

System Trace in Depth Explore the deep end of the Instruments pool Session 411

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Last Year... Session 412 - Time Profiling in Depth

Last Year... Session 412 - Time Profiling in Depth



WWDC 2015

Get more done

Get more done System load changes performance

Get more done

System load changes performance

High system load increases

- Preemption
- Lock contention
- Virtual memory activity

System Trace in Depth





Agenda System tracing in depth

Agenda System tracing in depth

System Trace for Apps

Agenda System tracing in depth

System Trace for Apps Using System Trace

- Theading
- Signposts
- Virtual Memory
- Best Practices



3:42 PM			100	0% 👝 🗲
1.92 ms = 1 point			301	93 ms
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Records a kernel trace

Scheduling activity

00:03.569.750 00:03.569.800 00:03.569.800 00:03.569.850 Running (27.62 μs) 5 5

- Scheduling activity
- System calls



- Scheduling activity
- System calls
- Virtual memory operations



- Scheduling activity
- System calls
- Virtual memory operations

Records a kernel trace

- Scheduling activity
- System calls
- Virtual memory operations

Windowed Mode in Instruments 8

NEW



Records a kernel trace

- Scheduling activity
- System calls
- Virtual memory operations

Windowed Mode in Instruments 8

Keeps last ~5 sec of data



5 sec

Time ------

Records a kernel trace

- Scheduling activity
- System calls
- Virtual memory operations

Windowed Mode in Instruments 8

- Keeps last ~5 sec of data
- Gives you more time to reproduce



5 sec

Time ------

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C	II	es	Run 1 of 1
	All Cores All Processes / Threa	ds All Events	
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1	dispatch_worker_thread3 0x3756 Instruments (4069)	5	
1	dispatch_worker_thread3 0x3757 Instruments (4069)		
T	dispatch_worker_thread3 0x3757 Instruments (4069)	b	
	Main Thread 0x33605 Instruments (4069)		
I	dispatch_worker_thread3 0x3756 Instruments (4069)		
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	dispatch worker thread3 0x3757	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	
	User Interactive Load (10ms)		
De	tails 〉Narrative		
	Timestamp^ Narrative		
	00:01.286.165 Virtual memory Zero Fill	took 1.33 μs	
	00:01.286.171 Virtual memory Zero Fill	took 1.78 μs	
	00:01.286.178 Virtual memory Zero Fill	took 2.29 μs	
1	00:01.286.186 Virtual memory Zero Fill	took 1.63 μs	

00:01.286.192 Virtual memory Zero Fill took 1.66 µs

00:01.286.199 Virtual memory Zero Fill took 1.74 μs

00:01.286.206 Virtual memory Zero Fill took 1.97 μs

00:01.286.237 Virtual memory Zero Fill took 2.46 µs

00:01.286.327 Ran for 255.70 μs on CPU 2 at priority 43

00:01.286.323 Interrupted for 3.95 µs while CPU 2 serviced an interrupt handler.







Run 0 of 0

0.000	00:10.000	00:20.000	00:30.0





You tell Instruments what's interesting





You tell Instruments what's interesting Signposts





You tell Instruments what's interesting Signposts Classic: syscall(SYS_kdebug_trace, ...)





- You tell Instruments what's interesting
- Signposts
- Classic:

syscall(SYS_kdebug_trace, ...)

iOS 10 / macOS Sierra / tvOS 10 / watchOS 3: kdebug_signpost kdebug_signpost_start kdebug_signpost_end





Indicate an interesting point in time Arbitrary code (0 - 16383) 4 uintptr_t arguments

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Indicate an interesting point in time Arbitrary code (0 - 16383) 4 uintptr_t arguments

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Indicate an interesting point in time Arbitrary code (0 - 16383) 4 uintptr_t arguments

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Indicate an interesting point in time Arbitrary code (0 - 16383) 4 uintptr_t arguments

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Points of Interest Named codes

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Points of Interest Named codes

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00:04.000 Mouse Down (0x0 0x0 0x0 0x0)



Regions of Interest States or actions

Indicate an interesting range of time Arbitrary code Four integer/pointer arguments at start and end

```
Timing an activity (code 10 - "Start Up")
  (void)applicationDidFinishLaunching:(NSNotification *)aNotification
   kdebug_signpost_start(10, 0, 0, 0, 0);
    [self loadAssets];
   kdebug_signpost_end(10, 0, 0, 0, 0);
}
```



Regions of Interest States or actions

Indicate an interesting range of time Arbitrary code Four integer/pointer arguments at start and end

