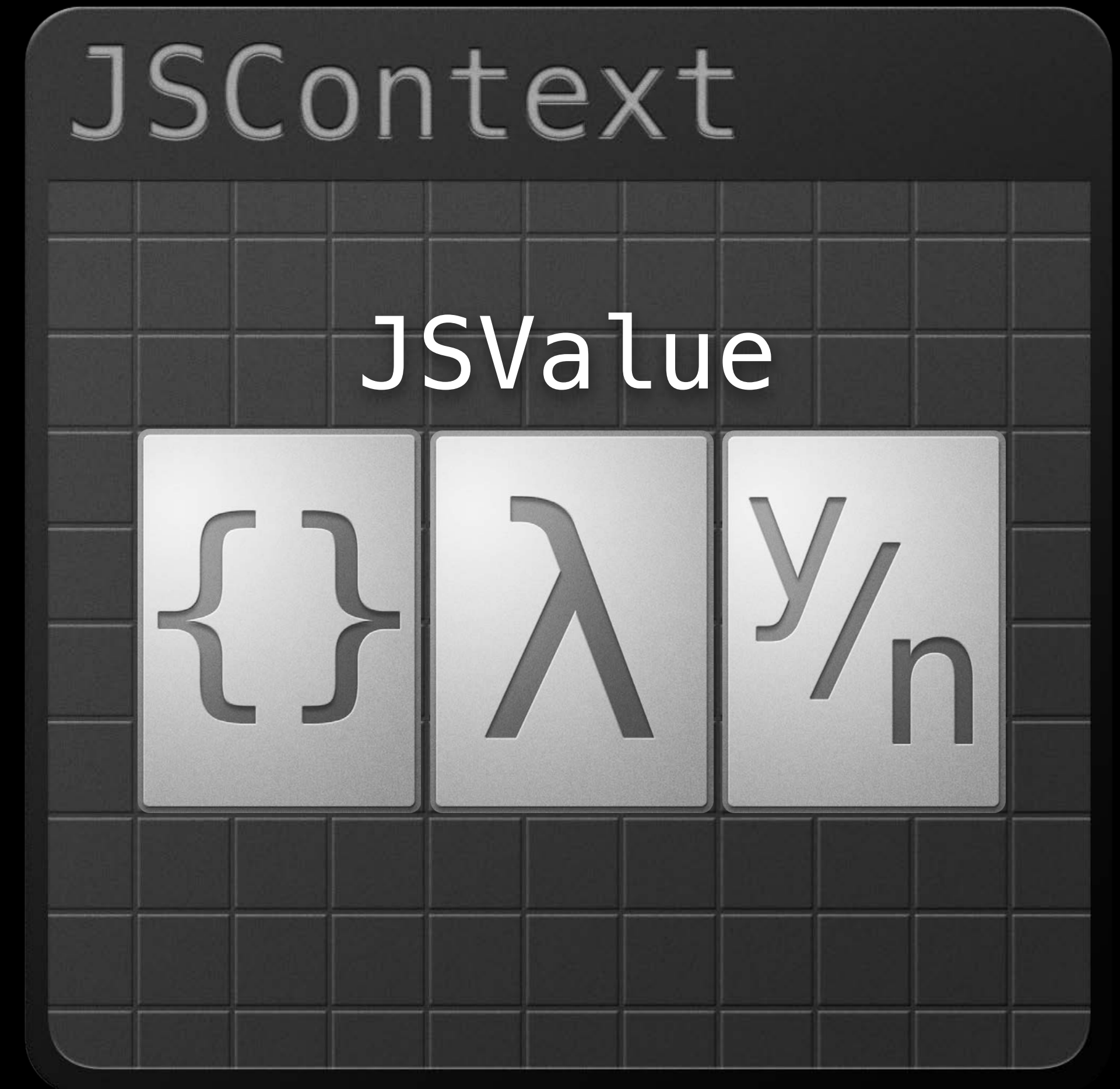
- Reference to JavaScript value
  - Strong reference
- Tied to a JSContext





# JSValue

- Reference to JavaScript value
  - Strong reference
- Tied to a JSContext
  - Strong reference



# 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

```
+ 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

## 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

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

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

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

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

# Calling JavaScript Functions

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

```
JValue *function = _context[@"factorial"];
```

```
JValue *result = [function callWithArguments:@[@5]];
```

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

# Calling JavaScript Functions

```
NSString *factorialScript = loadFactorialScript();  
[_context evaluateScript:factorialScript];  
  
JSValue *function = _context[@"factorial"];  
  
JSValue *result = [function callWithArguments:@[@5]];  
  
NSLog(@"factorial(5) = %d", [result toInt32]);
```

*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

# JavaScript → Objective-C

- 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];
};
```

JSContext

Objective-C Block

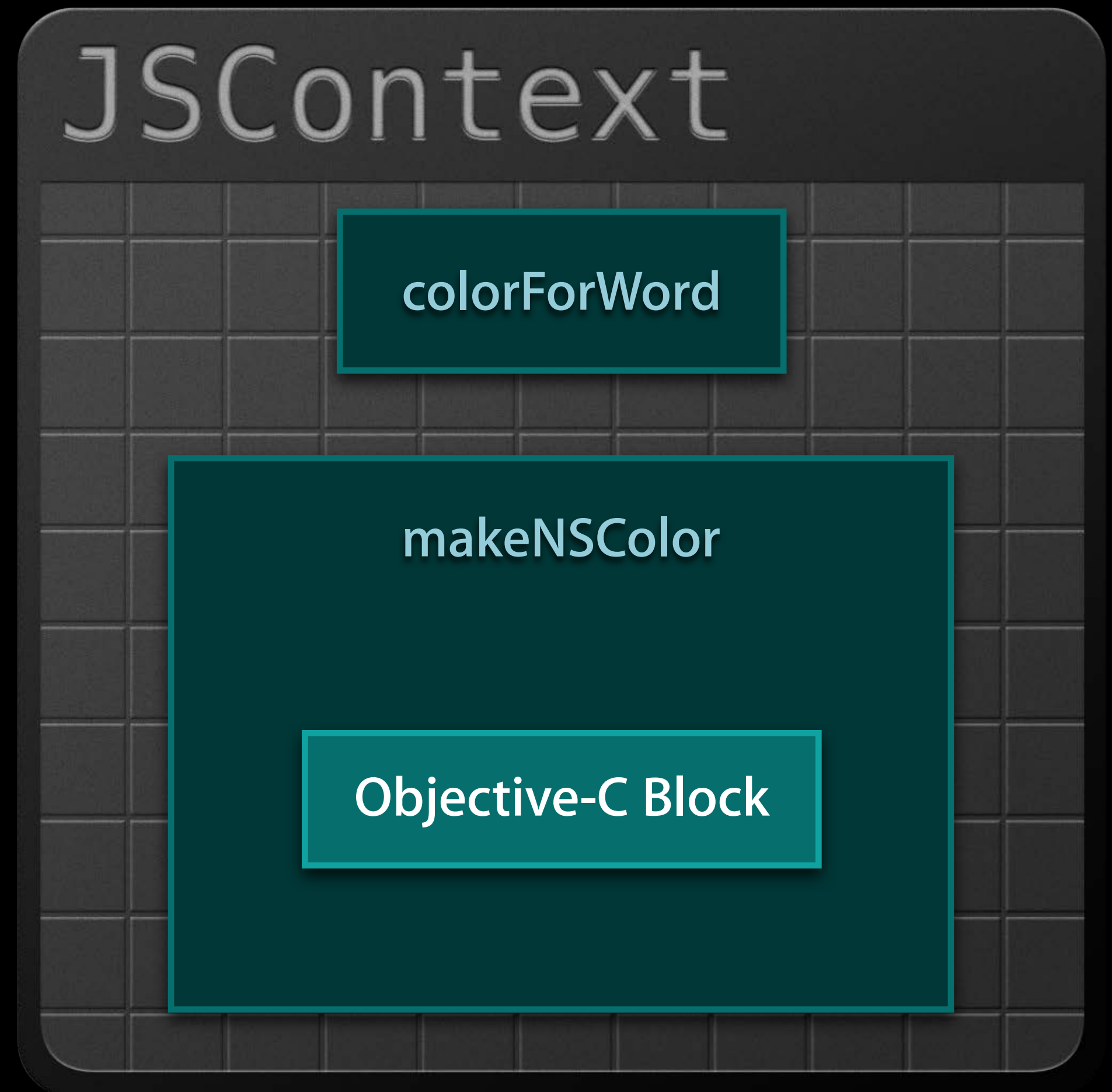
# Blocks

```
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];
};
```



