Tools

#WWDC14

Improving Your App with Instruments

Session 418
Daniel Delwood
Software Radiologist

Agenda

What's new in Instruments

Memory management

Time profiling

Performance counters

DTrace improvements

What's in Instruments

What's NEW in Instruments

Instruments1

WWDC2014 〉 All Processes

Run 2 of 2 00:00:29

All Cores 2 Processes / 81 Threads

Instruments

00:00 00:10 00:20 00:30 00:40 00:50 01:00 01:10 01

Time Profiler

Time Profiler 〉 Call Tree 〉 Call Tree

Process

Running Time		Self	Symbol Name
6480.0ms	68.4%	0.0	Eyemazing-Mac (905)
4216.0ms	44.5%	7.0	start_wqthread libsystem_pthread.dylib
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2.0ms	0.0%	0.0	_xpc_connection_resume_init libxpc.dylib
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Sample Perspective

- All Sample Counts
- Running Sample Times

Call Tree

- Separate by Thread
- Invert Call Tree
- Hide Missing Symbols
- Hide System Libraries
- Flatten Recursion
- Top Functions

Call Tree Constraints

- Count 0 ∞
- Time (ms) -∞ ∞

Data Mining

Symbol Library Restore

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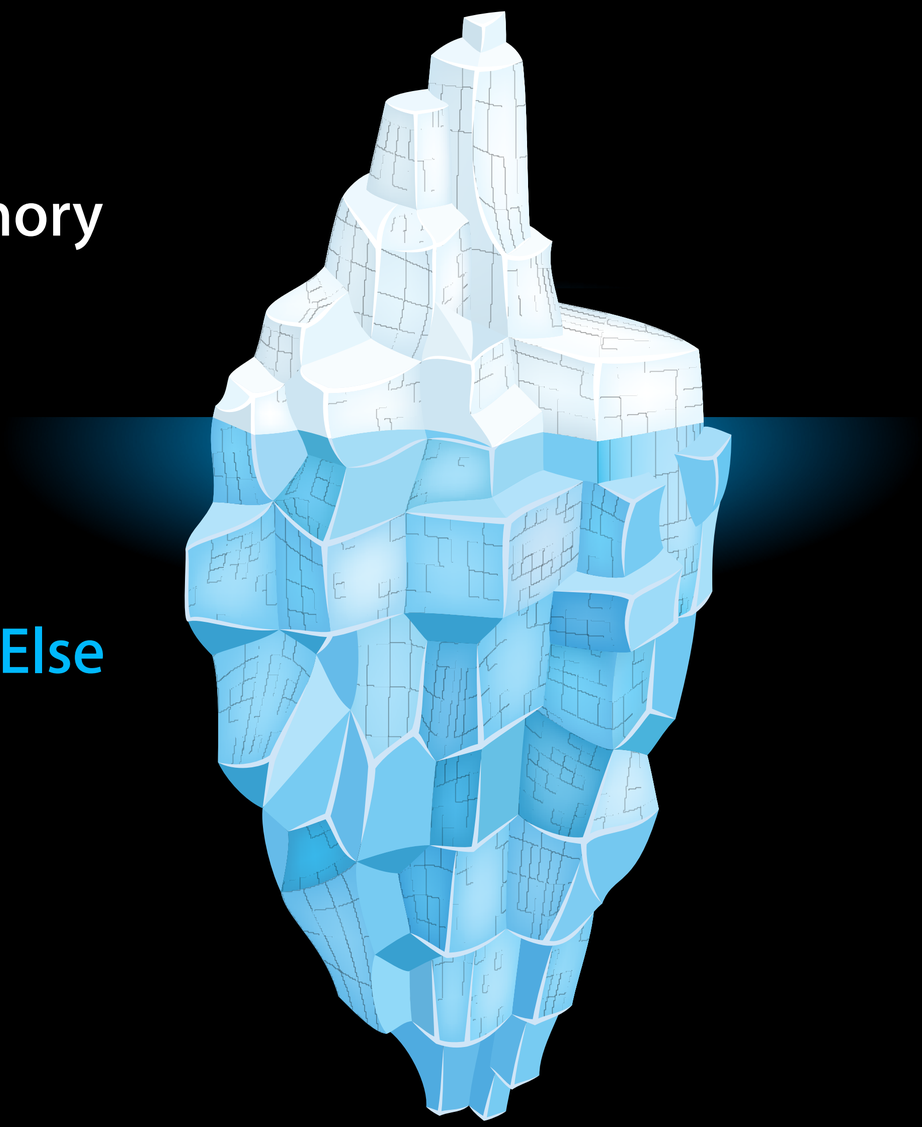
Memory Management

Heap Memory



Everything Else

Objective-C's Ownership Model

Retain/Release

Reference counting ownership model based on retain, release

When the count drops to zero, object is freed

Retain/release/autorelease rules established and easy to learn

- *Advanced Memory Management Programming Guide*

Deterministic, simple, and fast

Objective-C's Ownership Model

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Automated Reference Counting (ARC)

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Automated Reference Counting (ARC)

- Still have to manage autorelease pools

```
@autoreleasepool { /* code */ }
```

Swift's Ownership Model

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Reference counting ownership model based on retain, release

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Swift's Ownership Model

Managed Retain/Release

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When the count drops to zero, object is freed

Deterministic, simple, and fast

Automated Reference Counting (ARC)

- Working with Objective-C? Still have to manage autorelease pools

```
autoreleasepool { /* code */ }
```

Allocations

What does it report?

Heap allocations

- Class names — e.g. NSMutableArray, MyApp.MainViewController
- Reference types only (`class`, not `struct`)
- Retain/Release histories

