Performance on iOS and watchOS

Strategies and tools

Session 230

Ben Englert iOS Performance

Introduction

Why should I think about performance?

Introduction

Why should I think about performance?

How should I think about performance?

Introduction

Why should I think about performance?

How should I think about performance?

Specific strategies

Introduction

Why should I think about performance?

How should I think about performance?

Specific strategies

New platform: watchOS 2

Performance Is a Feature

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Responsiveness delights and engages users

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Be a good neighbor, especially in Multitasking on iPad

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Responsiveness delights and engages users

Be a good neighbor, especially in Multitasking on iPad

Efficient apps extend battery life

Performance Is a Feature

Responsiveness delights and engages users

Be a good neighbor, especially in Multitasking on iPad

Efficient apps extend battery life

Supports the whole range of iOS 9 hardware

Thinking About Performance

Thinking About Performance

Choosing technologies

Thinking About Performance

Choosing technologies

Taking measurements

Thinking About Performance

Choosing technologies

Taking measurements

Setting goals

Thinking About Performance

Choosing technologies

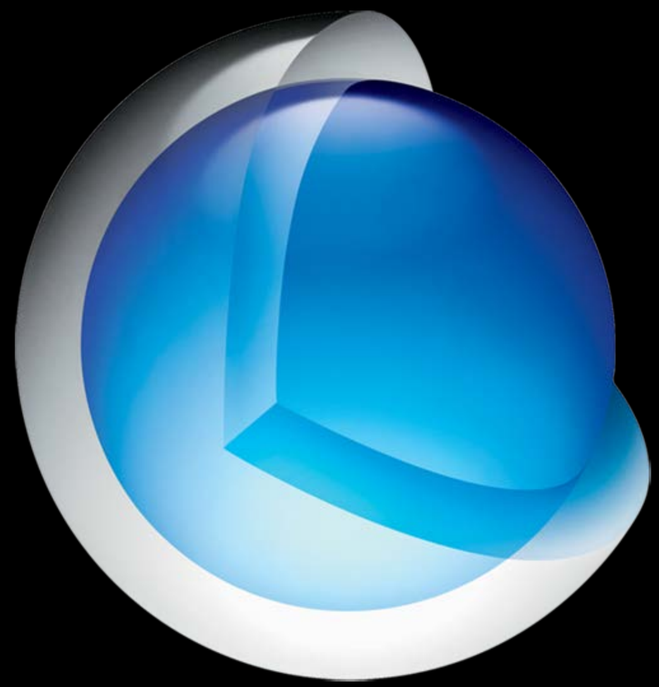
Taking measurements

Setting goals

Performance workflow

Use the Right Tool for the Job

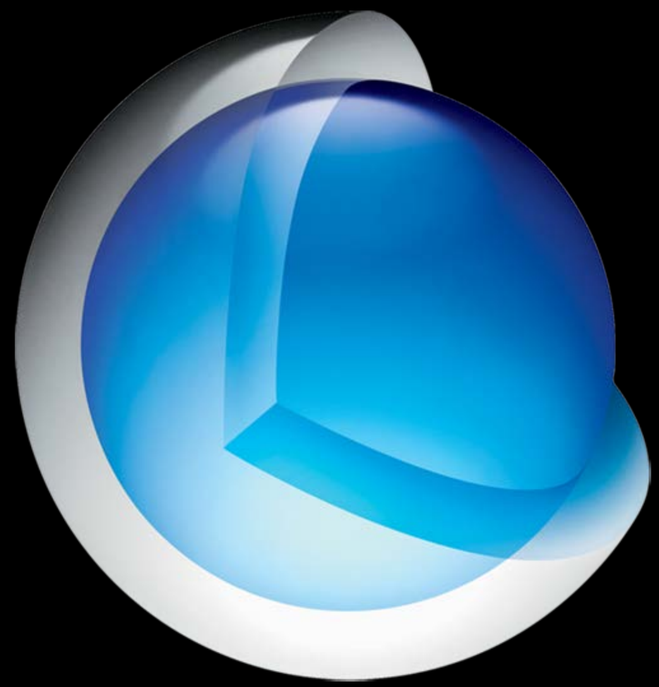
Proactively architect your app for great performance



Use the Right Tool for the Job

Proactively architect your app for great performance

Know the technologies



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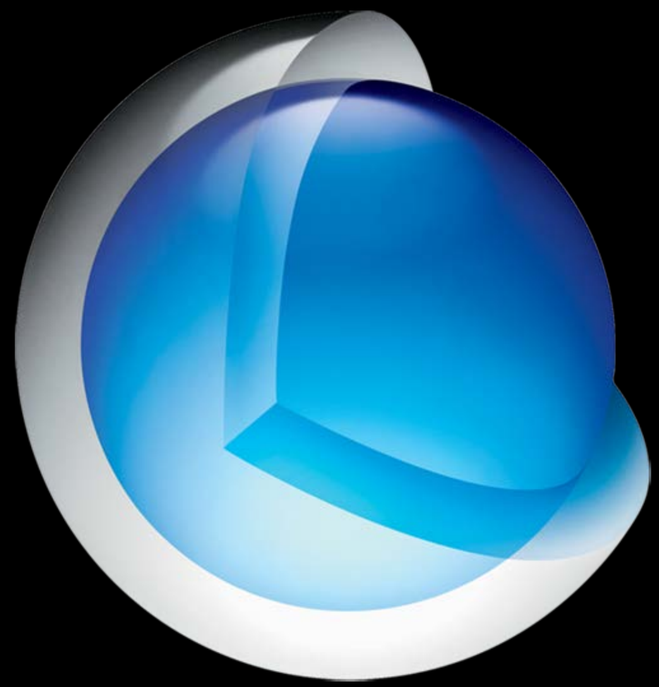

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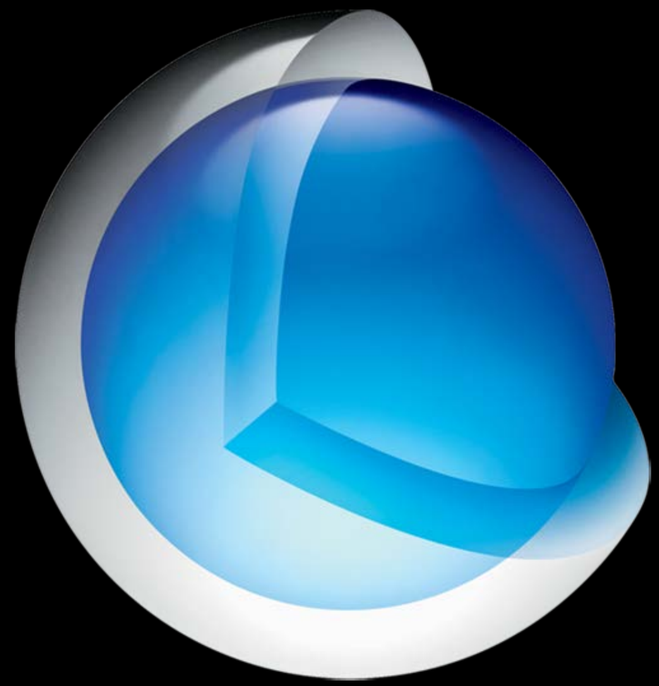
Apple technologies are optimized
(we use them)



Use the Right Tool for the Job

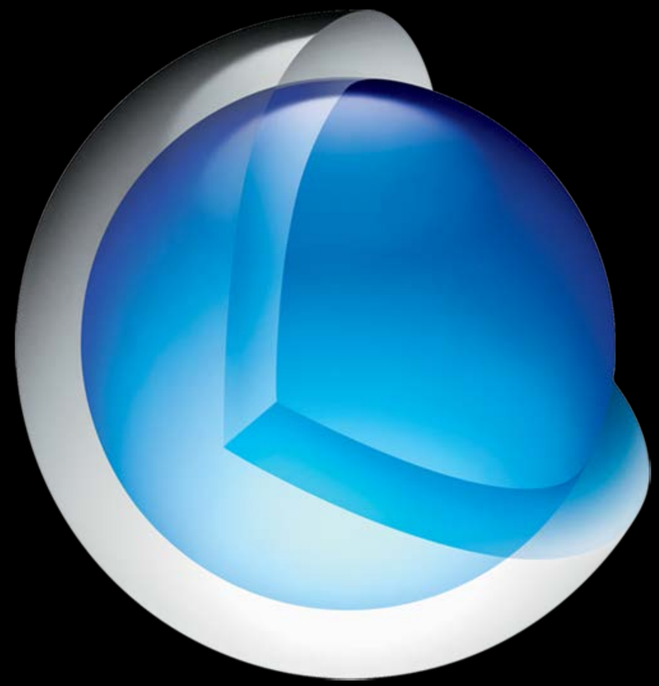
Proactively architect your app for great performance

Know the technologies

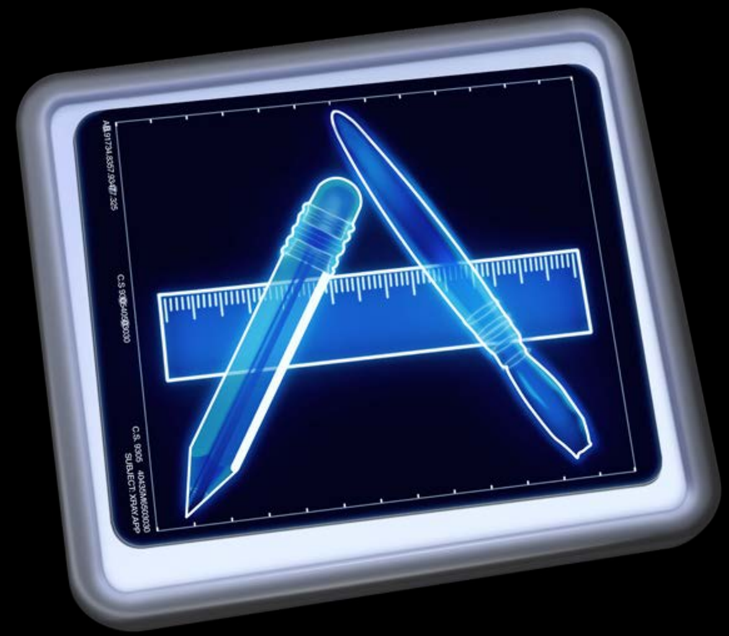
Pick the best ones for your app

Apple technologies are optimized (we use them)

