Developer Tools #WWDC16

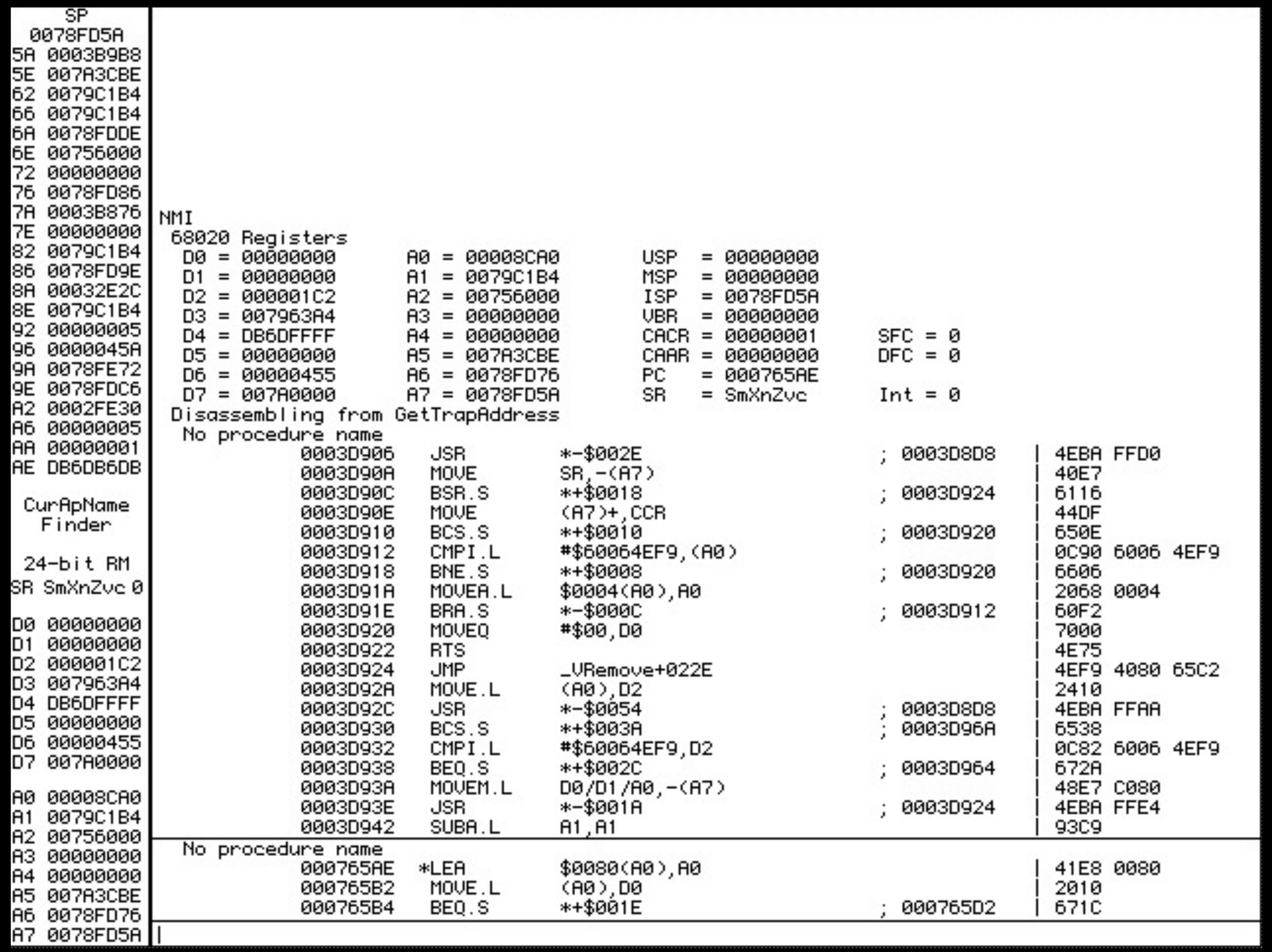
Visual Debugging with Xcode

Session 410

Chris Miles Xcode Debugger UI
Tyler Casella Game Technologies
Daniel Delwood Software Radiologist

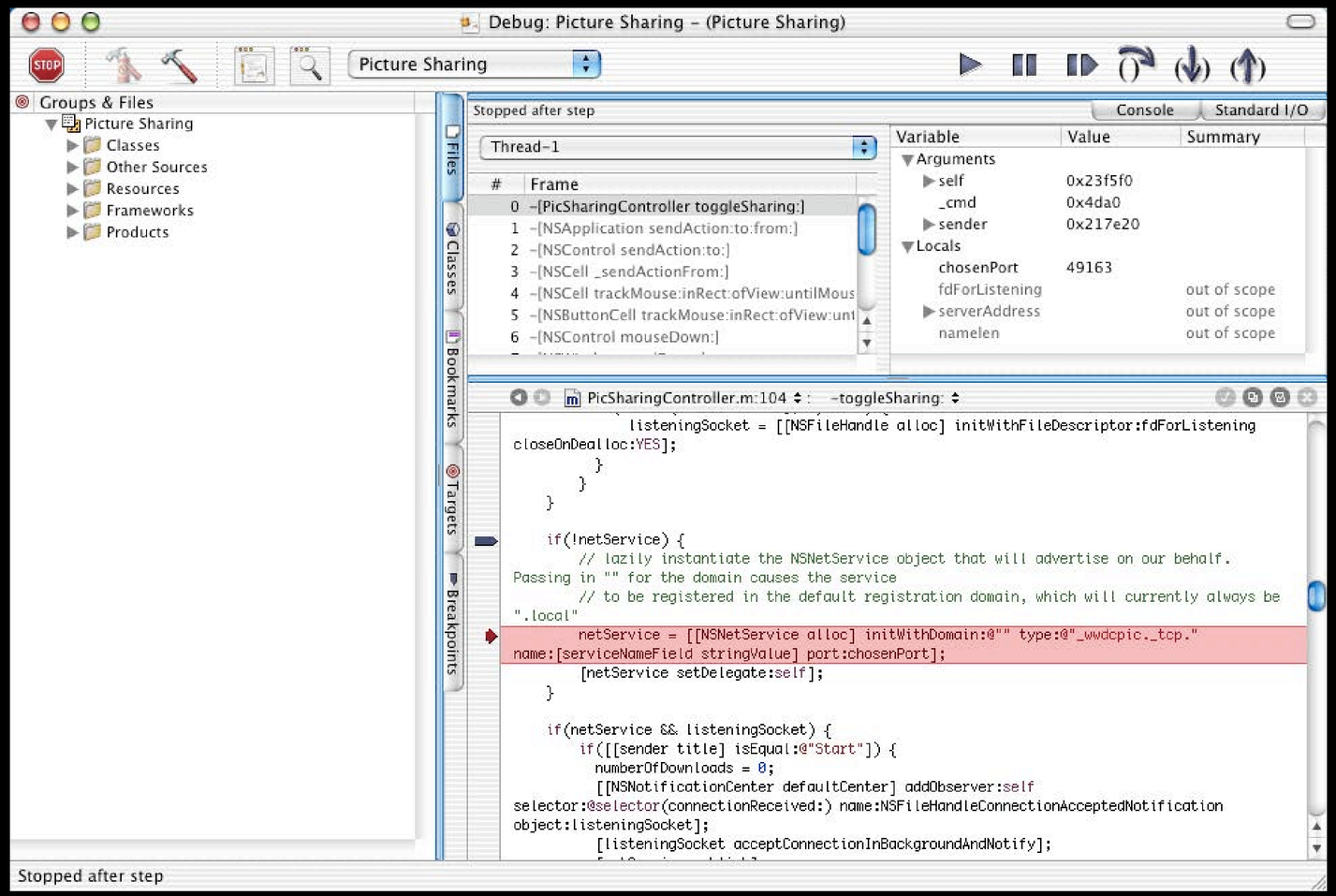
Debugging

Not too long ago…



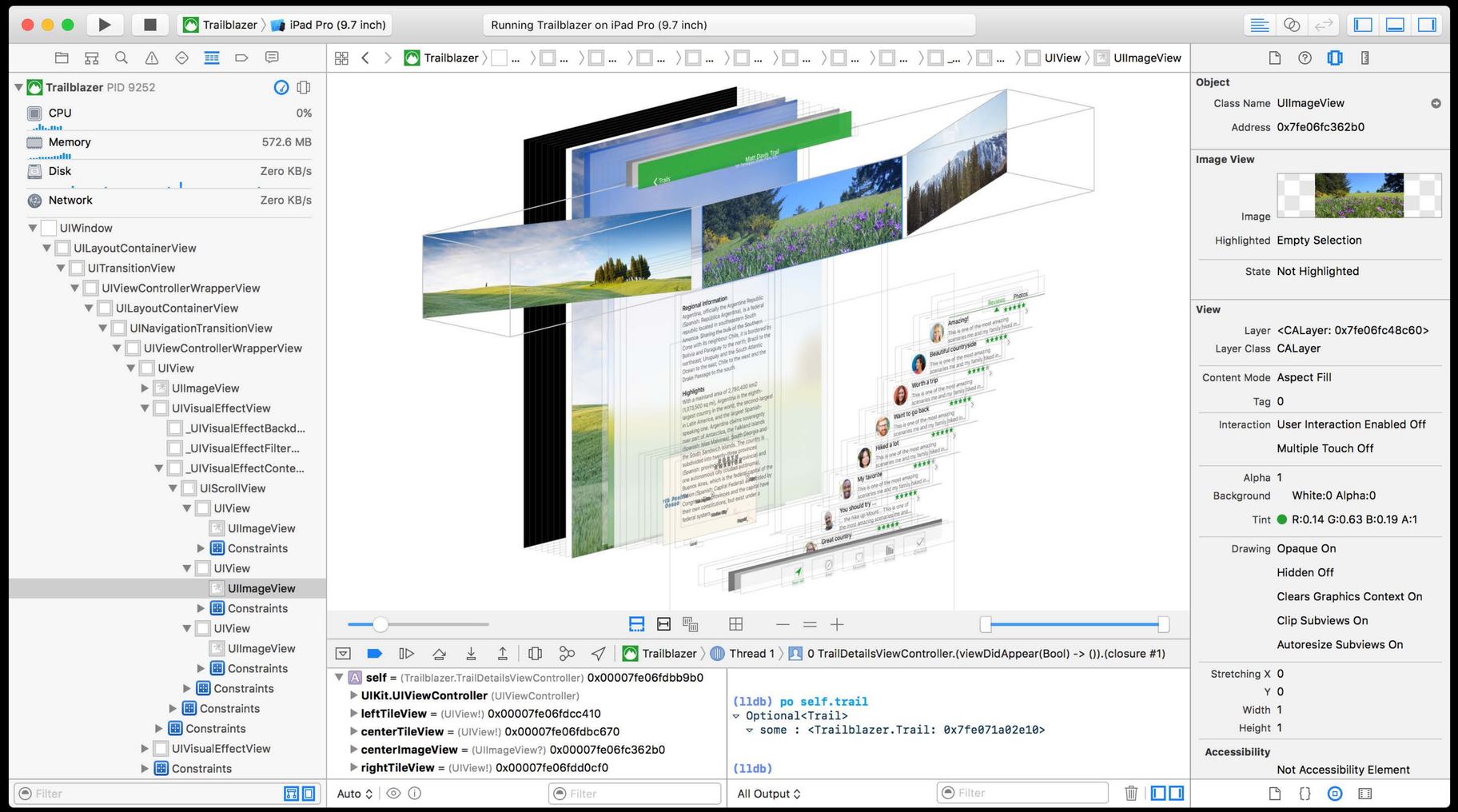
Debugging

Later…



Debugging

Now…



Overview

Runtime issues

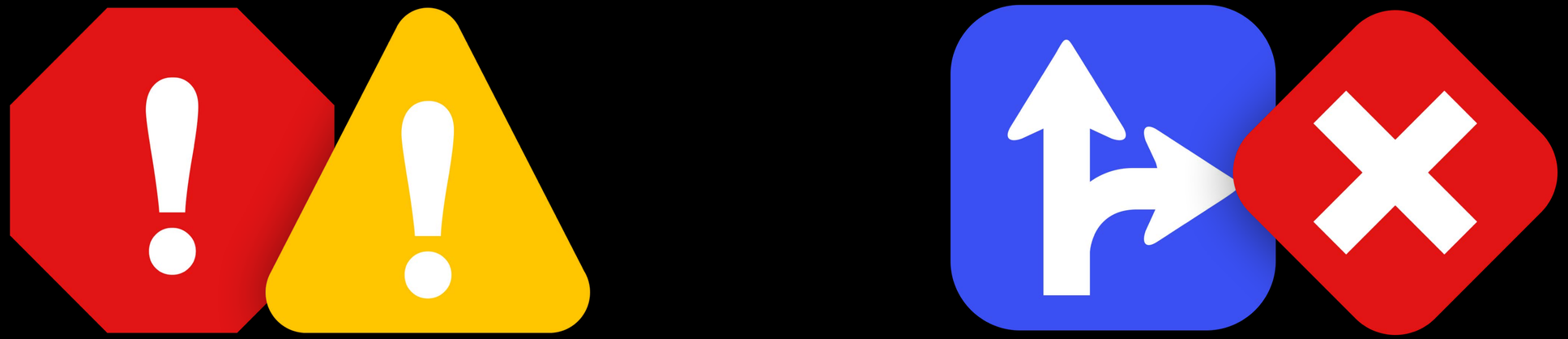
View debugging

State machine Quick Looks

SpriteKit/SceneKit FPS gauge

Memory graph debugging

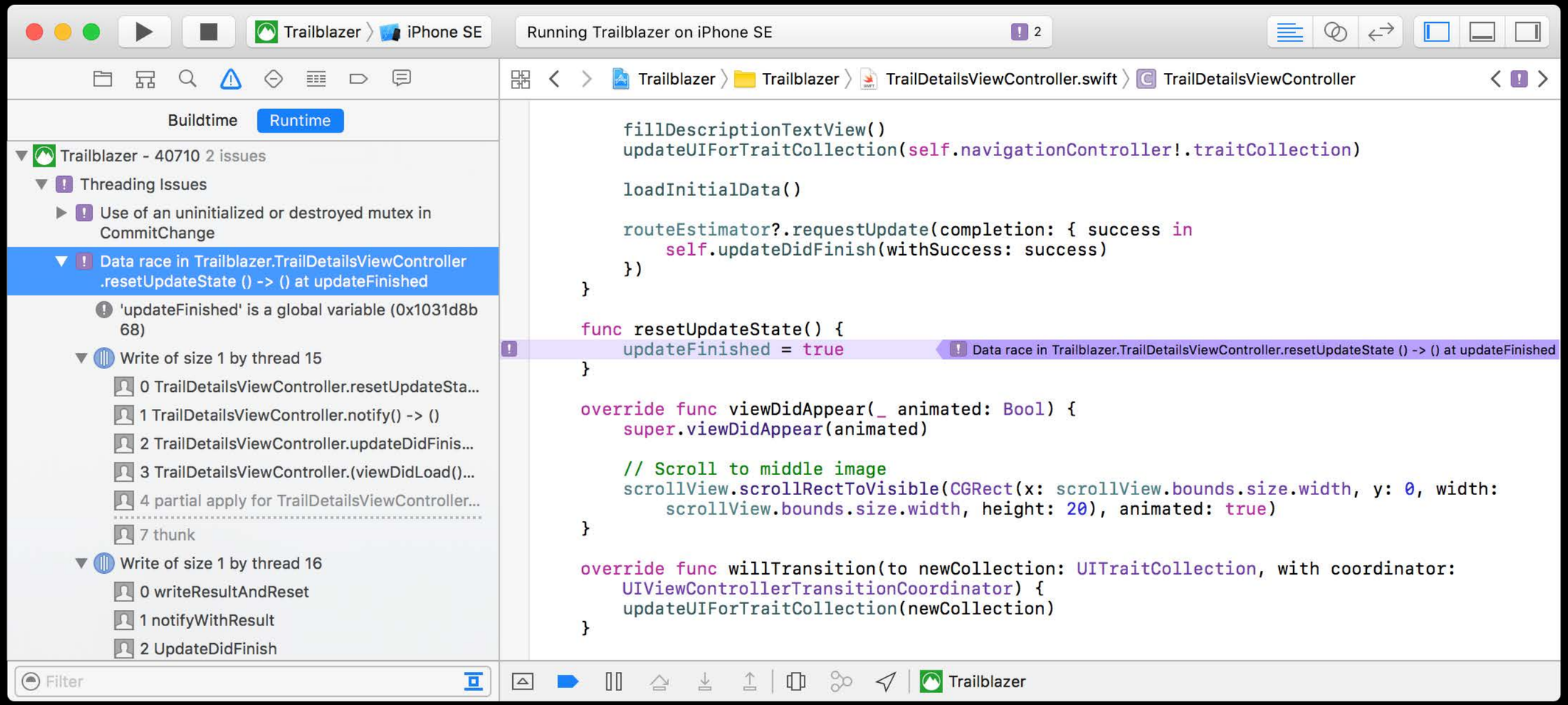
Runtime Issues



Runtime Issues

Runtime Issues

NEW



Runtime Issues

NEW

Trailblazer 〉 iPhone SE | Running Trailblazer on iPhone SE | 2

Runtime

sues

zed or destroyed mutex in

lazer.TrailDetailsViewController
() -> () at updateFinished

' is a global variable (0x1031d8b

y thread 15

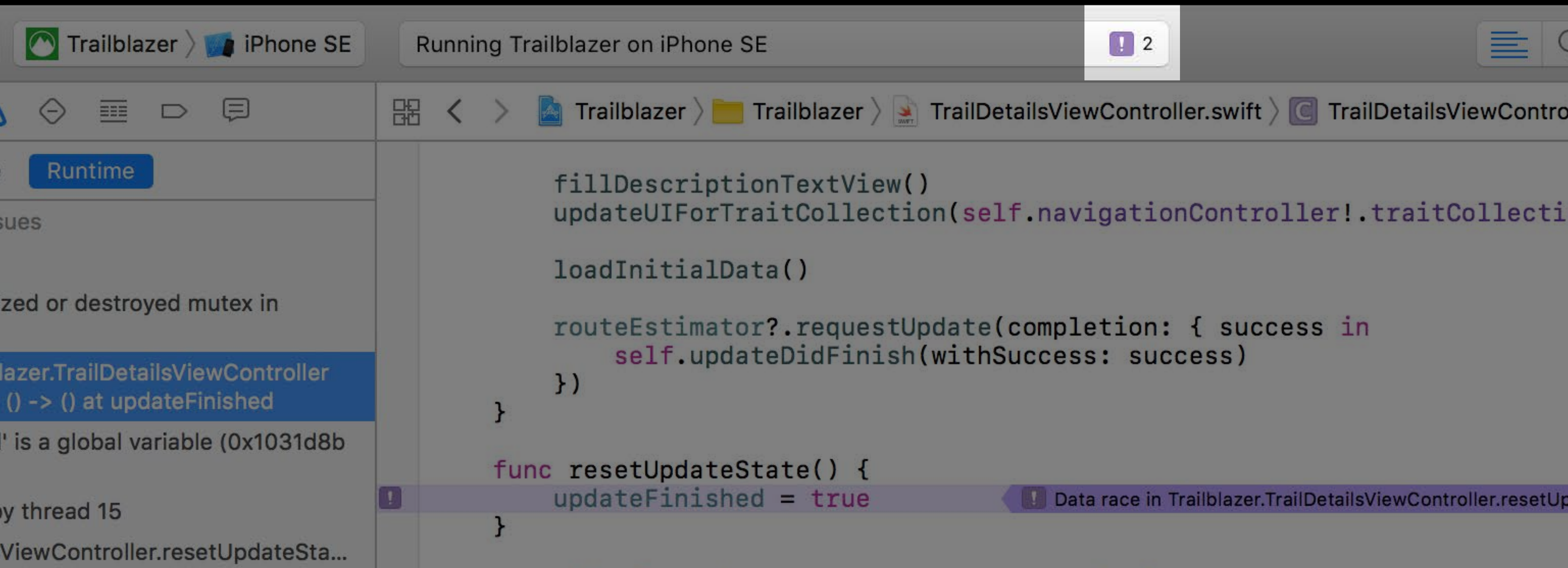
ViewController.resetUpdateSta...