Timing an activity (code 10 - "Start Up") (void)applicationDidFinishLaunching:(NSNotification *)aNotification kdebug_signpost_start(10, 0, 0, 0, 0); [self loadAssets]; kdebug_signpost_end(10, 0, 0, 0, 0);





Regions of Interest States or actions

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}
```



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- \bigcirc Code and Thread



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Points of Interest Matching rule: Code and First Argument

Concurrent Asynchronous



// Start the download (code 20 - "URL Download") - (NSURLSessionDownloadTask *)startURLDownload: (NSURL *) url { NSURLSessionDownloadTask *dlTask = [_urlSession downloadTaskWithURL:url]; kdebug_signpost_start(20, (uintptr_t)dlTask, 0, 0, 0); [dlTask resume]; return dlTask;

}

- (void)URLSession:(NSURLSession *)session task:(NSURLSessionTask *)dlTask didCompleteWithError:(nullable NSError *)error {

kdebug_signpost_end(20, (uintptr_t)dlTask, 0, 0, 0);



00:01.960	00:02.000	00:02.040	00:02.080	0

URL Download Start: (0x7fd42b72cb50 0x0 0x0 0x0), End: (0x7fd42b72cb50 0x0 0x0 0x1) URL Download Start: (0x7fd42b72ce70 0x0 0x0 0x0), End: (0x7fd42b72ce7...

Points of Interest Matching rule: Code and First Argument

Concurrent Asynchronous







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URL Download Start: (0x7fd42b72cb50 0x0 0x0 0x0), End: (0x7fd42b72cb50 0x0 0x0 0x1) URL Download Start: (0x7fd42b72ce70 0x0 0x0 0x0), End: (0x7fd42b72ce7...

Points of Interest Matching rule: Code and Thread

Concurrent "Loop" timing



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Loading Chu	ink Start: (0x1 0x0 0x0	0 0x0), End: (0x1 0x0 0x0	0 0x0) URL
Loading Chu	ink Start: (0x2 0x0 0x	0 0x0), End: (0x2 0x0 0x	0 0x0)
Loading Chu	ink Start: (0x3.0x0.0x	0.0x0) End: $(0x3.0x0.0x)$	(0×0)



Points of Interest Matching rule: Code and Thread

Concurrent "Loop" timing



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	Loading Chunk	Start: (0x2 0x0	0x0 0x0), I	End: (0x2 0x0 (0x0 0x0)	
	Loading Chunk	Start: (0x3.0x0	0x0 0x0) I	End: (0x3.0x0.($(x_0, 0x_0)$	



Points of Interest Matching rule: Code and Thread

Concurrent "Loop" timing



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	Loading Chunk	c Start: (0x2	0x0 0x0	0x0), End	: (0x2 0x0	0x0 0x0)	
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Points of Interest Color using last argument

Pass/Fail Frame overrun Differentiation

// Color by last argument

// 0 - Blue, 1 - Green, 2 - Purple, 3 - Orange, 4 - Red

-(void)URLSession:(NSURLSession *)session task:(NSURLSessionTask *)task

didCompleteWithError:(nullable NSError *)error {

kdebug_signpost_end(20,(uintptr_t)task, 0, 0, (error) ? 4 : 1);

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Points of Interest Color using last argument

Pass/Fail Frame overrun Differentiation

// Color by last argument

// 0 - Blue, 1 - Green, 2 - Purple, 3 - Orange, 4 - Red

-(void)URLSession:(NSURLSession *)session task:(NSURLSessionTask *)task

didCompleteWithError:(nullable NSError *)error {

kdebug_signpost_end(20,(uintptr_t)task, 0, 0, (error) ? 4 : 1);

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Points of Interest Color using last argument

Pass/Fail Frame overrun Differentiation

// Color by last argument

// 0 - Blue, 1 - Green, 2 - Purple, 3 - Orange, 4 - Red

-(void)URLSession:(NSURLSession *)session task:(NSURLSessionTask *)task

didCompleteWithError:(nullable NSError *)error {

kdebug_signpost_end(20,(uintptr_t)task, 0, 0, (error) ? 4 : 1);

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Points of Interest Correlation



NEW

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Points of Interest Correlation



NEW

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Graphasaurus 2 Alegacy, reborn

Real world problems New graphing style Time profiled Needs parallelism

- 5 ms per row
- Four rows
- 20 ms > 16 ms (60 fps)

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28	308 ms				
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3:42 PM