Benefit from software updates

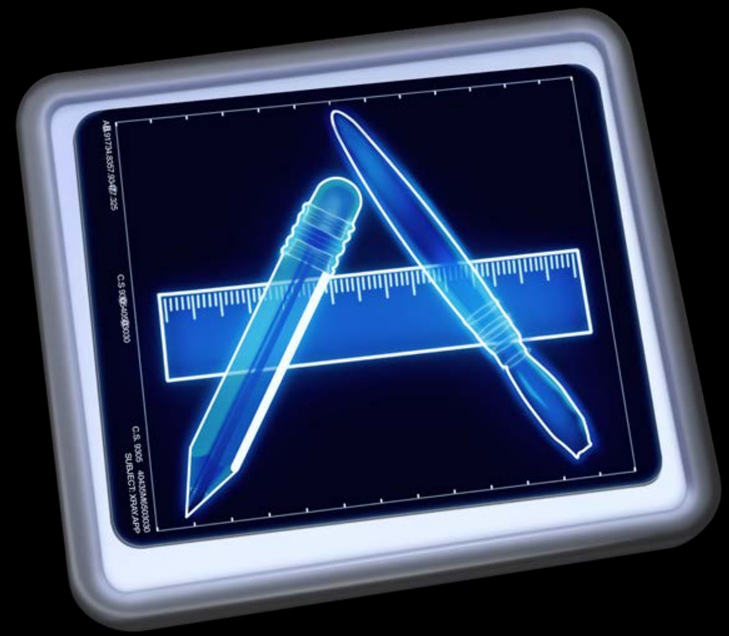


Measuring Performance



Measuring Performance

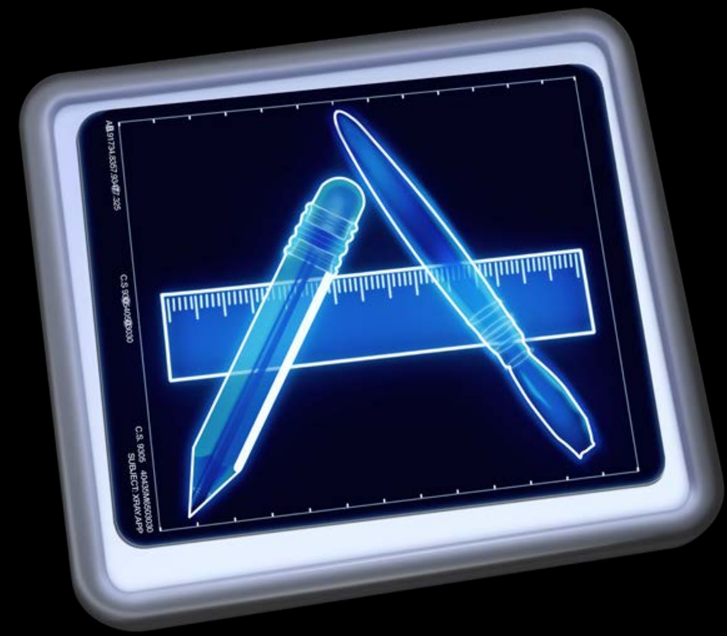
Animations



Measuring Performance

Animations

- Instruments: Core Animation



Measuring Performance

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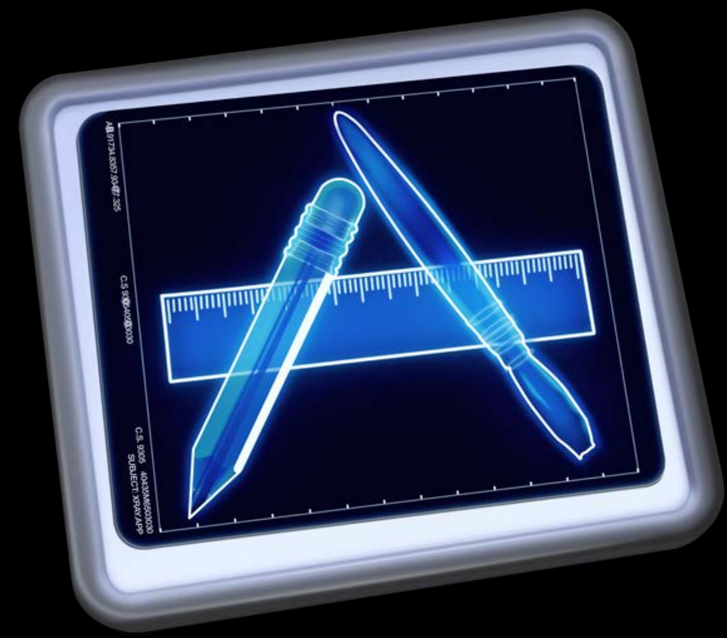
Responsiveness



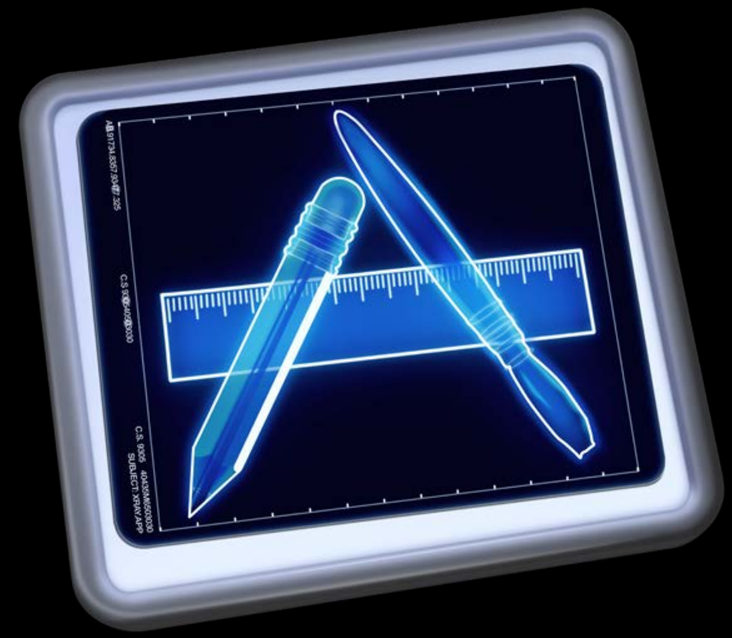
Measuring Performance

Animations

- Instruments: Core Animation

Responsiveness

- Code instrumentation



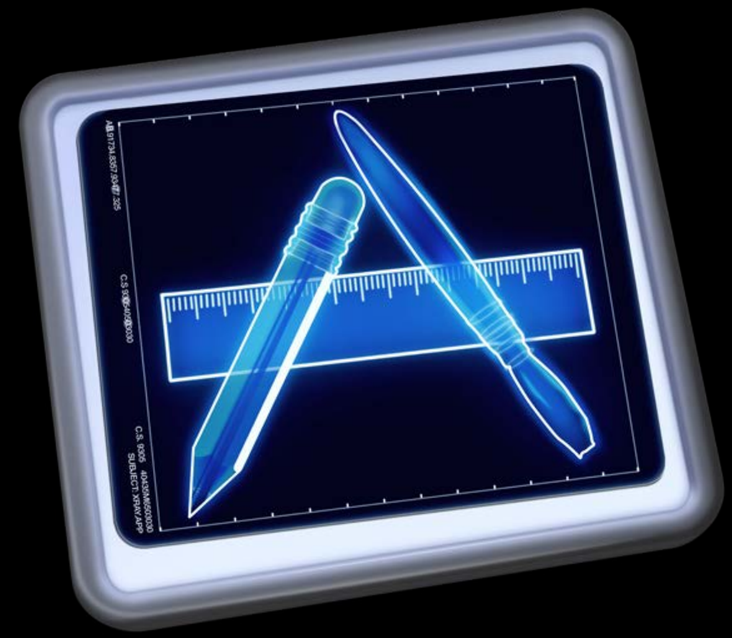
Measuring Performance

Animations

- Instruments: Core Animation

Responsiveness

- Code instrumentation
- Instruments: System Trace



Measuring Performance

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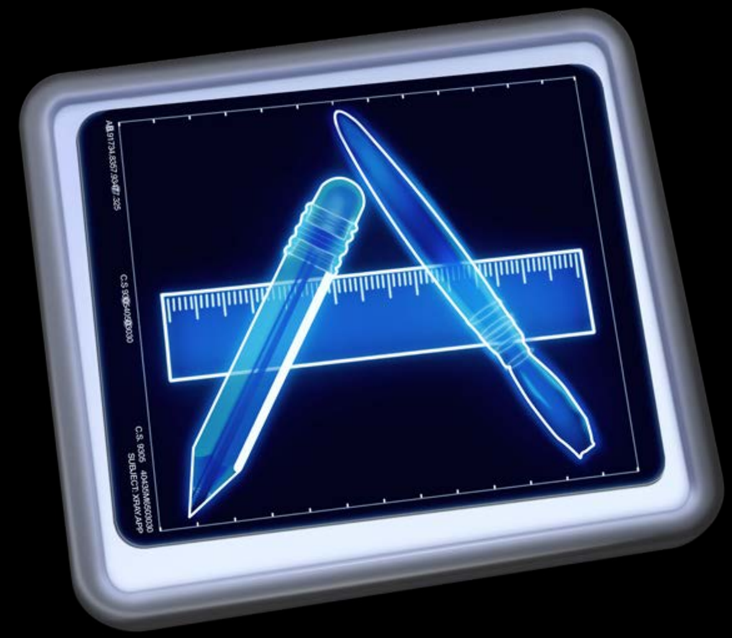
Memory