Trailblazer 〉 Trailblazer 〉 TrailDetailsViewController.swift 〉 TrailDetailsViewContro

```
        fillDescriptionTextView()
        updateUIForTraitCollection(self.navigationController!.traitCollecti

        loadInitialData()

        routeEstimator?.requestUpdate(completion: { success in
            self.updateDidFinish(withSuccess: success)
        })
    }

    func resetUpdateState() {
        updateFinished = true                Data race in Trailblazer.TrailDetailsViewController.resetUp
    }
```

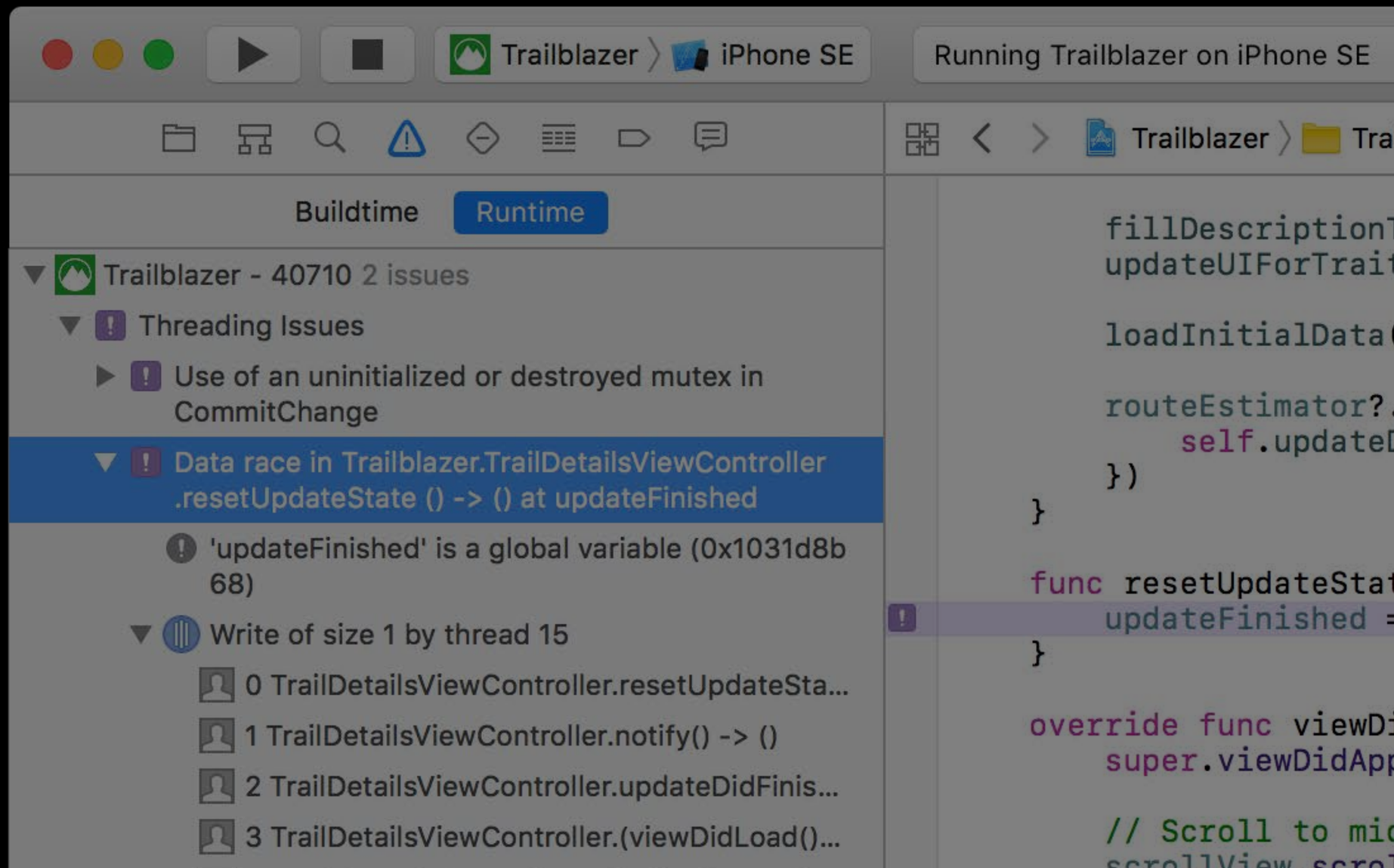
Runtime Issues

NEW



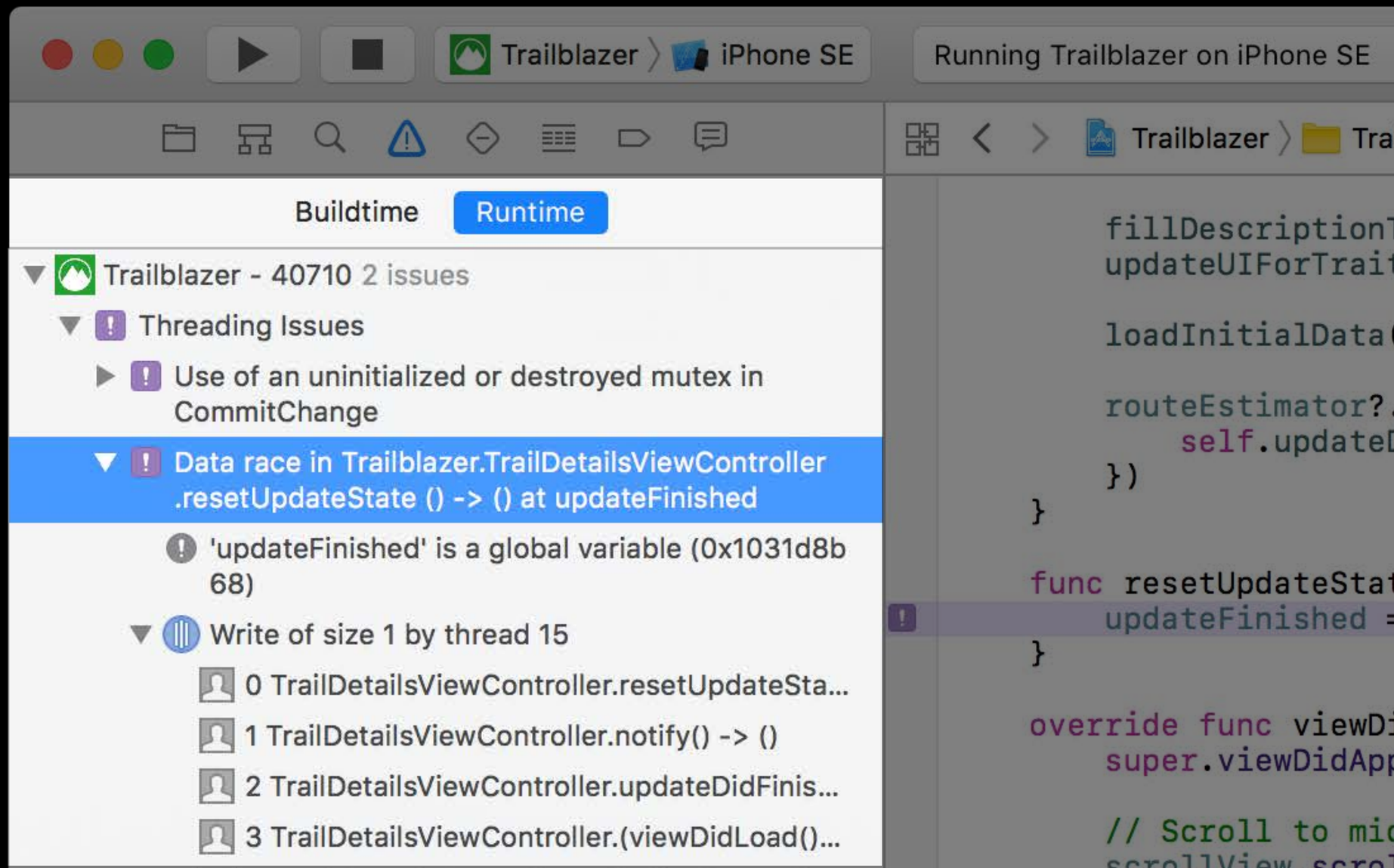
Runtime Issues

NEW



Runtime Issues

NEW



Runtime Issues

Participating tools

NEW

Runtime Issues

Participating tools

NEW

Threads

Runtime Issues

Participating tools

NEW

UI

Threads

Runtime Issues

Participating tools

NEW

UI

Threads

Memory

Runtime Issues

Thread Sanitizer

NEW

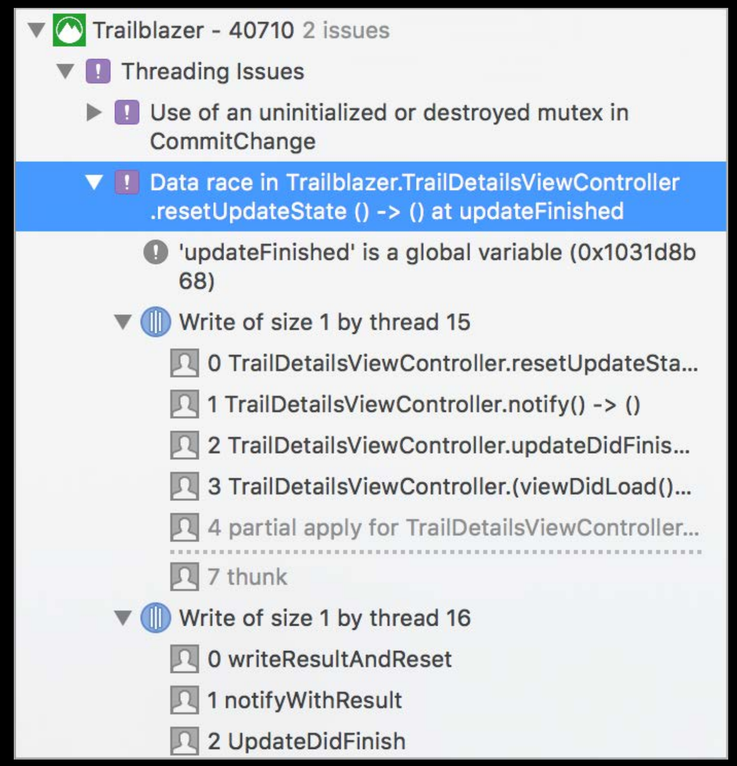
Data races

Use of uninitialized mutexes

Unlock from wrong thread

Thread leaks

Unsafe calls in signal handlers



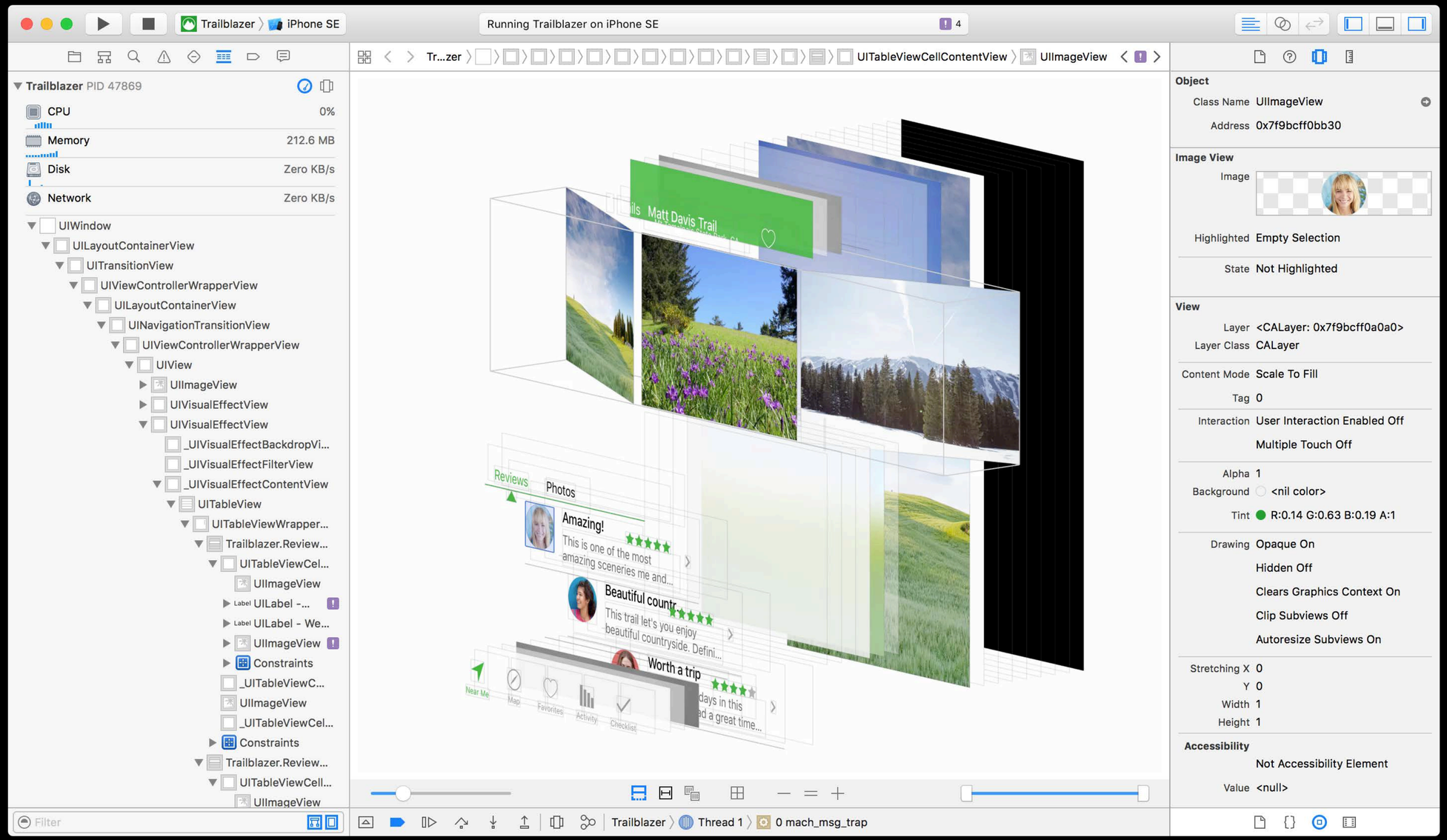
Thread Sanitizer and Static Analysis — Nob Hill — Thursday 10:00AM

View Debugging

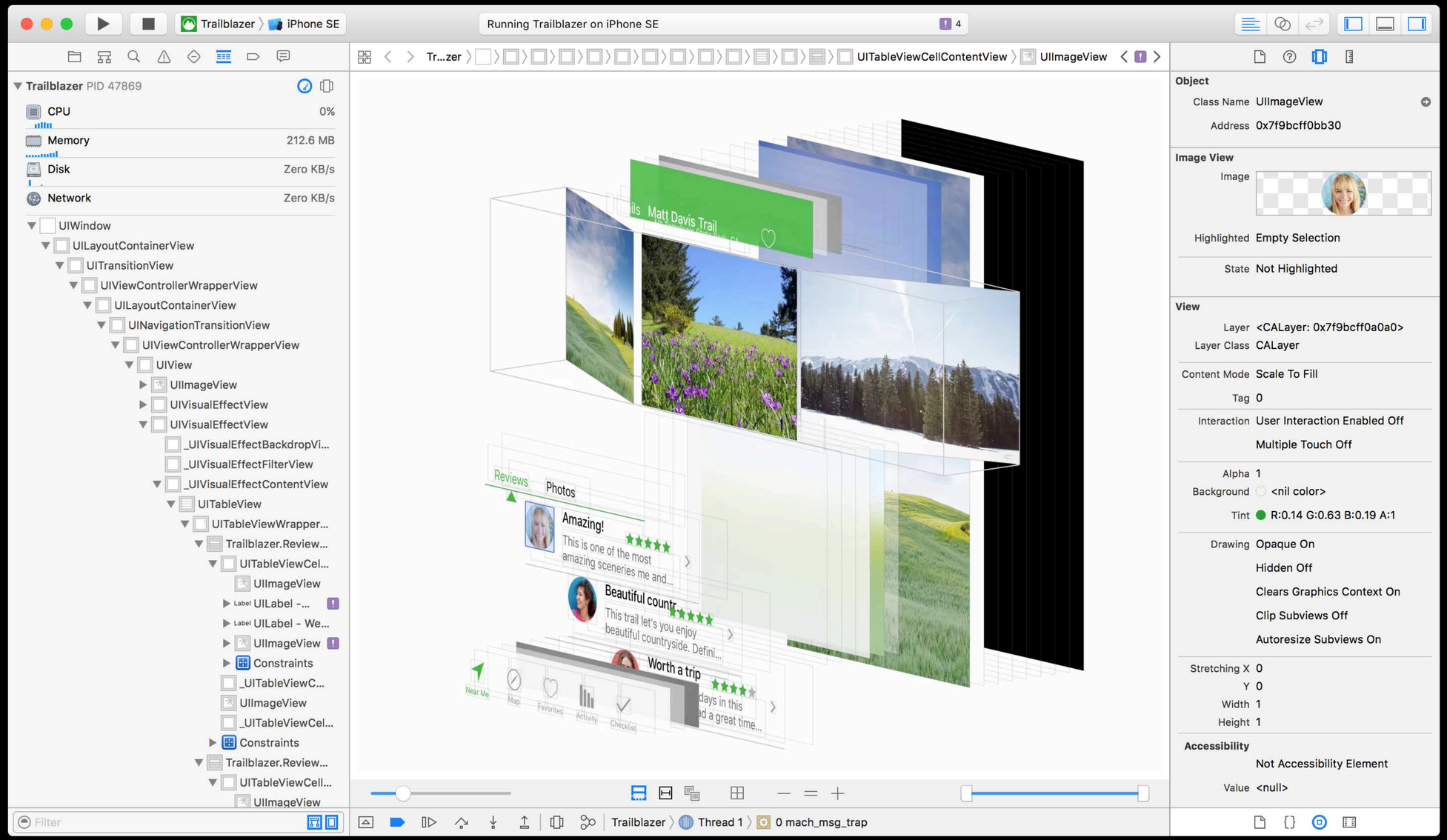
View Debugging

```
(lldb) po [self.view recursiveDescription]
<UIView: 0x7fcc9f613f60; frame = (0 0; 375 667); autoresize = RM+BM; layer = <CALayer: 0x7fcc9f6140f0>>
   | <UIScrollView: 0x7fcca181e400; frame = (0 0; 375 667); clipsToBounds = YES; autoresize = RM+BM; gestureRecognizers = <NSA
   |    | <UIView: 0x7fcc9f614270; frame = (0 0; 375 1673.5); autoresize = RM+BM; layer = <CALayer: 0x7fcc9f614130>>
   |    |    | <UILabel: 0x7fcc9f614400; frame = (166.5 24; 42 20.5); text = 'Label'; opaque = NO; autoresize = RM+BM; userInt
   |    |    | <UIButton: 0x7fcc9f614a10; frame = (164.5 52.5; 46 30); opaque = NO; autoresize = RM+BM; layer = <CALayer: 0x7f
   |    |    |    | <UIButtonLabel: 0x7fcca13c9fd0; frame = (0 6; 46 18); text = 'Button'; opaque = NO; userInteractionEnabled
   |    |    | <UISegmentedControl: 0x7fcc9f615080; frame = (127 138; 121 29); opaque = NO; autoresize = RM+BM; layer = <CALay
   |    |    |    | <UISegment: 0x7fcc9f6158a0; frame = (61 0; 60 29); opaque = NO; layer = <CALayer: 0x7fcc9f615d70>>
   |    |    |    |    | <UISegmentLabel: 0x7fcc9f6161d0; frame = (7 6.5; 46 16); text = 'Second'; opaque = NO; userInteractio
   |    |    |    |    | <UIImageView: 0x7fcc9f72a360; frame = (60 0; 1 29); alpha = 0; opaque = NO; autoresize = LM; userInte
   |    |    |    | <UISegment: 0x7fcca1341e10; frame = (0 0; 60 29); opaque = NO; layer = <CALayer: 0x7fcca1310cb0>>
   |    |    |    |    | <UISegmentLabel: 0x7fcca1342060; frame = (16.5 6.5; 27 16); text = 'First'; opaque = NO; userInteract
   |    |    |    |    | <UIImageView: 0x7fcca1342bb0; frame = (60 0; 1 29); opaque = NO; autoresize = LM; userInteractionEnab
   |    |    | <UITextField: 0x7fcc9f70fd50; frame = (98.5 246; 178 30); text = ''; clipsToBounds = YES; opaque = NO; autoresi
   |    |    |    | <_UITextFieldRoundedRectBackgroundViewNeue: 0x7fcca1267240; frame = (0 0; 178 30); opaque = NO; autoresize
   |    |    |    | <UITextFieldLabel: 0x7fcca1265b70; frame = (7 0.5; 164 27.5); text = 'This is a placeholder'; opaque = NO;
   |    |    | <UITextField: 0x7fcca1115e30; frame = (142.5 285; 90.5 24.5); text = 'This is text'; clipsToBounds = YES; opaqu
   |    |    |    | <UITextFieldLabel: 0x7fcca11163d0; frame = (2 2; 87 20.5); text = 'This is text'; opaque = NO; userInterac
   |    |    | <UIButton: 0x7fcca1268fa0; frame = (226.5 56.5; 22 22); opaque = NO; autoresize = RM+BM; layer = <CALayer: 0x7f
   |    |    |    | <UIImageView: 0x7fcca13c74c0; frame = (0 0; 22 22); clipsToBounds = YES; opaque = NO; userInteractionEnabl
```

View Debugging



View Debugging



View Debugging

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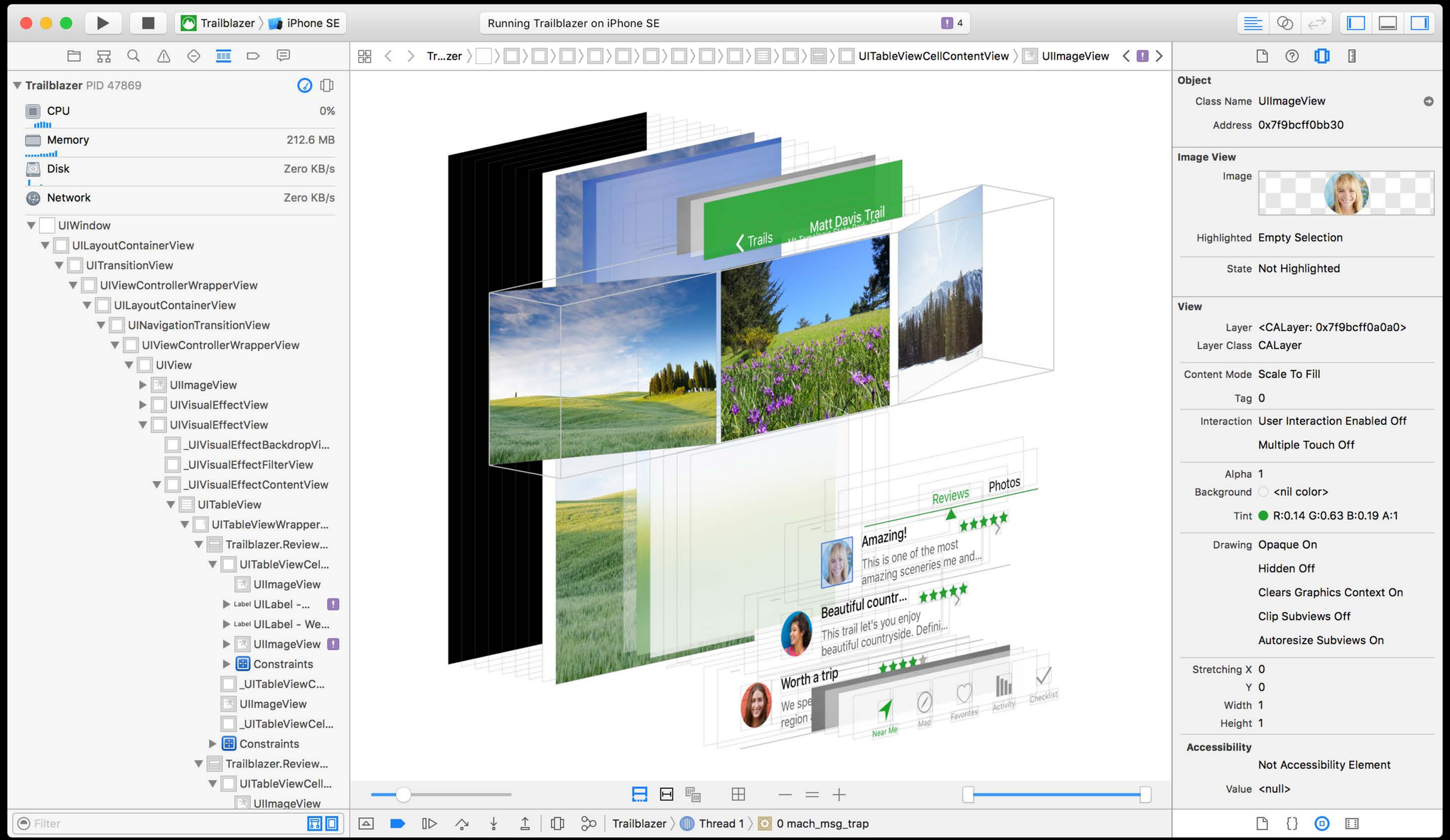