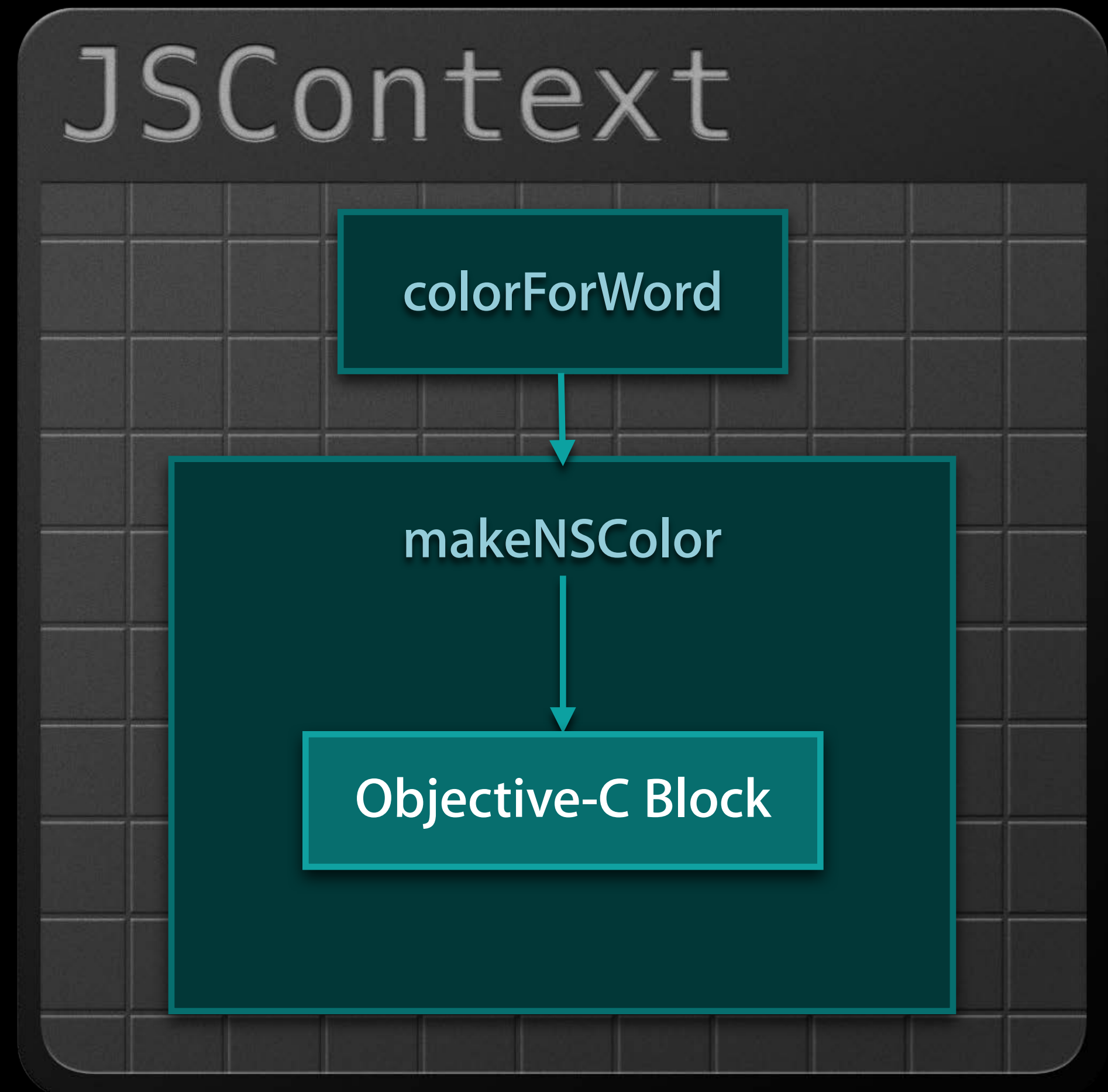
# Blocks

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



# Blocks

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



# 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

## 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;

point.description();
```

# 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;

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);
```

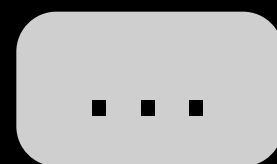
# JSExport

```
@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

- Enumeration of methods and properties to export to JavaScript
- @property → JavaScript getter/setter

# JSExport

- Enumeration of methods and properties to export to JavaScript
- @property → JavaScript getter/setter
- Instance method → JavaScript function



# 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];  
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];  
MyPoint *point2 = [[MyPoint alloc] initWithX:1.0 y:1.0];
```

```
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

# Memory Management

- Objective-C uses ARC
- JavaScriptCore uses garbage collection
  - All references are strong

# Memory Management

- Objective-C uses ARC
- JavaScriptCore uses garbage collection
  - All references are strong
- API memory management is mostly automatic

# 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:

# 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



# 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  
}
```

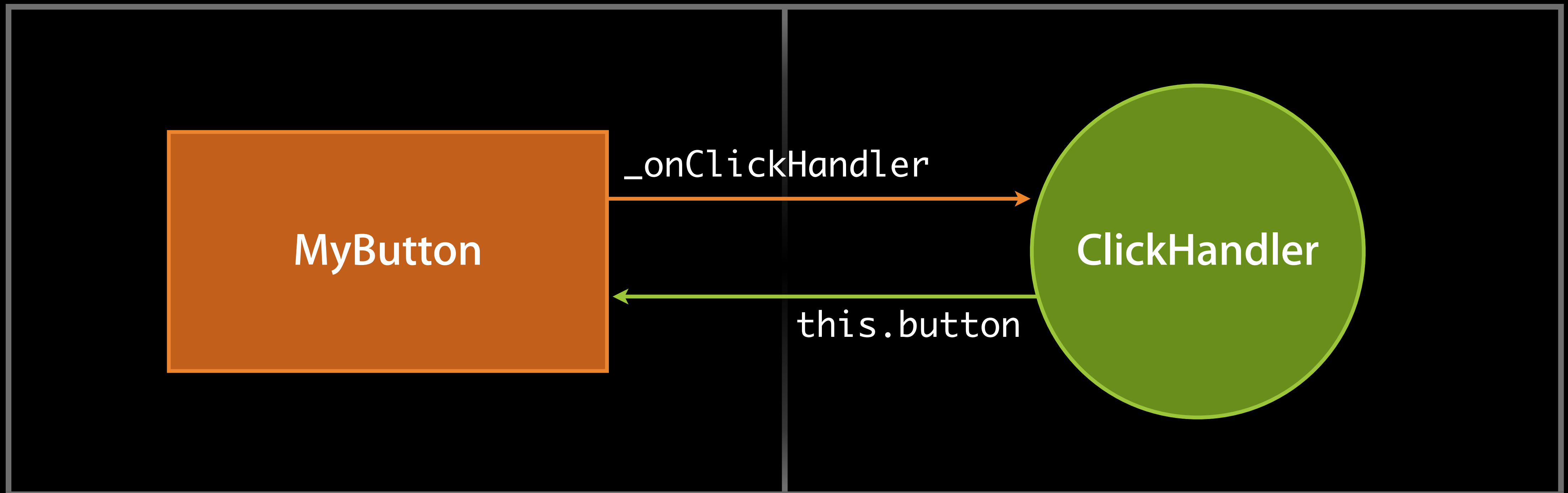
```
@end
```

# Retain Cycles



Objective-C

JavaScript



Strong

Weak

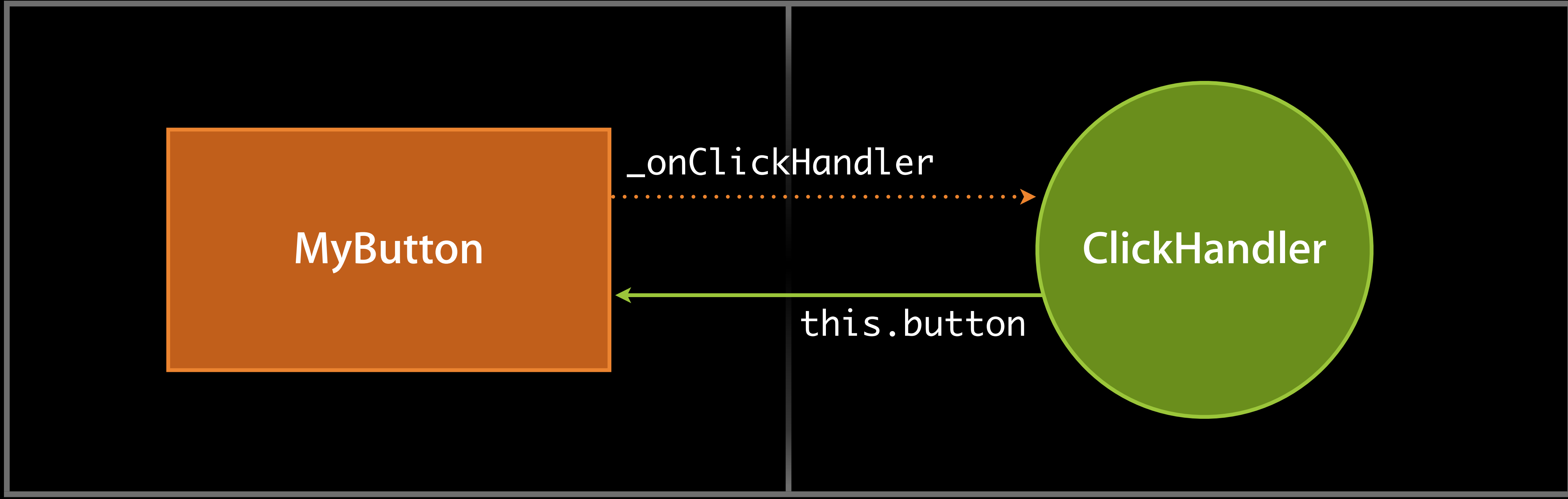




# Retain Cycles



Objective-C

JavaScript



Strong   
Weak 

# JSManagedValue

Good



```
@implementation MyButton
```

```
- (void)setOnClickListener:(JSValue *)handler
```

```
{
```

```
    _onClickHandler = [JSManagedValue managedValueWithValue:handler];
```

```
    [_context.virtualMachine addManagedReference:_onClickHandler  
                             withObject:self]
```

```
}
```

```
@end
```