Virtual Memory (VM) allocations

- Paths for mapped files

Stack traces for all

Demo

Allocations + App Extension

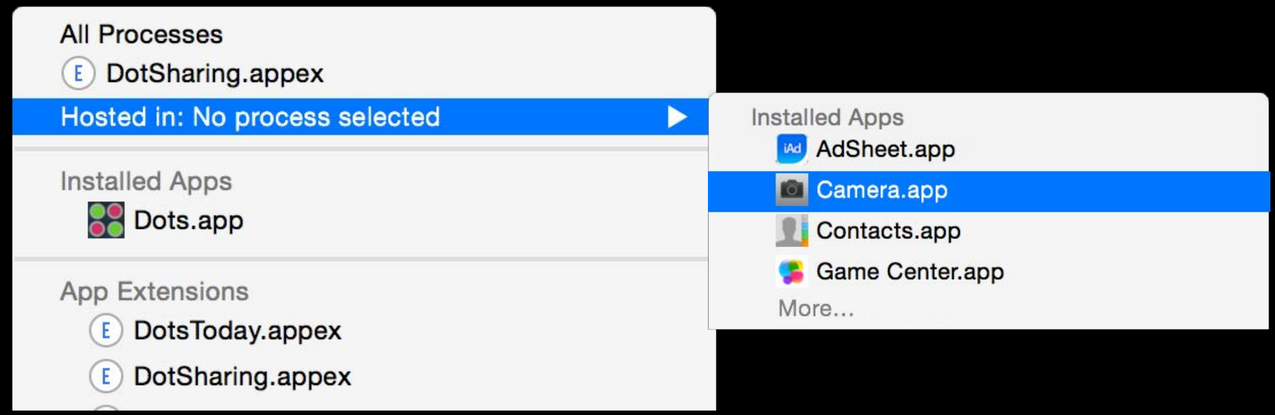
App Extensions

Profiling with Instruments

Specify host App

- When profiling Xcode scheme
- In Instruments

Transient, but memory matters



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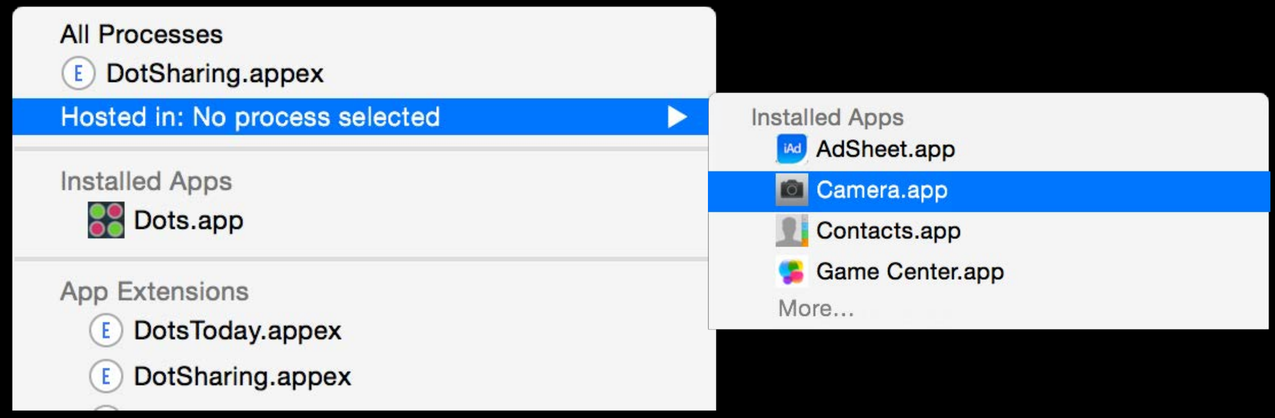


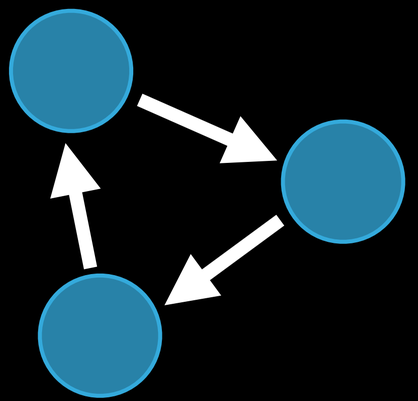
• Creating Extensions for iOS and OS X, Part 1	Mission	Tuesday 2:00PM
• Creating Extensions for iOS and OS X, Part 2	Mission	Wednesday 11:30AM

Memory Management with Swift

Language tools

Obj-C code can still mismatch Retain/Release

Can still form cycles in Swift



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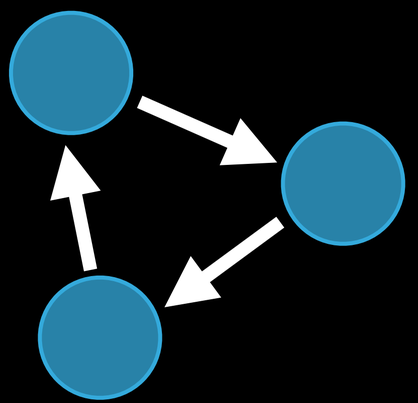
Manage graph, not retain/release

`weak`

`unowned`



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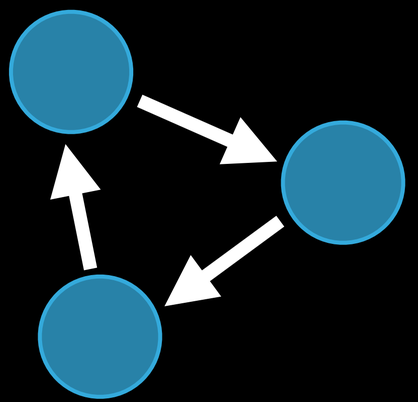

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Returns `T` or `nil` when accessed, based on existence of object

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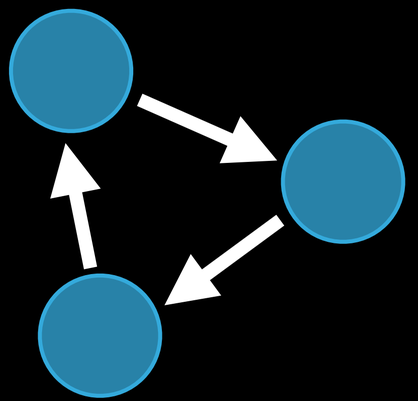

`weak` var x : Optional<T> / T? = object

Returns `T` or `nil` when accessed, based on existence of object

`unowned` let / var x : T = object

Returns `T` always, but if object doesn't exist… deterministic 💣

^block Captures

Here be dragons

```
[self.currentGame registerForStateChanges:^{
    if (self.currentGame == newGame) {
        [self.tableView reloadData];
    }
}];
```

'self' and 'newGame' captured strongly

^block Captures

Here be dragons

```
__weak typeof(newGame) weakGame = newGame;
__weak typeof(self) weakSelf = self;
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Swift Closures

Behold, the power of capture lists

```
currentGame.registerForStateChanges() {
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    }
}
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• Swift Interoperability In-Depth	Presidio	Wednesday 3:15PM
• Advanced Swift	Presidio	Thursday 11:30AM
• Fixing Memory Issues	Session 410	WWDC13 Videos

Time Profiling

Kris Markel
Performance Tools Engineer

Why?

Why?

To provide a great user experience

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- Faster app launch times

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- Faster app launch times
- Keep the frame rate at 60fps

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- Buttery-smooth scrolling

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To provide a great user experience

- Faster app launch times
- Keep the frame rate at 60fps
- Buttery-smooth scrolling
- Responsive UI

What?

An instrument that samples stack trace information at prescribed intervals

Provides an idea of how much time is spent in each method

When?

When?