View Debugging

Better than ever

NEW

View Debugging

Better than ever

NEW

Up to 70% faster snapshots

70%

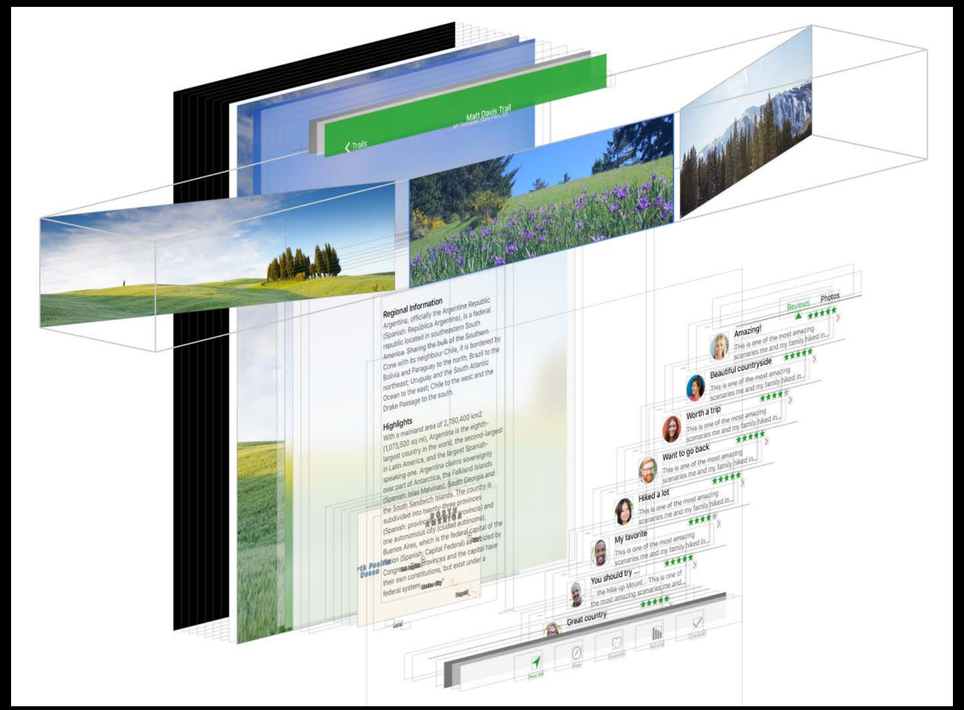
View Debugging

Better than ever

NEW

Up to 70% faster snapshots

Layout and transform accuracy



View Debugging

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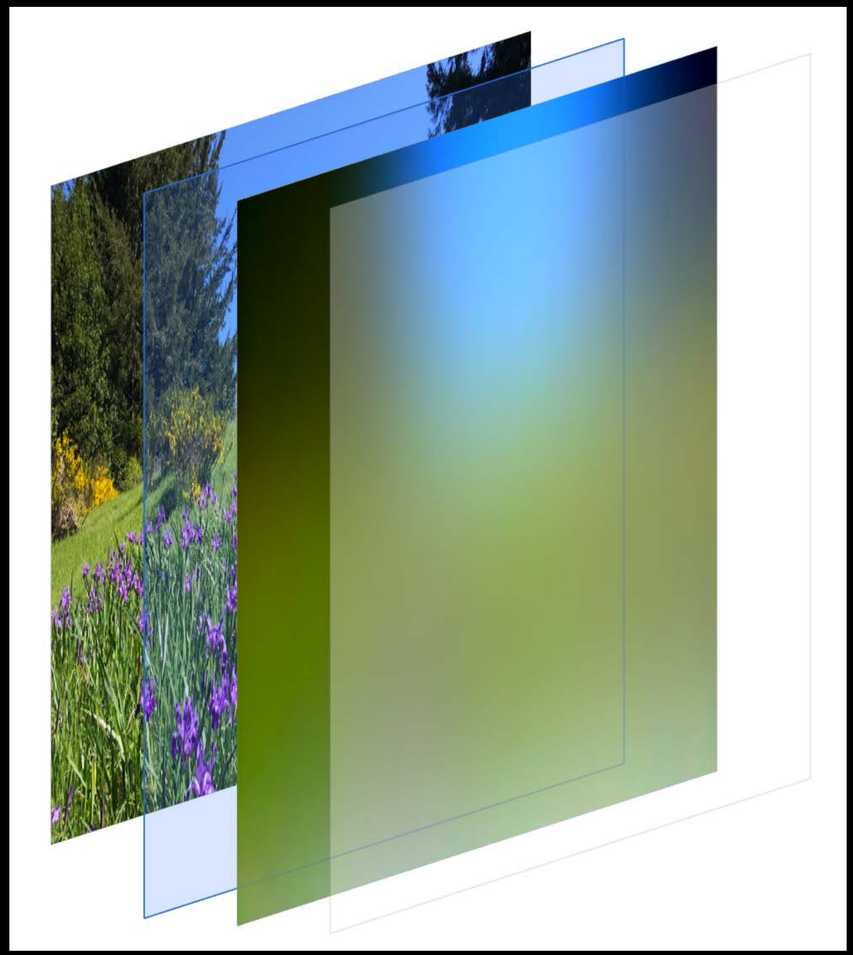
NEW

Up to 70% faster snapshots

Layout and transform accuracy

Blur rendering



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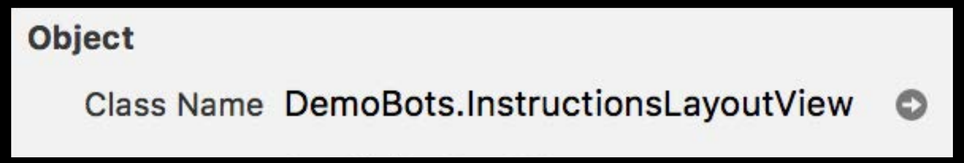
Layout and transform accuracy

Blur rendering

Jump to class



View Debugging

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NEW

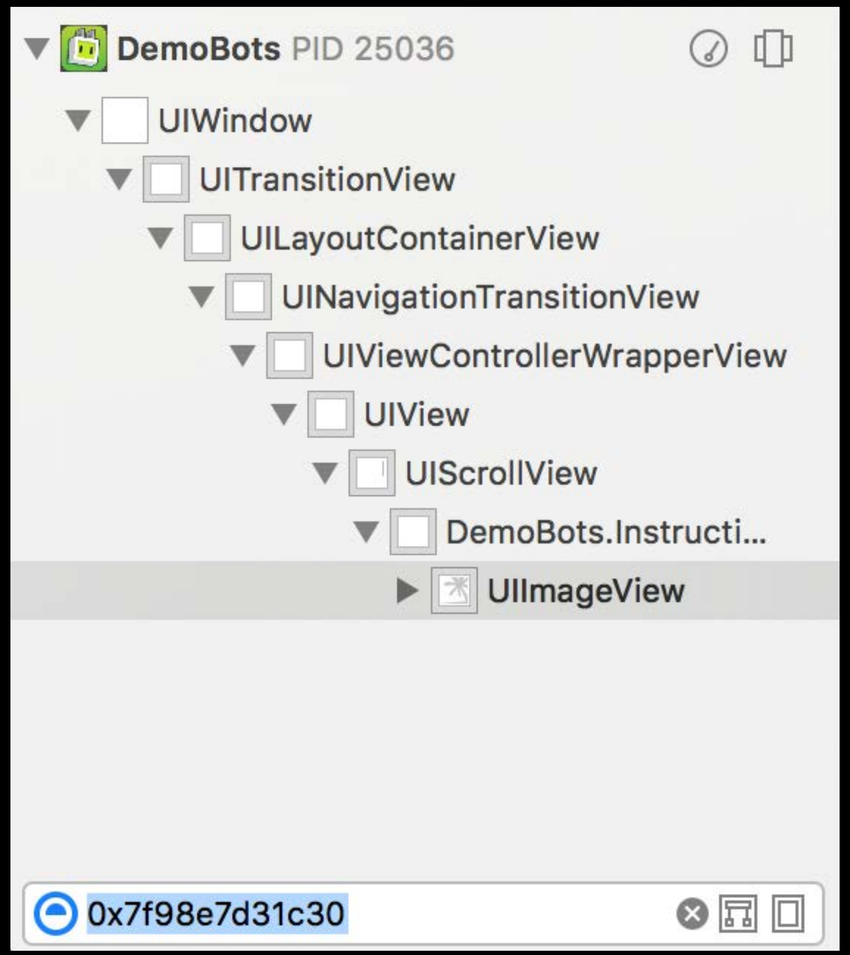
Up to 70% faster snapshots

Layout and transform accuracy

Blur rendering

Jump to class

Navigator filtering

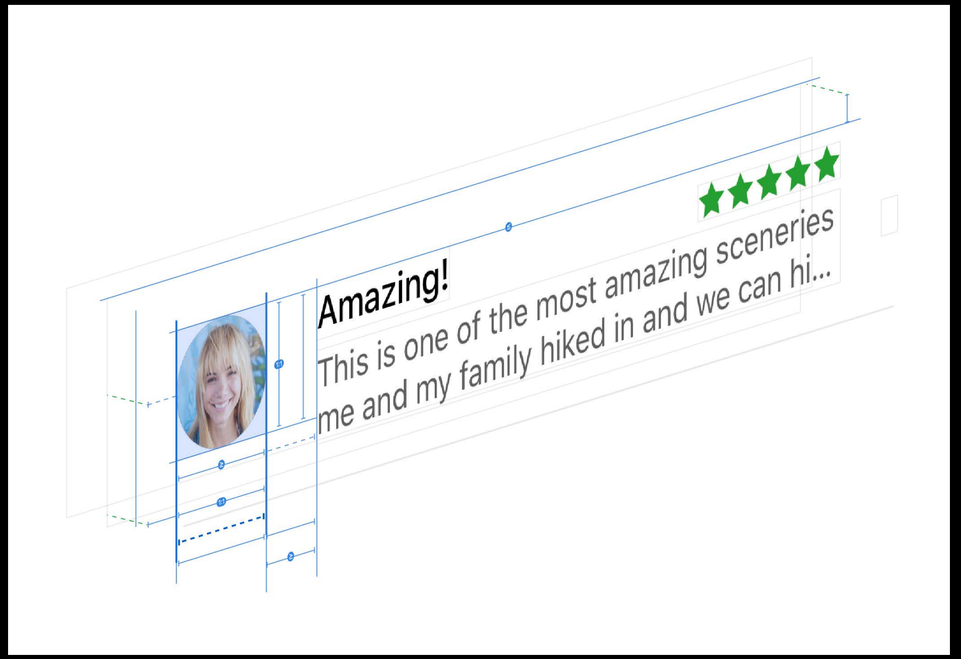


View Debugging

Better than ever

NEW

- Up to 70% faster snapshots
- Layout and transform accuracy
- Blur rendering
- Jump to class
- Navigator filtering
- Auto Layout debugging



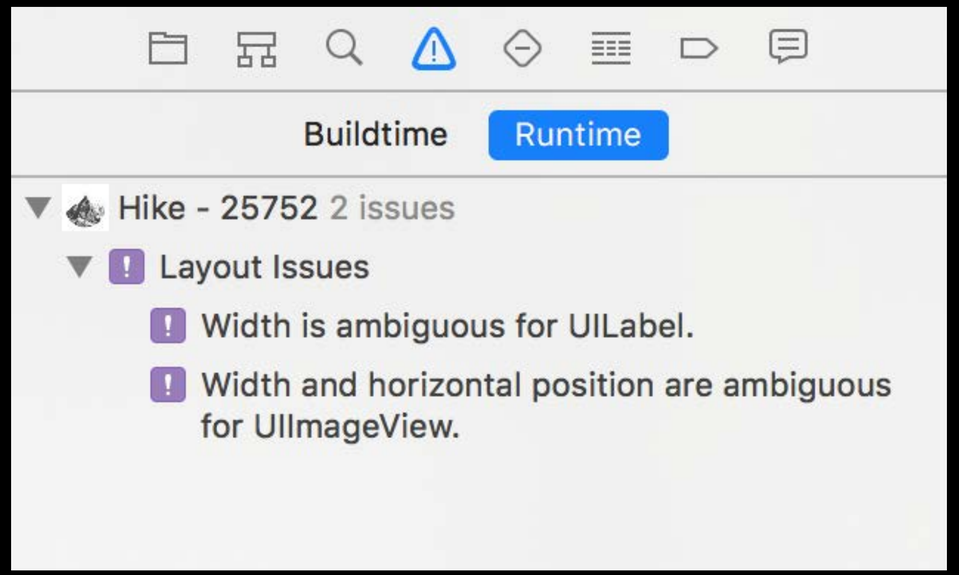
View Debugging

Ambiguous layout issues

NEW

Ambiguous layouts are reported as runtime issues

- Highlighted in the activity viewer
- Listed in the issue navigator

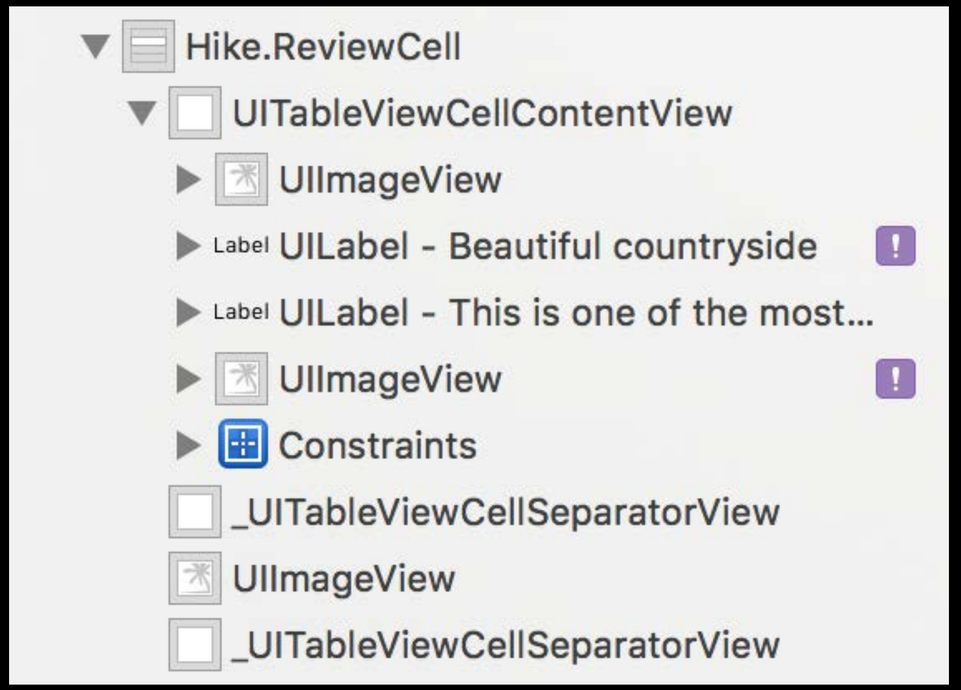


View Debugging

Ambiguous layout issues

NEW

Ambiguous layout issues are badged in the view hierarchy outline

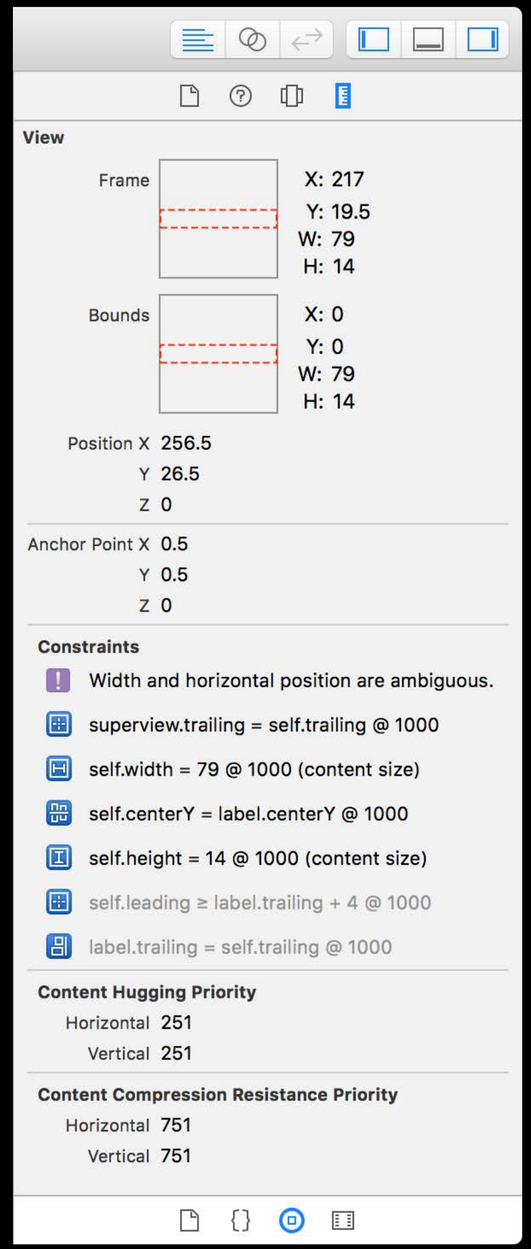


View Debugging

Ambiguous layout issues

NEW

Ambiguous layout issues are explained in the view's size inspector



View Debugging

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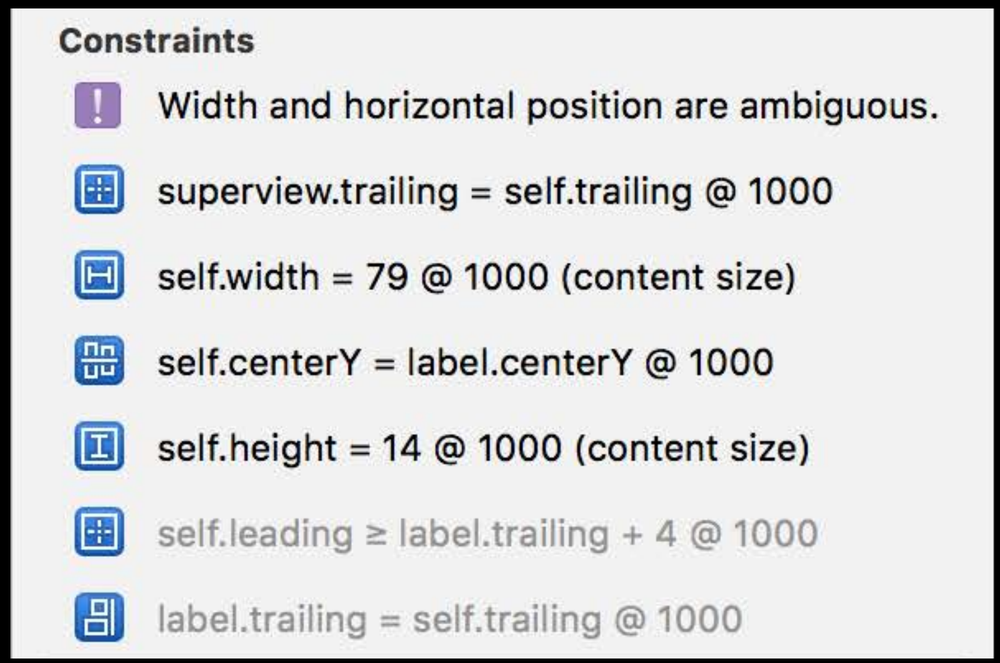


Demo

Xcode view debugging

Recap

Runtime issues

View debugging enhancements

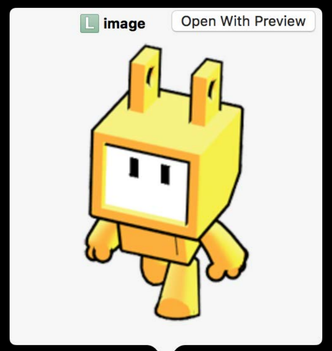
- Ambiguous layout issue reporting
- macOS, iOS, tvOS

State Machine Quick Look

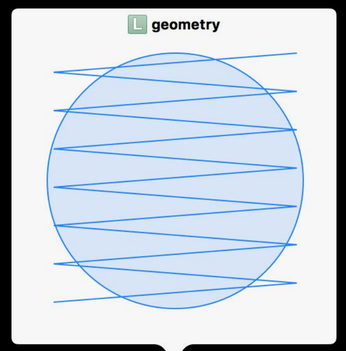
Tyler Casella Game Technologies

Quick Look

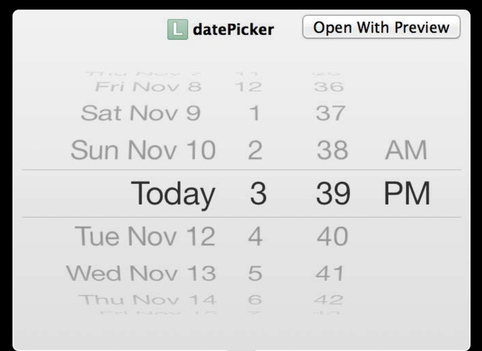
Xcode 7



Images

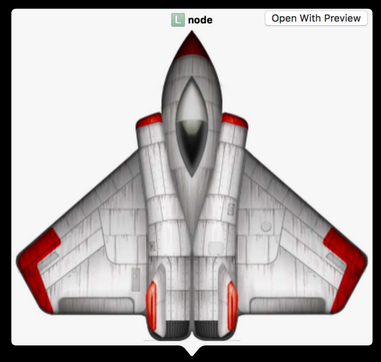


Geometry

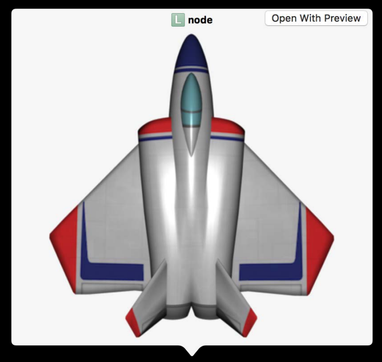


Views

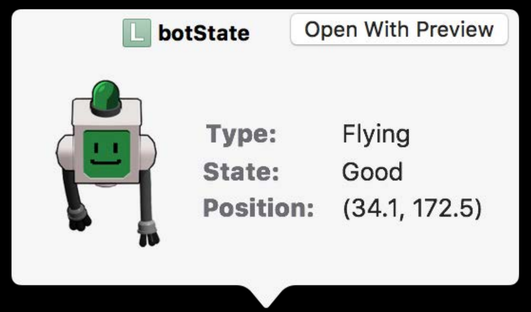
Colors



SpriteKit



SceneKit



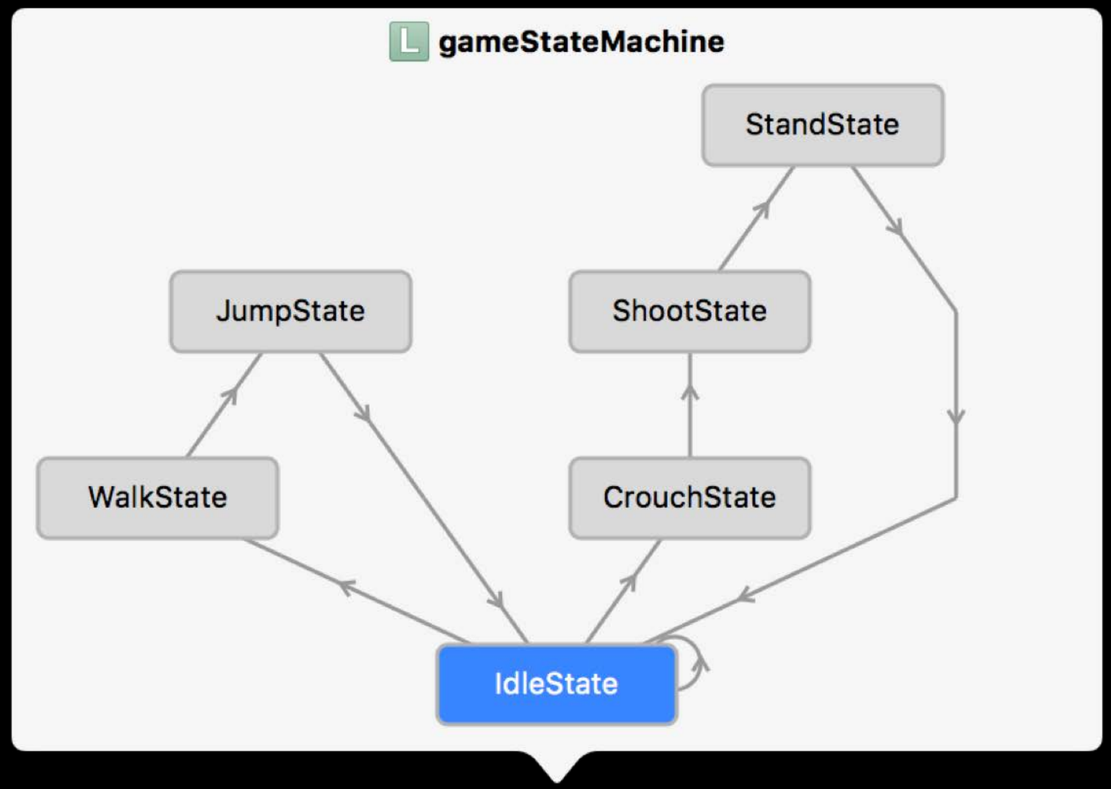
Custom

…and more!