# JSManagedValue

Good



```
@implementation MyButton
```

```
- (void)setOnClickHandler:(JSValue *)handler
```

```
{
```

```
    _onClickHandler = [JSManagedValue managedValueWithValue:handler];
```

```
    [_context.virtualMachine addManagedReference:_onClickHandler  
                             withObject:self]
```

```
}
```

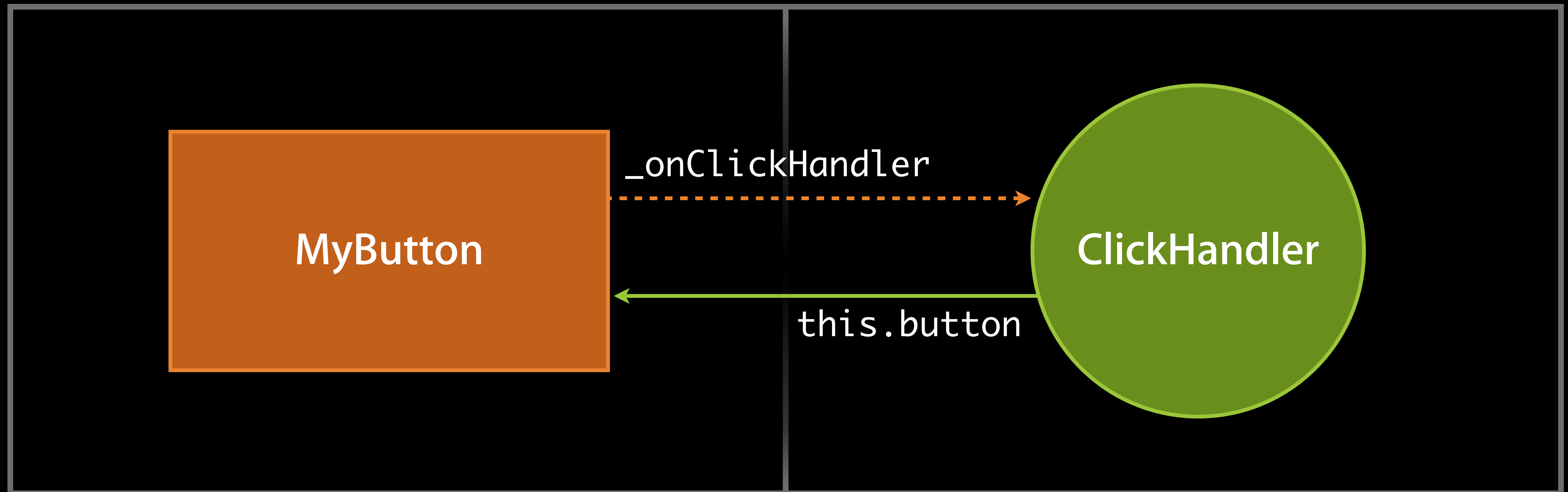
```
@end
```

# JSManagedValue



Objective-C

JavaScript



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

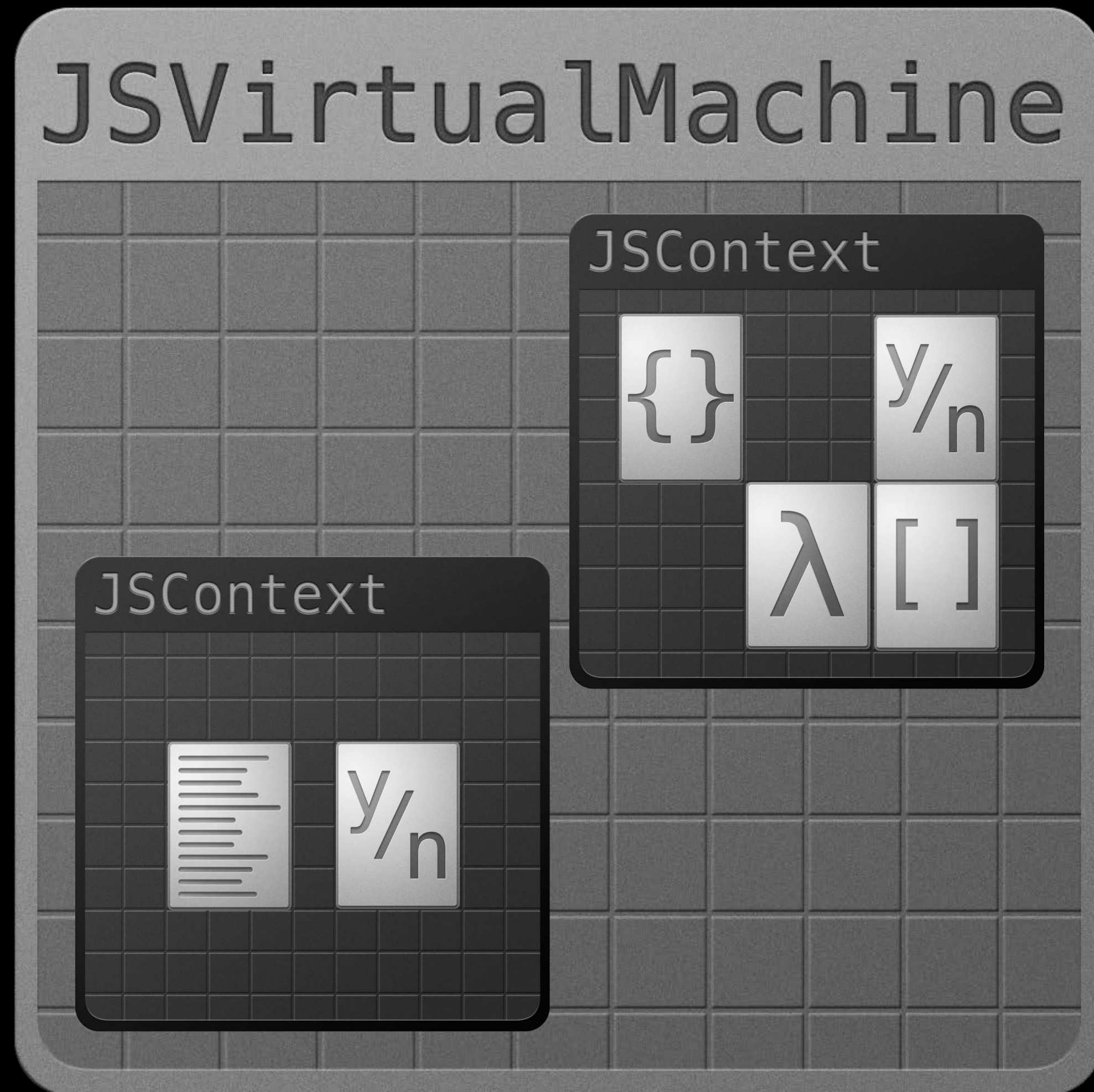
- If JavaScript can find the Objective-C owner of a managed reference
  - Reference is kept alive
- Otherwise
  - Reference is released

