Objective-C Runtime in Practice

CocoaheadsBE - Kontich, 2013-12-03

Introduction

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I love...

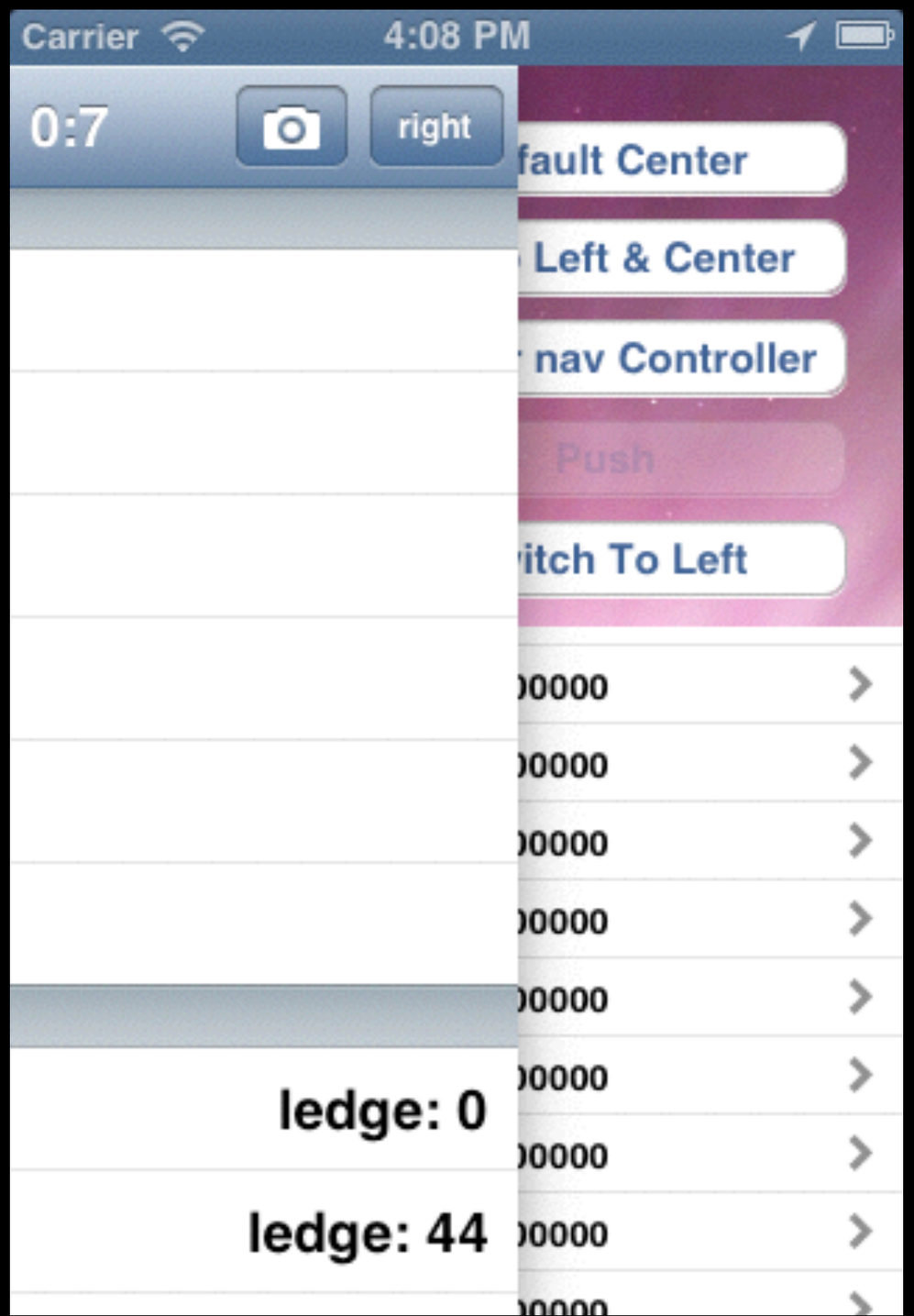
- ... my wife
- ... my 4 kids
- ... to code
- ... to play a game of squash
- ... good beer

I open sourced...

... some code:

- IIViewDeckController: “An implementation of the sliding functionality found in the Path 2.0 or Facebook iOS apps.”
- IIDateExtensions
- IIPopoverStatusItem

See: http://github.com/inferis



I made...

... some apps:

Butane

http://getbutane.com

Hi, @10to1!