Measuring Performance

Animations

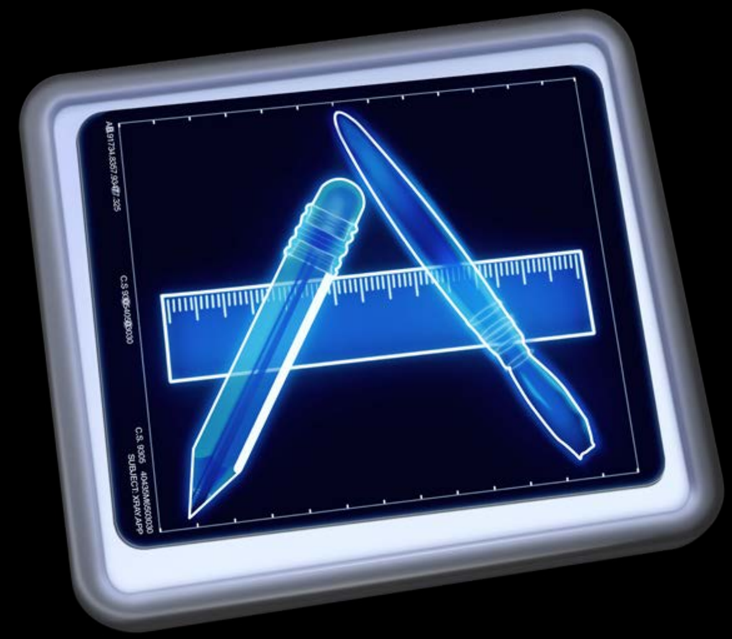
- Instruments: Core Animation

Responsiveness

- Code instrumentation
- Instruments: System Trace

Memory

- Xcode debugger



Measuring Performance

Animations

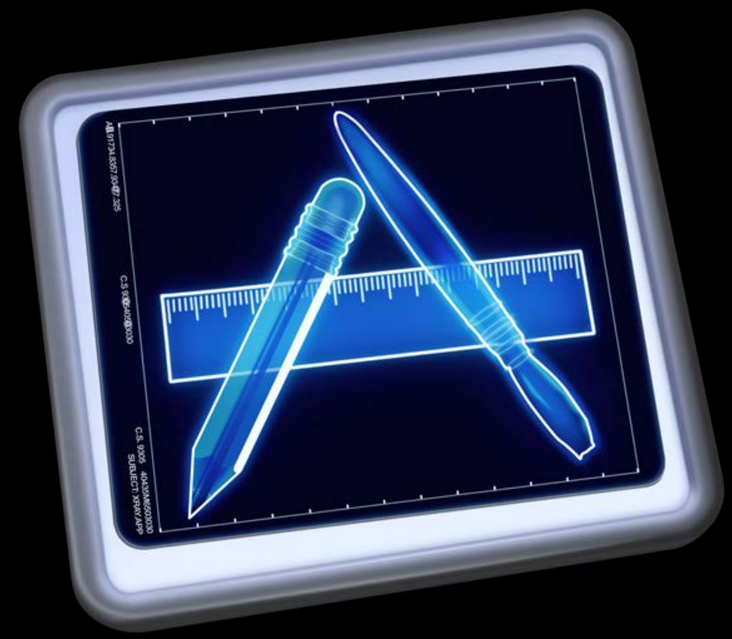
- Instruments: Core Animation

Responsiveness

- Code instrumentation
- Instruments: System Trace

Memory

- Xcode debugger
- Instruments: Allocations



Measuring Performance

Animations

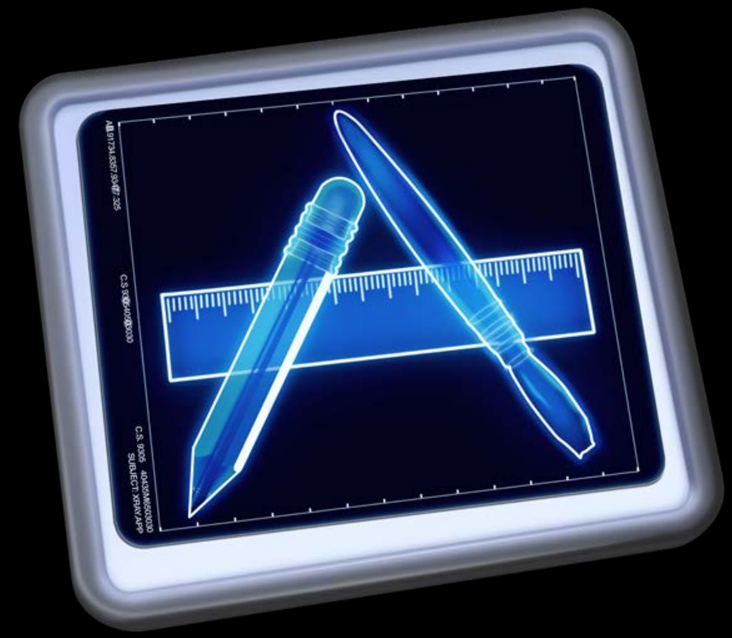
- Instruments: Core Animation

Responsiveness

- Code instrumentation
- Instruments: System Trace

Memory

- Xcode debugger
- Instruments: Allocations
- Instruments: Leaks



Code Instrumentation

Measuring responsiveness

```
@IBAction func showImageTapped(sender: UIButton) {
    let myData = NSData(contentsOfFile: self.path)!
    let myImage = self.watermarkedImageFromData(myData)
    self.imageView.image = myImage
}
```

Code Instrumentation

Collect start and end times

```
@IBAction func showImageTapped(sender: UIButton) {
    let startTime = CFAbsoluteTimeGetCurrent()
    let myData = NSData(contentsOfFile: self.path)!
    let myImage = self.watermarkedImageFromData(myData)
    self.imageView.image = myImage
    let endTime = CFAbsoluteTimeGetCurrent()
}
```

Code Instrumentation

Convert to appropriate units

```
@IBAction func showImageTapped(sender: UIButton) {
    let startTime = CFAbsoluteTimeGetCurrent()
    let myData = NSData(contentsOfFile: self.path)!
    let myImage = self.watermarkedImageFromData(myData)
    self.imageView.image = myImage
    let endTime = CFAbsoluteTimeGetCurrent()
    let totalTime = (endTime - startTime) * 1000
    print("showImageTappedTimed took \(totalTime) milliseconds")
}
```

Code Instrumentation

Don’t ship your instrumentation

```
    @IBAction func showImageTapped(sender: UIButton) {
#if MEASURE_PERFORMANCE
        let startTime = CFAbsoluteTimeGetCurrent()
#endif
        let myData = NSData(contentsOfFile: self.path)!
        let myImage = self.watermarkedImageFromData(myData)
        self.imageView.image = myImage
#if MEASURE_PERFORMANCE
        let endTime = CFAbsoluteTimeGetCurrent()
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Code Instrumentation

Measuring responsiveness

Code Instrumentation

Measuring responsiveness

Taps and button presses

Code Instrumentation

Measuring responsiveness

Taps and button presses

- IBAction

Code Instrumentation

Measuring responsiveness

Taps and button presses

- IBAction
- touchesEnded

Code Instrumentation

Measuring responsiveness

Taps and button presses

- IBAction
- touchesEnded
- UIGestureRecognizer target

Code Instrumentation

Measuring responsiveness

Taps and button presses

- IBAction
- touchesEnded
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Tabs and modal views

Code Instrumentation

Measuring responsiveness

Taps and button presses

- IBAction
- touchesEnded
- UIGestureRecognizer target

Tabs and modal views

- viewWillAppear and viewDidAppear

Setting Performance Goals

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60fps scrolling and animations

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60fps scrolling and animations

Setting Performance Goals

Setting Performance Goals

Respond to user actions in 100ms

Setting Performance Goals

Respond to user actions in 100ms

…on older devices!

Setting Performance Goals

Respond to user actions in 100ms

…on older devices!

Performance Workflow

Performance Workflow

Don’t guess

Performance Workflow

Don’t guess

Avoid premature optimization

Performance Workflow

Don’t guess

Avoid premature optimization

Make one change at a time

Performance Workflow

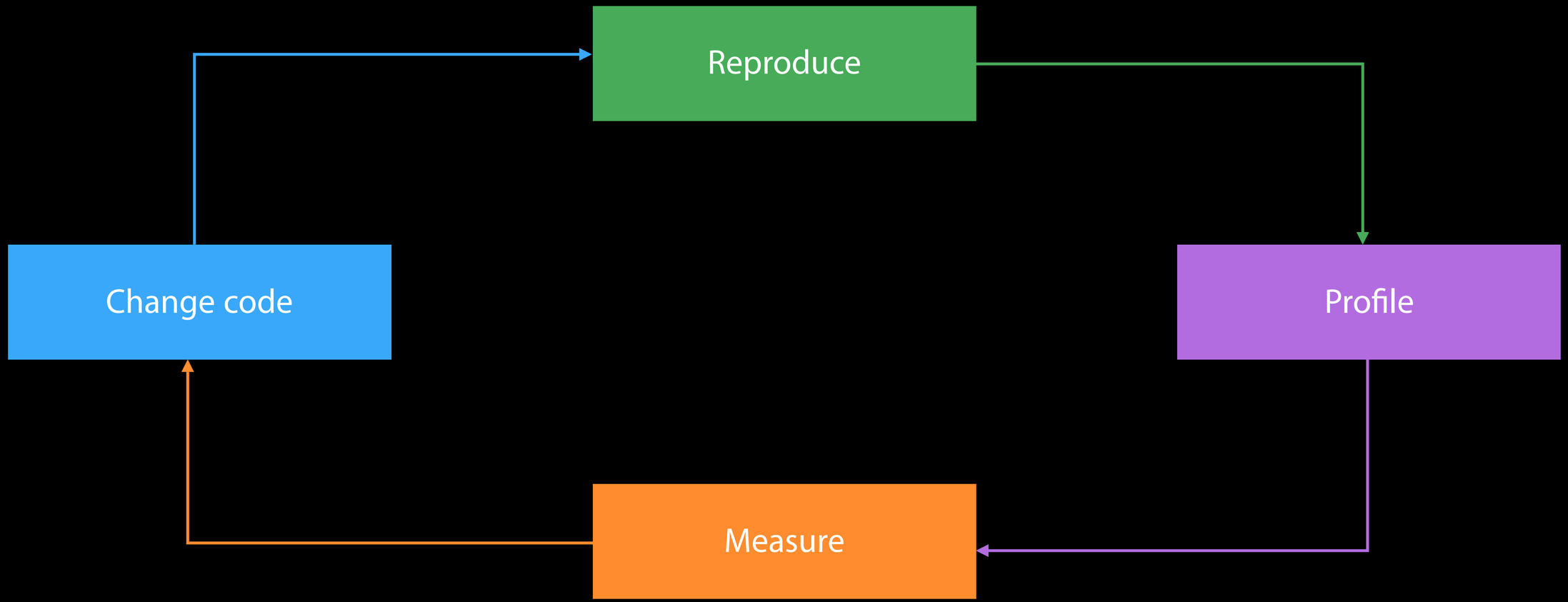
Don’t guess

Avoid premature optimization

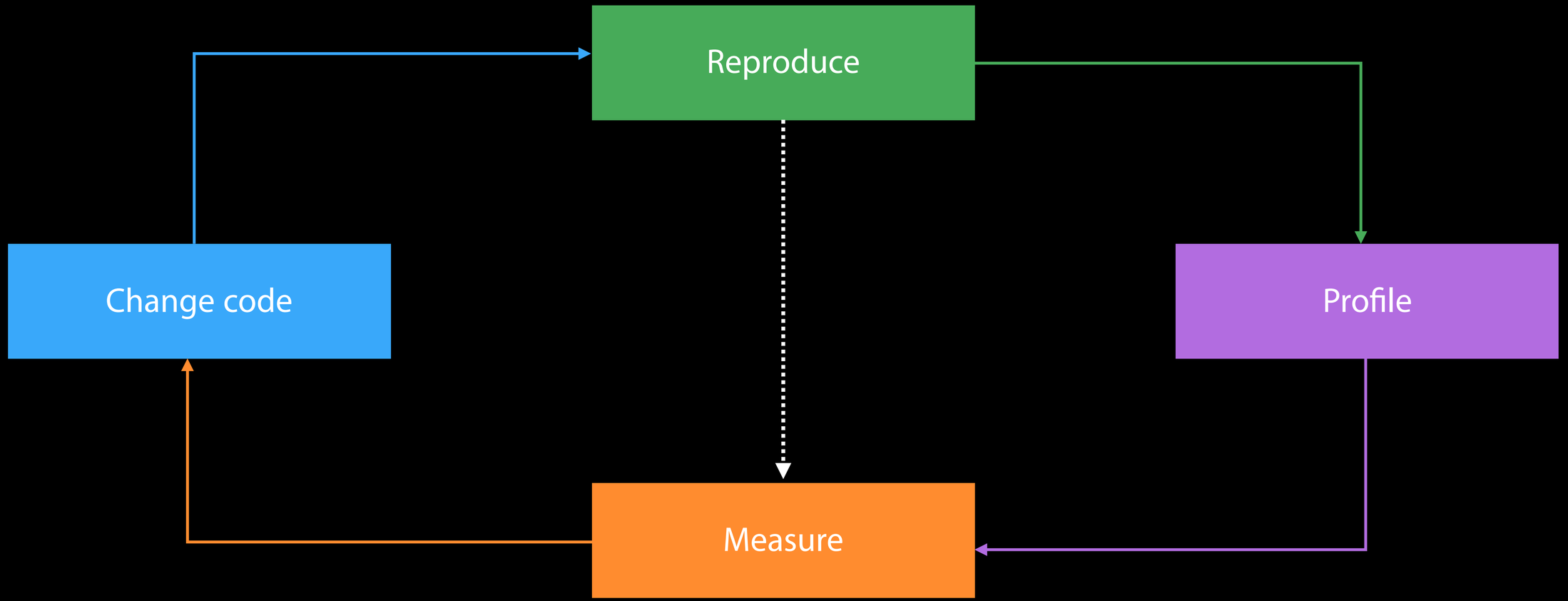
Make one change at a time

Just like ordinary debugging

Performance Workflow



Performance Workflow



Profiling vs. Measuring

Profiling: Understanding overall app activity

- Xcode debugger
- Instruments: Time Profiler

Measuring: Instrumenting a specific action

- CFAbsoluteTimeGetCurrent
- Instruments: System Trace

Responsiveness

Reacting to user input

Main Thread Consumes User Input

Touches and scrolling

Orientation

Multitasking resizes

Main Thread Consumes User Input

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A responsive main thread makes your app feel great

Main Thread Consumes User Input

Touches and scrolling

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Multitasking resizes

A responsive main thread makes your app feel great

Busy main thread makes your app appear frozen

Avoid Using the Main Thread for…

CPU-intensive work

Tasks that depend on external resources

Avoid Using the Main Thread for…

CPU-intensive work

Tasks that depend on external resources

Profiling in Depth Mission Thursday 3:30PM

What's a Blocking Call?

Any code path that ends up making a syscall

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Accessing resources not currently in memory

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- Disk I/O

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- Disk I/O
- Network access

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Waiting for work to complete on another thread

What's a Blocking Call?

"synchronous" is a synonym for blocking