# Threading

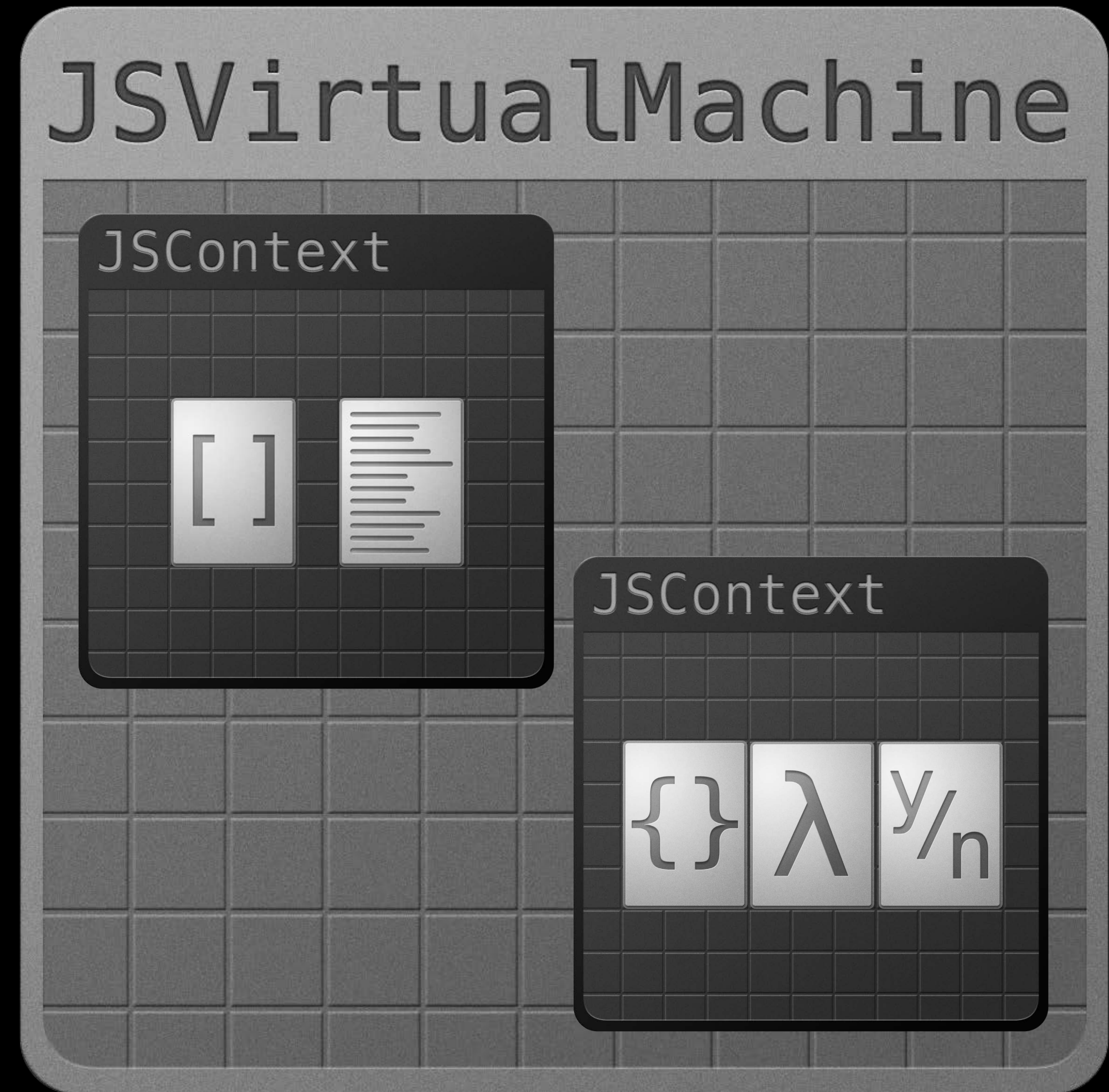
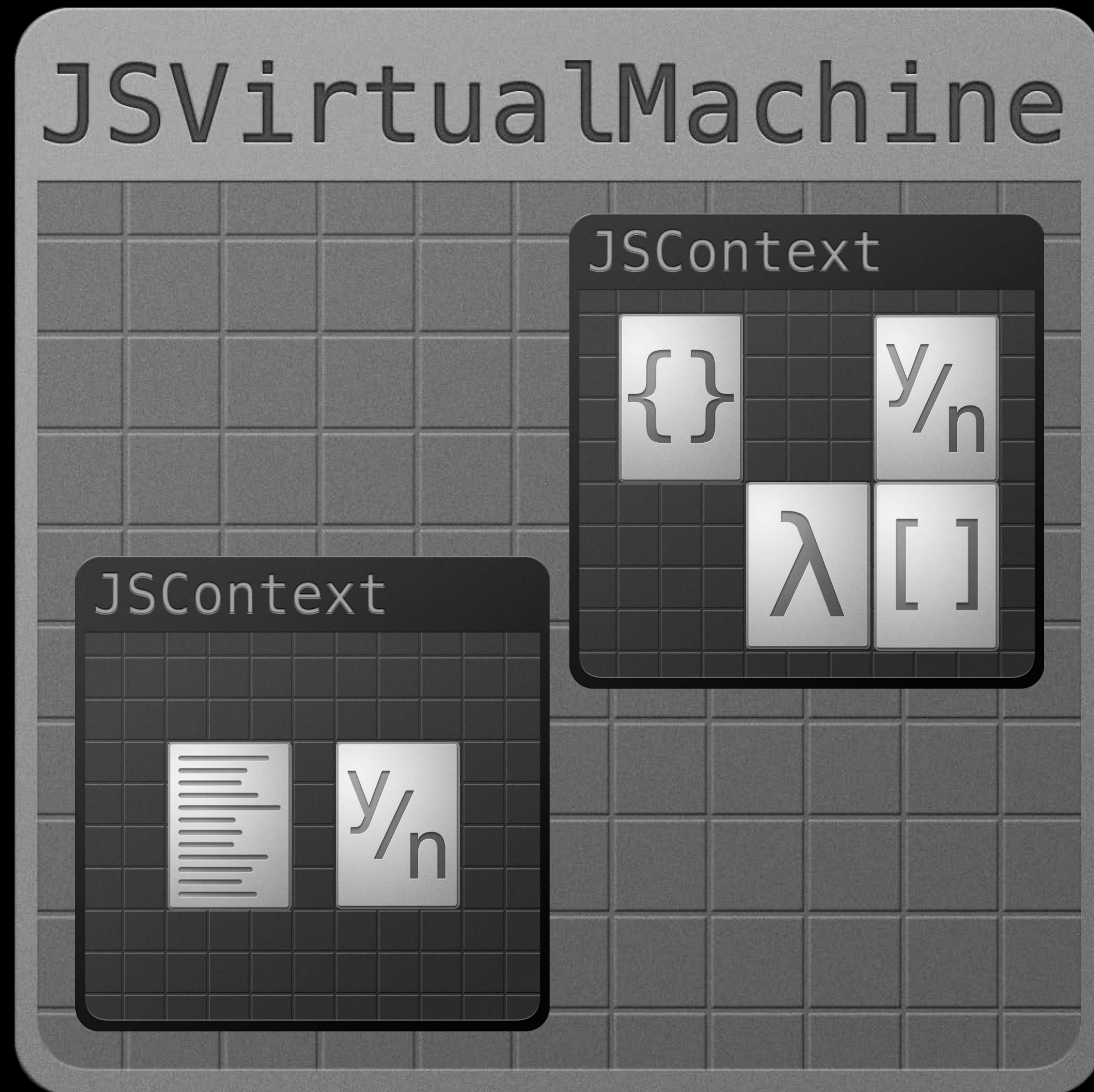
# JSVirtualMachine



