Optimizing App Launch

Spencer Lewson, Performance Engineer
Dan Sawada, Performance Engineer
What is launch
How to properly measure your launch
Use Instruments to profile your launch
Track your launch over time
App launch is a user experience interruption.
If we saved 1 millisecond per launch...
162 days

For each millisecond saved
162 days

For each millisecond saved
162 days
For each millisecond saved
Why Launch Is Important
Why Launch Is Important

First experience with your app should be delightful
Why Launch Is Important

First experience with your app should be delightful

Indicative of your code’s overall performance
Why Launch Is Important

First experience with your app should be delightful

Indicative of your code’s overall performance

Impacts the system performance and battery
Launch Types

- Cold
- Warm
- Resume
# Launch Types

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<tr>
<th>Cold</th>
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<th>Resume</th>
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## Launch Types

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To render first frame
Phases of App Launch
Phases of App Launch
Phases of App Launch
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Phases of App Launch
Phases of App Launch
Phases of App Launch

1. System Interface
2. Runtime Init
3. UIKit Init
4. Application Init
5. Initial Frame Render
6. Extended
System Interface

DYLD3
System Interface
DYLD3
System Interface

DYLD3

Dynamic Linker loads shared libraries and frameworks
System Interface

DYLD3

Dynamic Linker loads shared libraries and frameworks

Introduces caching of runtime dependencies to improve warm launch

App Startup Time: Past, Present, and Future

WWDC 2017
System Interface

DYLD3

NEW
System Interface

DYLD3

- Avoid linking unused frameworks
System Interface

DYLD3

- Avoid linking unused frameworks
- Avoid dynamic library loading during launch
System Interface

DYLD3

- Avoid linking unused frameworks
- Avoid dynamic library loading during launch
- Hard link all your dependencies
System Interface
libSystem Init
System Interface

libSystem Init

Initializes the interfaces with low level system components
System Interface

libSystem Init

Initializes the interfaces with low level system components

System side work with a fixed cost
Static Runtime Initialization

- System Interface
- Runtime Init
- UIKit Init
- Application Init
- Initial Frame Render
- Extended
Static Runtime Initialization

Initializes the language runtime
Static Runtime Initialization

Initializes the language runtime

Invokes all class static load methods
Static Runtime Initialization
Static Runtime Initialization

- Expose dedicated initialization API in frameworks
Static Runtime Initialization

✅ Expose dedicated initialization API in frameworks

✅ Reduce impact to launch by avoiding `+[Class load]`
Static Runtime Initialization

- Expose dedicated initialization API in frameworks
- Reduce impact to launch by avoiding `[Class load]`
- Use `[Class initialize]` to lazily conduct static initialization
UIKit Initialization

System Interface  Runtime Init  UIKit Init  Application Init  Initial Frame Render  Extended
UIKit Initialization

Instantiates the `UIApplication` and `UIApplicationDelegate`
UIKit Initialization

Instantiates the **UIApplication** and **UIApplicationDelegate**

Begins event processing and integration with the system
UIKit Initialization
UIKit Initialization

Minimize work in UIApplication subclass
UIKit Initialization

- Minimize work in `UIApplication` subclass
- Minimize work in `UIApplicationDelegate` initialization
Application Initialization
Lifecycle Callbacks
Application Initialization
Lifecycle Callbacks

Invokes UIApplicationDelegate app lifecycle callbacks

application:willFinishLaunchingWithOptions:
application:didFinishLaunchingWithOptions:
Application Initialization
Lifecycle Callbacks

Invokes UIApplicationDelegate app lifecycle callbacks

application:willFinishLaunchingWithOptions:
application:didFinishLaunchingWithOptions:

Invokes UIApplicationDelegate UI lifecycle callbacks

applicationDidBecomeActive:
**Application Initialization**

**Lifecycle Callbacks**

Invokes UIApplicationDelegate app lifecycle callbacks

- `application:willFinishLaunchingWithOptions:`
- `application:didFinishLaunchingWithOptions:`