Quick Look

Xcode 8

NEW



State Machine

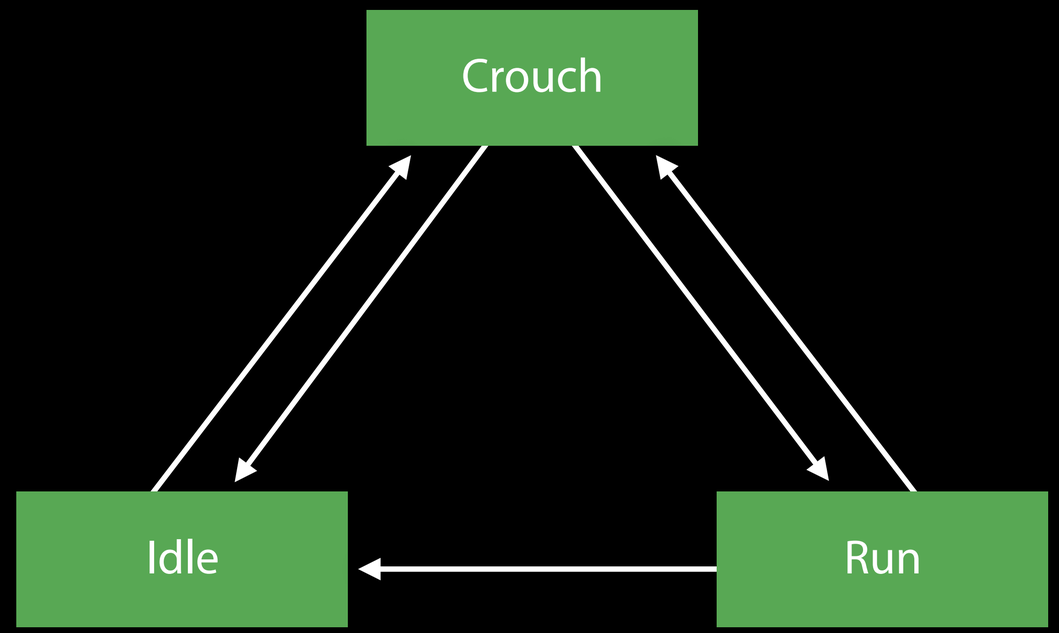
State Machine Quick Look

GKStateMachine

NEW

Available via GameplayKit

- macOS, iOS, tvOS



State Machine Quick Look

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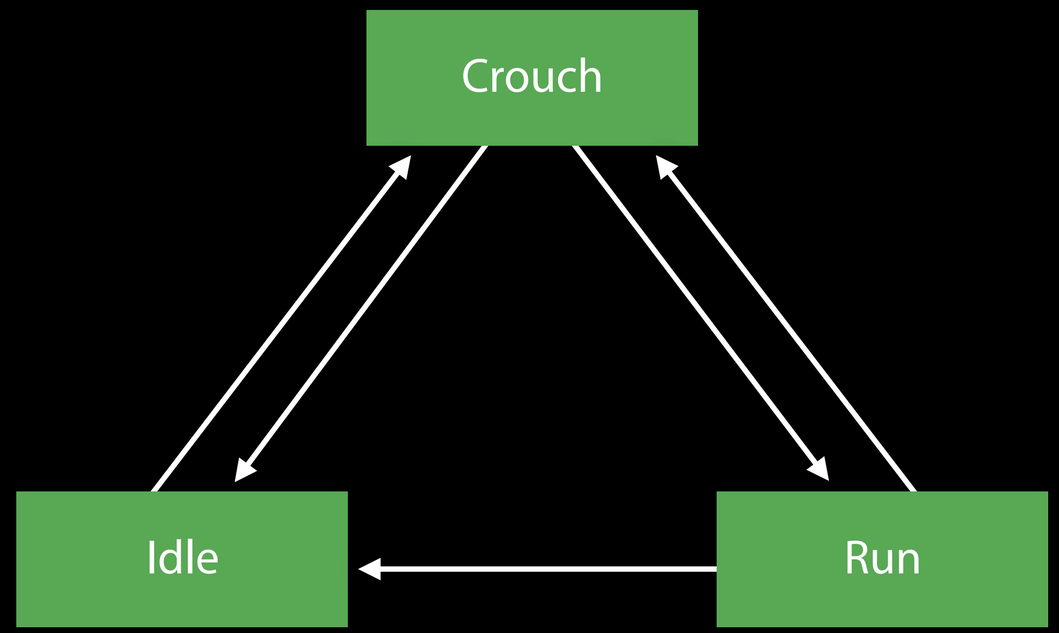
Directed graph defining complex behavior



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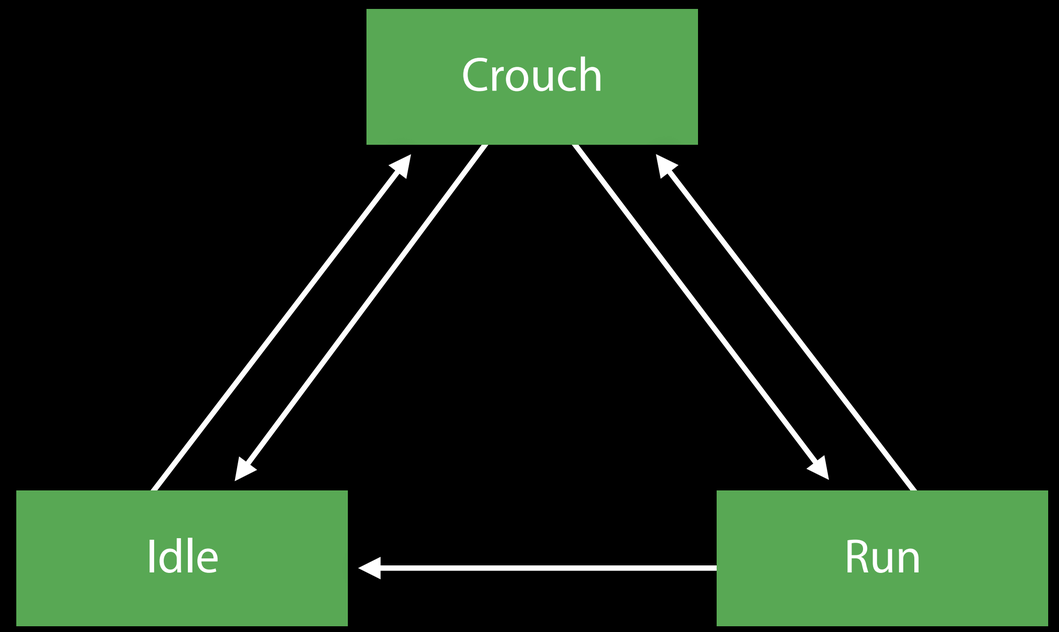
Directed graph defining complex behavior

Provide discrete behavior per-state



State Machine Quick Look

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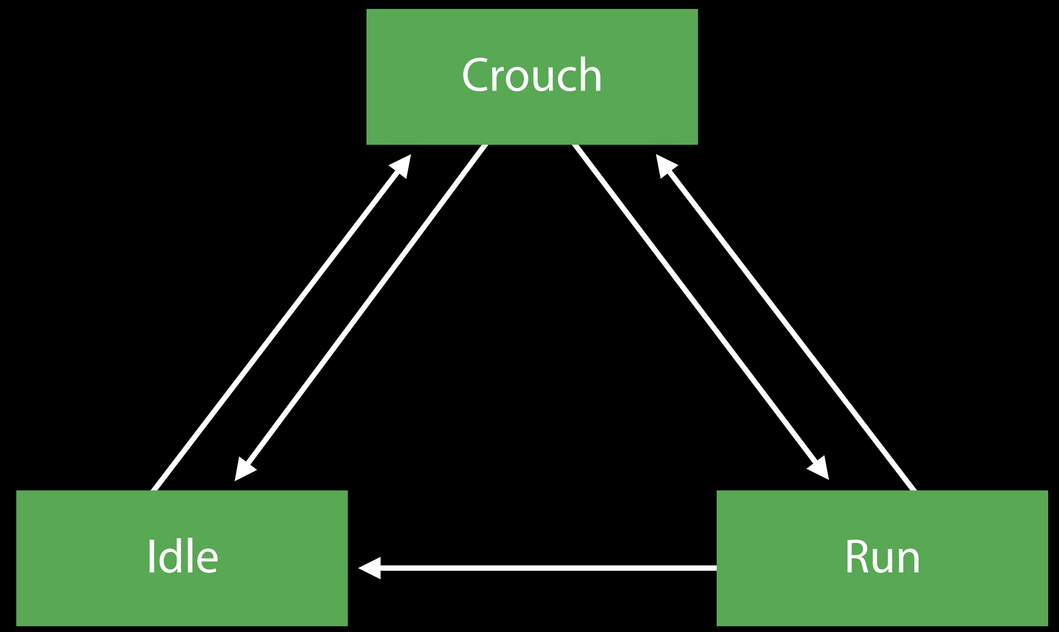
Directed graph defining complex behavior

Provide discrete behavior per-state

Define transitions between states



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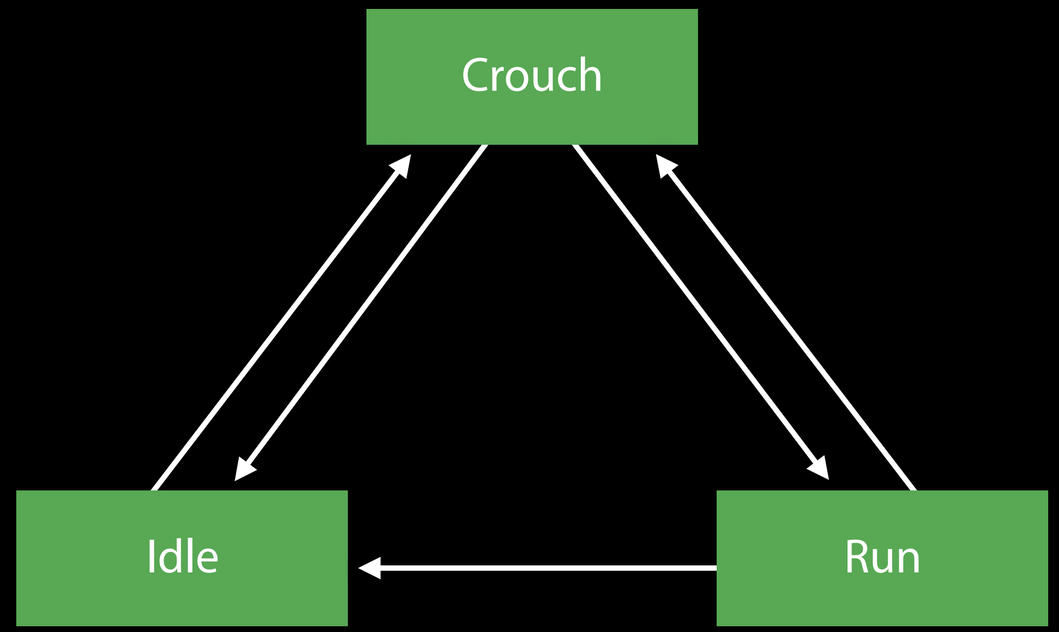
Define transitions between states

Difficult to visualize from code



State Machine Quick Look

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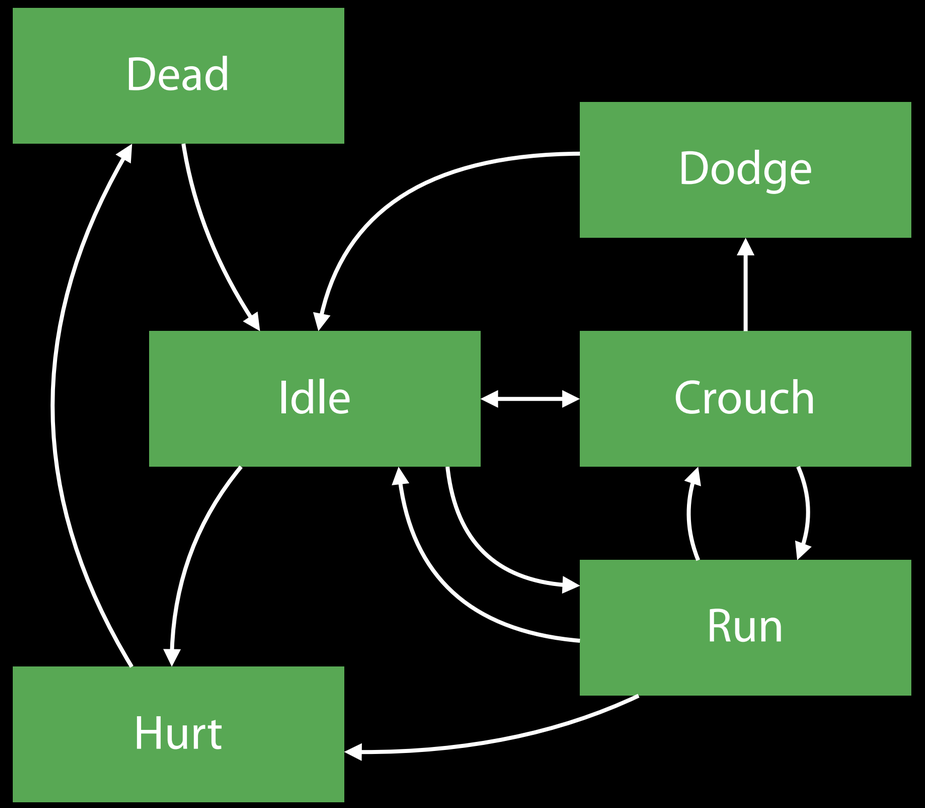

State Machine Quick Look

Then and now

```
(lldb) po machine.currentState
▿ Optional<GKState>
  ▿ some : <DemoBots.BeamIdleState: 0x174026c00>

(lldb) po machine.canEnterState(BeamIdleState)
false

(lldb) po machine.canEnterState(BeamFiringState)
true

(lldb) po machine.canEnterState(BeamCoolingState)
false

(lldb) po machine.canEnterState(BeamDisabledState)
false

(lldb) po machine.canEnterState(BeamChargingState)
false
```

Xcode 7.3

State Machine Quick Look

Then and now

NEW

```
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  ▿ some : <DemoBots.BeamIdleState: 0x174026c00>

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(lldb) po machine.canEnterState(BeamDisabledState)
false

(lldb) po machine.canEnterState(BeamChargingState)
false
```
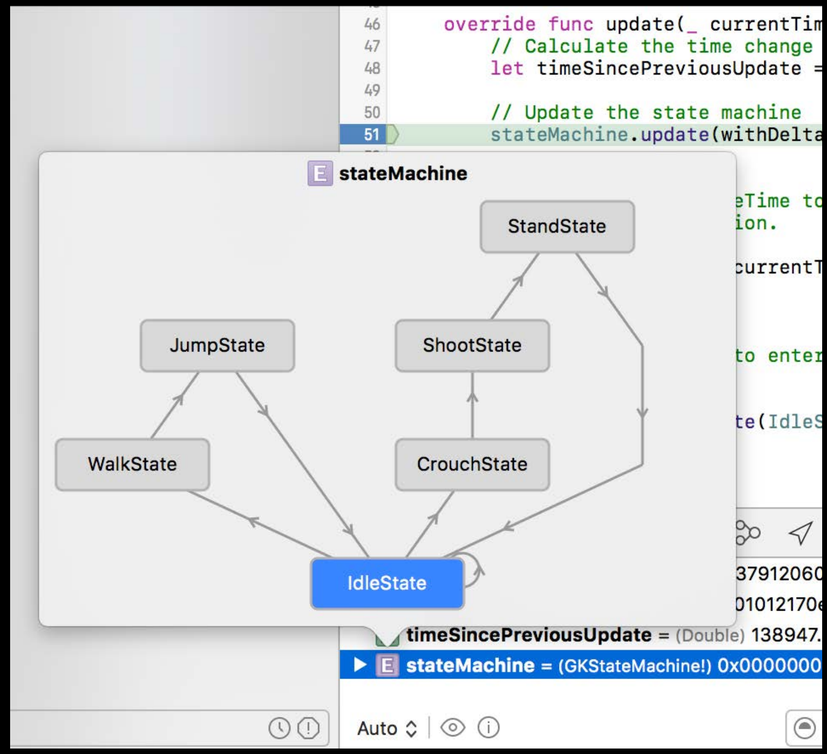