# JSVirtualMachine

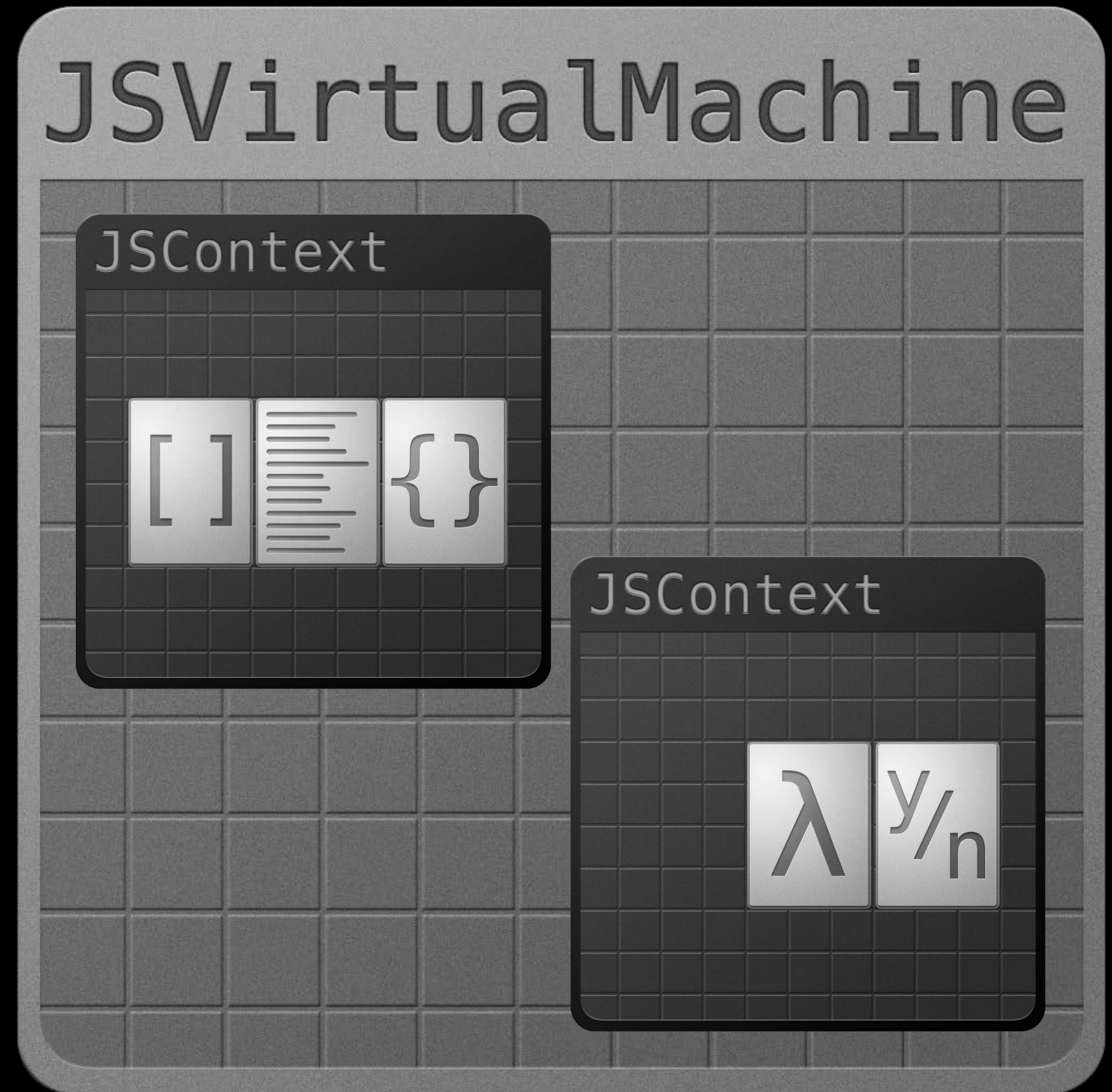
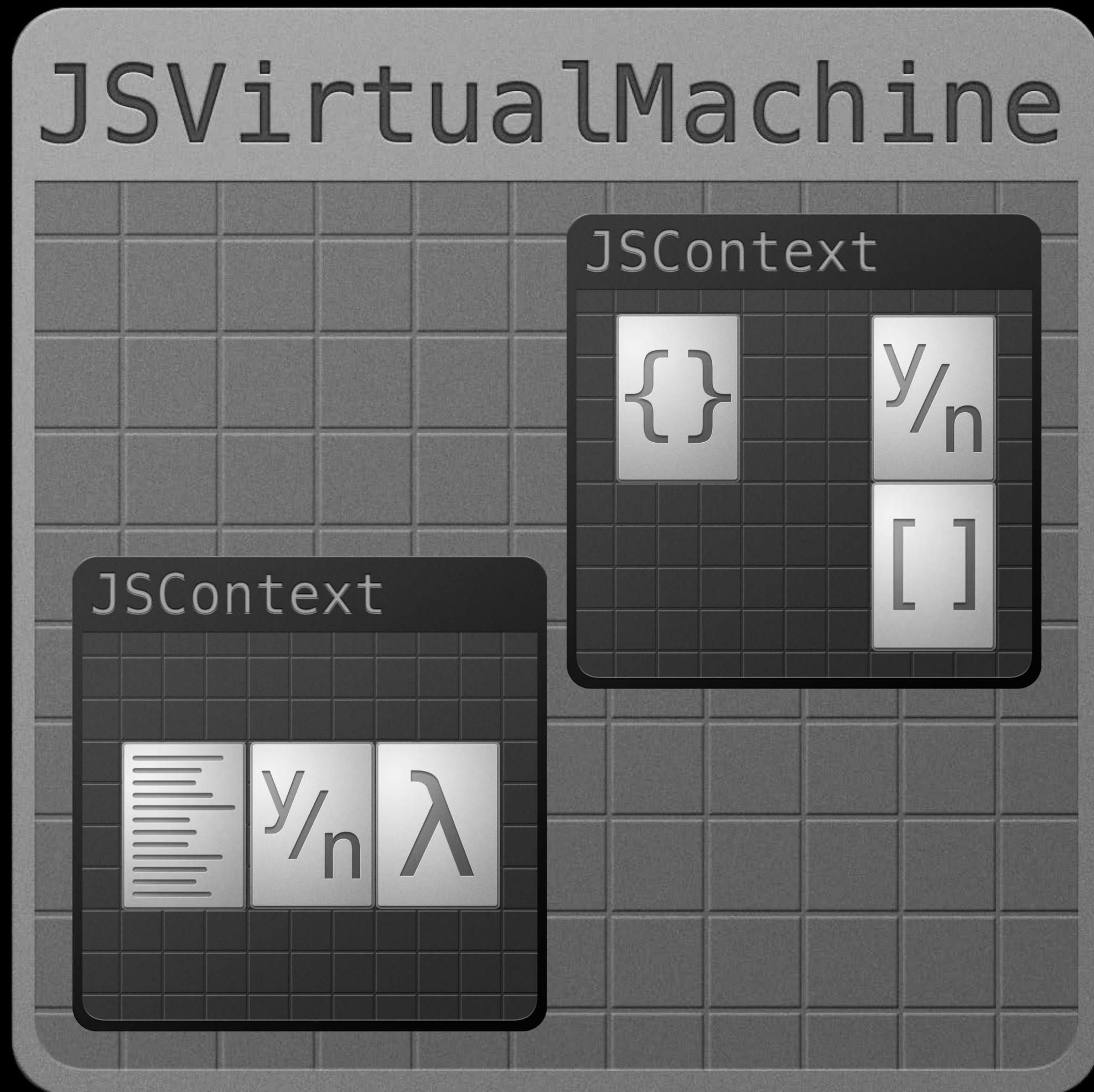