Investigate specific problems

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- If you see stuttering or frame rate slowdowns

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- Some part of your app is taking too long

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Identify and fix hotspots before they become problems

When?

Investigate specific problems

- If you see stuttering or frame rate slowdowns
- Some part of your app is taking too long

Identify and fix hotspots before they become problems

- Keep an eye on the CPU gauge in Xcode

Demo

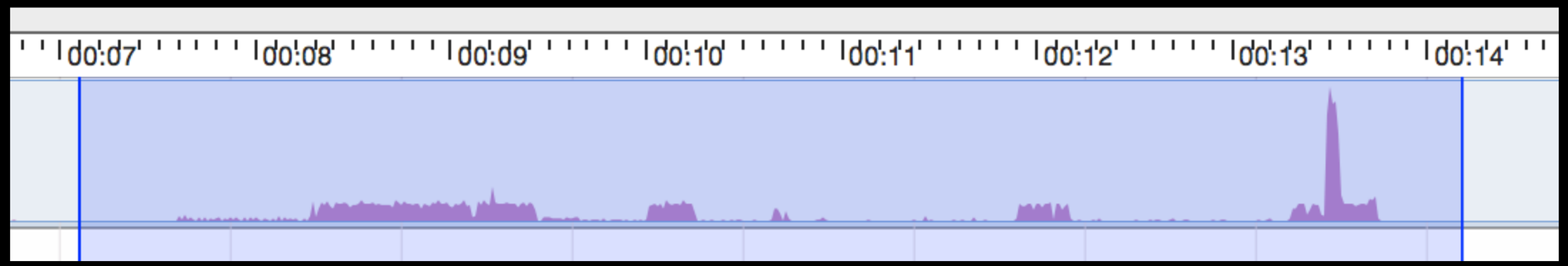
Time Profiler in action

Review

Track view

Identify and zoom into problem areas

- Drag to apply a time range filter
- Shift+drag to zoom in
- Control+drag to zoom out



Review

New Inspector panes

Use keyboard shortcuts to
quickly move between panes

Review

New Inspector panes

Use keyboard shortcuts to
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- ⌘1—Record settings

Review

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Use keyboard shortcuts to
quickly move between panes

- ⌘1—Record settings
- ⌘2—Display settings

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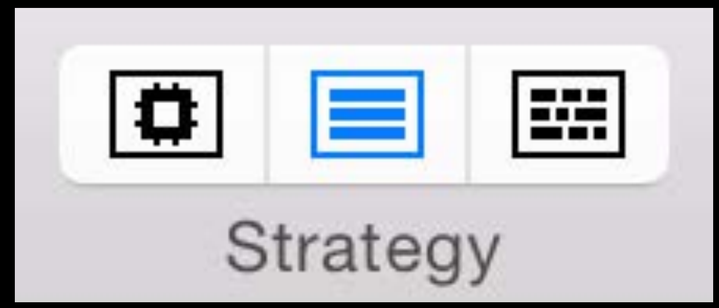
quickly move between panes

- ⌘1—Record settings
- ⌘2—Display settings
- ⌘3—Extended detail

Review

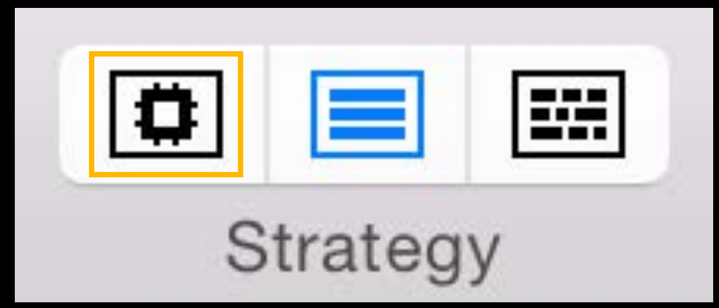
Strategy views



Review

Strategy views

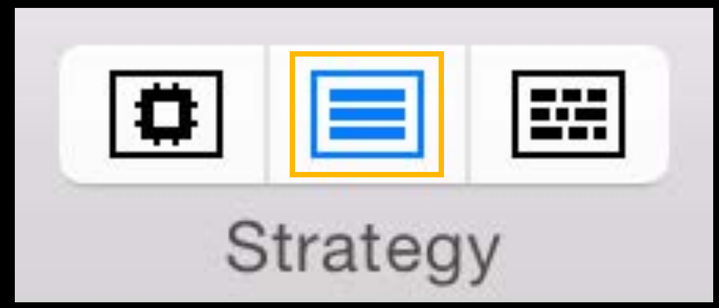
- Cores strategy



Review

Strategy views

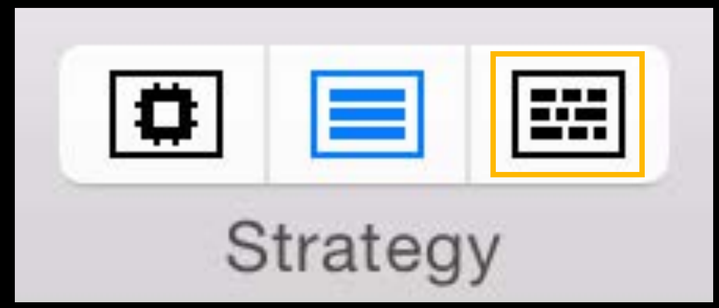
- Cores strategy
- Instruments strategy



Review

Strategy views

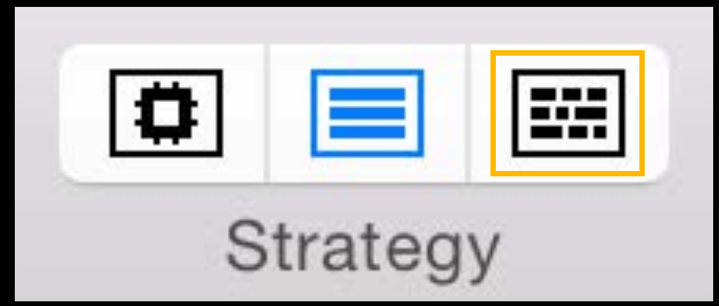
- Cores strategy
- Instruments strategy
- Threads strategy