```
NSURLConnection.sendSynchronousRequest(…
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Strategies for Avoiding Blocking Calls

In many cases, there is an existing asynchronous API you can switch to

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Strategies for Avoiding Blocking Calls

In many cases, there is an existing asynchronous API you can switch to

Some restructuring required

```
NSURLConnection.sendAsynchronousRequest(…
```

Strategies for Avoiding Blocking Calls

In other cases, there isn't an async equivalent

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Use Grand Central Dispatch (GCD)

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GCD manages a global thread pool

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Express tasks as closures (a.k.a. blocks)

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In other cases, there isn't an async equivalent

Use Grand Central Dispatch (GCD)

GCD manages a global thread pool

Express tasks as closures (a.k.a. blocks)

Closures run on an arbitrary thread

Strategies for Avoiding Blocking Calls

In other cases, there isn't an async equivalent

Use Grand Central Dispatch (GCD)

GCD manages a global thread pool

Express tasks as closures (a.k.a. blocks)

Closures run on an arbitrary thread

Ensure operations performed are thread-safe!

Thread Safety

Some objects are restricted to the main thread

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Some objects, once created, can be used from any thread

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- Implement protection using serial GCD queues

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Read the headers

Strategies for Avoiding Blocking Calls

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@IBAction func showImageTapped(sender: UIButton) {
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Strategies for Avoiding Blocking Calls

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Load file data

Strategies for Avoiding Blocking Calls

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Load file data

Decode and filter image

Strategies for Avoiding Blocking Calls

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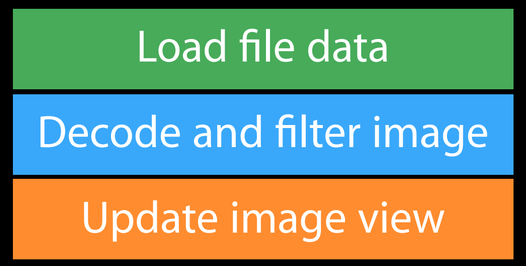
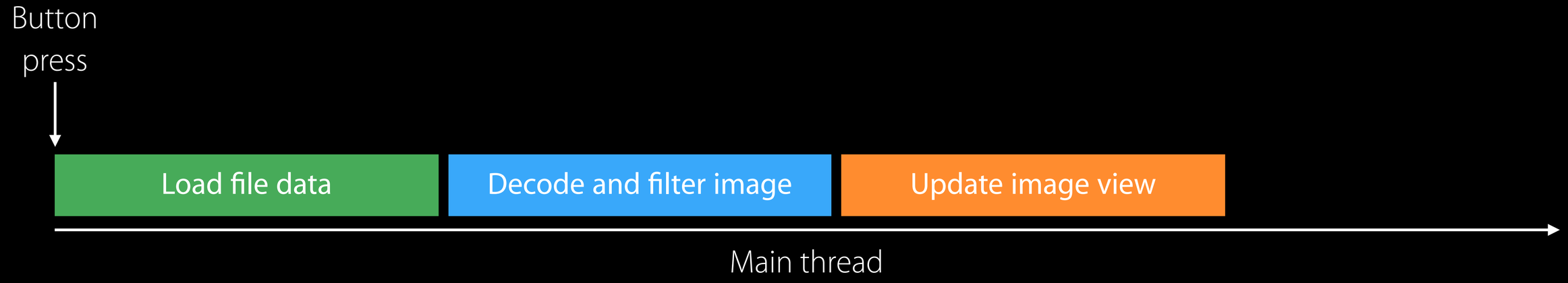


Grand Central Dispatch

Current implementation



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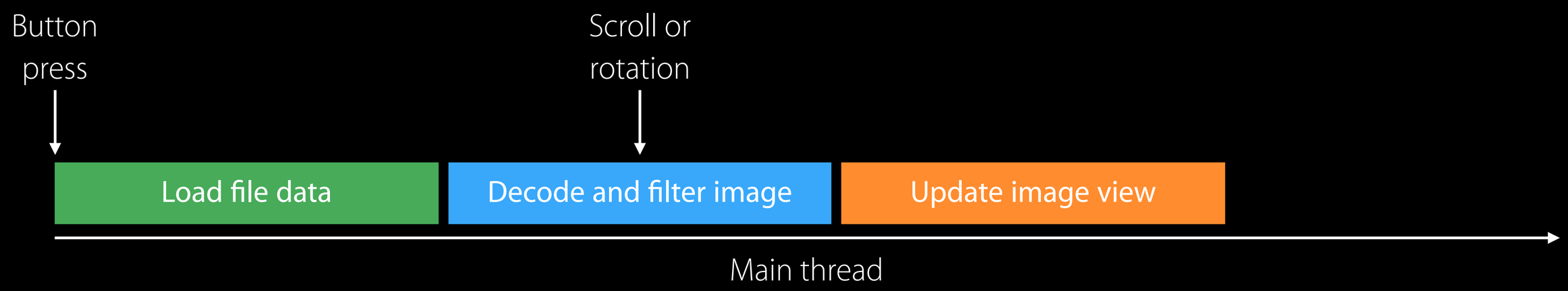

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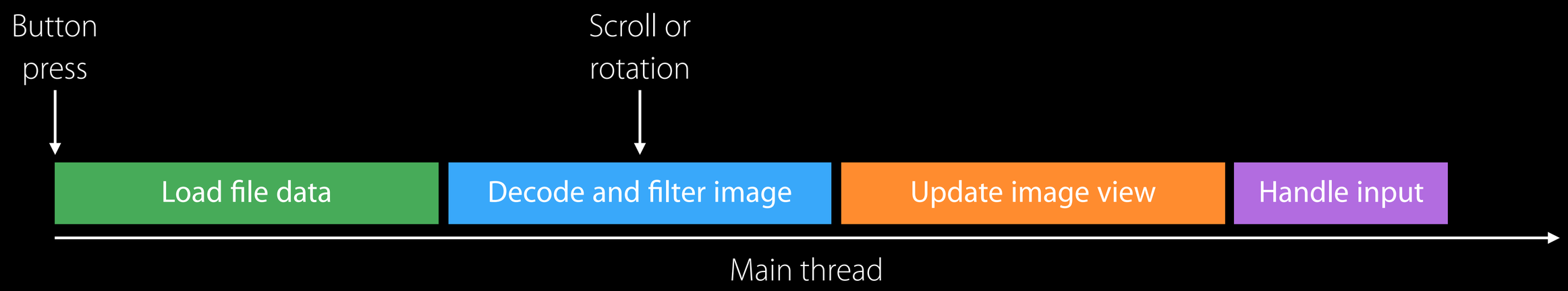
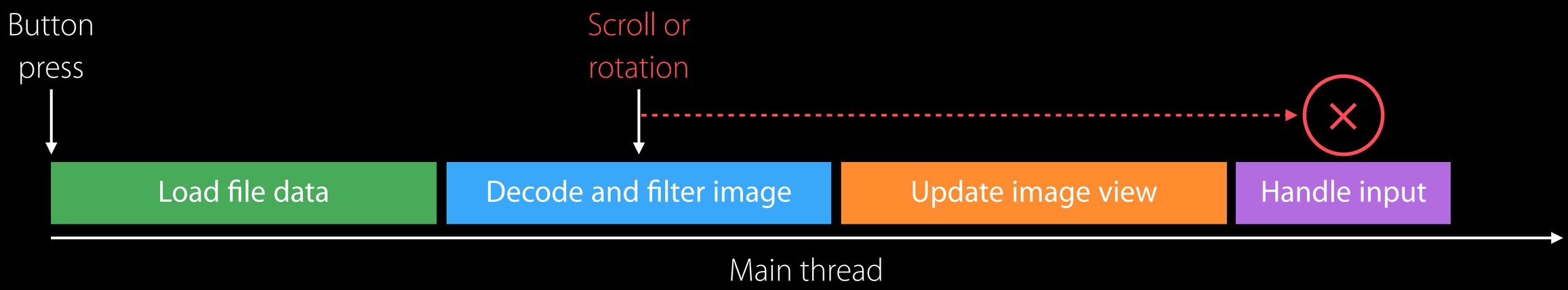


Grand Central Dispatch

User input delayed



Strategies for Avoiding Blocking Calls

```
dispatch_async(dispatch_get_global_queue(QOS_CLASS_USER_INITIATED, 0)) {
    let myData = NSData(contentsOfFile: self.path)!
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Strategies for Avoiding Blocking Calls

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Strategies for Avoiding Blocking Calls

Quality of Service (QoS)