# JSVirtualMachine



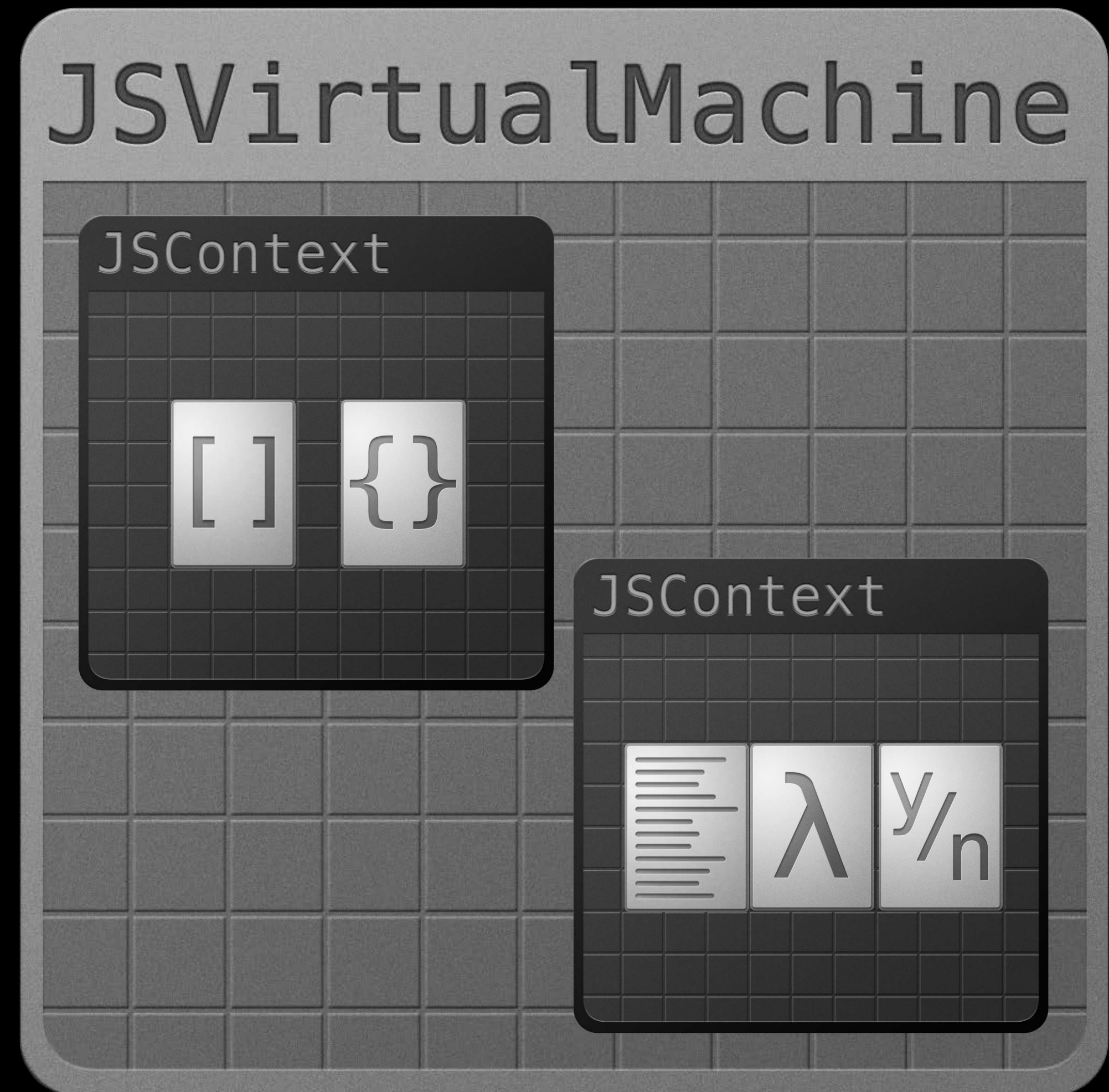
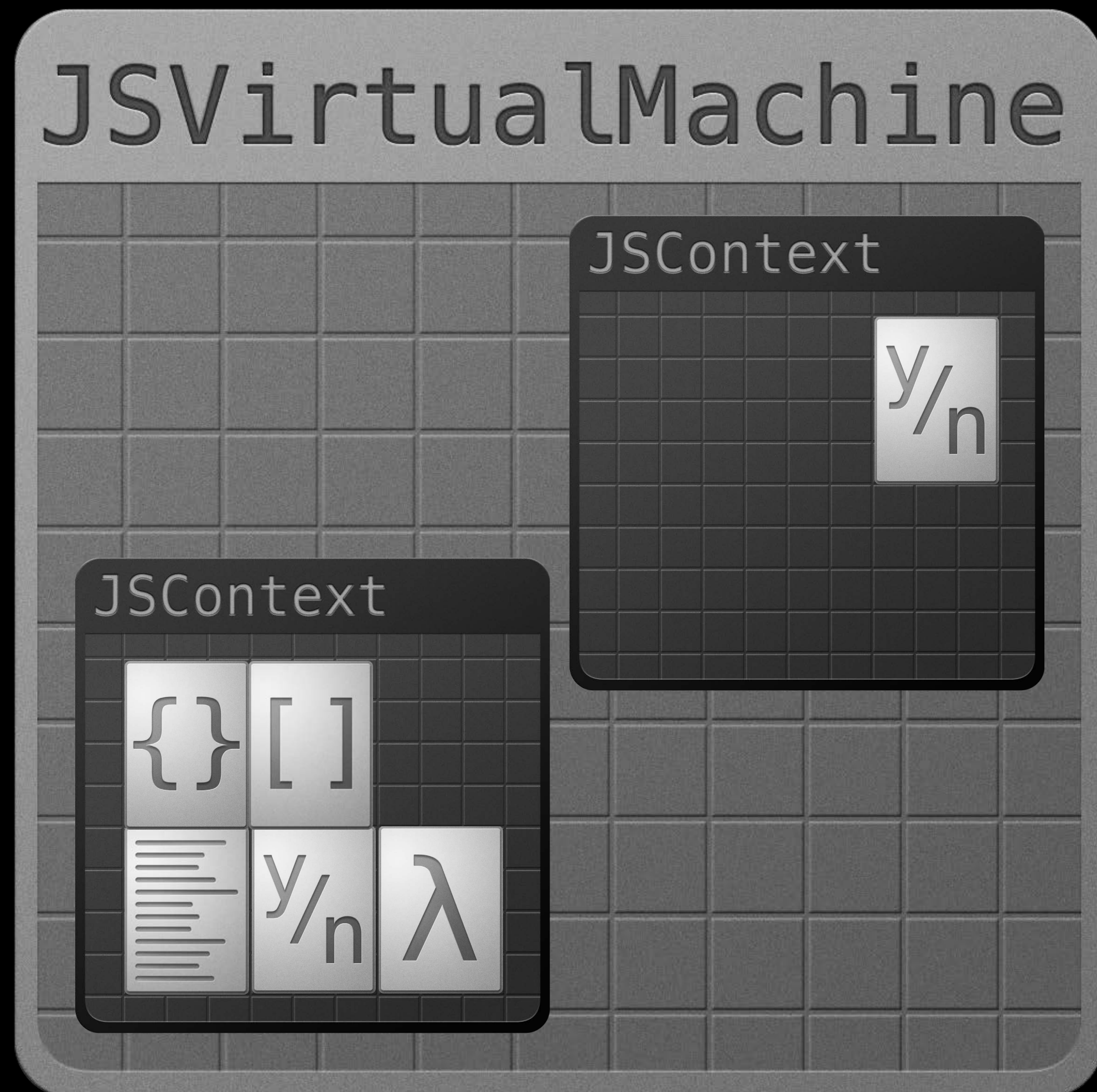