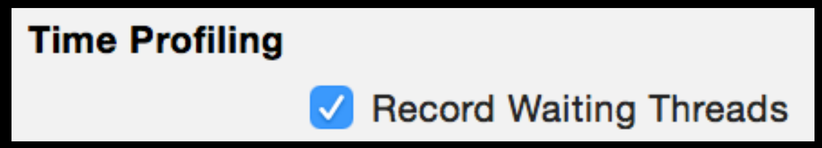


Review

Strategy views

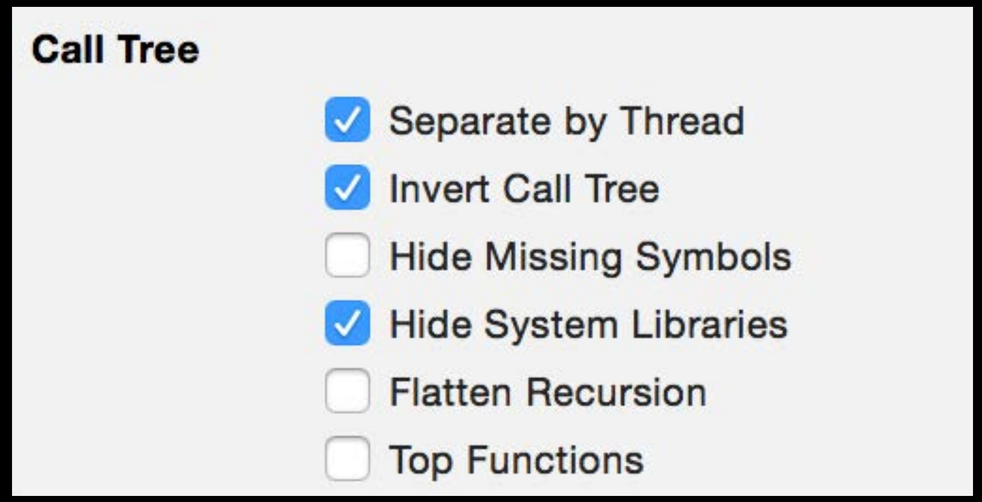
- Cores strategy
- Instructions strategy
- Threads strategy
  - Enable Record Waiting Threads to expose blocked threads





Review

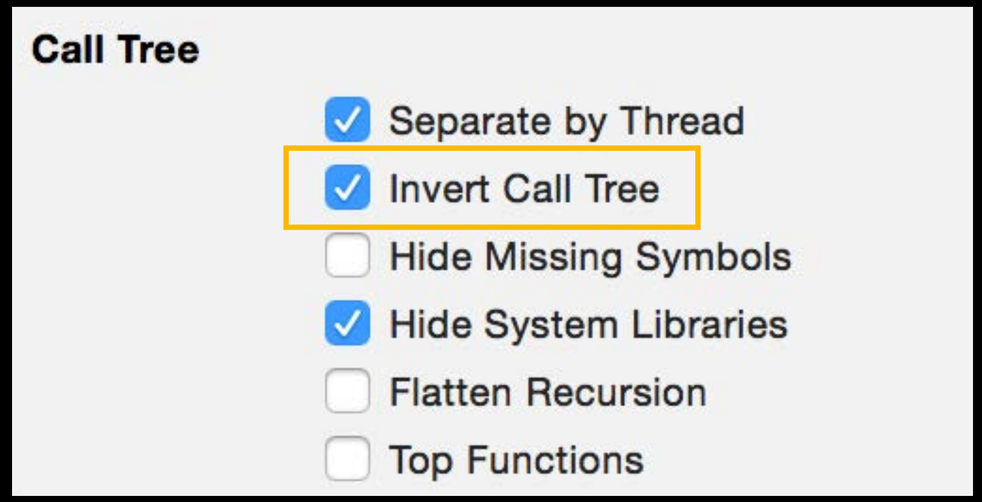
Call Tree settings



Review

Call Tree settings

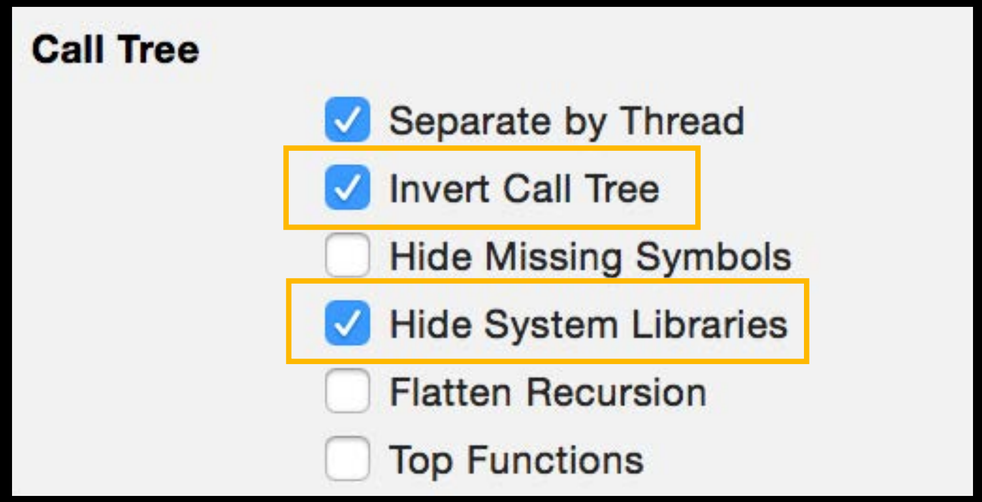
- Expensive calls are frequently near the end of the call stack



Review

Call Tree settings

- Expensive calls are frequently near the end of the call stack
- Focus on your own code