Invokes UIApplicationDelegate UI lifecycle callbacks

- `applicationDidBecomeActive:`
Application Initialization

Lifecycle Callbacks

Invokes UIApplicationDelegate app lifecycle callbacks

application:willFinishLaunchingWithOptions:
application:didFinishLaunchingWithOptions:

Invokes UIApplicationDelegate UI lifecycle callbacks

applicationDidBecomeActive:

Invokes UISceneDelegate UI lifecycle callbacks for each scene

scene:willConnectToSession:options:
sceneWillEnterForeground:
sceneDidBecomeActive:
Application Initialization
Lifecycle Callbacks

Invokes UIApplicationDelegate app lifecycle callbacks

- application:willFinishLaunchingWithOptions:
- application:didFinishLaunchingWithOptions:

Invokes UIApplicationDelegate UI lifecycle callbacks

- applicationDidBecomeActive:

Invokes UISceneDelegate UI lifecycle callbacks for each scene

- scene:willConnectToSession:options:
- sceneWillEnterForeground:
- sceneDidBecomeActive:
Application Initialization
Lifecycle Callbacks

application:willFinishLaunchingWithOptions:
application:didFinishLaunchingWithOptions:

applicationDidBecomeActive:

scene:willConnectToSession:options:
sceneWillEnterForeground:
sceneDidBecomeActive:
Application Initialization
Lifecycle Callbacks

- Defer unrelated work

```objective-c
void application:willFinishLaunchingWithOptions:(NSDictionary *)options;
void application:didFinishLaunchingWithOptions:(NSDictionary *)options;

void applicationDidBecomeActive:

void scene:willConnectToSession:options:(NSDictionary *)options;
void sceneWillEnterForeground:
void sceneDidBecomeActive:
```
Application Initialization
Lifecycle Callbacks

- Defer unrelated work
- Share resources between scenes

application:willFinishLaunchingWithOptions:
application:didFinishLaunchingWithOptions:

applicationDidBecomeActive:

scene:willConnectToSession:options:
sceneWillEnterForeground:
sceneDidBecomeActive:
<table>
<thead>
<tr>
<th>Event</th>
<th>WWDC 2019</th>
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<tbody>
<tr>
<td>Multitasking and the Application Lifecycle</td>
<td>WWDC 2019</td>
</tr>
<tr>
<td>Getting the Most out of Multitasking</td>
<td>WWDC 2019</td>
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First Frame Render
First Frame Render

Creates, performs layout for, and draws views

loadView
viewDidLoad
viewDidLoad
layoutSubviews
First Frame Render

Creates, performs layout for, and draws views

Commits and renders first frame

loadView
viewDidLoad
viewDidLoad
layoutSubviews
First Frame Render
First Frame Render

☐ Flatten view hierarchies and lazily load views
First Frame Render

- Flatten view hierarchies and lazily load views
- Optimize auto layout usage
Extended

App-specific period after first frame
Extended

App-specific period after first frame
Displays asynchronously loaded data
App-specific period after first frame

Displays asynchronously loaded data

App should be interactive and responsive
Extended
Leverage os_signpost to measure work
What is launch
How to properly measure your launch
Use Instruments to profile your launch
Track your launch over time
Trading Representativeness for Consistency

Comparison requires controlled variables
Trading Representativeness for Consistency

Comparison requires controlled variables
Trading Representativeness for Consistency
Trading Representativeness for Consistency

Remove sources of variance to produce more consistent results
Trading Representativeness for Consistency

Remove sources of variance to produce more consistent results

May result in launch times that are not representative
Trading Representativeness for Consistency

Remove sources of variance to produce more consistent results

May result in launch times that are not representative

Use consistent results to evaluate progress
Test in a Clean and Consistent Environment
Test in a Clean and Consistent Environment