# JSVirtualMachine



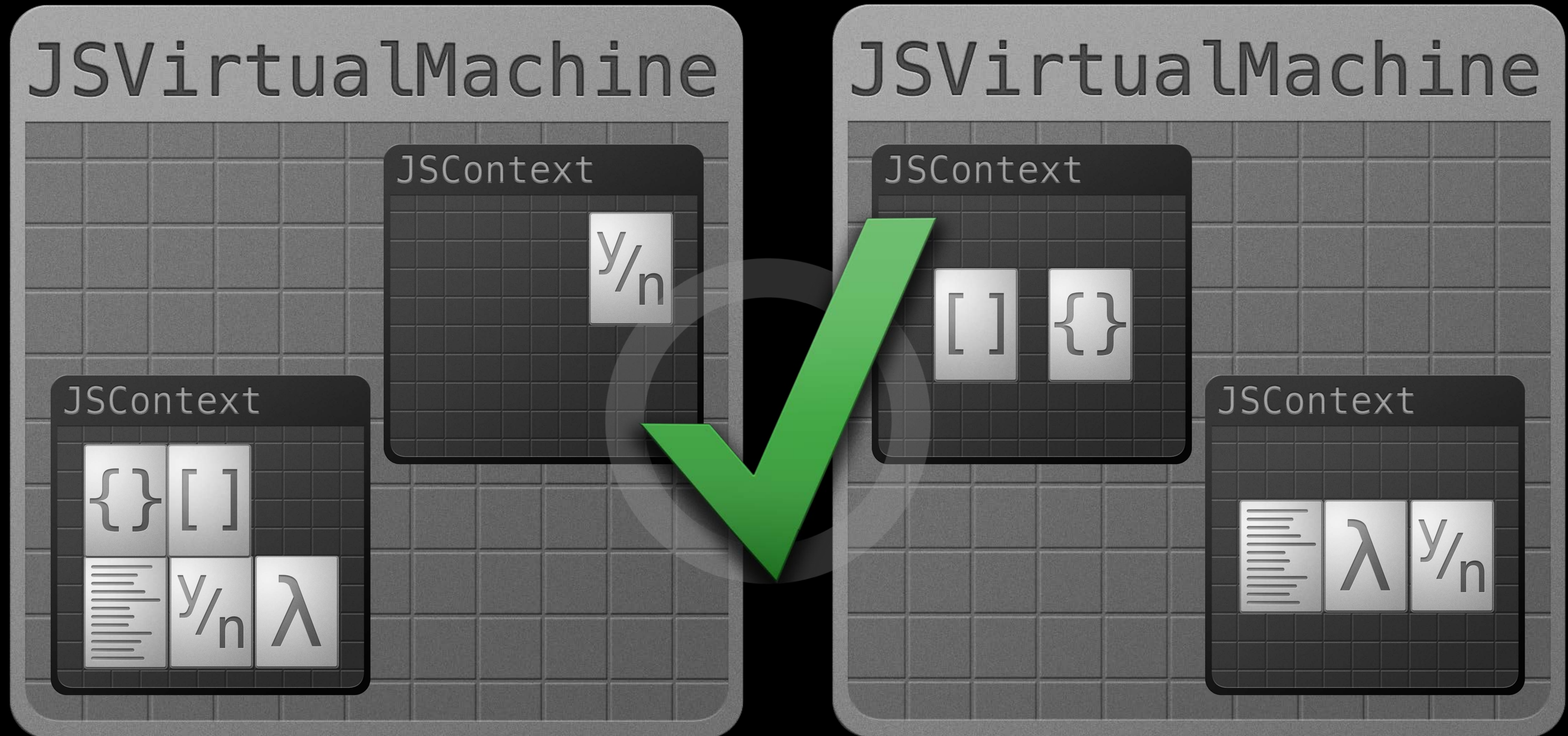


# JSVirtualMachine



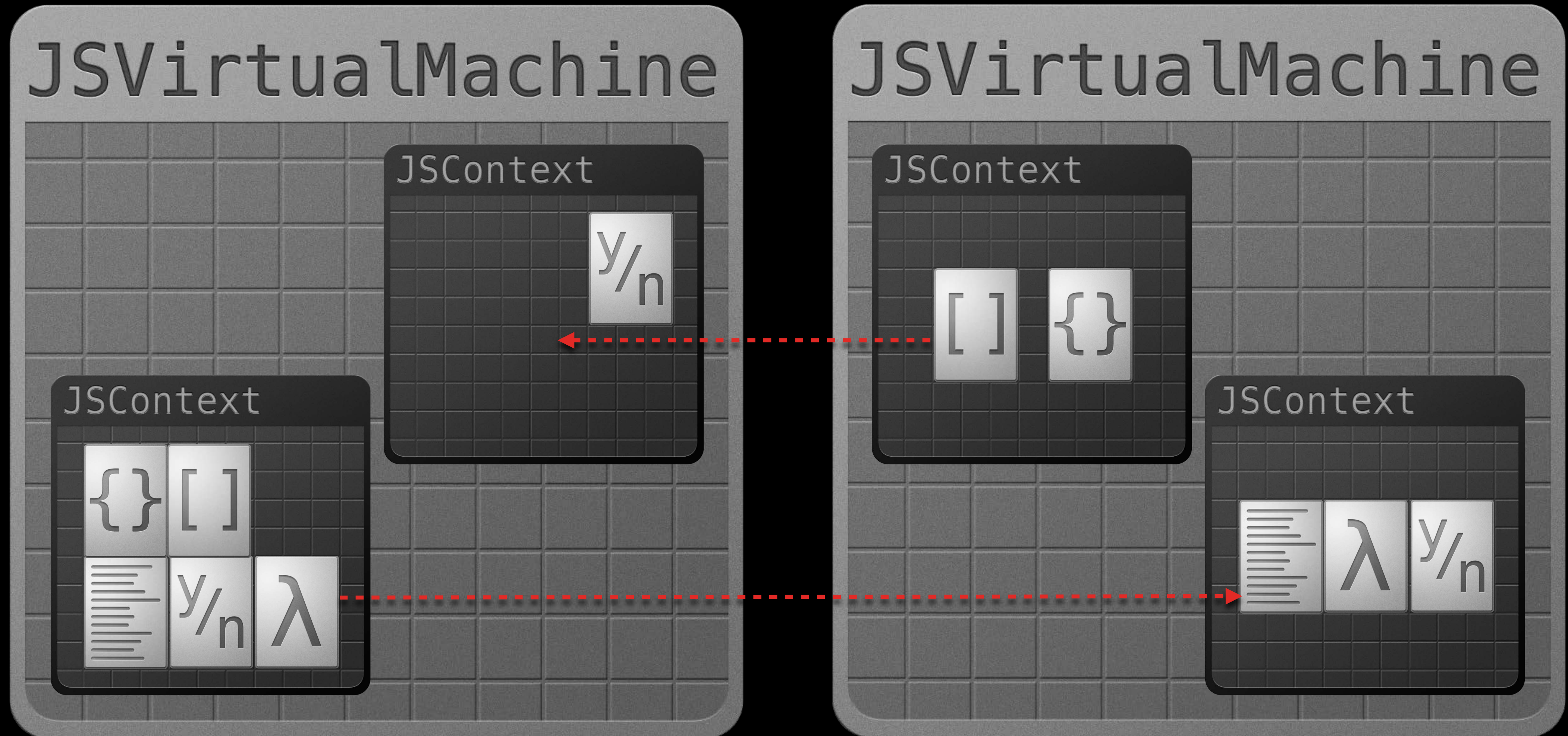


# JSVirtualMachine



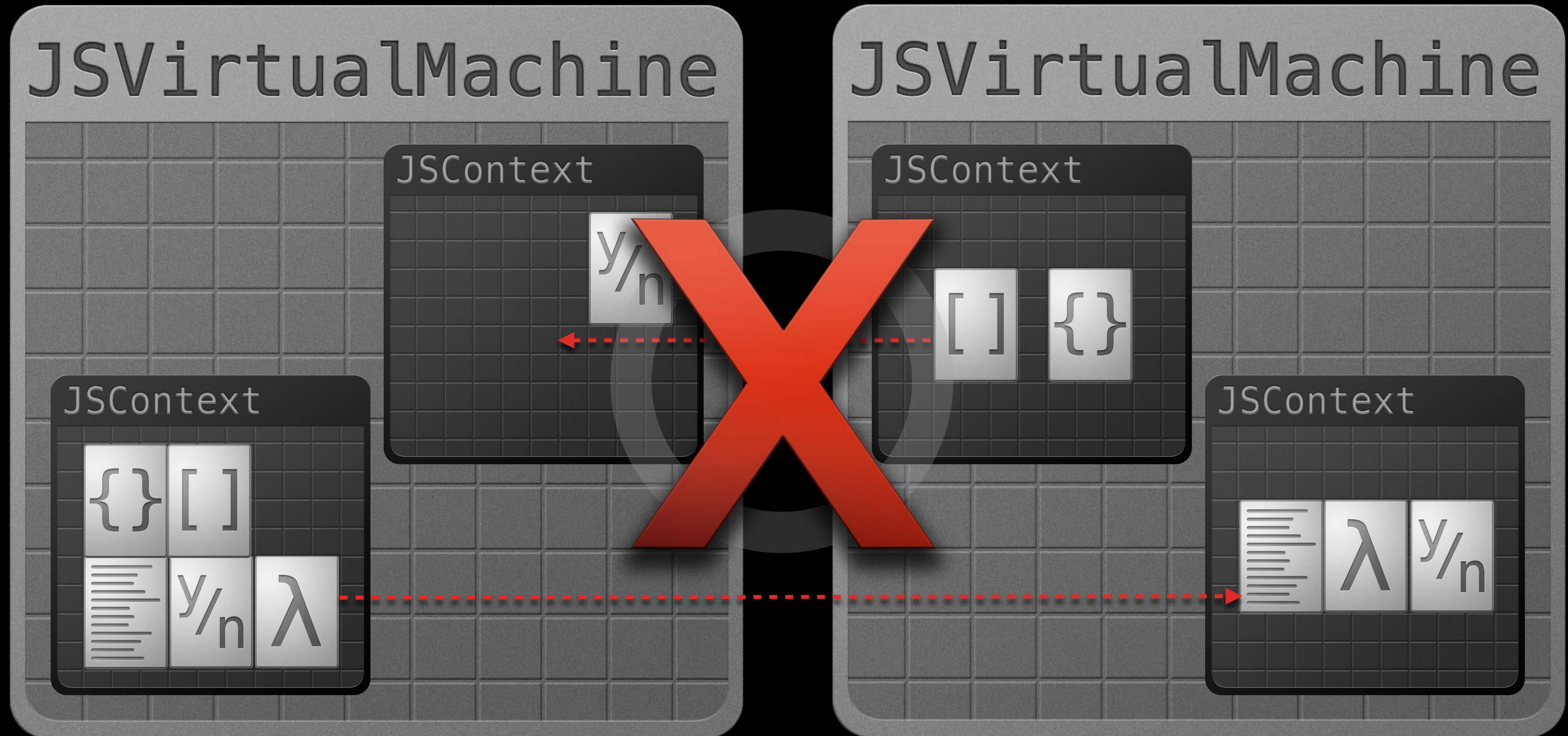


# JSVirtualMachine





# 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

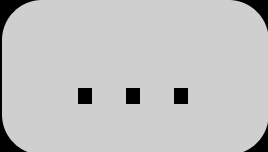
# Interfacing with the JavaScriptCore C API

# Interfacing with the C API

- JSValue  $\leftrightarrow$  JSValueRef
- JSContext  $\leftrightarrow$  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