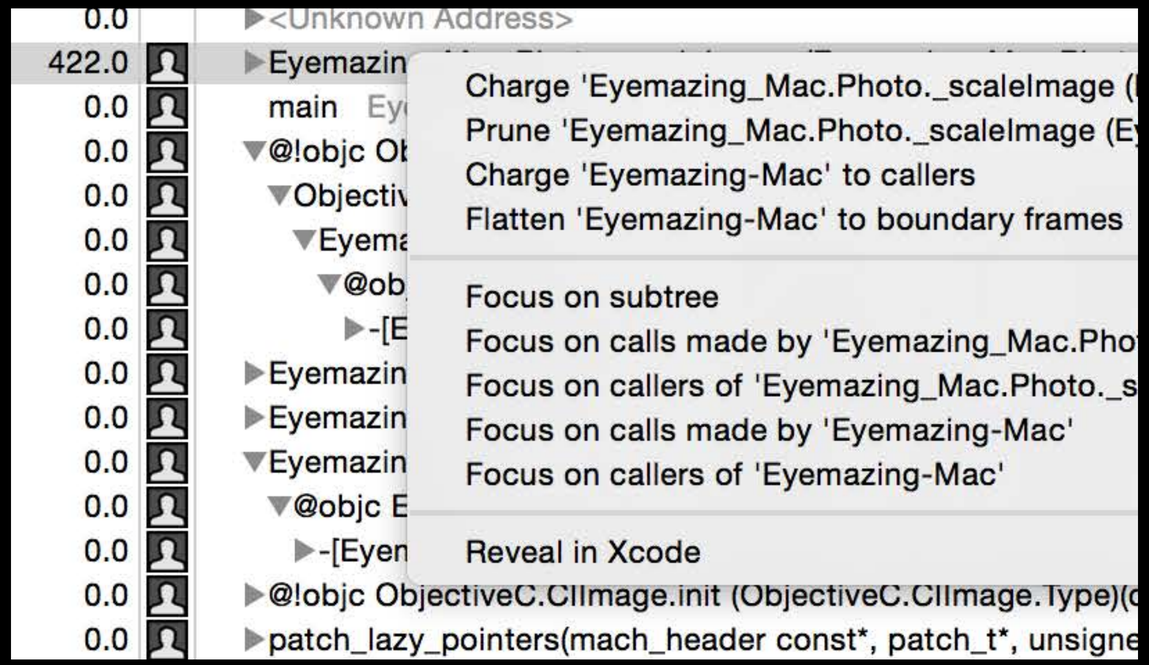


Tips

Focus and Prune

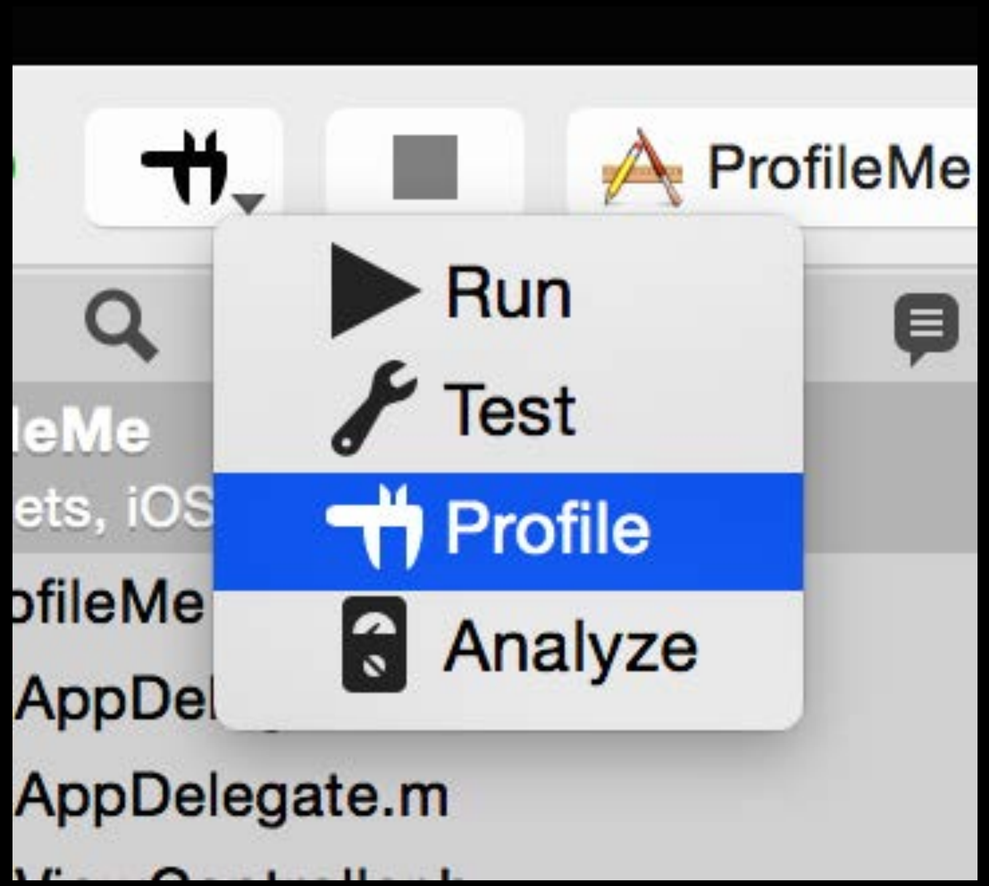
Ignore unwanted data

- Charge moves the associated cost
- Prune removes the associated cost
- Focus is “prune everything but”



Two More Guidelines

When using Time Profiler



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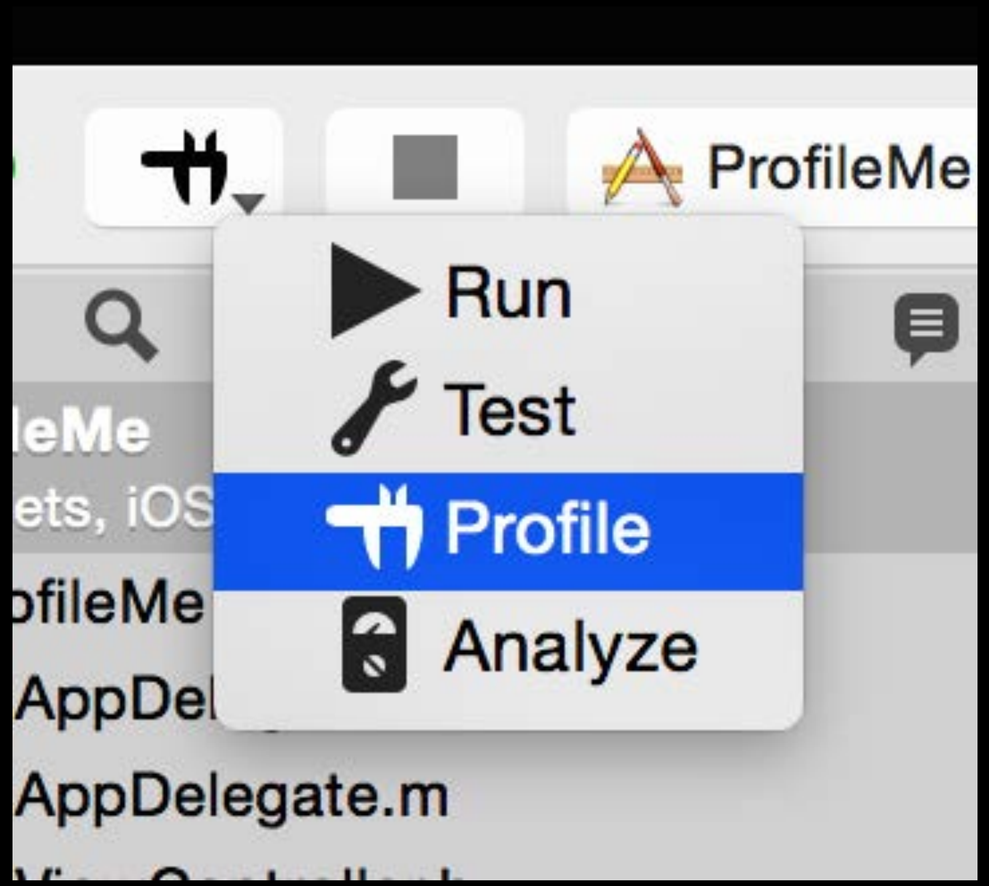
When using Time Profiler