Drash

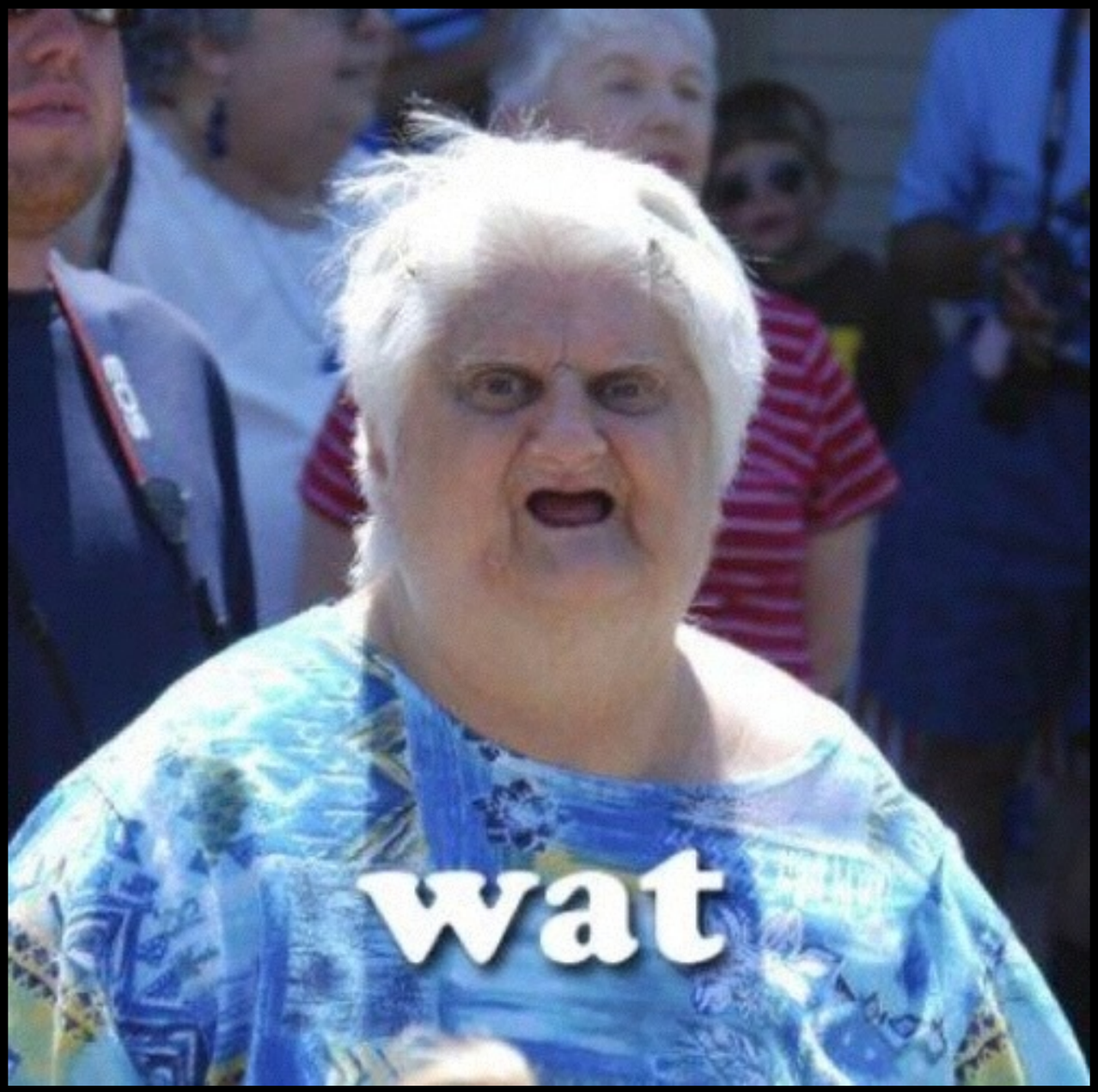
http://dra.sh

Agenda

Agenda

- RUNTIME WHUT?
- What is an object?
- In practice

RUNTIME



Runtime WHUT?

- obj-c runtime is "always present"
  - You can't use Objective-c without the runtime.
- Works behind the scenes:
  - most developers aren't even aware it is there and that they’r using it
  - puts the objective in Objective-C
- implemented as dynamic shared library
  - loaded by default by the OS

Runtime WHUT?

- Supports the most important features of the language
  - object oriented
  - messaging
  - protocols
  - dynamic typing
  - forwarding

Foundation

- is a support framework
  - included by default
- The Foundation framework defines a base layer of Objective-C classes.
  - a set of useful primitive object classes (NSObject, NSProxy, …)
  - introduces several paradigms that define functionality not covered by the Objective-C language.
  - reflection
  - memory management
  - archiving

C + Runtime = Obj-C

- The runtime is what makes objective-c.
- The runtime is the implementation of the syntactic "objective" sugar on top of c
  - You can write any cocoa program using pure C, but it's hard and verbose.