Xcode 7.3

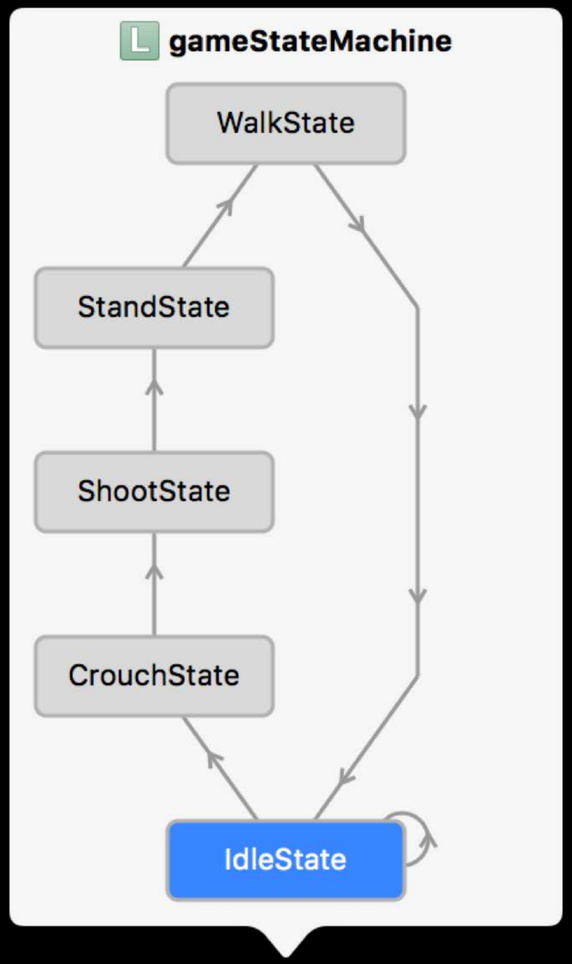


Xcode 8.0

State Machine Quick Look

Examples

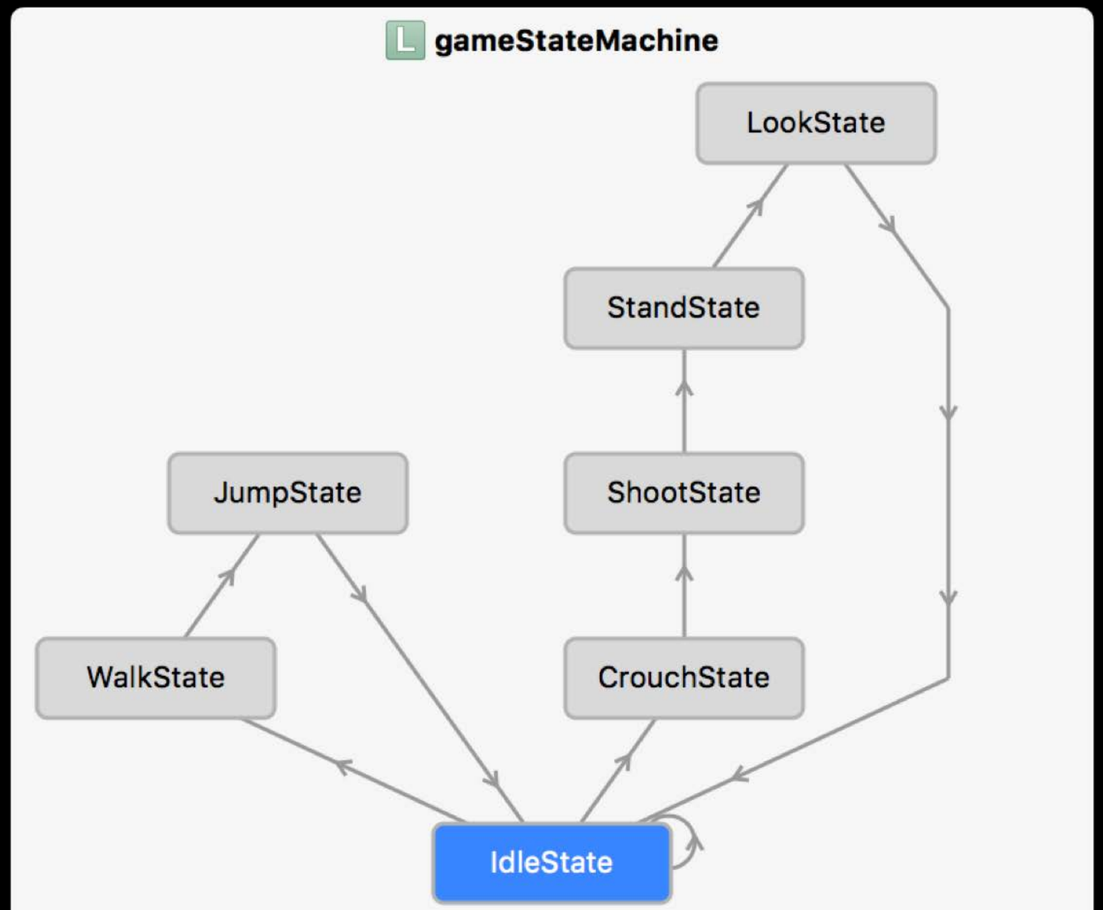
NEW

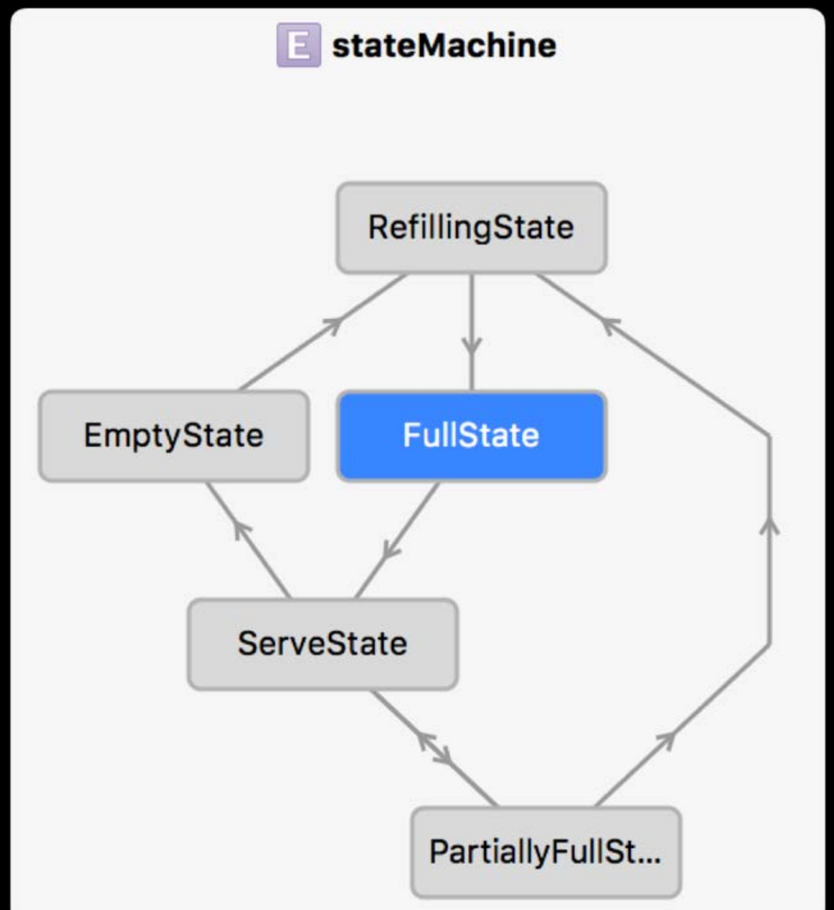


State Machine Quick Look

Examples

NEW

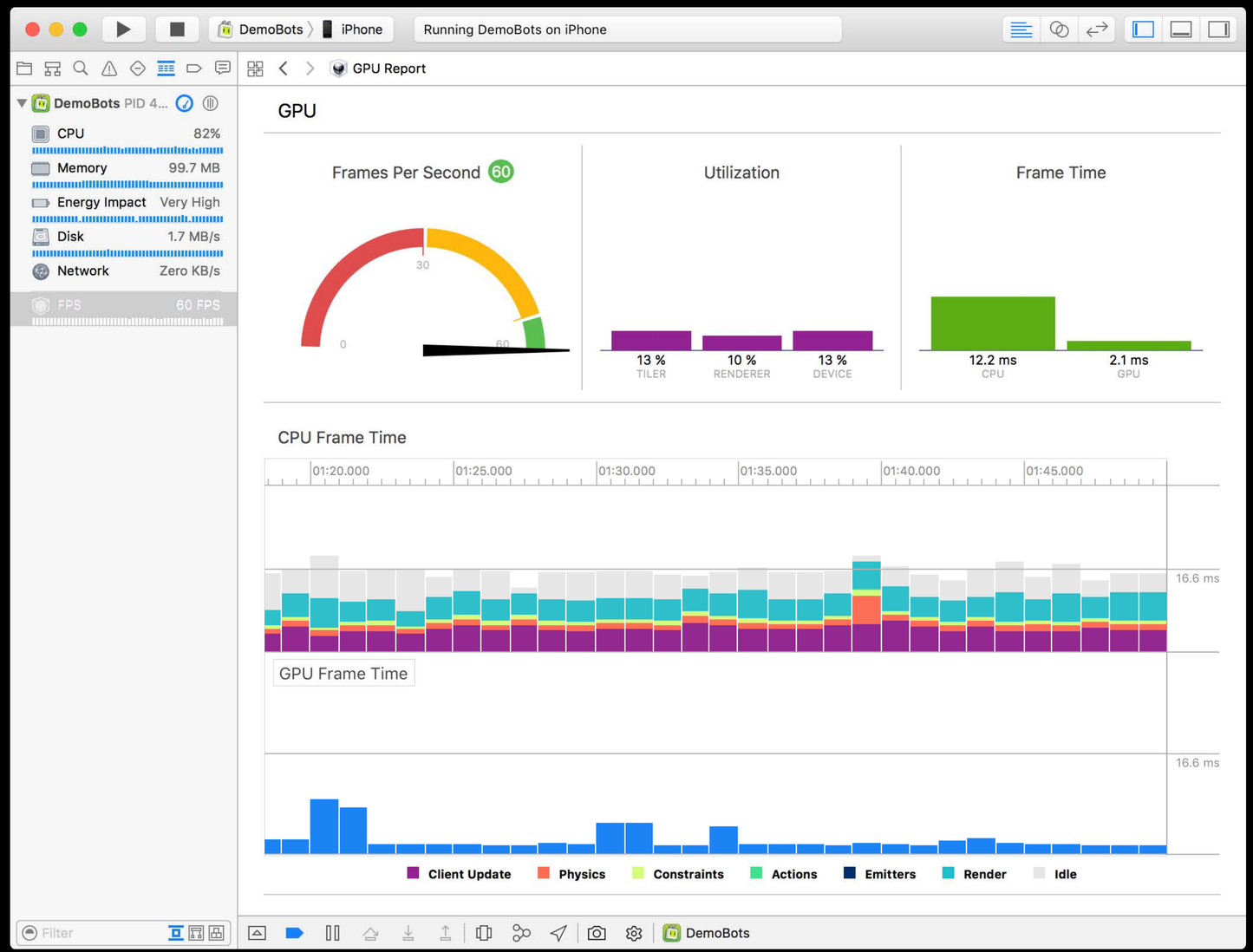




FPS Performance Gauge

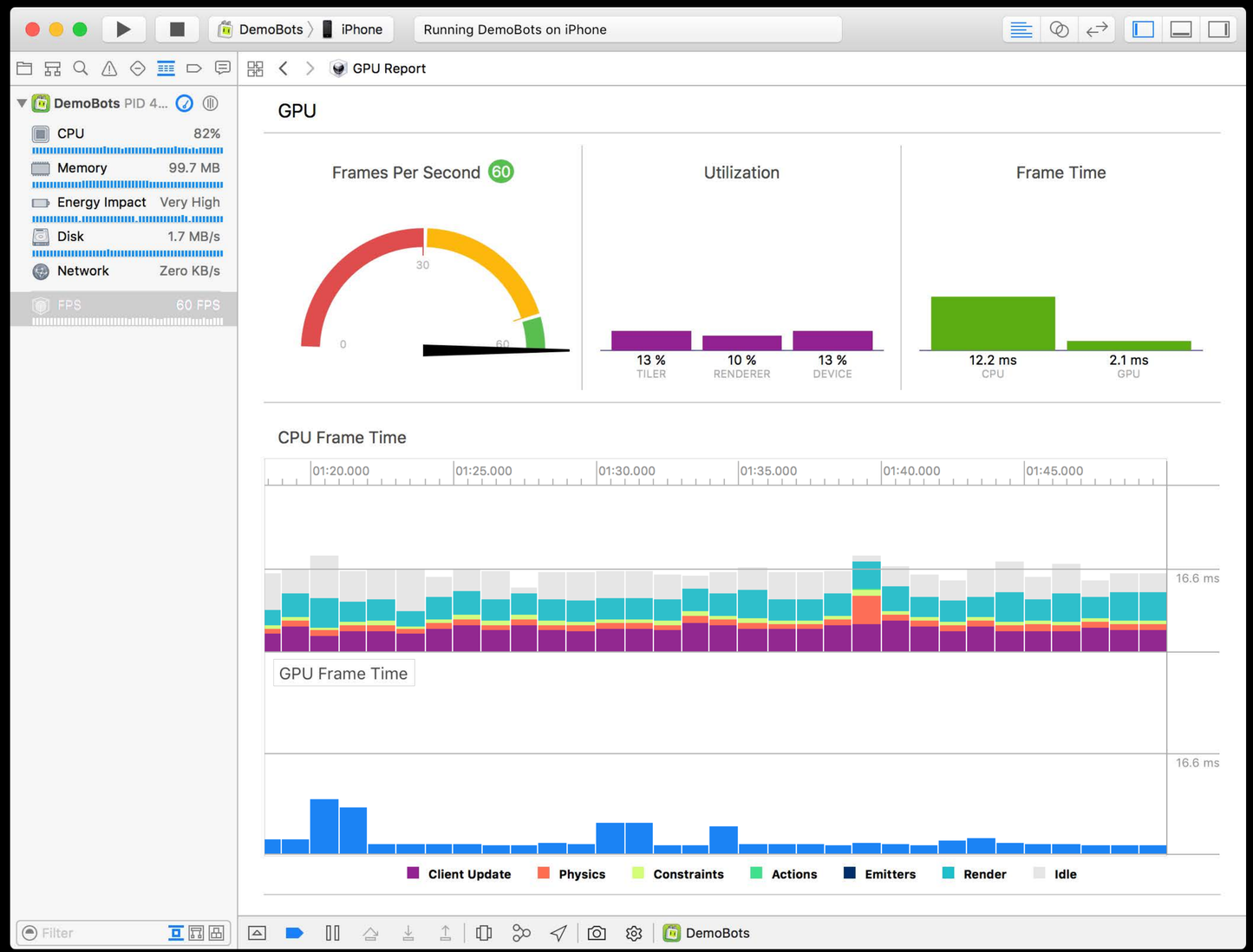
FPS Performance Gauge

Real-time performance



FPS Performance Gauge

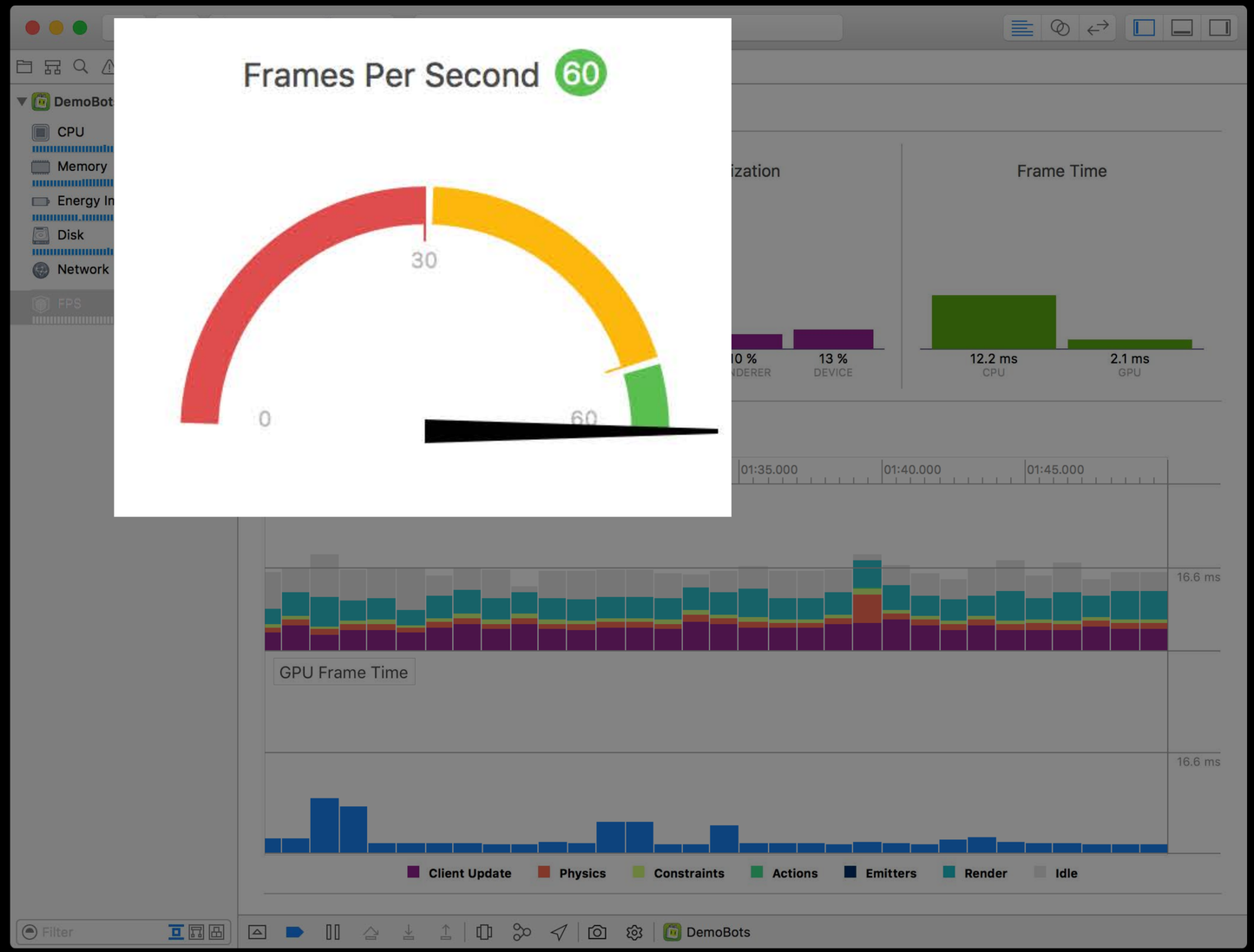
Real-time performance



FPS Performance Gauge

Real-time performance

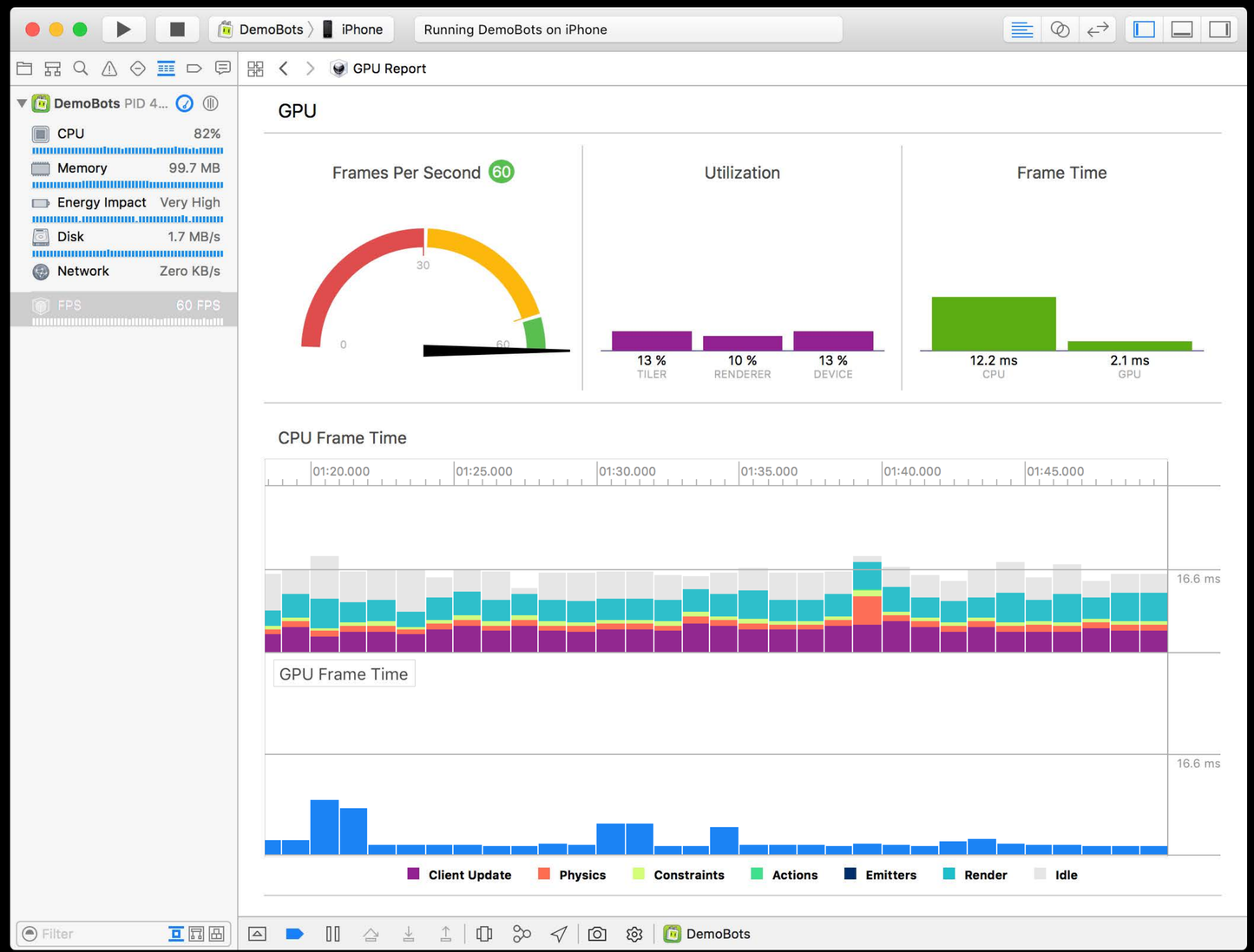
Frame rate



FPS Performance Gauge

Real-time performance

Frame rate



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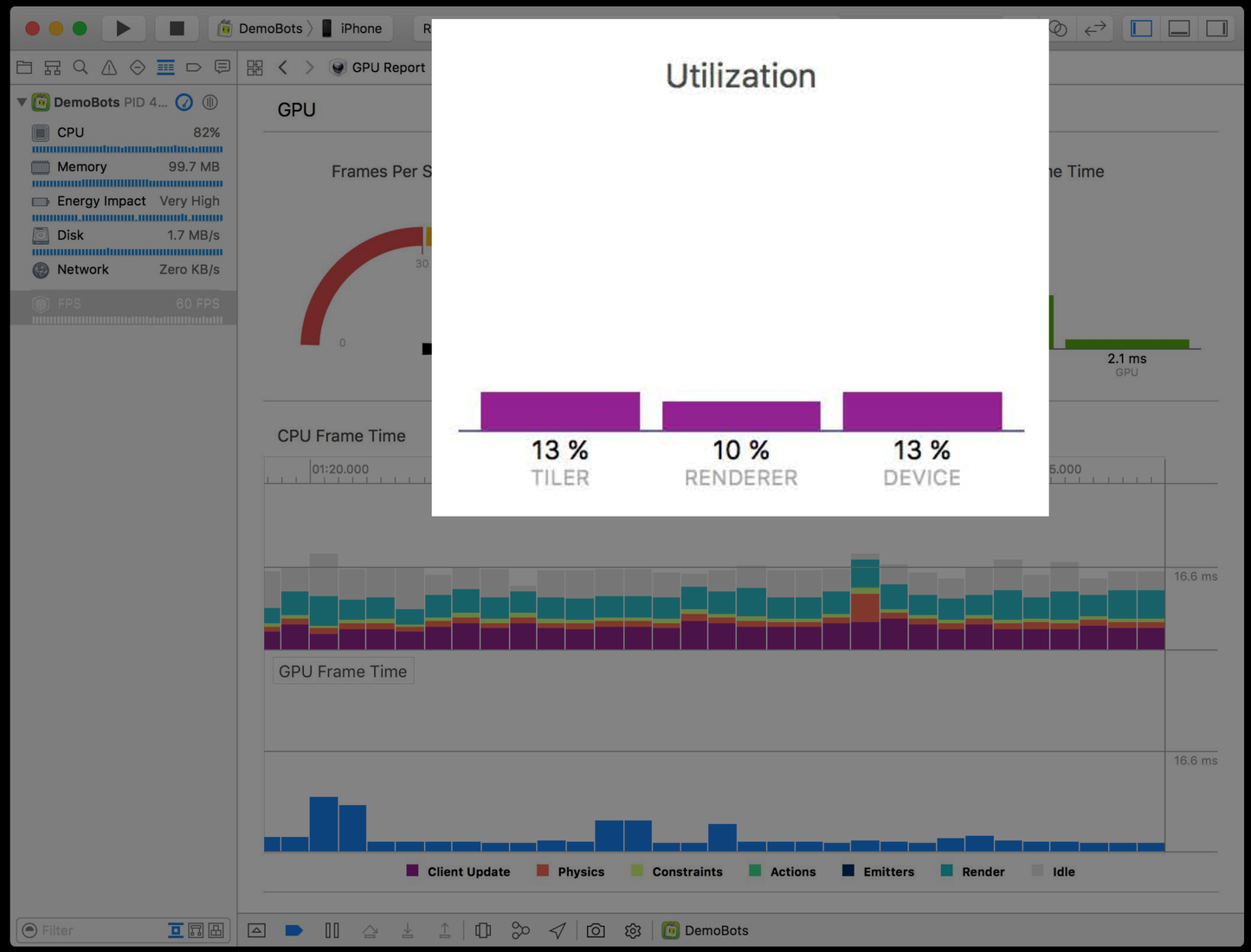
GPU utilization



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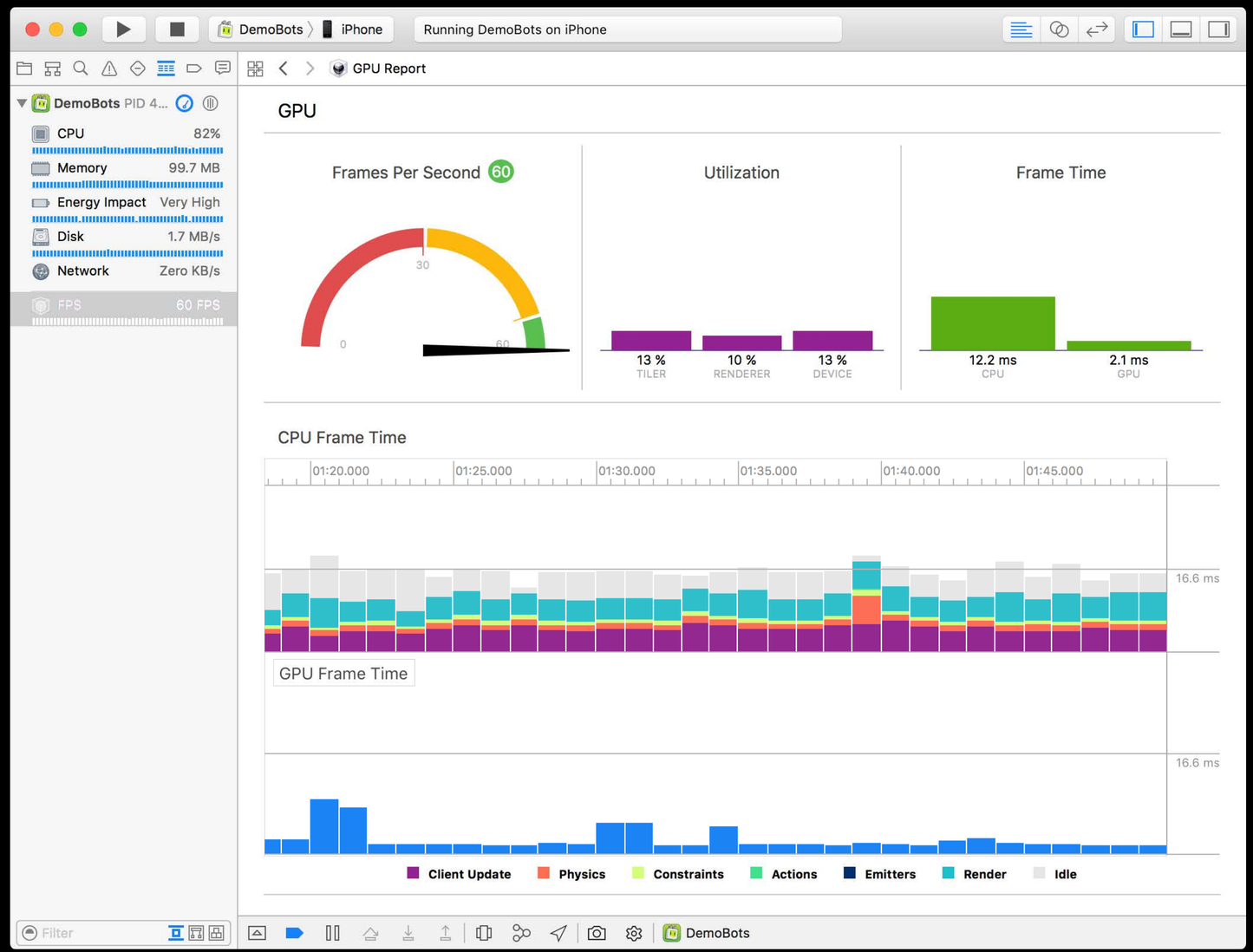