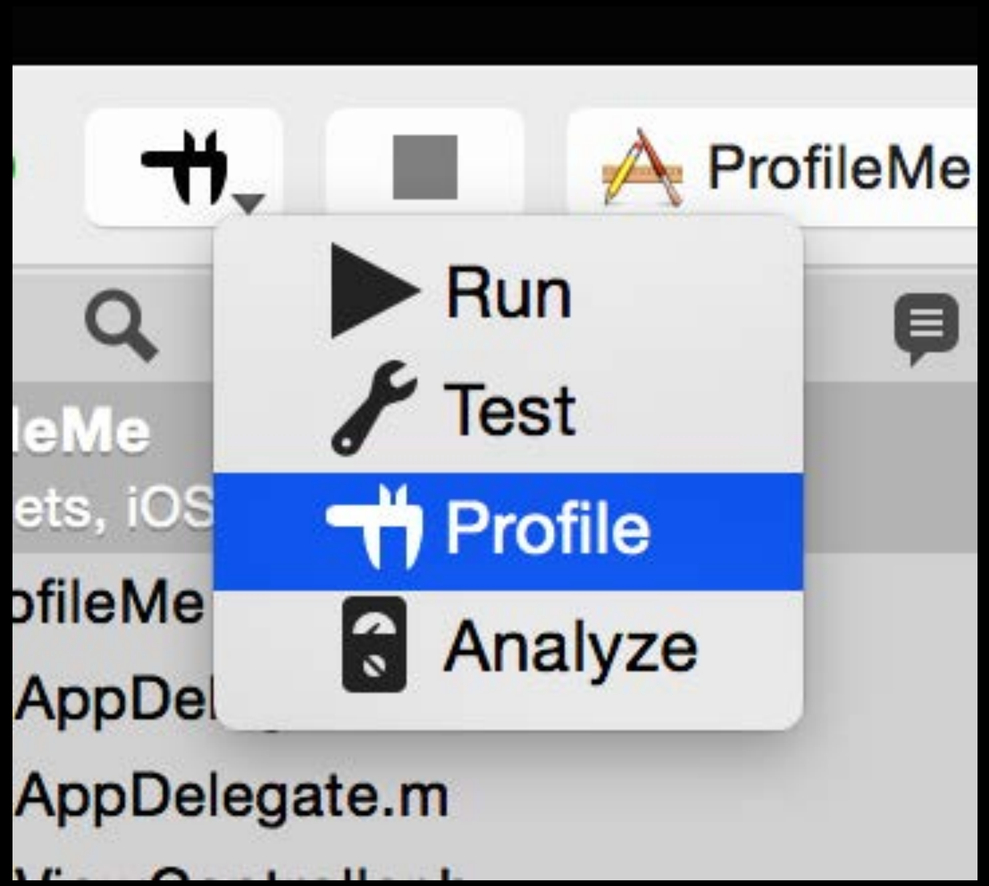
- Profile Release builds



Two More Guidelines

When using Time Profiler

- Profile Release builds
- For iOS, profile on the device



Performance Counters

Joe Grzywacz
Performance Tools Engineer

What Are Counters?

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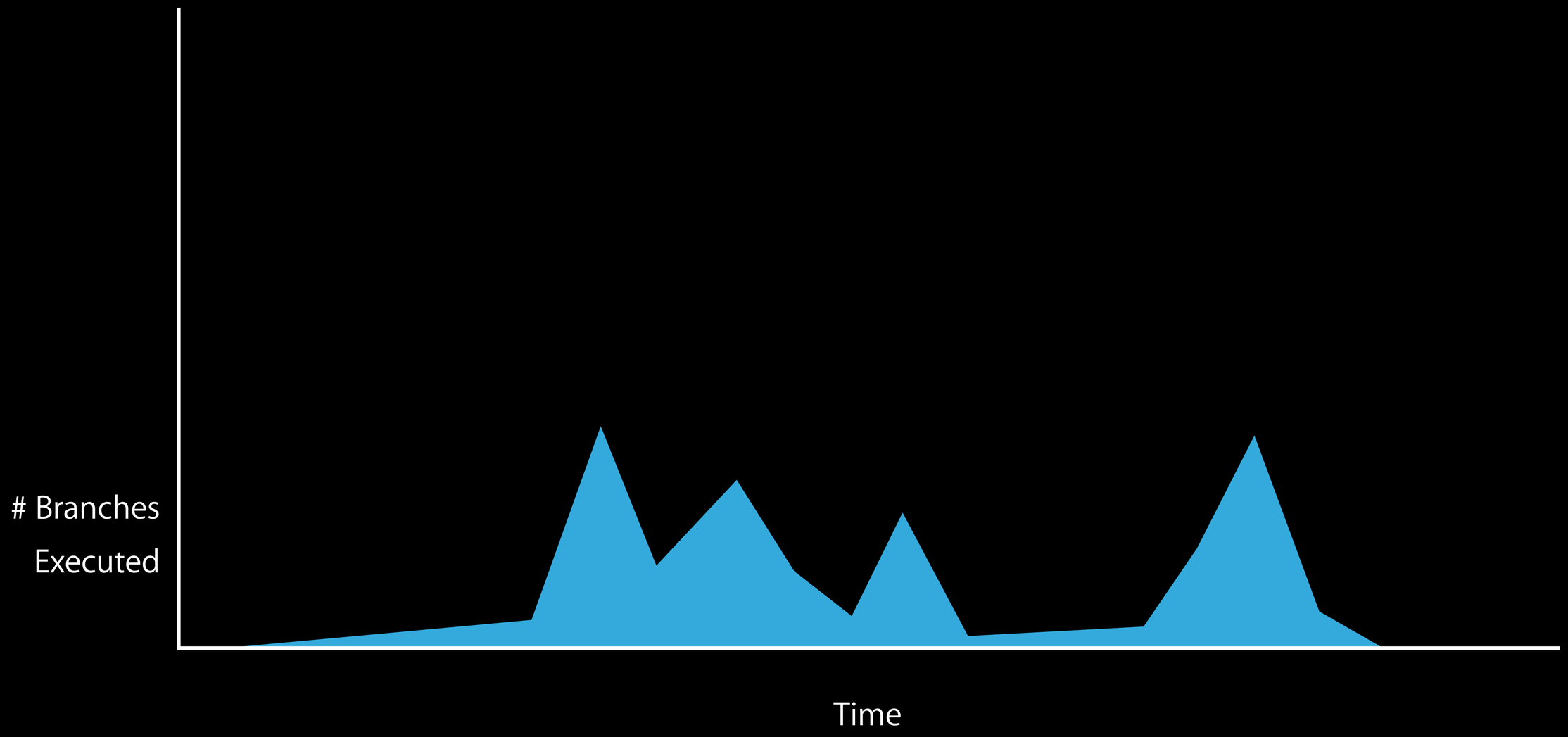
Each register can be configured to either:

- Count one of a small number of events
  - Instructions executed, L2 Cache Misses, Branches Taken, …
- Take a callstack every time a predetermined number of events occurs

Performance Monitoring Interrupts

(PMIs)



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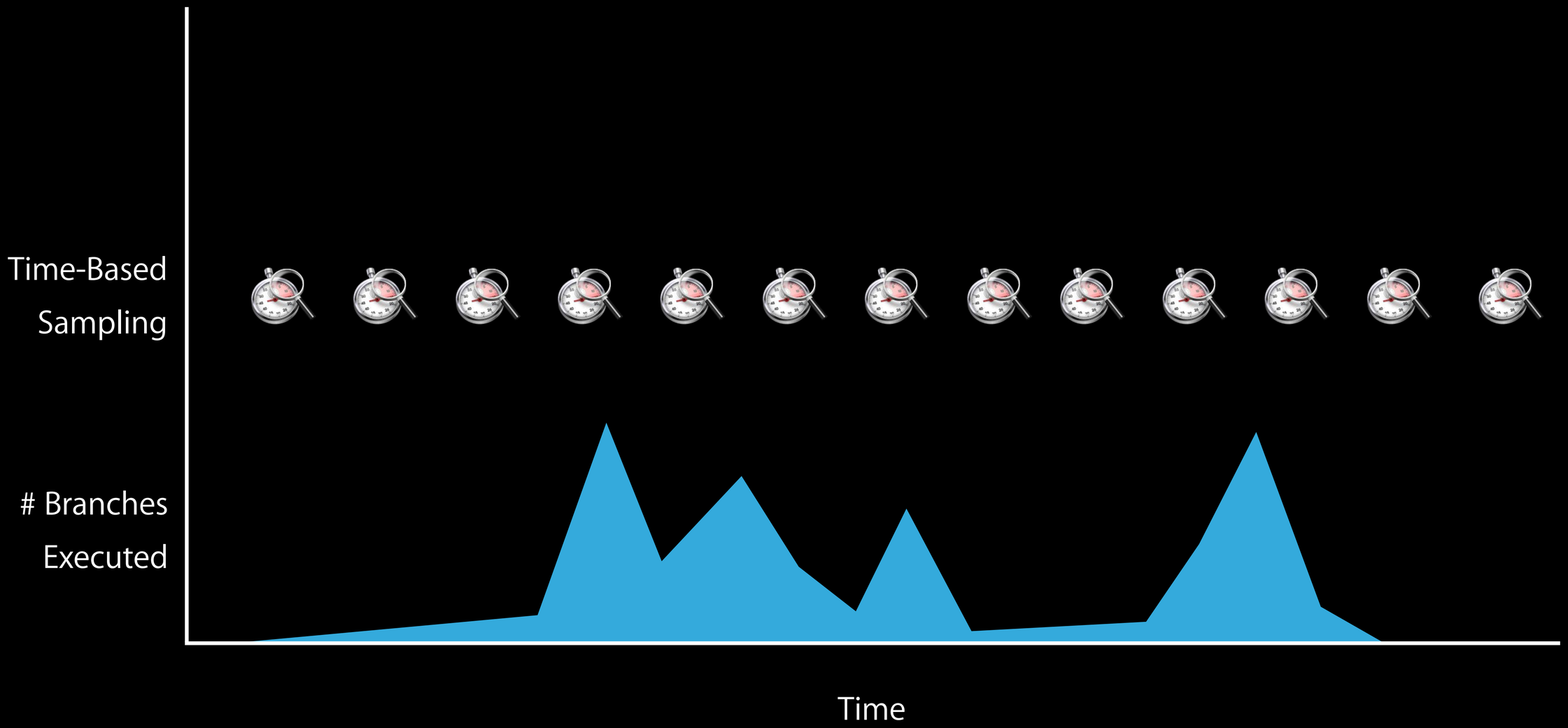

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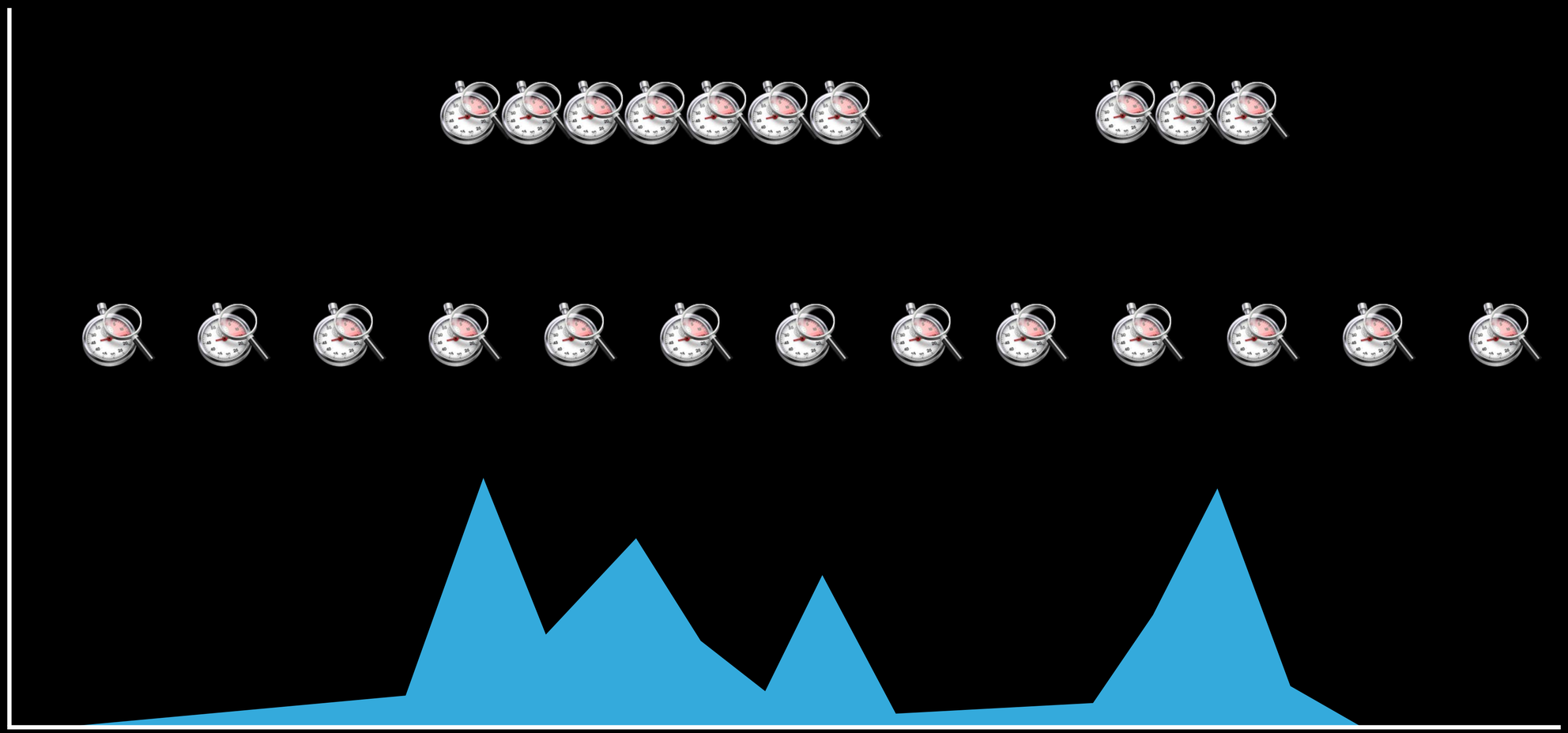