```
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Strategies for Avoiding Blocking Calls

```
var myImage: UIImage? = nil
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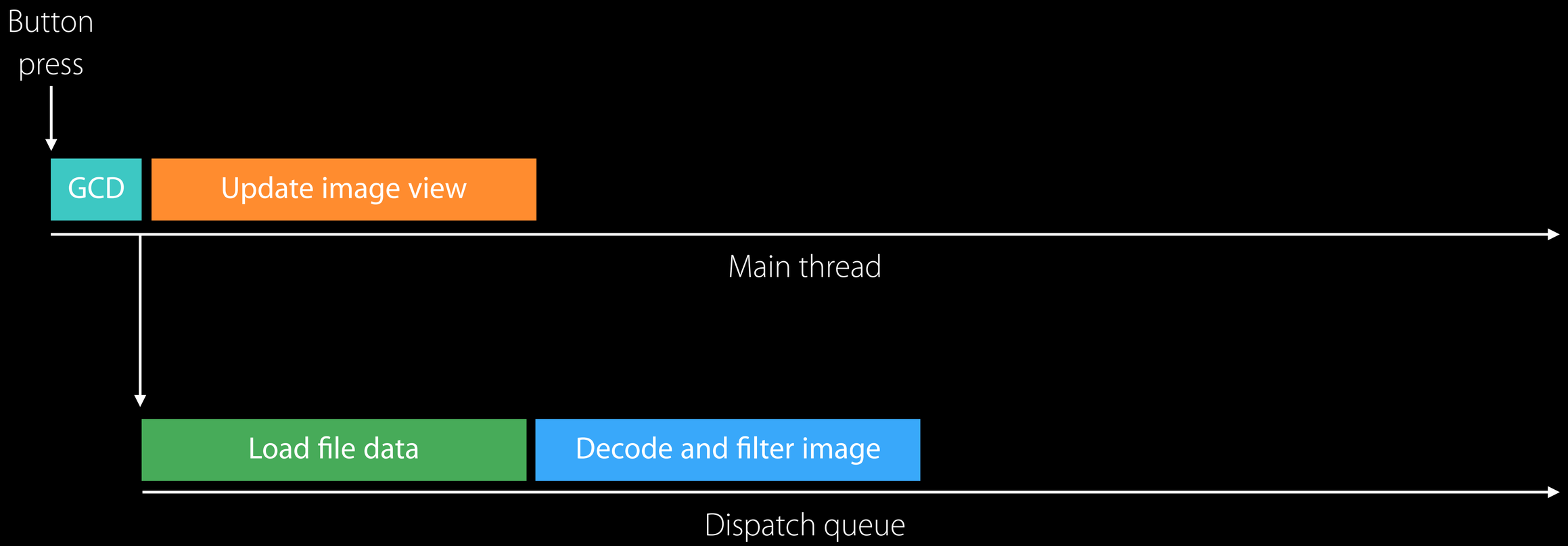
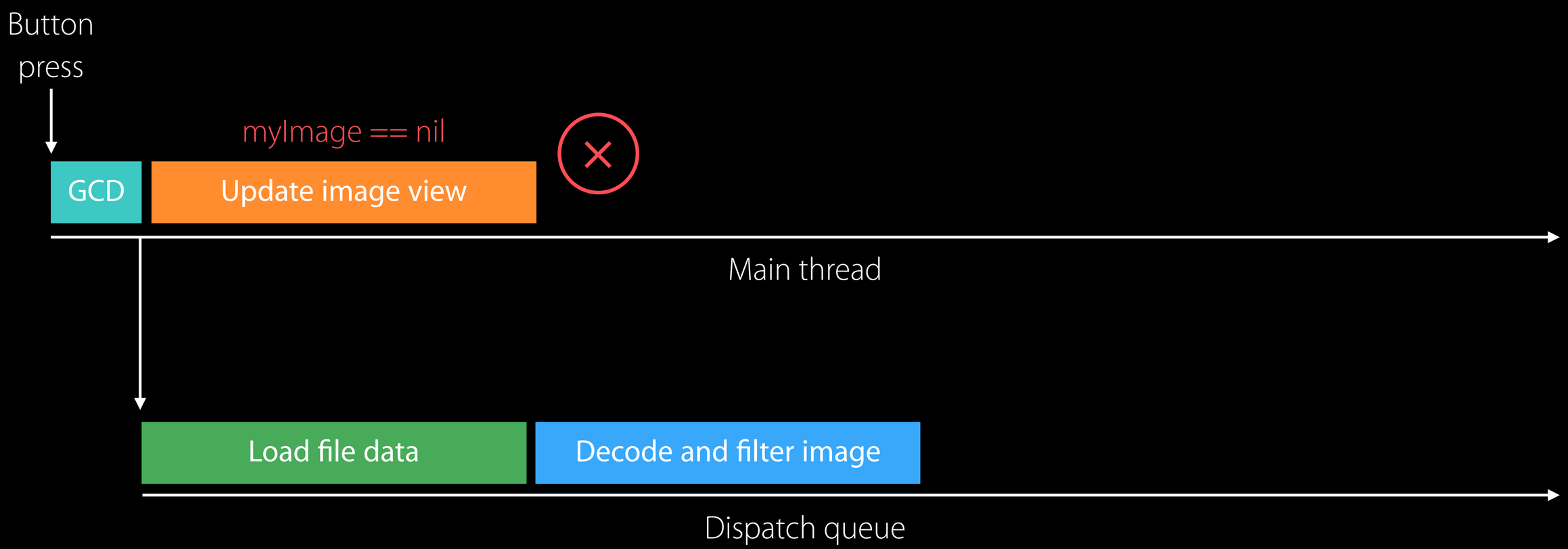
Grand Central Dispatch



Grand Central Dispatch



Strategies for Avoiding Blocking Calls

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Strategies for Avoiding Blocking Calls

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Strategies for Avoiding Blocking Calls

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```
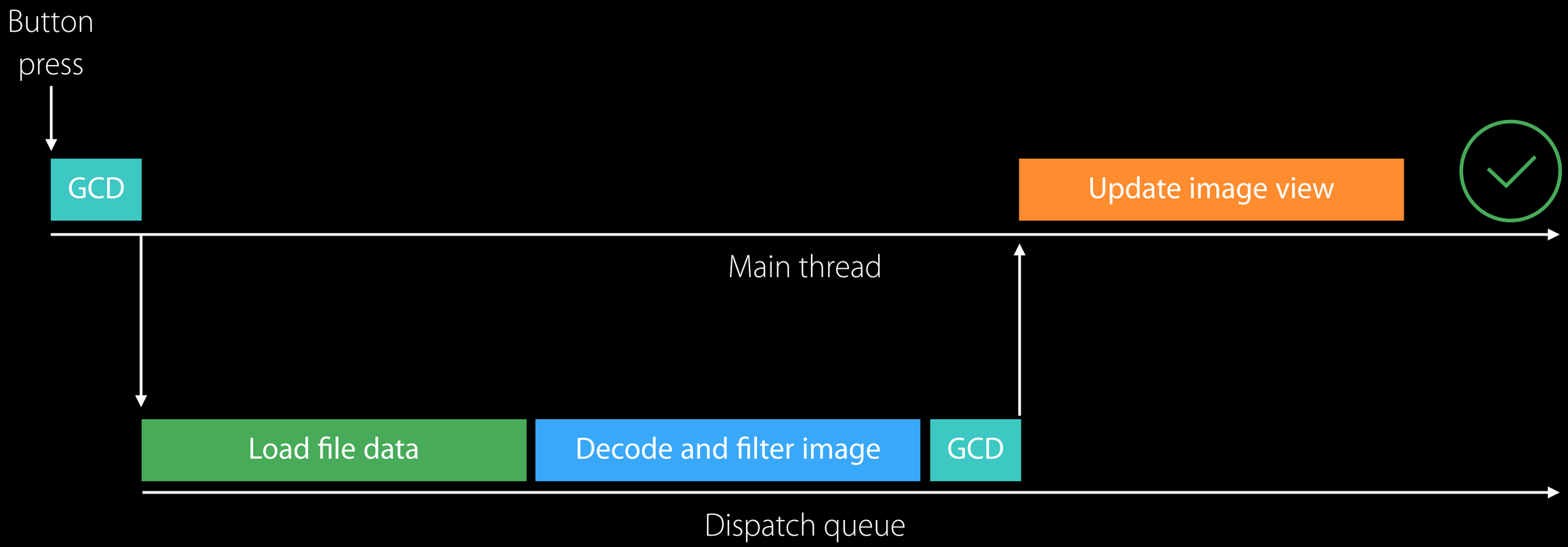
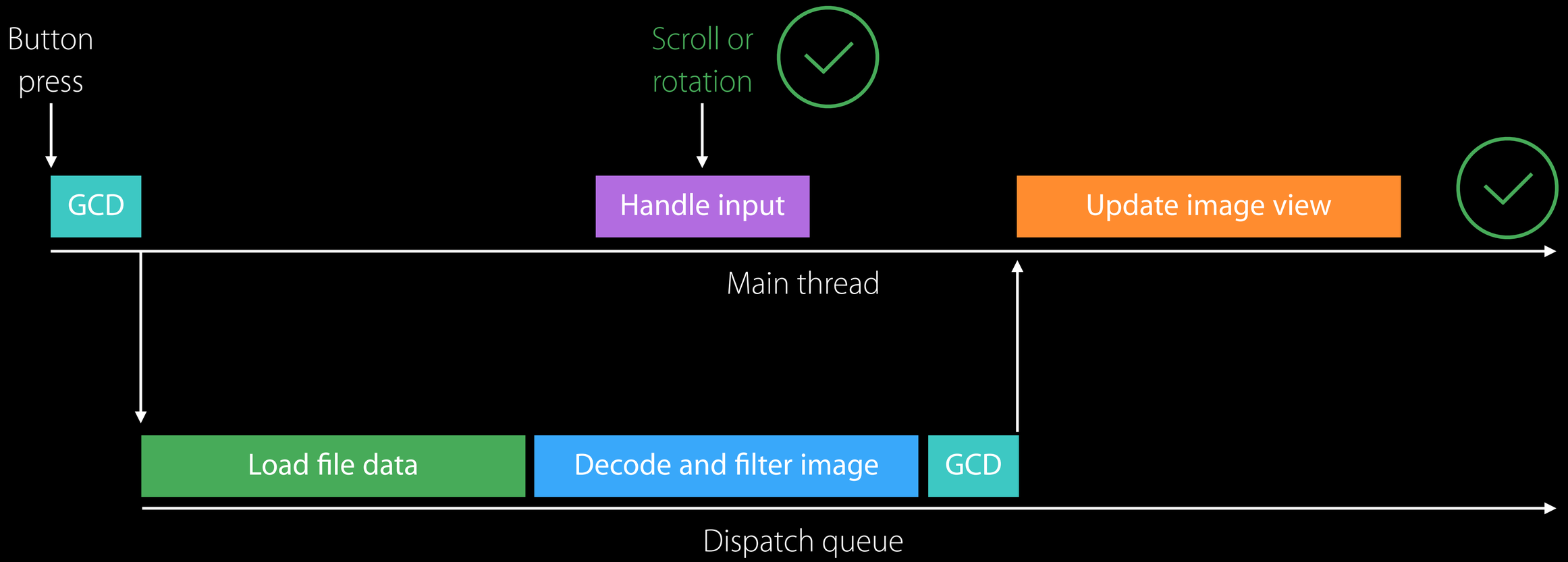

Grand Central Dispatch

Timely and thread-safe object access



Grand Central Dispatch

Timely handling of user input



Common Blocking Calls

Common Blocking Calls

Networking: NSURLConnection and friends

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- Use asynchronous API

Common Blocking Calls

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- NSURLSession background session

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Foundation initializers

Common Blocking Calls

Networking: NSURLConnection and friends

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Foundation initializers

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Common Blocking Calls

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Common Blocking Calls

Networking: NSURLConnection and friends

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Core Data

Common Blocking Calls

Networking: NSURLConnection and friends

- Use asynchronous API
- NSURLSession background session

Foundation initializers

- contentsOfFile:
- contentsOfURL:

Core Data

- Move some Core Data work to different concurrency modes

Common Blocking Calls

Networking: NSURLConnection and friends

- Use asynchronous API
- NSURLSession background session

Foundation initializers

- contentsOfFile:
- contentsOfURL:

Core Data

- Move some Core Data work to different concurrency modes

What's New in Core Data Mission Thursday 2:30PM

Strategies for Avoiding Blocking Calls

Switch to asynchronous API

Strategies for Avoiding Blocking Calls

Switch to asynchronous API

Use GCD

Strategies for Avoiding Blocking Calls

Switch to asynchronous API

Use GCD

Building Responsive and Efficient Apps with GCD Nob Hill Friday 10:00AM

Memory

Memory

Multitasking requires memory tuning

Memory

Multitasking requires memory tuning

watchOS considerations

Memory

Multitasking requires memory tuning

watchOS considerations

Older hardware

Memory

Multitasking requires memory tuning

watchOS considerations

Older hardware

Extensions

iOS Memory System

Never enough to go around

iOS Memory System

Never enough to go around

Suspended apps are not persisted

iOS Memory System

Never enough to go around

Suspended apps are not persisted

They are evicted without storing

iOS Memory System

Never enough to go around

Suspended apps are not persisted

They are evicted without storing

Memory

Memory is time

Reclaiming memory takes time

Memory

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Reclaiming memory takes time

Sudden high-memory demand impacts responsiveness

Memory

Memory is time

Reclaiming memory takes time

Sudden high-memory demand impacts responsiveness

Preserves state in the background

Rationalize Your App's Memory Footprint

Rationalize Your App's Memory Footprint

Resources

Rationalize Your App's Memory Footprint

Resources

- Strings

Rationalize Your App's Memory Footprint

Resources

- Strings
- Images

Rationalize Your App's Memory Footprint

Resources

- Strings
- Images
- Core Data managed objects

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Create a mental model of accessed resources

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Create a mental model of accessed resources

Check your work using Xcode debugger

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Instruments: Allocations and Leaks

Rationalize Your App's Memory Footprint

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Create a mental model of accessed resources

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Instruments: Allocations and Leaks

Sam…App 〉 iPhone (9.0) | Running SamplePhotosApp on iPhone | 3

SamplePhotosApp 〉 SamplePhotosApp 〉 AAPLAppDelegate.m 〉 No Selection

SamplePhotosApp PID 1737

CPU	0%
Memory	14.3 MB
Energy Impact	Low
Disk	Zero KB/s
Network	Zero KB/s
FPS	