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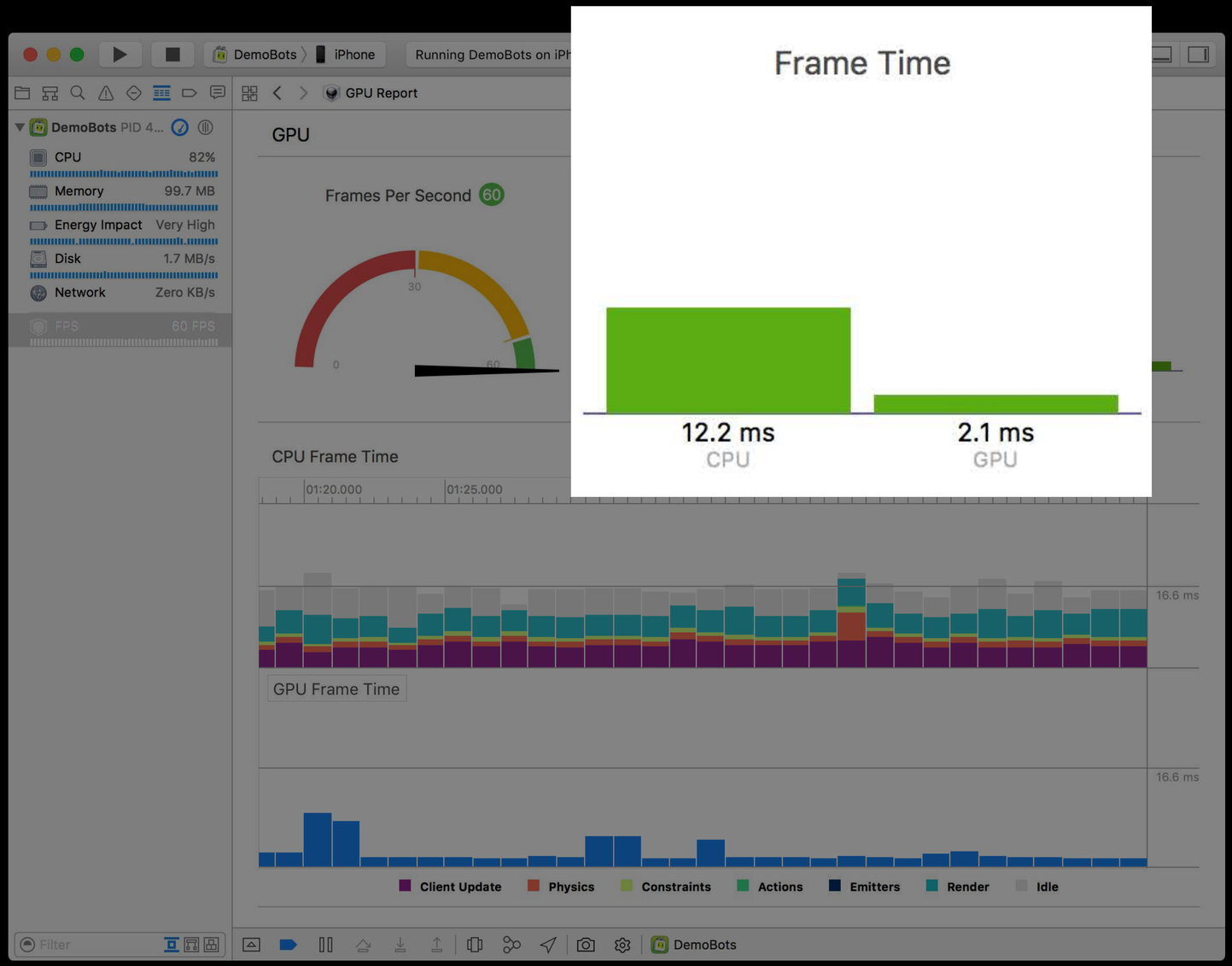

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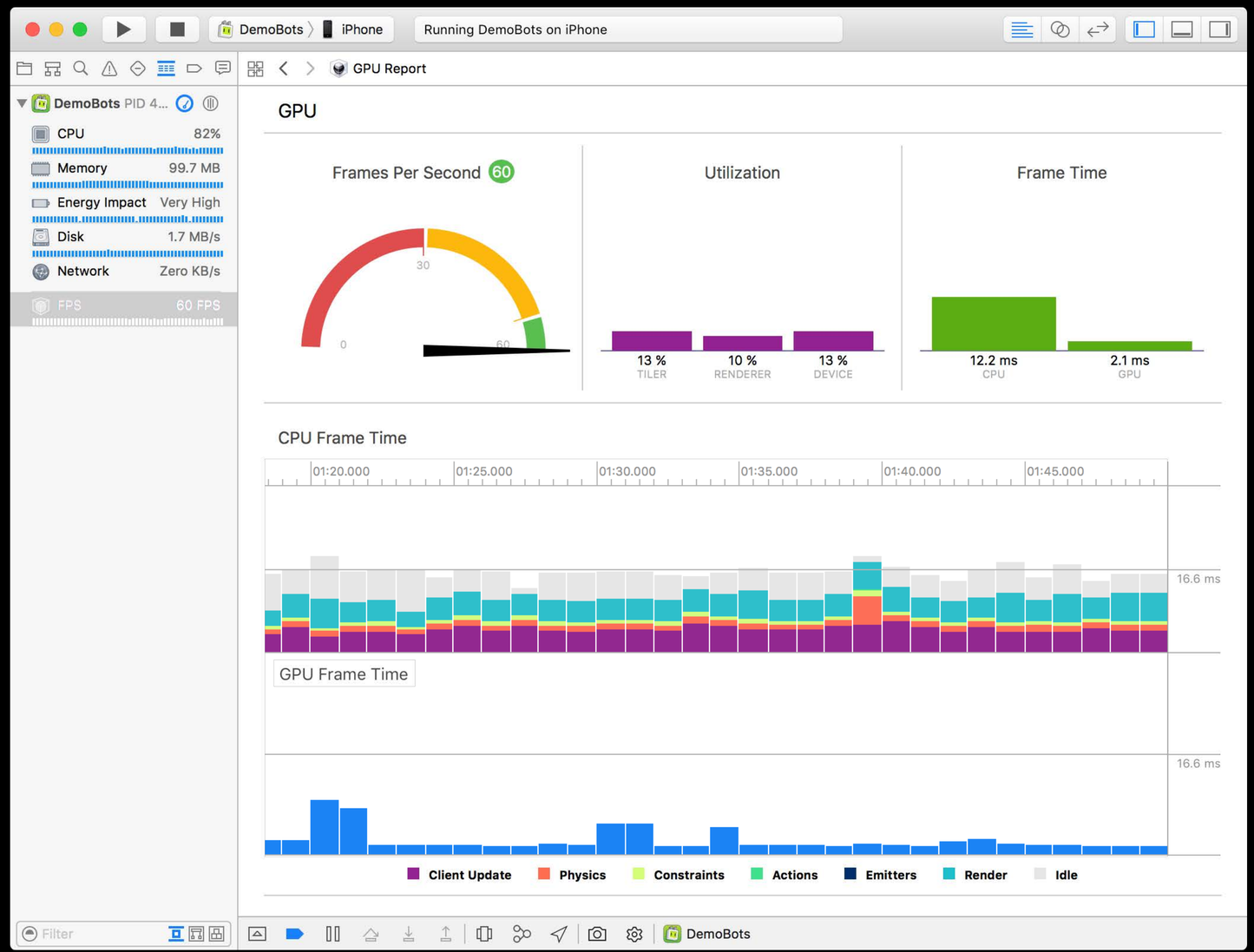

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Real-time performance

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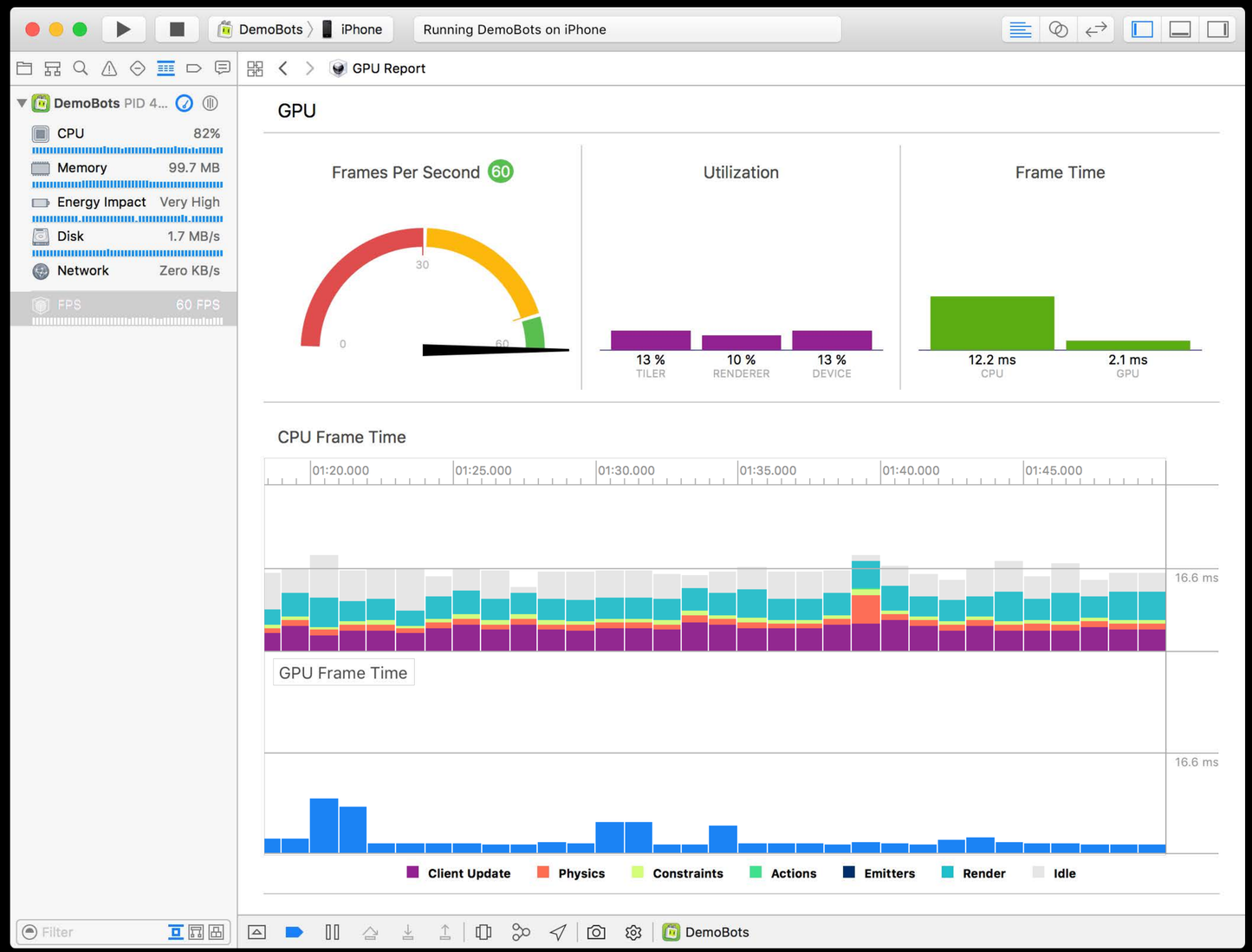
Breakdown of update loop

- Render
- Client update
- Actions
- Physics

Easy to identify bottlenecks

Available on iOS and watchOS



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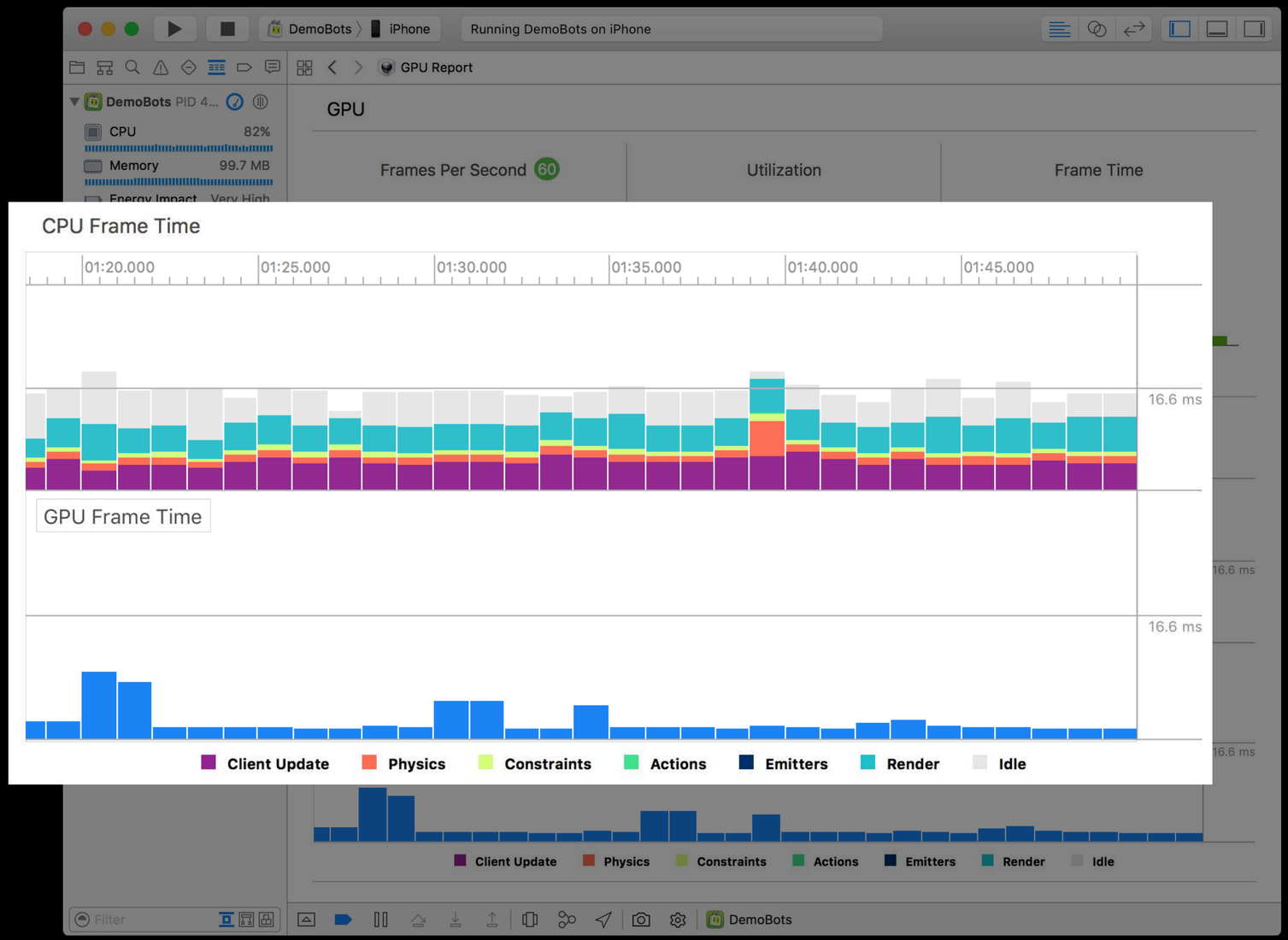

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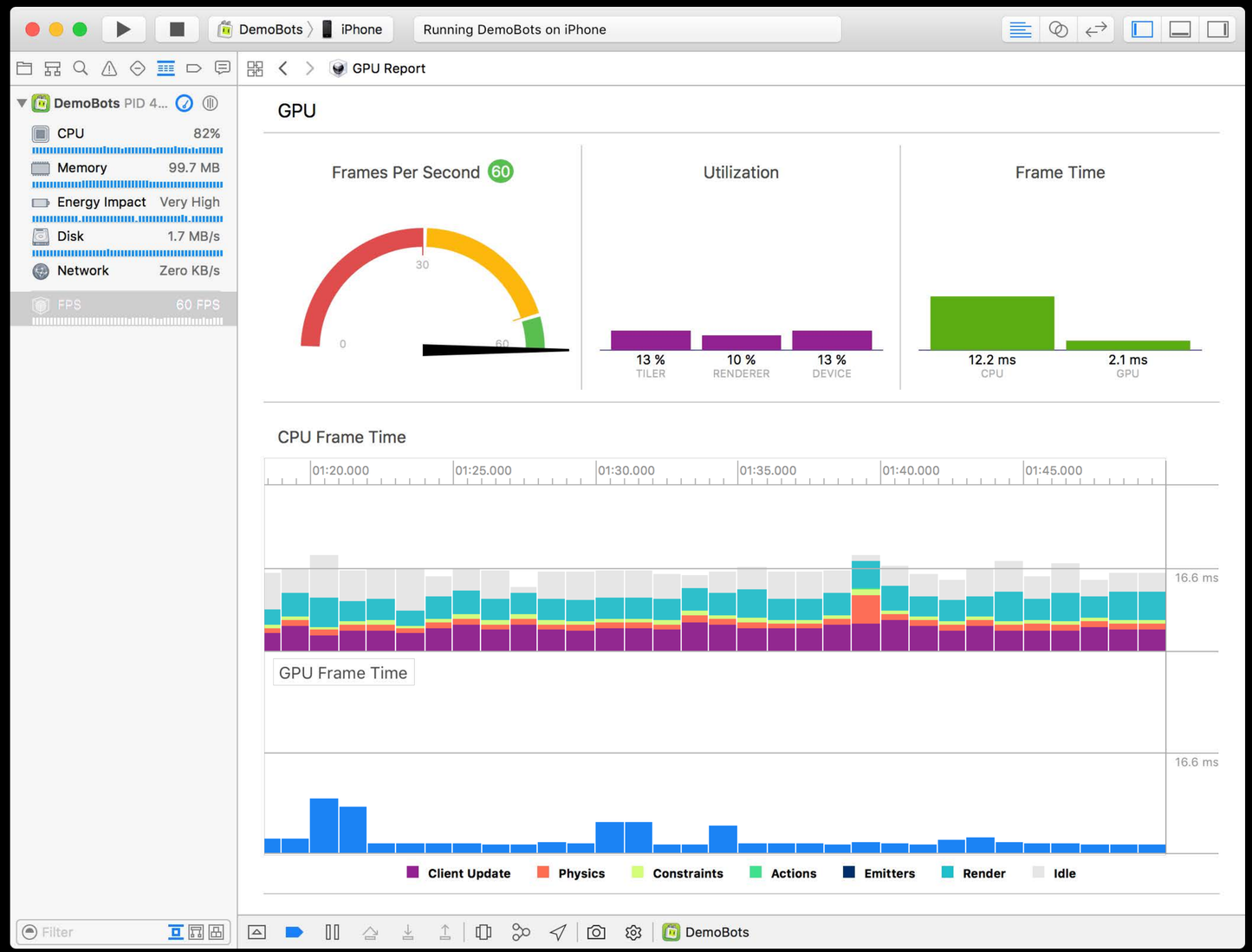

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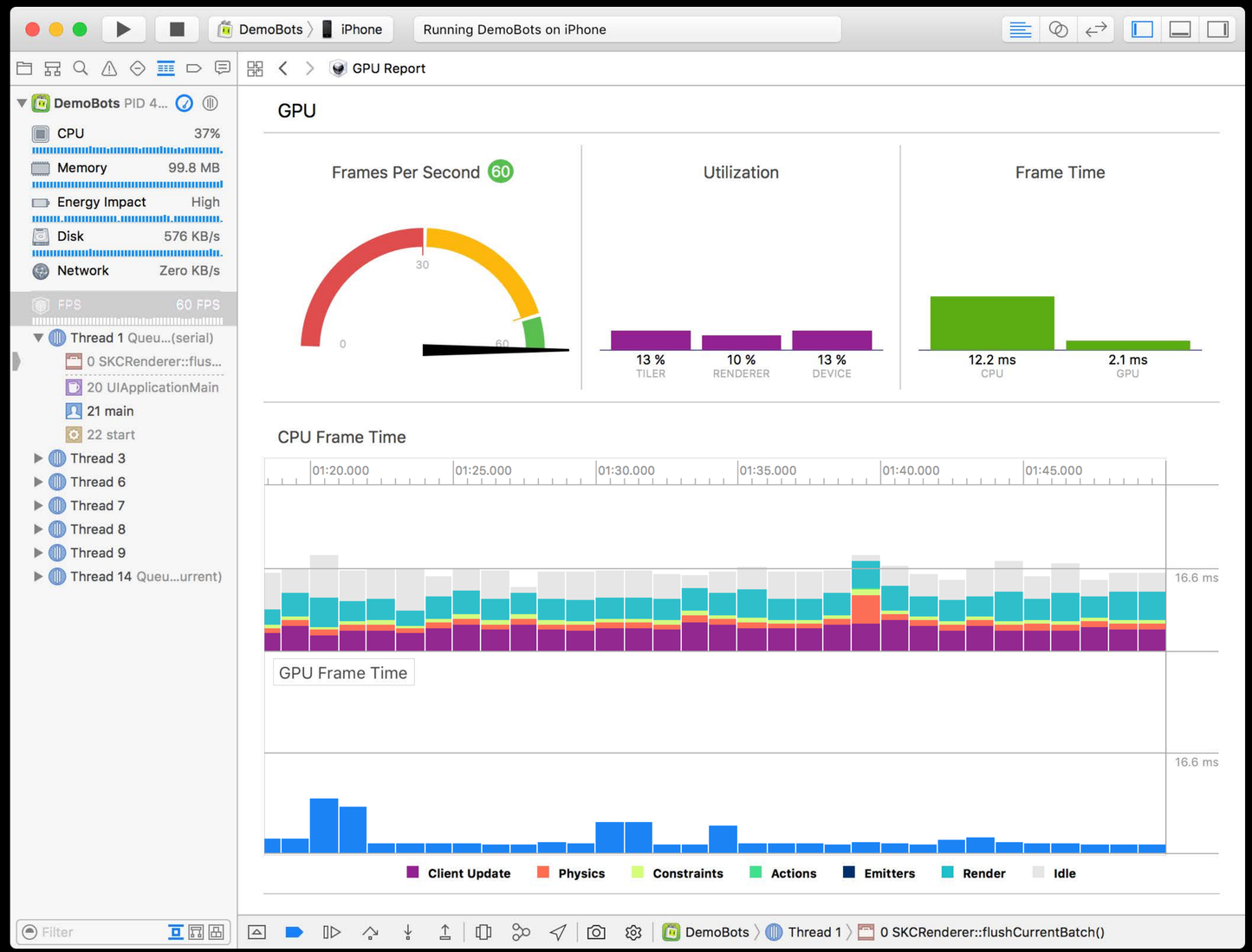