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- How well CPU resources are being used
  - Caches, execution units, TLBs, …
- Runtime process traits
  - Branch frequency, instruction mix, …

What's New with Counters

Formulas support

$$\textbf{IPC} = \frac{\text{Instructions}}{\text{Cycles}}$$

$$\textbf{Branch Mispredict Rate} = \frac{\text{BranchesMispredicted}}{\text{BranchesExecuted}}$$

$$\textbf{L1 Cache Miss \%} = 100 \times \frac{(\text{L1CacheLoadMisses} + \text{L1CacheStoreMisses})}{(\text{L1CacheLoads} + \text{L1CacheStores})}$$

What's New with Counters

iOS 8 support

- 64-bit ARM devices only

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iOS 8 support

- 64-bit ARM devices only

Event Profiler instrument is deprecated

- Same PMI functionality is available within the Counters instrument

Demo

iOS Performance Counters

Counters Summary

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Collects data in a similar manner to Time Profiler

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Formulas allow you to combine raw event counts in custom ways

- Be sure to save your common formulas in a template

What's New with DTrace

What's New with DTrace

Dynamic tracemem

Dynamic tracemem, provides a way to trace dynamically sized arrays

- tracemem(address, nbytes_max, nbytes)
  - nbytes_max: maximum size of the array, must be known at compile time
  - nbytes: the actual size of the array you want to copy
  - Example:

```
void CGContextFillRects(CGContextRef c, const CGRect rects[], size_t count);

pid$pid_MyAppName::CGContextFillRects:entry
{
 this->array = copyin(arg1, sizeof(struct CGRect) * arg2);
 tracemem(this->array, 512, sizeof(struct CGRect) * arg2);
}
```

Improved Histograms

Histogram improvements: `agghist`, `aggzoom`, `aggpack`

http://dtrace.org/blogs/bmc/2013/11/10/agghist-aggzoom-and-aggpack/

```
  key  ------------- Distribution ------------- count
ntpd |                                         4
sudo |                                         4
coreservicesd |                                 8
syslogd |                                       8
Finder |                                        13
configd |                                       18
pacemaker |                                     21
sshd |                                          21
sysmond |                                       26
mds_stores |                                    29
UserEventAgent |                                35
distnoted |                                     51
mds |                                           62
dtrace |                                        63
fseventsd |                                     64
xpcproxy |                                      74
notifyd |                                       87
cfprefsd |                                      240
opendirectoryd |                                303
softwareupdated |                               326
launchd.develop |                               655
cupsd |                                         981
```

```
                key  min .-------------. max    | count
     thread_selfid   64 :  |           : 524288 | 1
         sigaction   64 :  |           : 524288 | 4
         sigreturn   64 :  |           : 524288 | 2
      sigprocmask    64 :  |           : 524288 | 8
           fstat64   64 :  |           : 524288 | 1
    process_policy   64 :  |           : 524288 | 1
      gettimeofday   64 :  |           : 524288 | 14
  psynch_mutexdrop   64 :  |           : 524288 | 1
           recvfrom  64 :  |           : 524288 | 1
               read  64 :  |           : 524288 | 2
           stat64    64 :  |           : 524288 | 2
            madvise  64 :  |           : 524288 | 1
     write_nocancel  64 :  |           : 524288 | 1
            adjtime  64 :  |           : 524288 | 3
      open_nocancel  64 :  |           : 524288 | 2
             select  64 :  |           : 524288 | 4
          telemetry  64 :  |           : 524288 | 38
  psynch_mutexwait   64 :  |           : 524288 | 1
    select_nocancel  64 :  |           : 524288 | 1
             sysctl  64 :  |           : 524288 | 9
      psynch_cvwait  64 :  |           : 524288 | 3
              write  64 :  |           : 524288 | 7
  workq_kernreturn   64 :  |           : 524288 | 55
              ioctl  64 :  |           : 524288 | 35
           kevent64  64 :  |           : 524288 | 173
```

Other New Features

Wait for process to start with –W

```
dtrace –Z –W MyAppName ‘pid$target::*CALayer*:entry’
```

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dtrace –Z –W MyAppName ‘pid$target::*CALayer*:entry’
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Tunable internal DTrace variables

```
# List the tunable variables
sysctl kern.dtrace
```

Other New Features

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```
dtrace –Z –W MyAppName ‘pid$target::*CALayer*:entry’
```

Tunable internal DTrace variables

```
# List the tunable variables
sysctl kern.dtrace
```

Updated documentation

```
man dtrace
```

Summary

Profile Swift and Objective-C alike

Be proactive

Don't assume—profile, change, and iterate

More Information

Dave DeLong
Developer Tools Evangelist
delong@apple.com

Instruments Documentation
Instruments User Guide
Instruments User Reference
http://developer.apple.com

Apple Developer Forums
http://devforums.apple.com

Related Sessions

• Creating Extensions for iOS and OS X, Part 1	Mission	Tuesday 2:00PM
• Integrating Swift with Objective-C	Presidio	Wednesday 9:00AM
• Creating Extensions for iOS and OS X, Part 2	Mission	Wednesday 11:30AM
• Swift Interoperability In-Depth	Presidio	Wednesday 3:15PM
• Advanced Swift Debugging in LLDB	Mission	Friday 9:00AM

Labs

• Swift Lab	Tools Lab A	All Week
• Instruments Lab	Tools Lab B	Wednesday 9:00AM
• Power and Performance Lab	Core OS Lab B	Wednesday 2:00PM
• Instruments Lab	Tools Lab B	Thursday 9:00AM
• Power and Performance Lab	Core OS Lab A	Thursday 3:15PM

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