```
/*
 Copyright (C) 2014 Apple Inc. All Rights Reserved.
 See LICENSE.txt for this sample's licensing information

 Abstract:

  The application's delegate.

 */

#import "AAPLAppDelegate.h"

@implementation AAPLAppDelegate

@end
```

SamplePhotosApp

Auto

Sam...App 〉 iPhone (9.0) | Running SamplePhotosApp on iPhone | 3

SamplePhotosApp 〉 SamplePhotosApp 〉 AAPLAppDelegate.m 〉 No Selection

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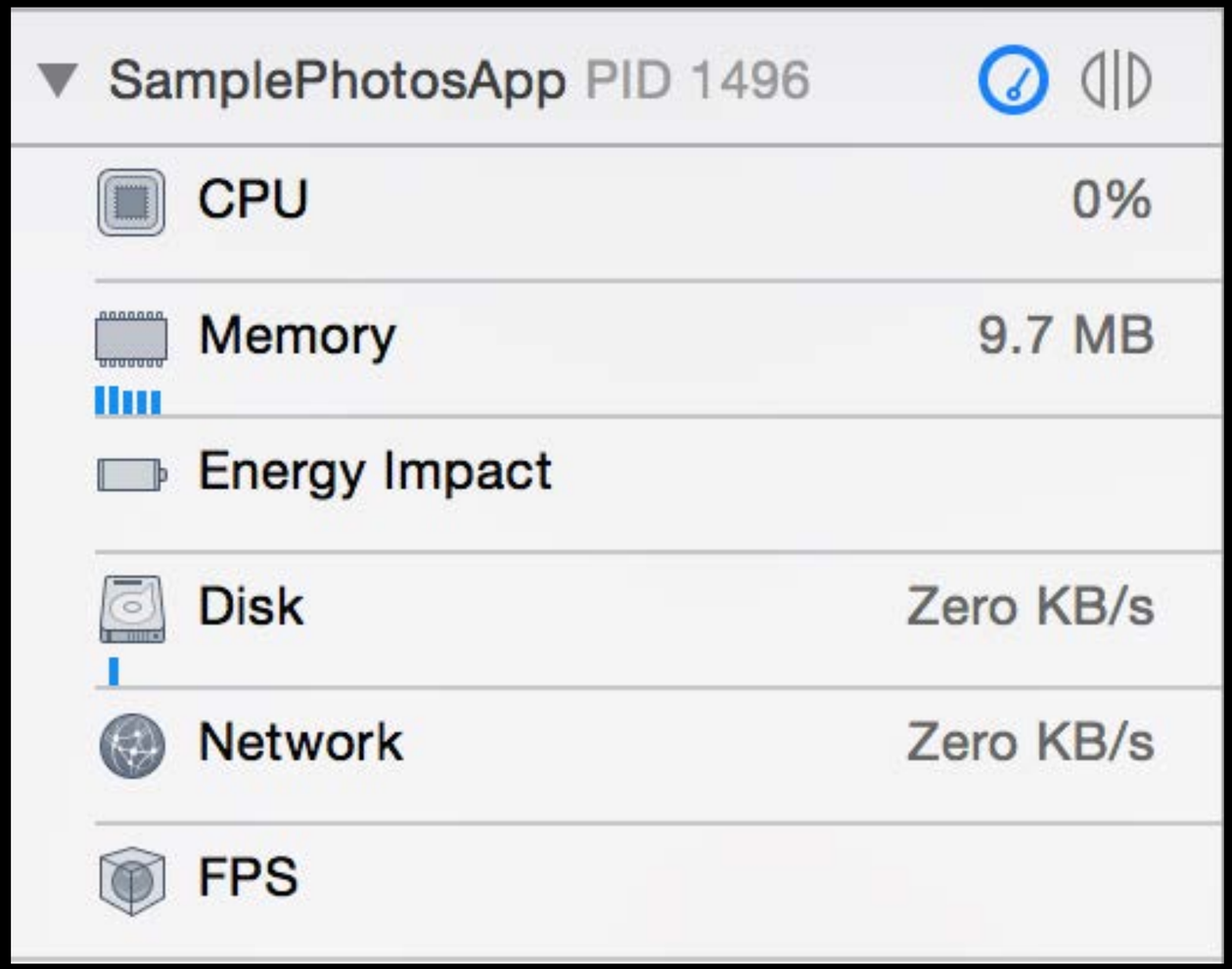
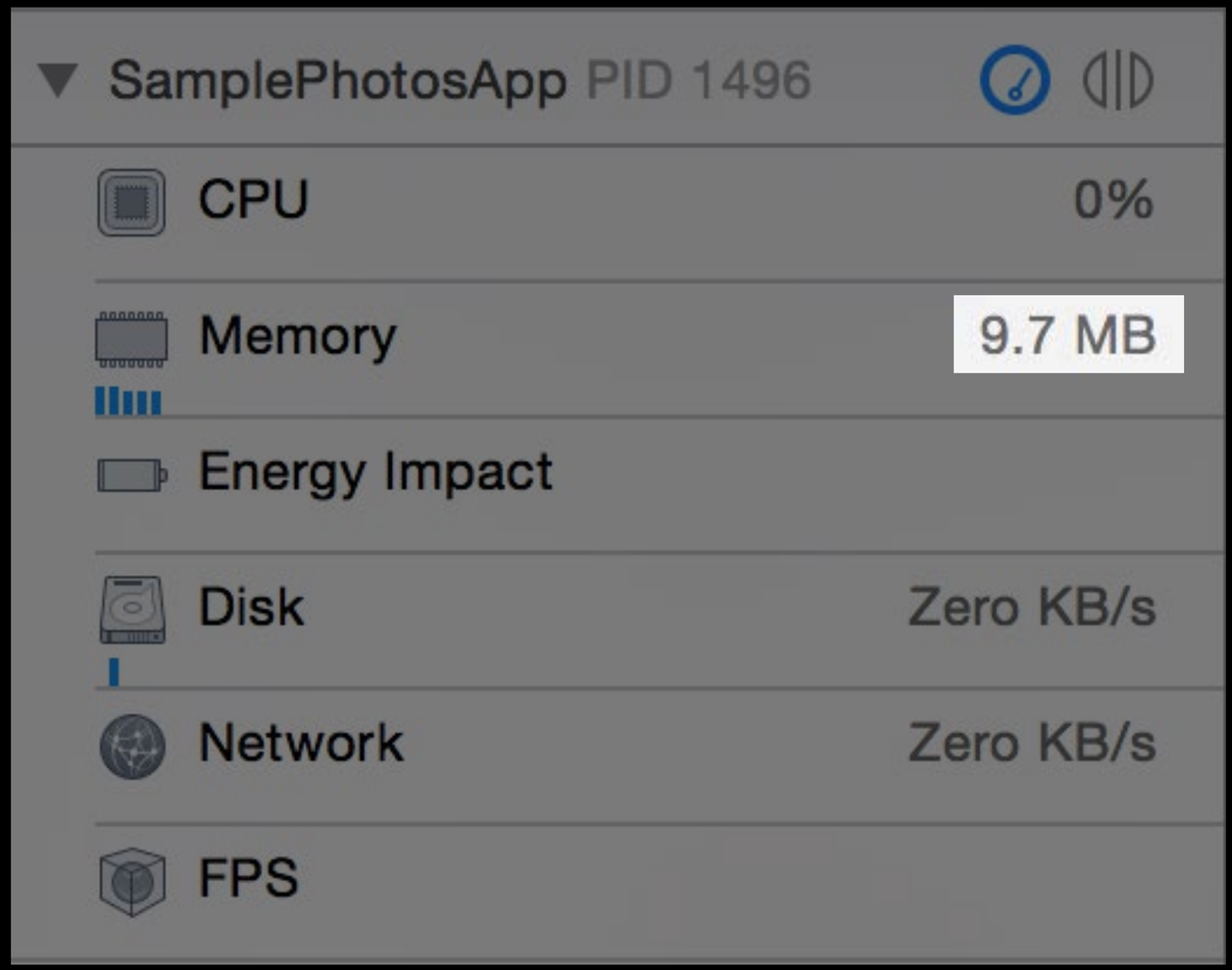
SamplePhotosApp

Auto


SamplePhotosApp PID 1496
CPU
0%
Memory
9.7 MB
Energy Impact
Disk
Zero KB/s
Network
Zero KB/s
FPS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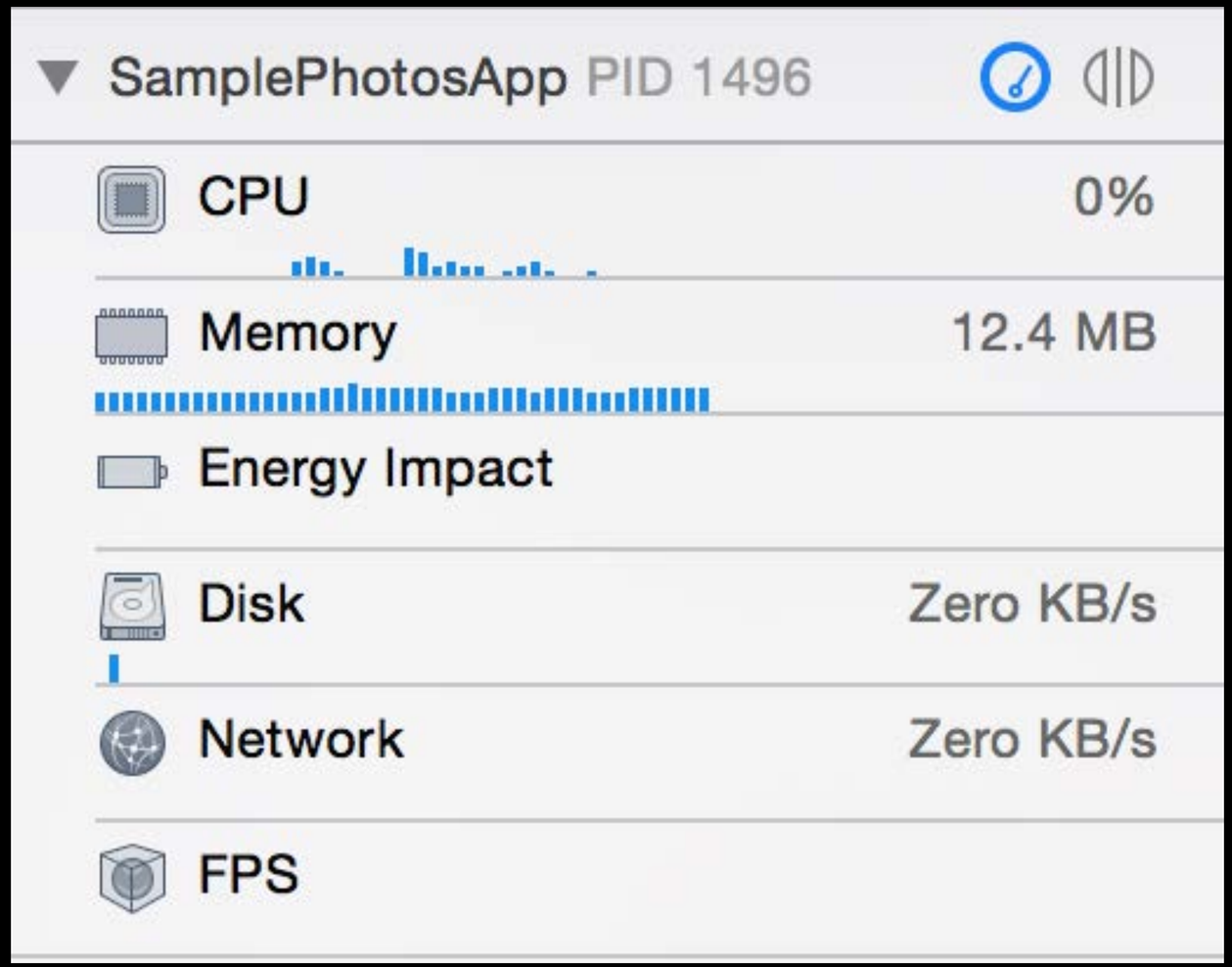
SamplePhotosApp PID 1496
CPU
0%
Memory
12.4 MB
Energy Impact