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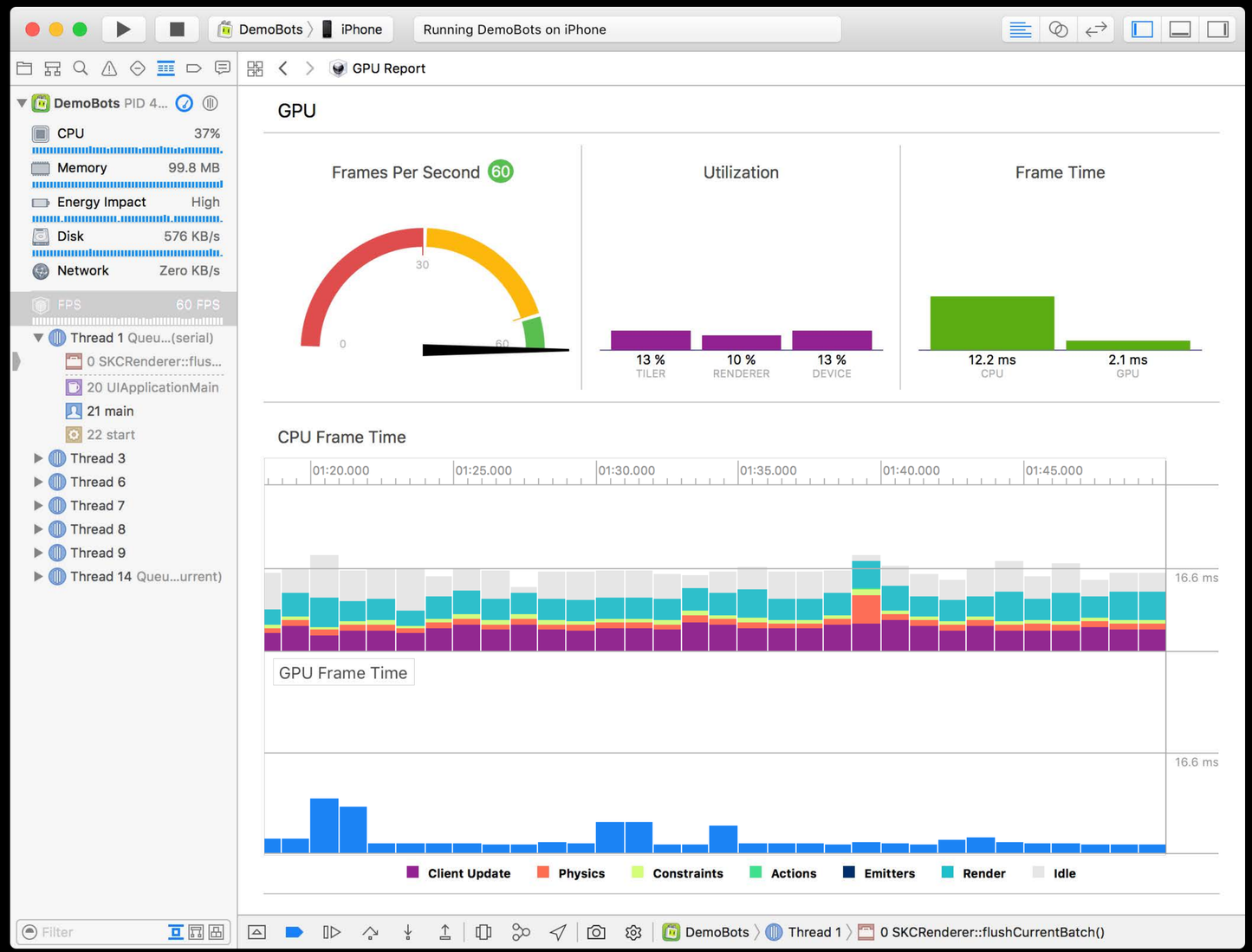

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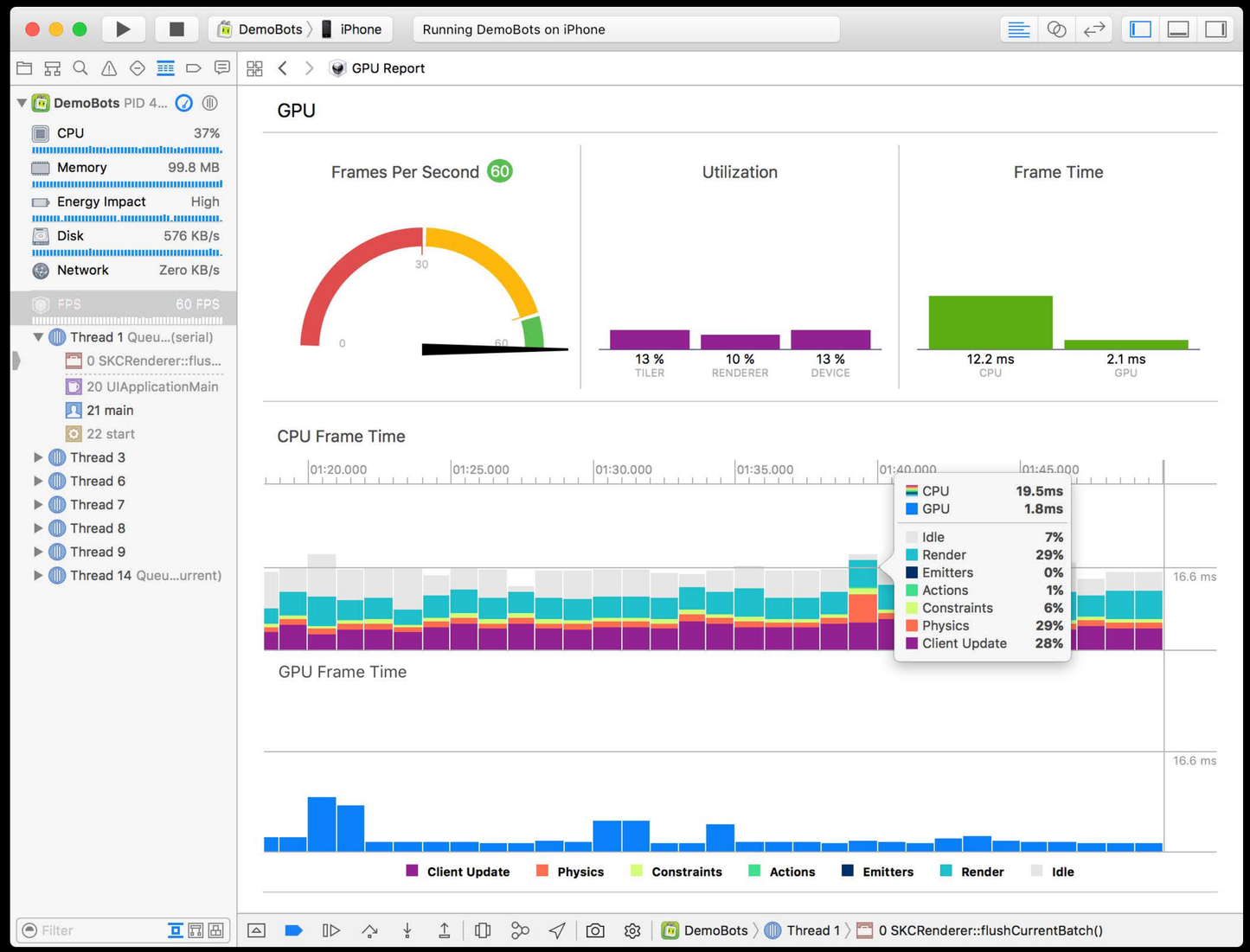

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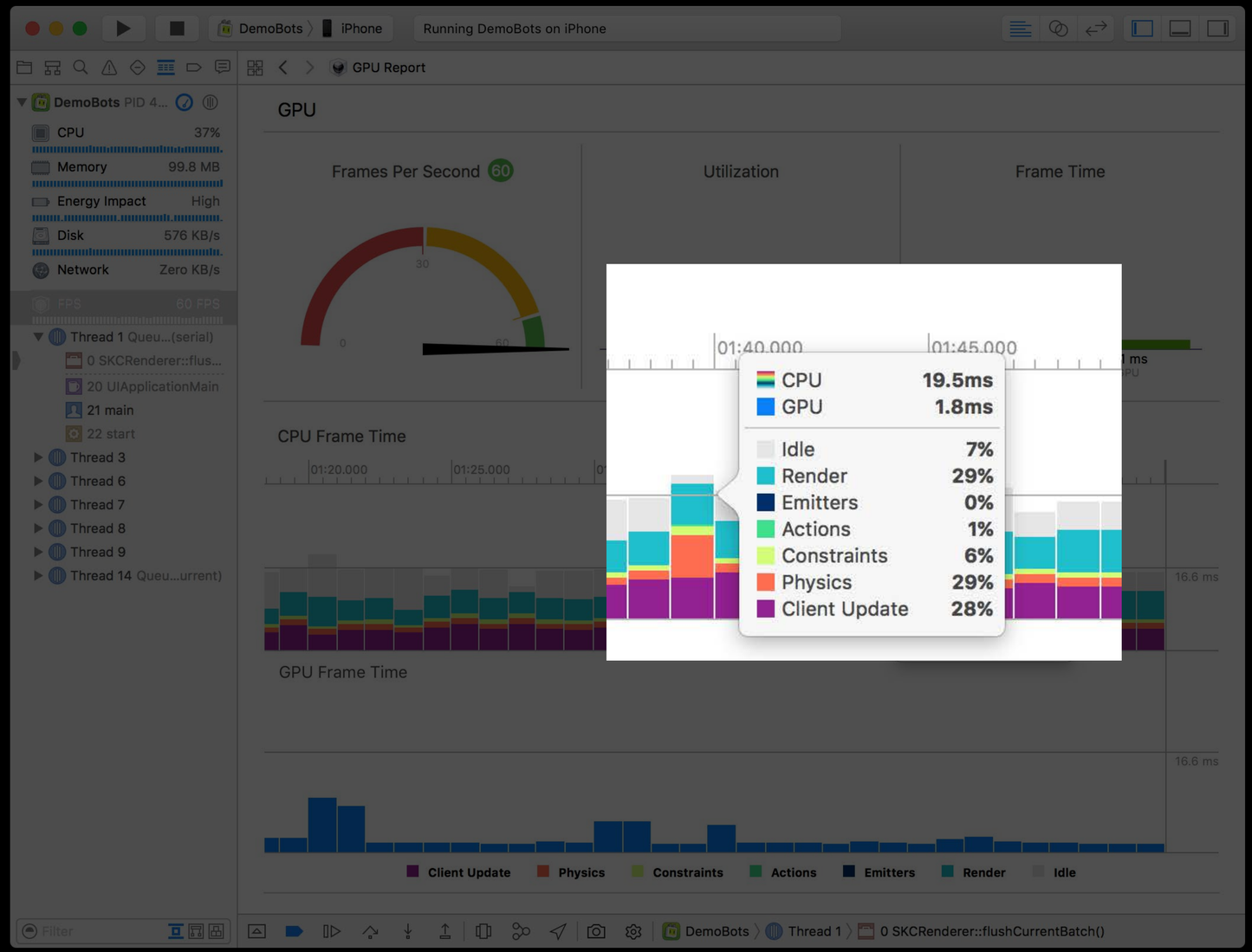


Demo

State machine Quick Look and FPS performance gauge

Recap

State machine Quick Look

FPS performance gauge

Memory Graph Debugging

Daniel Delwood Software Radiologist

"Why does this object exist?"

Memory Graph Debugging

$ heap DemoBots [--addresses='.*Action']

```
Zone DefaultMallocZone_0x121016000: 61176 nodes (68571200 bytes)

    COUNT      BYTES       AVG   CLASS_NAME                                  TYPE    BINARY
    =====      =====       ===   ==========                                  ====    ======
    22875   63015952    2754.8   non-object
     8898     429360      48.3   __NSCFString                                ObjC    CoreFoundation
     2402     576480     240.0   SKTexture                                   ObjC    SpriteKit
     2183     209568      96.0   CUIRenditionKey                             ObjC    CoreUI
     1124      71936      64.0   NSConcreteData                              ObjC    Foundation
     1085     260400     240.0   CGImage                                     CFType  CoreGraphics
     1080     171504     158.8   CGImageProvider                             CFType  CoreGraphics
     1075     172000     160.0   SKTextureCache                              ObjC    SpriteKit
     1070     256800     240.0   CGDataProvider                              CFType  CoreGraphics
     1065     187440     176.0   CUIRenditionMetrics                         ObjC    CoreUI
     1059      84720      80.0   CUIRenditionLayerReference                  ObjC    CoreUI
     1053    1027728     976.0   _CUIInternalLinkRendition                   ObjC    CoreUI
     1052      70160      66.7   NSPathStore2                                ObjC    Foundation
      814      39072      48.0   NSMutableArray                              ObjC    CoreFoundation
      582      64240     110.4   NSArray (Object Storage)                    C       CoreFoundation
      470      22560      48.0   NSMutableDictionary                         ObjC    CoreFoundation
      451       7216      16.0   NSArray                                     ObjC    CoreFoundation
      444      21312      48.0   Swift._NSContiguousString                   Swift   libswiftCore.dylib
      411      22048      53.6   __NSMallocBlock__                           ObjC    CoreFoundation
```

Memory Graph Debugging

$ leaks DemoBots --trace=0x7fc2e9e83c90

```
Region __DATA 0x110d6f000-0x110d75000[24K] rw-/rwx  System/Library/Frameworks/UIKit.framework/UIKit
__DATA __bss: '_UIKeyWindow'           0x110d6f730 --> <UIWindow 0x7fc2e9c2ebd0> [816]
  +584: __strong _rootViewController 0x7fc2e9c2ee18 --> <DemoBots.GameViewController 0x7fc2e9c1ddc0> [768]
   +24: __strong _view               0x7fc2e9c1ddd8 --> <SKView 0x7fc2ec049a00> [1536]
 +1144: __strong _scene              0x7fc2ec049e78 --> <DemoBots.LevelScene 0x7fc2f63daad0> [560]
  +392: playerBot                    0x7fc2f63dac58 --> <DemoBots.PlayerBot 0x7fc2e9d69600> [64]
    +8: __strong _components         0x7fc2e9d69608 --> <NSMutableDictionary 0x7fc2e9d1d340> [48]  item count: 10
   +40: __strong _keys               0x7fc2e9d1d368 --> <NSDictionary (Key Storage) 0x7fc2e9df0820> [208]
  +112: __strong                     0x7fc2e9df0890 --> <DemoBots.RenderComponent 0x7fc2f4071120> [48]
   +40: node                         0x7fc2f4071148 --> <SKNode 0x7fc2ef712970> [128]
   +40: __strong _actions            0x7fc2ef712998 --> <NSMutableArray 0x7fc2f640ec00> [48]  item count: 23
   +40: __strong _list               0x7fc2f640ec28 --> <NSArray (Object Storage) 0x7fc2e9ed8150> [208]
  +120: __strong                     0x7fc2e9ed81c8 --> <SKRepeat 0x7fc2e9ed0db0> [32]
   +24: __strong _repeatedAction     0x7fc2e9ed0dc8 --> <SKSequence 0x7fc2e9e9eb40> [48]
   +24: __strong _actions            0x7fc2e9e9eb58 --> <NSArray 0x7fc2f51a3ee0> [32]  item count: 2
   +24: __strong                     0x7fc2f51a3ef8 --> <SKRunBlock 0x7fc2e9e84760> [32]
    +8: _caction                     0x7fc2e9e84768 --> <SKCAction 0x7fc2e9e83c90> [112]

Region __DATA 0x1162e0000-0x1162e6000[24K] rw-/rwx /System/Library/PrivateFrameworks/FrontBoardServices.framework/FrontBoardServices
__DATA __bss: '__instance'             0x1162e50e8 --> <FBSUIApplicationWorkspace 0x7fc2e9e0c9e0> [80]
   +16: _delegate                    0x7fc2e9e0c9f0 --> <UIApplication 0x7fc2e9d12290> [576]
  +112: __strong _statusBarWindow    0x7fc2e9d12300 --> <UIStatusBarWindow 0x7fc2e9c13ec0> [912]
  +416: __strong _scene              0x7fc2e9c14060 --> <FBSSceneImpl 0x7fc2e9f12990> [144]
```

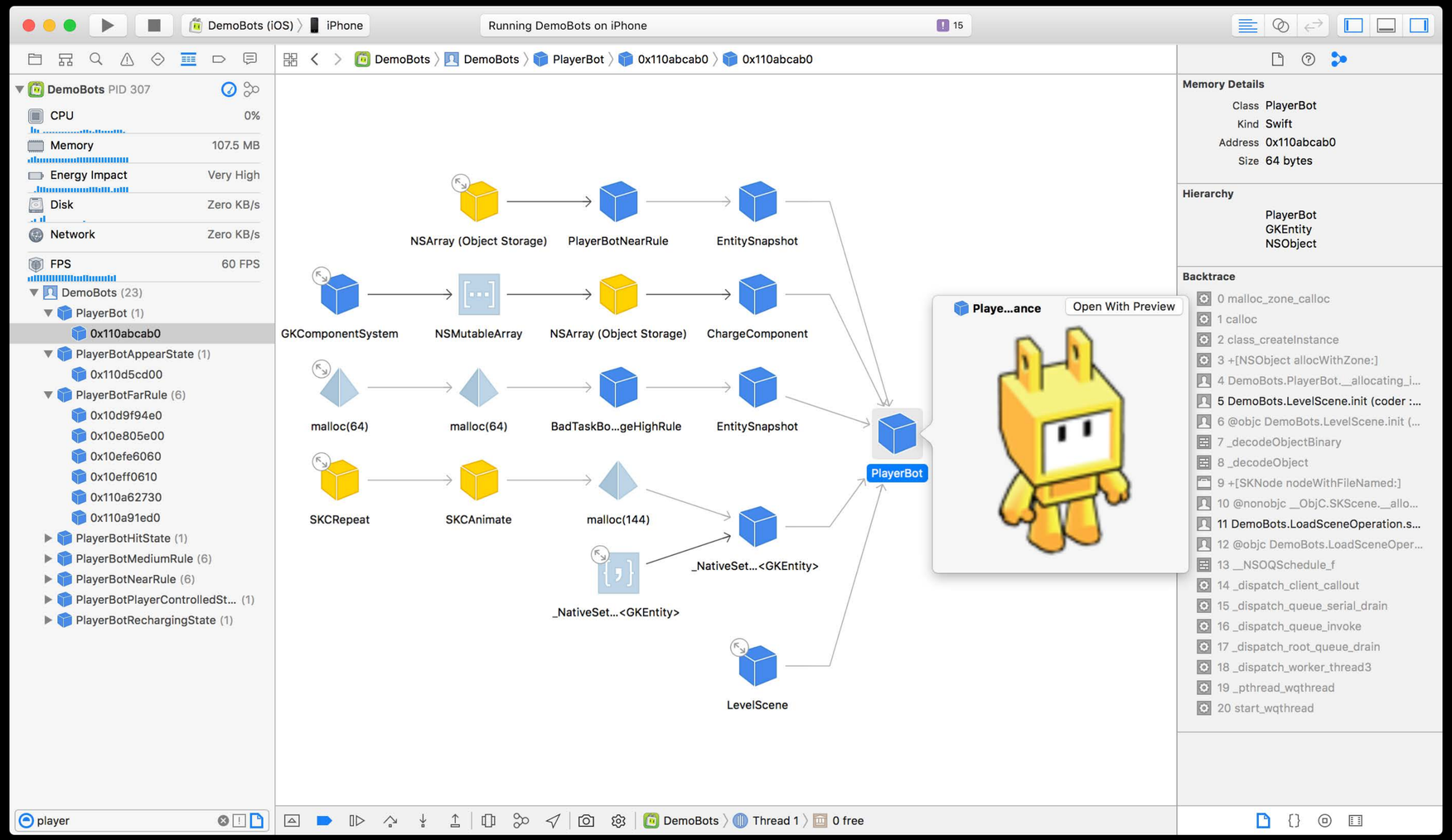
Memory Graph Debugging

$ malloc_history DemoBots 0x7fc2e9e83c90

```
ALLOC 0x7fc2e9e83c90-0x7fc2e9e83cff [size=112]: thread_112f48000 | start | main | UIApplicationMain | GSEventRunModal | CFRunLoopRunSpecific | __CFRunLoopRun | __CFRunLoopDoTimers | __CFRunLoopDoTimer | __CFRUNLOOP_IS_CALLING_OUT_TO_A_TIMER_CALLBACK_FUNCTION__ | CA::Display::DisplayLink::dispatch_items(unsigned long long, unsigned long long, unsigned long long) | CA::Display::DisplayLinkItem::dispatch() | -[SKDisplayLink _callbackForNextFrame:] | __29-[SKView setUpRenderCallback]_block_invoke | -[SKView _vsyncRenderForTime:preRender:postRender:] | __51-[SKView _vsyncRenderForTime:preRender:postRender:]_block_invoke.312 | -[SKView _update:] | -[SKScene _update:] | @objc DemoBots.LevelScene.update (Swift.Double) -> () | DemoBots.LevelScene.update (Swift.Double) -> () | DemoBots.PlayerBot.update (withDeltaTime : Swift.Double) -> () | -[SKNode runAction:] | -[SKRepeat copyWithZone:] | +[SKRepeat repeatActionForever:] | -[SKSequence copyWithZone:] | +[SKSequence sequenceWithActions:] | -[SKAction copyWithZone:] | -[SKWait init] | -[SKAction init] | operator new(unsigned long) | malloc

----

FREE  0x7fc2e9e83c90-0x7fc2e9e83cff [size=112]: thread_112f48000 | start | main | UIApplicationMain | GSEventRunModal | CFRunLoopRunSpecific | __CFRunLoopRun | __CFRunLoopDoTimers | __CFRunLoopDoTimer | __CFRUNLOOP_IS_CALLING_OUT_TO_A_TIMER_CALLBACK_FUNCTION__ | CA::Display::DisplayLink::dispatch_items(unsigned long long, unsigned long long, unsigned long long) | CA::Display::DisplayLinkItem::dispatch() | -[SKDisplayLink _callbackForNextFrame:] | __29-[SKView setUpRenderCallback]_block_invoke | -[SKView _vsyncRenderForTime:preRender:postRender:] | __51-[SKView _vsyncRenderForTime:preRender:postRender:]_block_invoke.312 | -[SKView _update:] | -[SKScene _update:] | @objc DemoBots.LevelScene.update (Swift.Double) -> () | DemoBots.LevelScene.update (Swift.Double) -> () | DemoBots.PlayerBot.update (withDeltaTime : Swift.Double) -> () | -[SKNode runAction:] | -[SKRepeat copyWithZone:] | +[SKRepeat repeatActionForever:] | -[SKSequence copyWithZone:] | +[SKSequence sequenceWithActions:] | -[SKAction copyWithZone:] | -[SKWait init] | -[SKAction(Internal) setCppAction:] | operator delete(void*)


ALLOC 0x7fc2e9e83c90-0x7fc2e9e83cff [size=112]: thread_112f48000 | start | main | UIApplicationMain | GSEventRunModal | CFRunLoopRunSpecific | __CFRunLoopRun | __CFRunLoopDoTimers | __CFRunLoopDoTimer | __CFRUNLOOP_IS_CALLING_OUT_TO_A_TIMER_CALLBACK_FUNCTION__ | CA::Display::DisplayLink::dispatch_items(unsigned long long, unsigned long long, unsigned long long) | CA::Display::DisplayLinkItem::dispatch() | -[SKDisplayLink _callbackForNextFrame:] | __29-[SKView setUpRenderCallback]_block_invoke | -[SKView _vsyncRenderForTime:preRender:postRender:] | __51-[SKView _vsyncRenderForTime:preRender:postRender:]_block_invoke.312 | -[SKView _update:] | -[SKScene _update:] | @objc DemoBots.LevelScene.update (Swift.Double) -> () | DemoBots.LevelScene.update (Swift.Double) -> () | DemoBots.PlayerBot.update (withDeltaTime : Swift.Double) -> () | -[SKNode runAction:] | -[SKRepeat copyWithZone:] | +[SKRepeat repeatActionForever:] | -[SKSequence copyWithZone:] | +[SKSequence sequenceWithActions:] | -[SKRunBlock copyWithZone:] | +[SKRunBlock runBlock:queue:] | -[SKRunBlock init] | -[SKAction init] | operator new(unsigned long) | malloc
```