- Reboot then let system quiesce for 2–3 minutes
Test in a Clean and Consistent Environment

- Reboot then let system quiesce for 2–3 minutes
- Enable Airplane Mode or mock the network
Test in a Clean and Consistent Environment

- Reboot then let system quiesce for 2–3 minutes
- Enable Airplane Mode or mock the network
- Use unchanging or no iCloud Account
Test in a Clean and Consistent Environment

- Reboot then let system quiesce for 2–3 minutes
- Enable Airplane Mode or mock the network
- Use unchanging or no iCloud Account
- Use release build of your app
Test in a Clean and Consistent Environment

- Reboot then let system quiesce for 2–3 minutes
- Enable Airplane Mode or mock the network
- Use unchanging or no iCloud Account
- Use release build of your app
- Measure warm launches
Test with Representative Data

Small versus Large Datasets
Target Older and Newer Devices

Older devices

Newer devices
Measuring Launch with XCTest

Improving Battery Life and Performance  WWDC 2019
What is launch

How to properly measure your launch

Use Instruments to profile your launch

Track your launch over time
Tips and Tricks

1. Minimize
2. Prioritize
3. Optimize
1. Minimize Work
1. Minimize Work

✔️ Defer work unrelated to first frame
1. Minimize Work

- Defer work unrelated to first frame
- Move blocking work off main thread
1. Minimize Work

- Defer work unrelated to first frame
- Move blocking work off main thread
- Reduce memory usage
2. Prioritize Work
2. Prioritize Work

- Identify the right QoS for your task
2. Prioritize Work

- Identify the right QoS for your task
- Utilize scheduler optimizations for app launch
2. Prioritize Work

- Identify the right QoS for your task
- Utilize scheduler optimizations for app launch
- Preserve the priority with the right primitives
3. Optimize Work
3. Optimize Work

- Simplify or limit existing work
3. Optimize Work

- Simplify or limit existing work
- Optimize algorithms and data structures
3. Optimize Work

- Simplify or limit existing work
- Optimize algorithms and data structures
- Cache resources and computations
Demo

Using the App Launch Template

Dan Sawada, Performance Engineer
<table>
<thead>
<tr>
<th>Name</th>
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</tr>
<tr>
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Gamma 2I9B8

Located at the Xenon Galaxy...
723.96 Light Years Ahead...
Gamma 2I9B8

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System Improvements

- GCD thread policy tunings
- Sandbox improvements
- Constant classes
- Improved scheduler
- Reduced ARC overhead
- Runtime syscall elimination
- Trampoline-less launch
- App Packaging
- Hot/cold code splitting
- Elimination of priority inversions
- Cached runtime dependencies
- Auto Layout optimizations
- kevent improvements
- Static initializer reduction
- Darwin notification optimizations
- Adaptive spinning for contended runtime locks
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Track Your Launch Over Time
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✔ Make performance a development-time priority
Track Your Launch Over Time

- Make performance a development-time priority
- Plot it and have a target
Monitor Customer Launches with Xcode Organizer

Improving Battery Life and Performance

WWDC 2019
Adopt MetricKit for More Statistics
Adopt MetricKit for More Statistics

Collect custom power and performance metrics
Adopt MetricKit for More Statistics

Collect custom power and performance metrics
Aggregated results delivered every 24 hours
Adopt MetricKit for More Statistics

Collect custom power and performance metrics
Aggregated results delivered every 24 hours

Improving Battery Life and Performance

WWDC 2019
Summary
Start understanding your launch today
Summary

☑ Start understanding your launch today
☑ Measure — don’t estimate — performance
Summary

- Start understanding your launch today
- Measure — don’t estimate — performance
- Track performance in all phases of development
More Information

developer.apple.com/wwdc19/423

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<tr>
<td>High Performance Auto Layout</td>
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<td>Modernizing Grand Central Dispatch Usage</td>
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