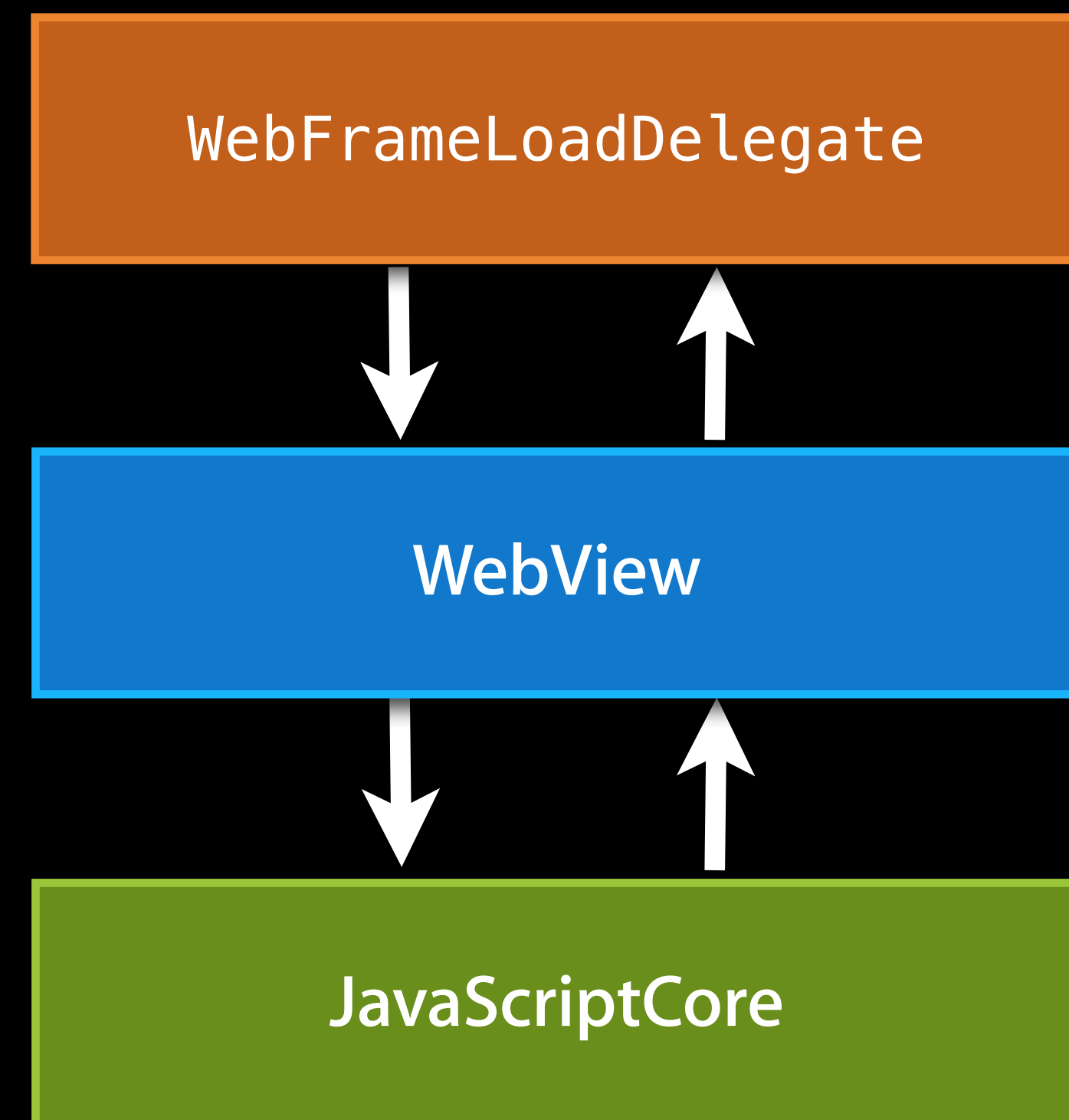


**WebKit WebView**

# WebKit WebView (Mac)

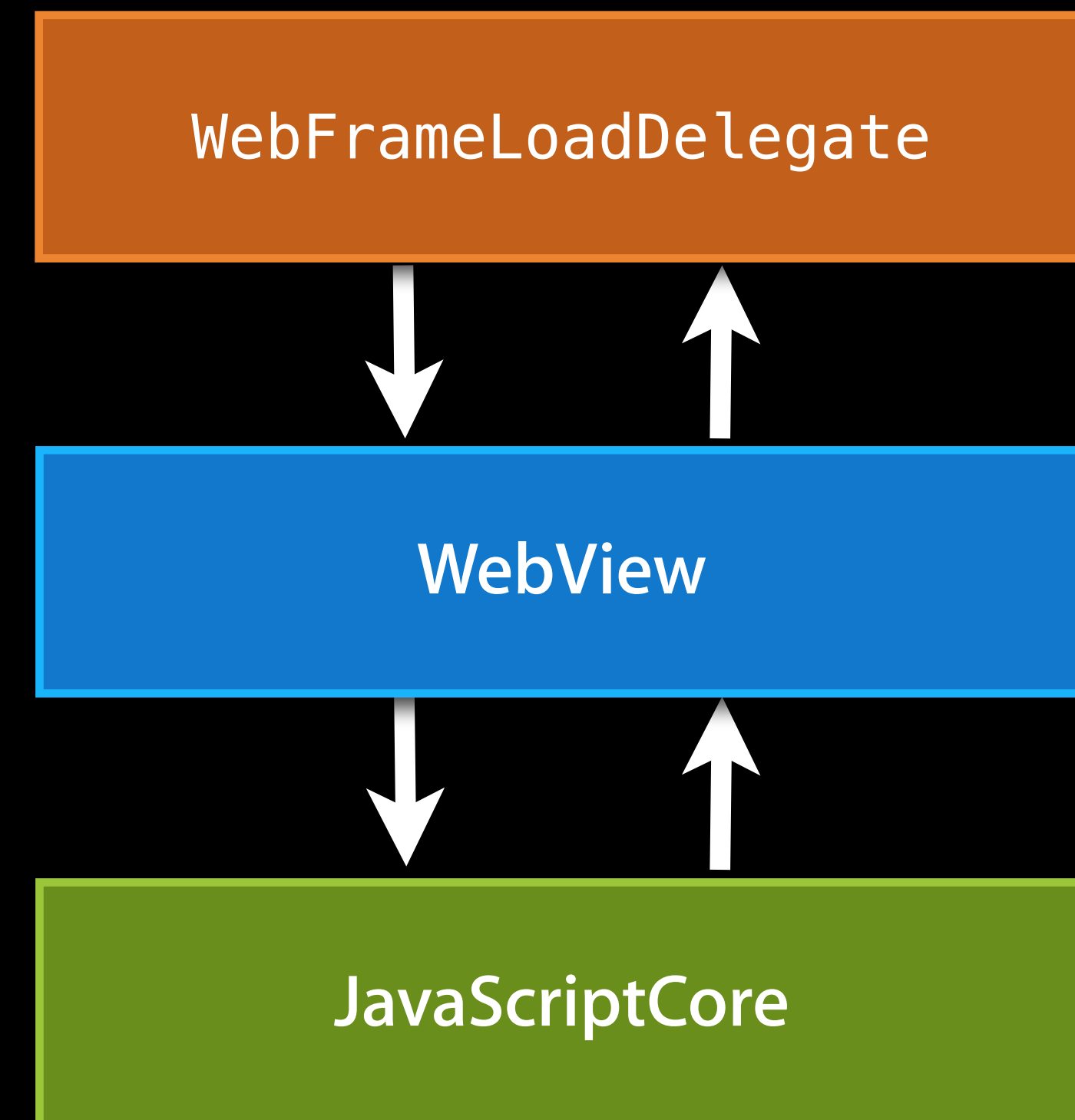
# WebKit WebView (Mac)

- `-webView:didCreateJavaScriptContext:forFrame:`



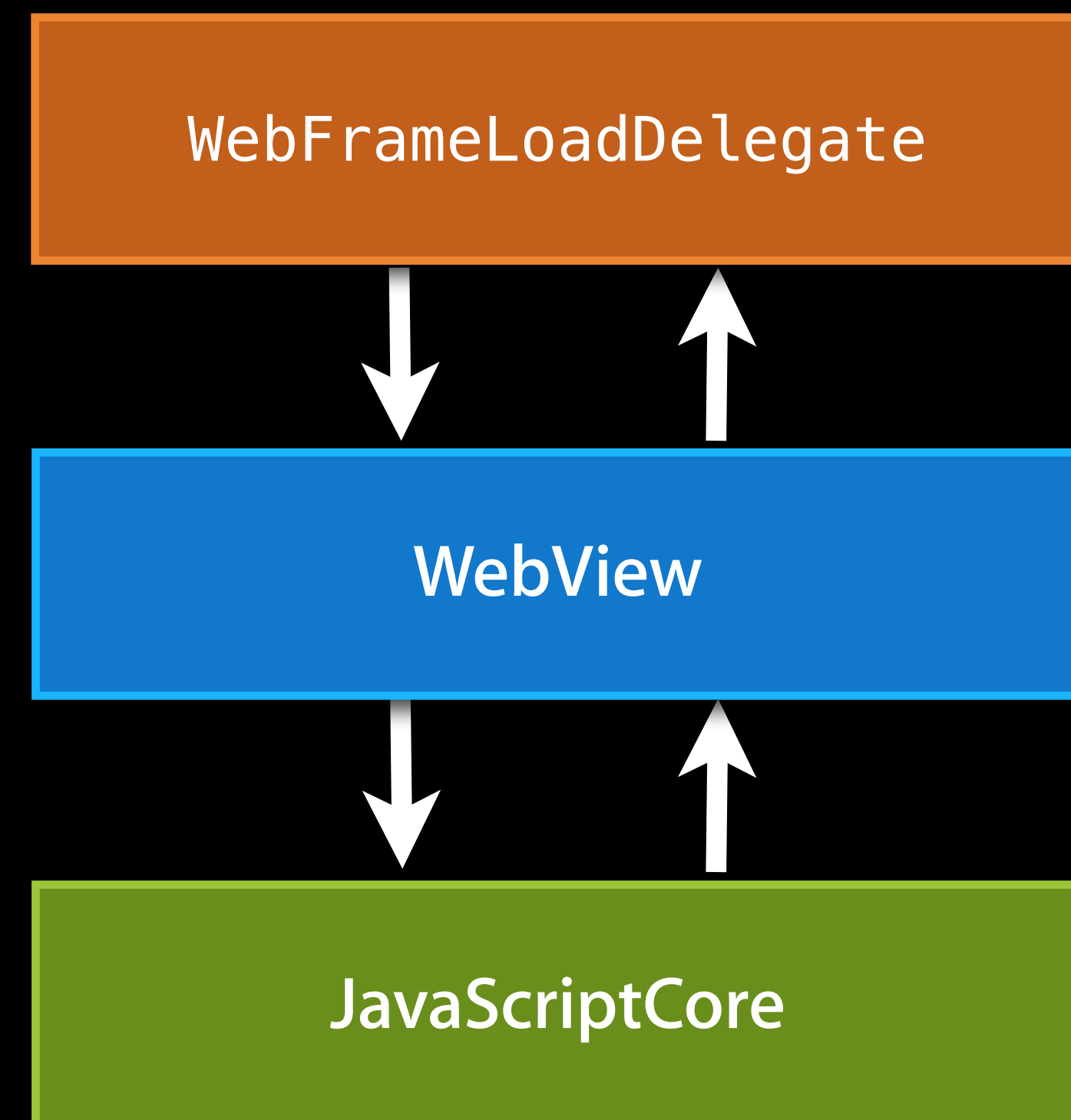
# WebKit WebView (Mac)

- `-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

## John Geleynse

Director, Technology Evangelism  
[geleynse@apple.com](mailto:geleynse@apple.com)

## Documentation

JavaScriptCore.framework Headers

[https://developer.apple.com/library/mac/#documentation/Carbon/Reference/  
WebKit\\_JavaScriptCore\\_Ref/](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

 WWDC2013