Memory Graph Debugging

NEW



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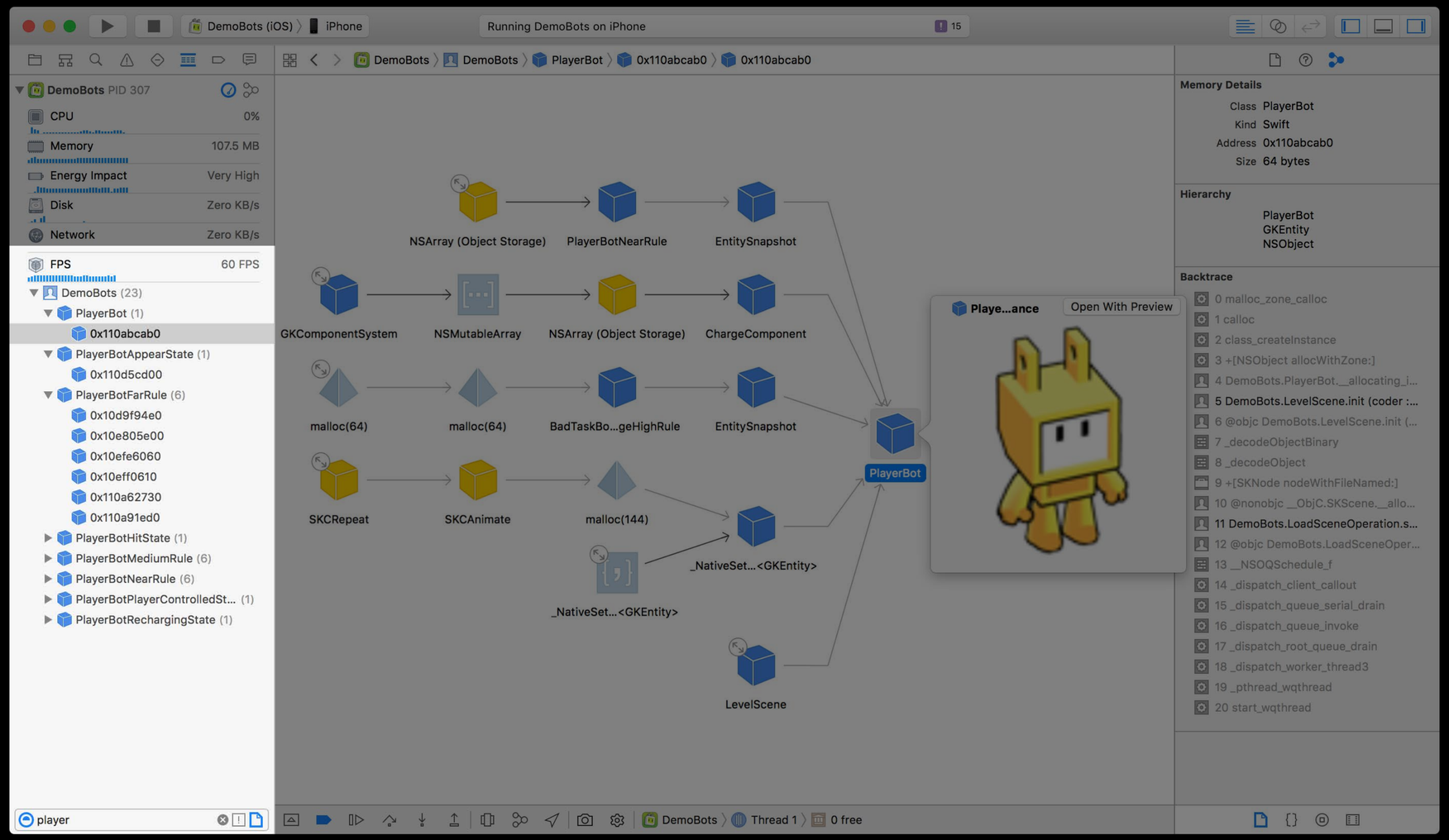

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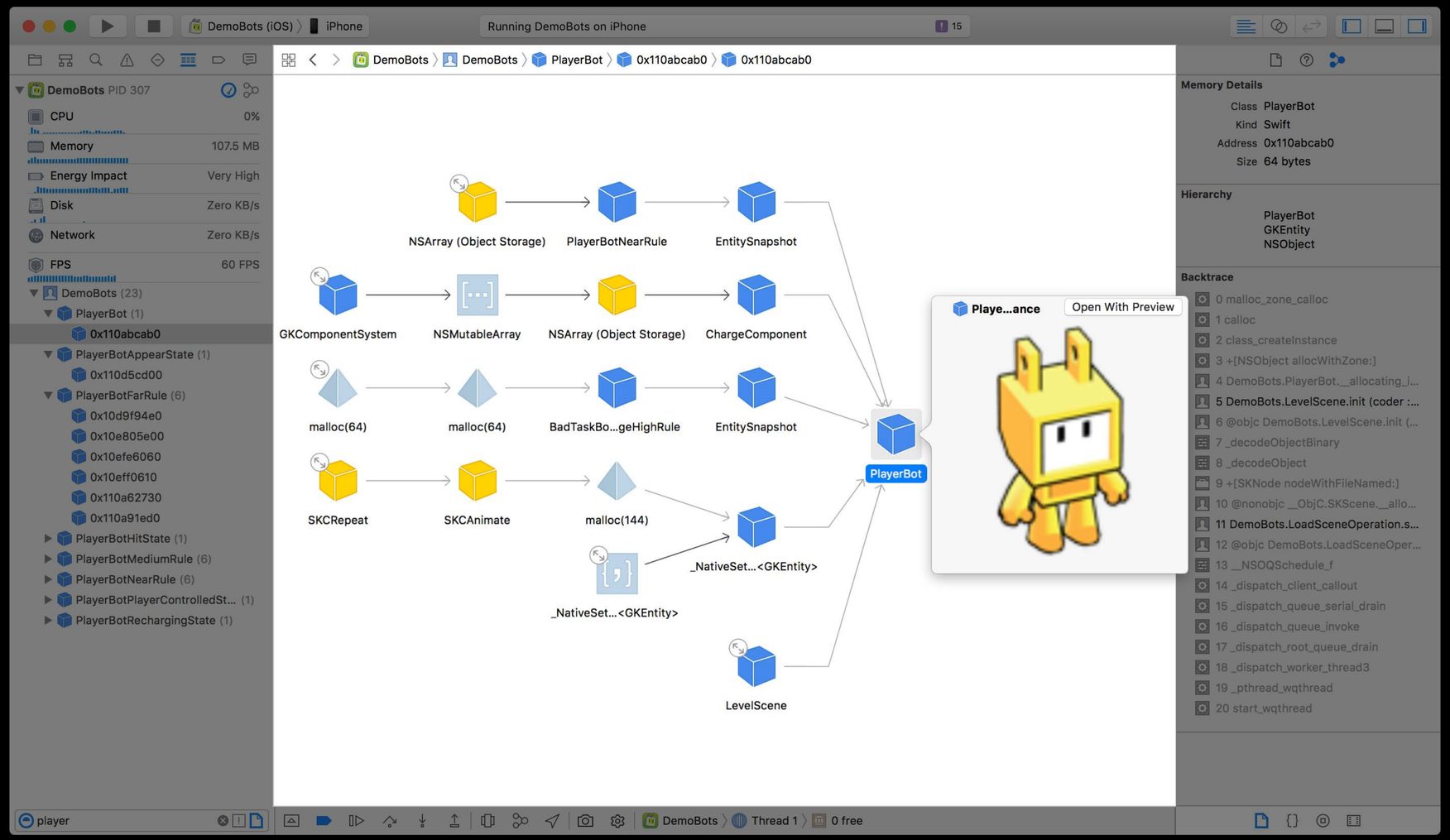

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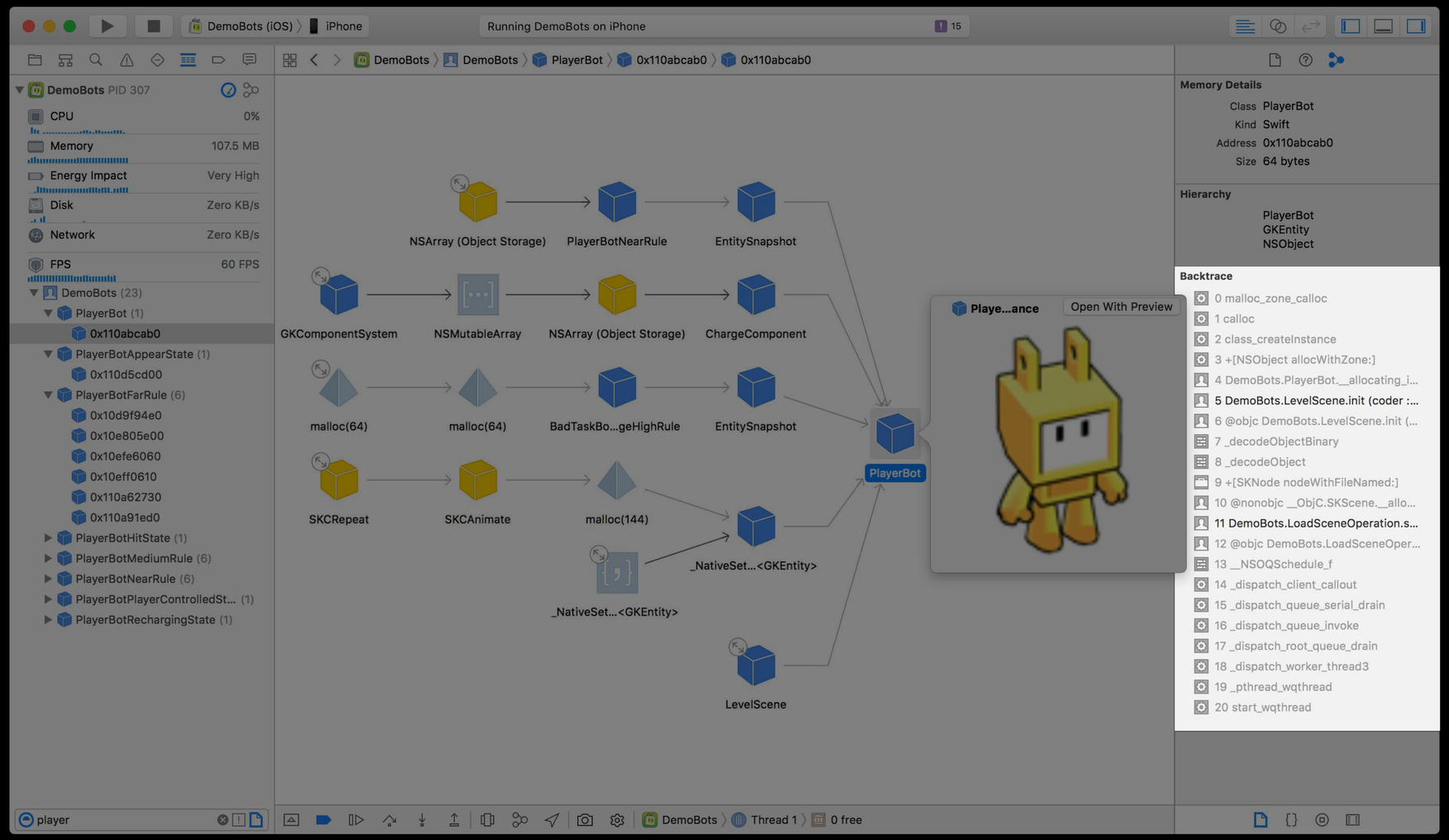

Demo

Memory graph debugging

Memory Graph Debugging

Leaked and abandoned memory

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Debugger mode, pauses to inspect app

- Available on macOS, iOS 10, tvOS 10, watchOS 3

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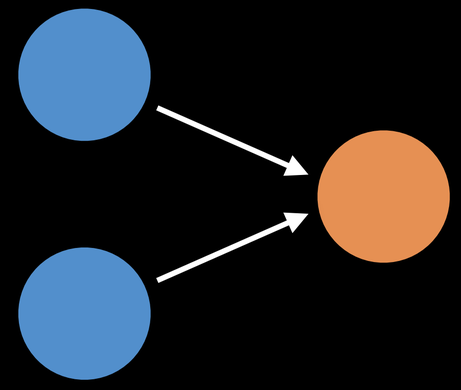
Two graph styles:

- Root paths
  - Referenced memory
  - How is the memory held by globals/stacks?



Memory Graph Debugging

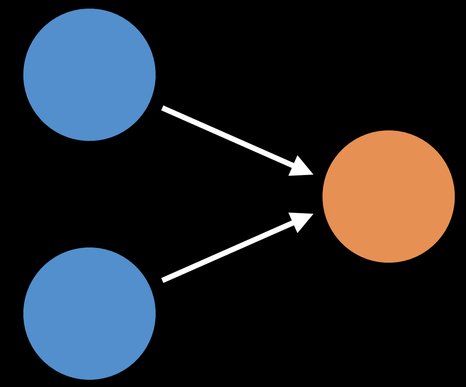
Leaked and abandoned memory

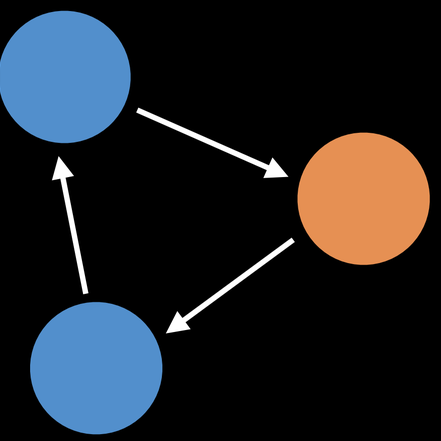
Debugger mode, pauses to inspect app

- Available on macOS, iOS 10, tvOS 10, watchOS 3

Two graph styles:

- Root paths
  - Referenced memory
  - How is the memory held by globals/stacks?
- Cycles
  - Leaked memory
  - How does the leak reference other leaks?





Memory Graph Debugging

Stack logging integration

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Opt-in via Diagnostics scheme tab

- All Allocations
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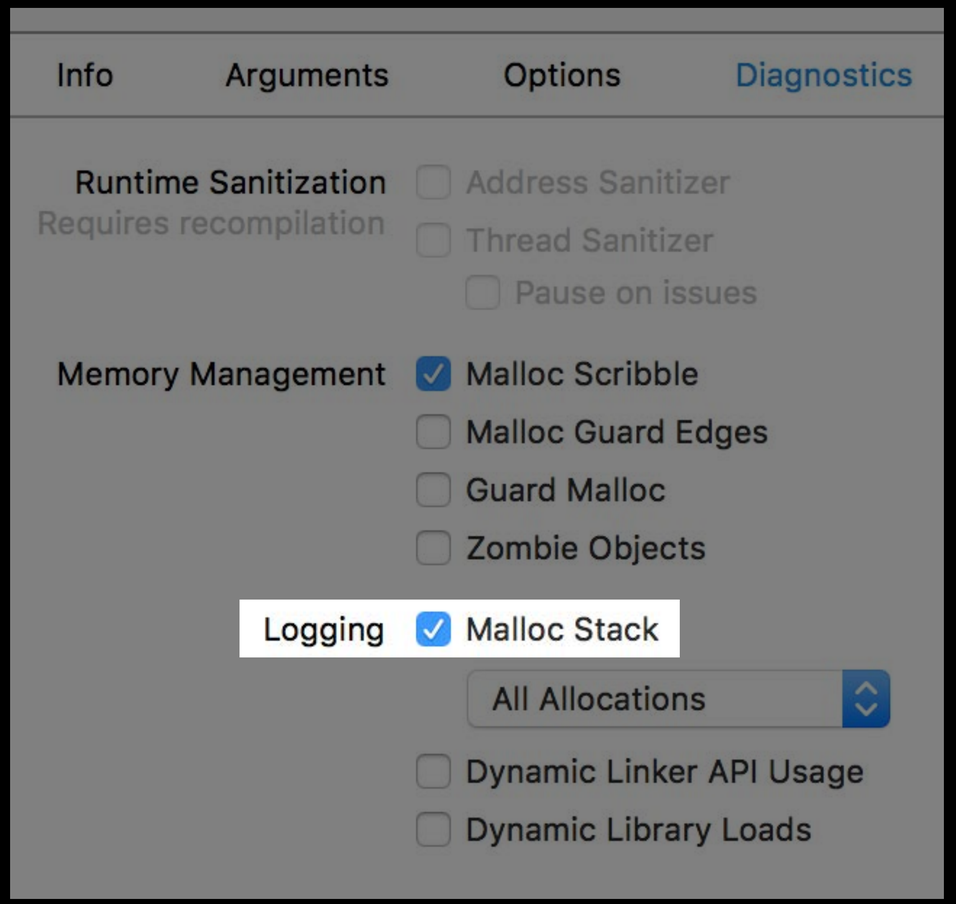


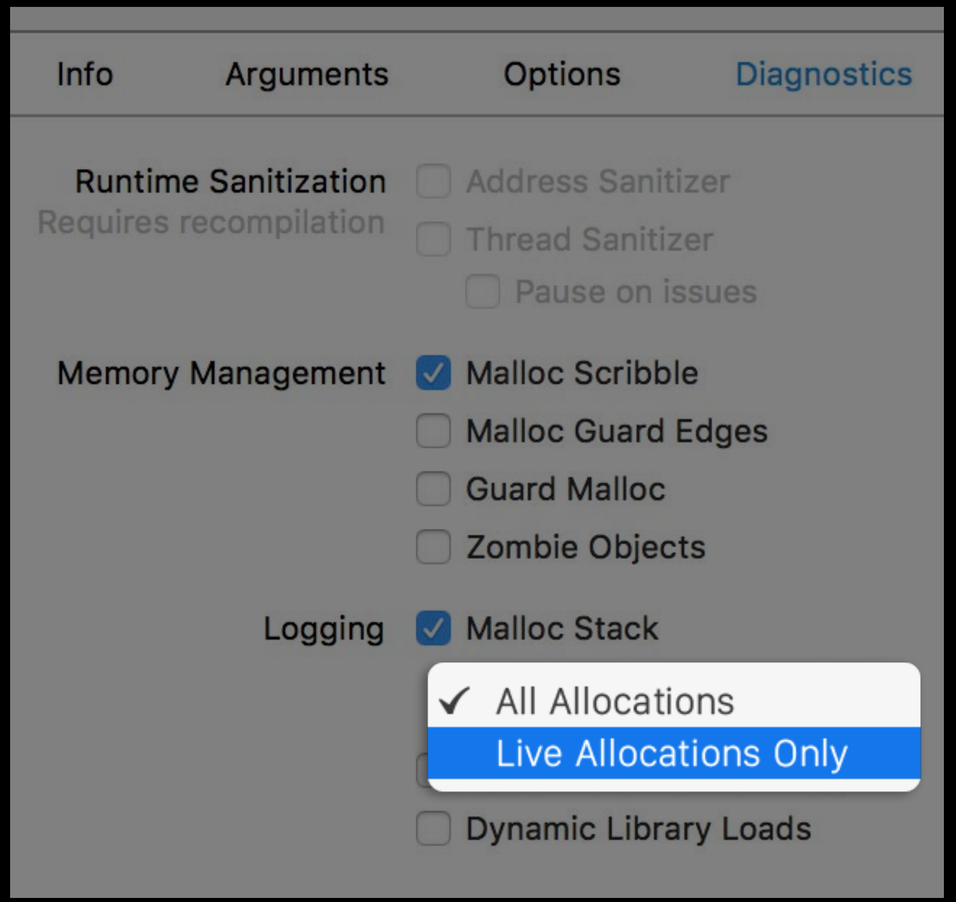
Memory Graph Debugging

Stack logging integration

NEW

Opt-in via Diagnostics scheme tab

- All Allocations
  - MallocStackLogging=1
- Live Allocations Only
  - Less memory/disk overhead
  - MallocStackLogging=lite



Memory Graph Debugging

Introducing .memgraph

NEW

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Within Xcode:

- Save: File → “Export Memory Graph…”
- Load: double-click or drag to Xcode
  - No process in debugger — no backtraces, Quick Look, ‘po’

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Introducing .memgraph

NEW

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From command-line:

```
$ leaks --outputGraph=<path> <process>                    # creates .memgraph file
$ {leaks|vmmap|heap} <path/to/file.memgraph> [options]    # operates on .memgraph file
```

Memory Graph Debugging

Usage tips

Memory Graph Debugging

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Graph is conservative

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- Avoids ‘leaks’ false-positives, but there may be extraneous references

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Requires turning off sanitizers

Memory Graph Debugging

Where to start

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Validate your expectations

- Are there more objects of your types than you expect?
- Are objects deallocated when they're no longer necessary?

Memory Graph Debugging

Where to start

Validate your expectations

- Are there more objects of your types than you expect?
- Are objects deallocated when they're no longer necessary?

Find the path that shouldn't be holding your object

- Strong captures from blocks and closures
- Back-references that should be weak/unowned

Summary

New and improved visual tools in Xcode 8

Built right into your debugging workflow

Try them out, improve your App today!

More Information

https://developer.apple.com/wwdc16/410

Related Sessions

System Trace in Depth	Nob Hill	Thursday 9:00AM
Thread Sanitizer and Static Analysis	Nob Hill	Thursday 10:00AM
Debugging Tips and Tricks	Pacific Heights	Friday 1:40PM
Using Time Profiler in Instruments	Nob Hill	Friday 3:00PM

Labs

GameplayKit Lab	Graphic, Games and Media Lab B	Tuesday 10:10AM
Profiling and Debugging Lab	Tools Lab C	Thursday 3:00PM
SceneKit Lab	Graphic, Games and Media Lab A	Thursday 3:00PM
SpriteKit Lab	Graphic, Games and Media Lab B	Friday 12:00PM

WWDC16