Demo

A pure C Objective-C app

In practice

- runtime.h overview
- Foundation.h, the “simple” stuff
- runtime.h, the “spicy” stuff

runtime.h

- #import <objc/runtime.h>
  - a number of C functions to interact with the runtime
- Several “categories” of interactions
  - `objc_...` interact with toplevel runtime (eg register a class)
  - `class_...` interact with classes (eg make subclass)
  - `object_...` interact with objects (eg get classname)
  - `method_...` interact with methods (eg get the number of arguments)
  - `ivar_...` interact with ivars (eg get the type of an ivar)
  - `property_...` interact with properties (eg get the name of a property)
  - `protocol_...` interact with protocols (eg get properties of a protocol)
  - `sel_...` interact with selectors (eg register selector names)
  - `imp_...` interact with method implementations (provide implementations using blocks)

C? Yuk.

Foundation.h to the rescue

- The Foundation library provides an obj-c interface to some of the runtime calls.

```
#include <Foundation/Foundation.h>
```

- Check your .pch file: it should be there
  - iOS: directly
  - OSX: via `#include <Cocoa.h>`.

Foundation.h to the rescue

- NSObject:
  - `-(BOOL)isKindOfClass:(Class)class;`
  - `-(Class)class;`
- Functions:
  - `NSString* NSStringFromClass(Class aClass);`
  - `Class NSSelectorFromString(NSString* aSelectorName);`

Dealing with classes

- `+ (Class)class;`
  - Returns self (the class object). Since this is a class object, it returns the class itself.
- `+ (Class)superclass;`
  - Returns the class object for the receiver's superclass. Gets the parent class of a given class.
- `+ (BOOL)isSubclassOfClass:(Class)aClass;`
  - Returns a Boolean value that indicates whether the receiving class is a subclass of, or identical to, a given class.

Demo

Classes

Dealing with classes

- `- (BOOL)isKindOfClass:(Class)aClass;`
  - Returns a Boolean value that indicates whether the receiver is an instance of given class or an instance of any class that inherits from that class.
- `- (BOOL)isMemberOfClass:(Class)aClass;`
  - Returns a Boolean value that indicates whether the receiver is an instance of a given class.
- These are not the same!
  - isKindOfClass also works on subclass instances
  - isMemberOfClass only works on exact class instances

Demo

More classes

Protocols

- `- (BOOL)conformsToProtocol:(Protocol *)aProtocol;`
  - Returns a Boolean value that indicates whether the receiver conforms to a given protocol.
  - A class is said to “conform to” a protocol if it adopts the protocol or inherits from another class that adopts it. Protocols are adopted by listing them within angle brackets after the interface declaration.
  - This does not mean that the class listens to the protocols messages explicitly!

Messages

- `- (BOOL)respondsToSelector:(SEL)selector`
  - Returns a Boolean value that indicates whether the receiving class responds to a given selector.
  - If this returns YES, you can safely send the message to the object.
- `+ (BOOL)instancesRespondToSelector:(SEL)aSelector;`
  - Returns a Boolean value that indicates whether instances of the receiver are capable of responding to a given selector.
  - When you have a Class handy and not an instance of that class. Saves you creating an instance.
  - Is smart enough to discover if the class actually implements the message!
- `- (id)performSelector:(SEL)selector`
  - Sends a specified message to the receiver and returns the result of the message.

Demo

protocols & messages

Dynamic messaging

- So what actually happens when you call [foo bar]?
  - when foo implements bar, that bar get executed. **Instant happy.**
  - but what when there's no bar implementation?
    1. try Lazy Method Resolution
    2. try Fast forwarding
    3. try Normal forwarding
    4. *kaboom*

Dynamic messaging

1. **Lazy method resolution**
   the runtime sends +resolveInstanceMethod:
   (or +resolveClassMethod: for class methods)
   to the class in question.
   - If that method returns YES, the message send is restarted under the assumption that the appropriate method has now been added.
2. **Fast forwarding**
3. **Normal forwarding**
4. ***kaboom***

Dynamic messaging

1. **Lazy method resolution**
2. **Fast forwarding**
   The instance receiving the message is sent `-forwardingTargetForSelector:`, but only if it implements it.
   - If it implements this method and it returns something other than nil or self, the whole message sending process is restarted with that return value as the new target.
     - forwards the message to another object
     - no method implementation is added
     - target object can use whatever method implementation as it sees fit.
3. **Normal forwarding**
4. ***kaboom***

Dynamic messaging

1. **Lazy method resolution**
2. **Fast forwarding**
3. **Normal forwarding**
   Two step process:
   1. First the runtime will send -instanceMethodSignatureForSelector: to see what kind of argument and return types are present.
   2. If a valid method signature is returned, the runtime creates an NSInvocation describing the message being sent
   3. finally -forwardInvocation: is sent to the instance. The instance should then use the NSInvocation on a target object to execute the method.
4. ***kaboom***

Dynamic messaging

1. **Lazy method resolution**
2. **Fast forwarding**
3. **Normal forwarding**
4. ***kaboom***

The runtime calls -doesNotRecognizeSelector: on the instance.