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Zero KB/s
Network
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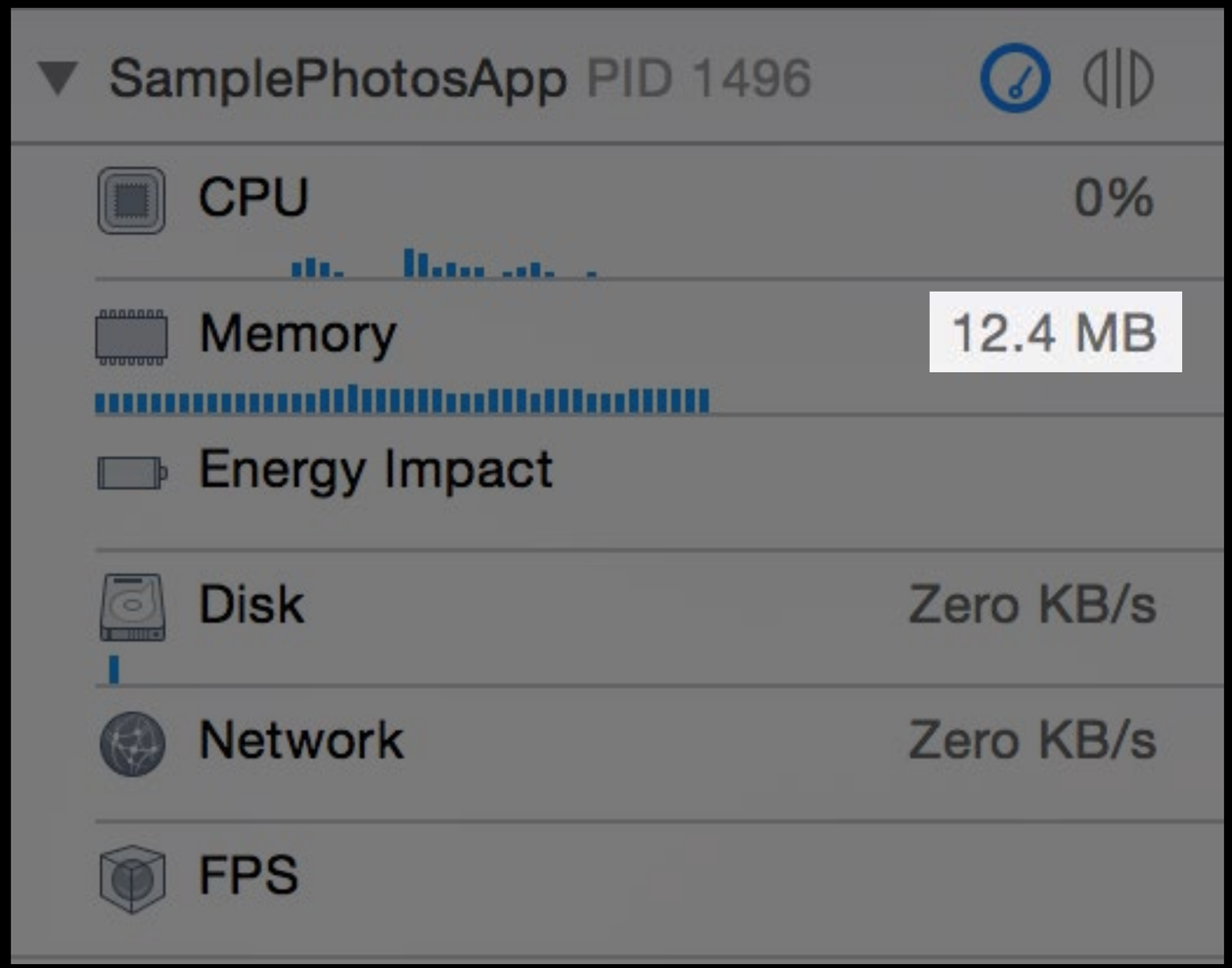
FPS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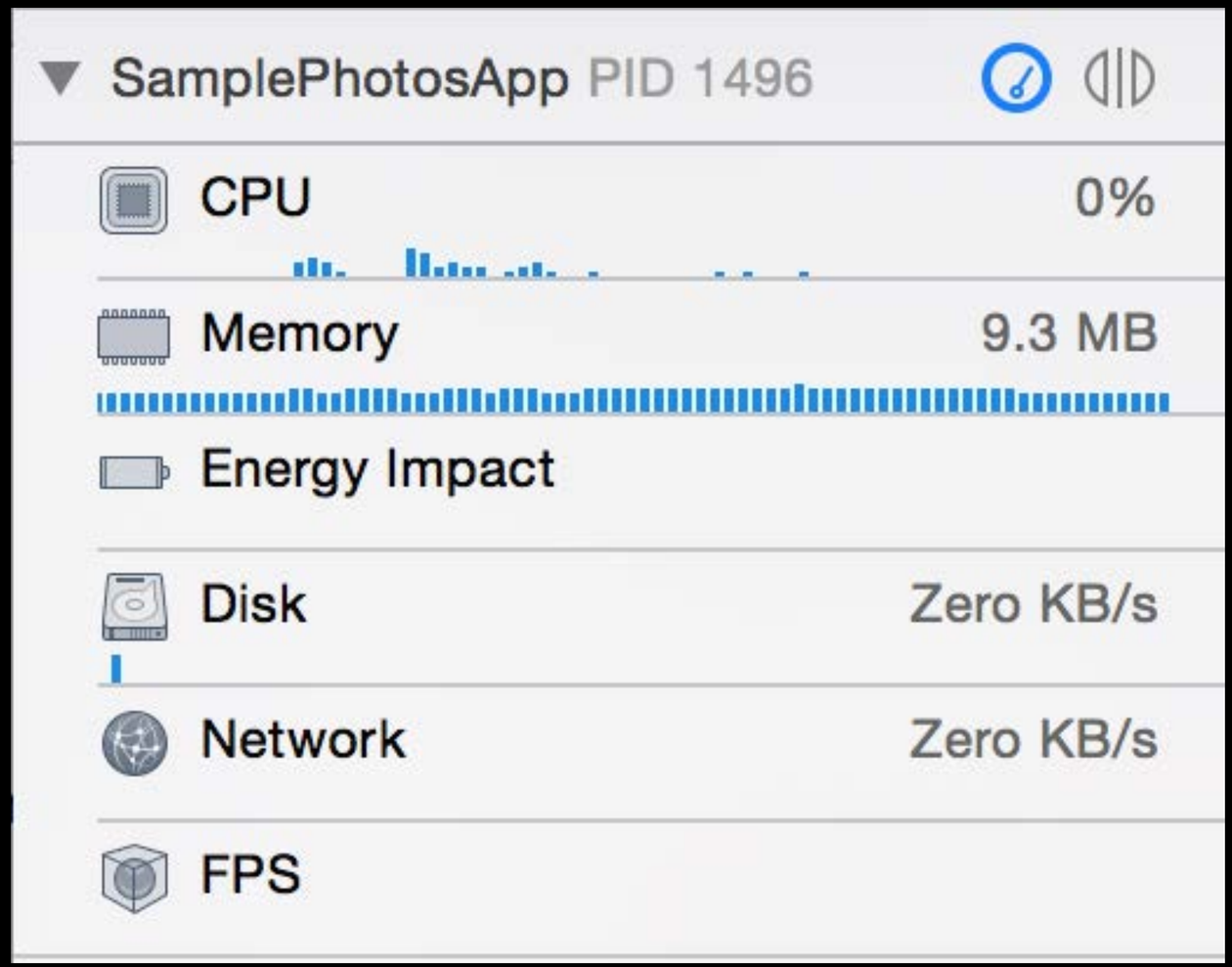
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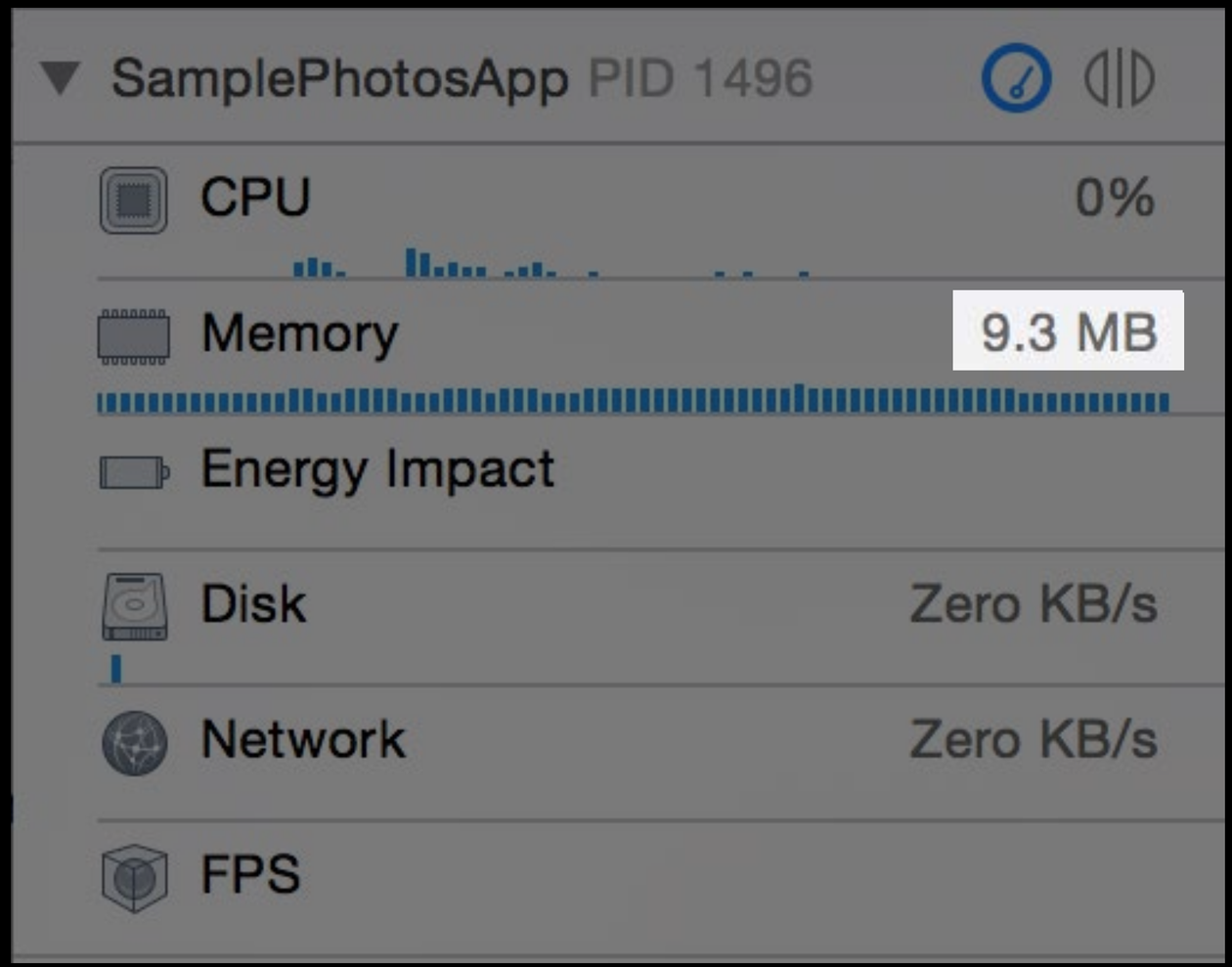
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Application Lifecycle

Use NSCache

Application Lifecycle

Use NSCache

Listen for notifications

Application Lifecycle

Use NSCache

Listen for notifications

- UIApplicationDidEnterBackgroundNotification

Application Lifecycle

Use NSCache

Listen for notifications

- UIApplicationDidEnterBackgroundNotification
- UIApplicationDidReceiveMemoryWarningNotification

Application Lifecycle

Responding to changes