- Default behavior is to throw an NSInvalidArgumentException, but you could override this if you'd want to
  - but! be careful -> errors will go undetected!

Lazy method resolution

- Resolves/creates a method at runtime. Allows a class to create a method when it doesn't exist.
- Override one (or both) of these:
- `+ (BOOL)resolveClassMethod:(SEL)sel;`
  - Dynamically provides an implementation for a given selector for a class method.
- `+ (BOOL)resolveInstanceMethod:(SEL)sel;`
  - Dynamically provides an implementation for a given selector for an instance method.

Lazy method resolution

- So how does this work?
  - implement +resolveInstanceMethod:
  - check the selector
  - provide an implementation
    - class_addMethod()
    - need a method IMP:
      - copy an existing method
      - use a function
      - make new method using a block

- Same applies to +resolveClassMethod:
- resolve happens the first time a method is not found (and only then if you return YES from the resolver method)
- if you don't add an implementation but return YES anyway the you'll get an NSInvalidArgumentException.

Demo

lazy method resolution

Fast forwarding

- You can provide an interface but have the actual implementation be in another object.
- forward messages from one object to another
  - for the user, it is as if the first object handles the call
  - the actual handling object is "hidden" from the user

- So how does this work?
  - implement -forwardingTargetForSelector:
  - check the selector
  - provide an object that can handle the selector

Demo

fast forwarding

Normal forwarding

- have the object provide a method signature for the selector, so the runtime knows what arguments and return type there should be.
  - then forward an NSInvocation on an object you choose.
  - basically the same as fast forwarding but more low level and a bit more verbose
- So how does this work?
  - implement +instanceMethodSignatureForSelector:
  - check the selector
  - provide an NSMethodSignature* that describes the selector
  - implement forwardInvocation:

Demo

normal forwarding

Swizzling

- Swizzling is exchanging the implementation of one *factor* of the runtime with another *factor*. In Objective-C, you can apply this on two levels: method swizzling and class swizzling.
  - Method swizzling
  - Class swizzling
  - Dynamic class generation

Method swizzling

- You need to have two methods with an implementation
- Can exchange the implementation of the methods with each other
- Not only in your own code, but you can modify framework code too! (eg UIView, …)

Demo

method swizzling

Class swizzling

- No real swizzling…
- Just change the class on an existing object
  - best used with subclasses or classes with the same layout/interface
    - memory allocation is not changed when changing classes
  - otherwise: NUKULAR EXCEPTION

Demo

class swizzling

Dynamic class generation

- Generate a class at runtime
  - Provide methods and implementations as you see fit
  - add new functionality
  - change existing functionality

Demo

dynamic class generation

For closing…

- Generated properties
  - provide property storage in your own backing (eg plist)
- No implementations in code
  - generate them at runtime
  - only provide methods in interface
    - no compiler warnings

Demo

property generation

Warning-fixing

- When providing dynamic implementations of selectors, the compiler will emit warnings for the “unimplemented” messages.
  - Fix these by placing them in a category instead of in the @interface declaration

```
@interface AwesomeClass
@end

@interface AwesomeClass (Dynamic)
// look ma, no warning
- (void)withoutCodeButDynamicallyGenerated;

@end
```

- For properties
  - declare a property as you normally would using @property syntax in your @interface
  - specify @dynamic <propertyName> in you @implementation to make sure the compiler doesn’t autosynthesize the property
  - or use the same technique as above

Opensourced examples

- You can find the example projects use to demo each aspect in my Github account:
  - https://github.com/Inferis/Objective-C-Runtime

Useful References

- Apple's runtime documentation:
  - runtime reference: https://developer.apple.com/library/mac/documentation/cocoa/reference/objcruntimeref/Reference/reference.html
  - programming guide: https://developer.apple.com/library/mac/documentation/cocoa/conceptual/objcruntimeguide/objcruntimeguide.pdf
- Mike Ash's blog: http://www.mikeash.com/pyblog
  - objective-c: http://www.mikeash.com/pyblog/?tag=objectiveC
  - friday Q&A: http://www.mikeash.com/pyblog/?tag=fridayqna
- Jon Rentzsch swizzling helpers:
  - https://github.com/rentzsch/jrswizzle

Thanks for listening.

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