```
init() {
  NSNotificationCenter.defaultCenter()
    .addObserverForName(UIApplicationDidReceiveMemoryWarningNotification,
        object: self,
        queue: NSOperationQueue.mainQueue())
            { [unowned self] (NSNotification notification) -> Void in
                self.purgeCaches() // custom cache purging behavior
            }
}

deinit {
  NSNotificationCenter.defaultCenter().removeObserver(self)
}
```

Application Lifecycle

Responding to changes

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Application Lifecycle

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Memory Strategies

Covered in detail

Memory Strategies

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Optimizing Your App for Multitasking on iPad in iOS 9	Presidio	Wednesday 3:30PM

Memory Strategies

Covered in detail

Resource types and access patterns

Optimizing Your App for Multitasking on iPad in iOS 9	Presidio	Wednesday 3:30PM

Memory Strategies

Covered in detail

Resource types and access patterns

Responding to system memory state while running

Optimizing Your App for Multitasking on iPad in iOS 9	Presidio	Wednesday 3:30PM

New Platform

Native code on watchOS

NEW

New Platform

Native code on watchOS

NEW

Designing for Apple Watch

Presidio

Wednesday 4:30PM

New Platform

Native code on watchOS

Reuse what makes sense

Designing for Apple Watch — Presidio — Wednesday 4:30PM

New Platform

Native code on watchOS

NEW

Reuse what makes sense

- Your existing code

Designing for Apple Watch Presidio Wednesday 4:30PM

New Platform

Native code on watchOS

NEW

Reuse what makes sense

- Your existing code
- Familiar APIs and frameworks

Designing for Apple Watch Presidio Wednesday 4:30PM

New Platform

Native code on watchOS

NEW

Reuse what makes sense

- Your existing code
- Familiar APIs and frameworks

Implement new mechanisms

Designing for Apple Watch Presidio Wednesday 4:30PM

watchOS

Quick and simple

Short, simple interactions

watchOS

Quick and simple

Short, simple interactions

Recent and relevant data in Apps, Notifications, Glances

watchOS

Quick and simple

Short, simple interactions

Recent and relevant data in Apps, Notifications, Glances

Launch time is critical

watchOS Performance Strategies

Minimize network traffic and processing

Implementing new server logic

watchOS Performance Strategies

Minimize network traffic and processing

Implementing new server logic

- Send appropriately sized and formatted responses

watchOS Performance Strategies

Minimize network traffic and processing

Implementing new server logic

- Send appropriately sized and formatted responses
- Remove unused keys from JSON or XML blobs

watchOS Performance Strategies

Minimize network traffic and processing

Implementing new server logic

- Send appropriately sized and formatted responses
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- Send appropriately sized images

watchOS Performance Strategies

Minimize network traffic and processing

Implementing new server logic

- Send appropriately sized and formatted responses
- Remove unused keys from JSON or XML blobs
- Send appropriately sized images
- Send an appropriate number of records (one screen)

watchOS Performance Strategies

Show fresh, relevant information

Keep app context updated

watchOS Performance Strategies

Show fresh, relevant information

Keep app context updated

- Bidirectional shared state

watchOS Performance Strategies

Show fresh, relevant information

Keep app context updated

- Bidirectional shared state
- `WCSession.defaultSession().updateApplicationContext(…)`

watchOS Performance Strategies

Show fresh, relevant information

Keep app context updated

- Bidirectional shared state
- `WCSession.defaultSession().updateApplicationContext(…)`
- Benefit from Background App Refresh

watchOS Performance Strategies

Minimize network traffic and processing

Relying on existing server logic

watchOS Performance Strategies

Minimize network traffic and processing

Relying on existing server logic

- Implement a lightweight service on iPhone

watchOS Performance Strategies

Minimize network traffic and processing

Relying on existing server logic

- Implement a lightweight service on iPhone
- `WCSession.defaultSession().sendMessage(…)`

watchOS Performance Strategies

Minimize network traffic and processing

Relying on existing server logic

- Implement a lightweight service on iPhone
- `WCSession.defaultSession().sendMessage(…)`
- Parse and pare down server responses on iPhone

watchOS Performance Strategies

Minimize network traffic and processing

Relying on existing server logic

- Implement a lightweight service on iPhone
- `WCSession.defaultSession().sendMessage(…)`
- Parse and pare down server responses on iPhone
- Reply over WCSession with minimal working set

Summary

Performance is a feature

Efficient apps feel great, build trust, and save power

Learn about Apple technologies and choose the best ones for your app

Keep your main thread ready for user input

Understand when and why your app uses memory

On watchOS, fetch and process a minimal set of information

More Information

Documentation

Performance Overview

Instruments User Guide

Concurrency Programming Guide

Threading Programming Guide

http://developer.apple.com/library

Technical Support

Apple Developer Forums

Developer Technical Support

http://developer.apple.com/forums

General Inquiries

Curt Rothert, App Frameworks Evangelist

rothert@apple.com

Related Sessions

Optimizing Your App for Multitasking on iPad in iOS 9	Presidio	Wednesday 3:30PM
Designing for Apple Watch	Presidio	Wednesday 4:30PM
What's New in Core Data	Mission	Thursday 2:30PM
Profiling in Depth	Mission	Thursday 3:30PM
Building Responsive and Efficient Apps with GCD	Nob Hill	Friday 10:00AM
iOS App Performance: Memory		WWDC12
Advanced Graphics and Animations for iOS Apps		WWDC14
Improving Your App with Instruments		WWDC14

Related Labs

Power and Performance Lab	Frameworks Lab C	Friday 12:00PM

WWDC15