1.92 ms = 1 point

100% 💭 30193 ms

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Demo Graphasaurus 2

Joe Grzywacz

Lock Contention A side effect of system load



Lock Contention Running



Lock Contention Blocking



Lock Contention Runnable



LockContention Overhead

0 00:03.631.100 00:03.6	632.200 00:03.633.300 00:03.634.40
_dispatch_worker_thread3 0 Graphasaurus (419)	0x8906
_dispatch_worker_thread3 0 Graphasaurus (419)	0x8907
Main Thread Ov88e8	
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Ne	UpdateGraph Start: (0x3 0x0 0x0
	Points

Details > Thre	ad States						Instru	ment Detail	⊙ \$\$ €
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▼ * All *		233	13.57 ms	416 ns	58.23 µs	353.60 μs	3.93 ms		
Running		87	<mark>11.11 ms</mark>	709 ns	<mark>127.76 μ</mark> s	563.24 μs	3.93 ms		
Blocked		60	204.33 µs	416 ns	3.41 μs	3.70 μs	27.00 µs		
Runnable		60	918.25 µs	2.17 µs	15.30 μs	31.80 µs	192.12 μs		
Interrupted	d	16	170.71 μs	2.88 µs	10.67 μs	17.47 μs	55.46 μs		
Preempted	ł	10	1.16 ms	2.79 µs	11 <mark>5.</mark> 94 μs	<mark>312.57 μs</mark>	1.00 ms		

00:03.635.500 00:03.636.600 00:03.637.700 00:03.638.800 00:03.639.900 (S) S x1), End: (0x2 0x0 0x0 0x1) RenderGraph Start: x1), End: (0x3 0x0 0x0 0x1)

Lock Contention Overhead

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Blocked	60	204.33 µs	416 ns	3.41 µs	3.70 µs	27.00 µs							
Runnable	60	918.25 µs	2.17 μs	15.30 µs	31.80 µs	192.12 μs							
Interrupted	16	170.71 μs	2.88 µs	10.67 µs	17.47 μs	55.46 µs							
Preempted	10	1.16 ms	2.79 μs	115.94 μs	312.57 µs	1.00 ms							

LockContention Overhead

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Interrupted	16	170.71 μs	2.88 µs	10.67 µs	17.47 μs	55.46 µs	;						
Preempted	10	1.16 ms	2.79 μs	115.94 µs	312.57 µs	1.00 ms	;						

Only 82% in Running

Lock Contention Fixed

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LockContention Fixed

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▼ * All *		1 2.4 1 2.4		45 ms	2.45	ms	2.45 ms	
Running				45 ms	2.45	ms	2.45 ms	

	00:04.	736.050	4.736.160	60 00:04.736.270 0					00:04.736.380			00	00:04.736.			
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)x0 0	x1), En	nd: (0x2 0x	0 0x0 0x1)										Rend	lerG	rap
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				In:	strum	ent Det	ail)				\odot	<u></u>	E)
ev D	u M	ax Durati.														
2	0 s	2.45 m	S													
	0 s	2.45 m	S													

100% in Running

Involuntary

- Priority decayed
- High priority work runnable

Involuntary

- Priority decayed
- High priority work runnable

Voluntary

- Spin locks
- thread_switch

Involuntary

- Priority decayed
- High priority work runnable

Voluntary

- Spin locks
- thread_switch

00:00.521.052 Called "thread_switch()" for 18.08 μs

00:00.521.055 Preempted for 13.19 µs (73.0% of thread_switch's duration) because thread was yielding CPU 2 to mach_kernel

Involuntary

- Priority decayed
- High priority work runnable

Voluntary

- Spin locks
- thread_switch

00:00.521.052 Calle "thread_switch()" r 18.08 μs

00:00.521.055 Preempted for 13.19 µs (73.0% of thread_switch's duration) because thread was yielding PU 2 to mach_kernel
Interrupted

Interrupt handler Priority doesn't matter Brief

Interrupted (4.96 µs)

	00:00.000	00:10
Points of Interest		
▶ 🞰 System Load		
Thread State Trace		
Virtual Memory Trace		
System Call Trace		





NEW



	00:01.400	00:02.800	00:03.500	00:04.2	200	00:04.900 00
	dispatch_worker_thread3 0x raphasaurus (419)	8906				
	dispatch_worker_thread3 0x raphasaurus (419)	8907				
A M	ain Thread 0x88e8	000000000000000000000000000000000000000				
	User Interactive Load (10	Oms)	date dadid	ALL BALL		A THE REAL PROPERTY AND A
👳 Detai	Is > Active Threads				Instr	rument Detail
Priority~	Process	Thread		State	Coro	
		Inicad		State	Core	
93	mach_kernel	0x711f		Running	CPU 0	
93 47	mach_kernel Graphasaurus (419)	0x711f _dispatch_worker_thread3 0	x8906	Running Running	CPU 0 CPU 1	
93 47 47	mach_kernel Graphasaurus (419) Graphasaurus (419)	0x711f _dispatch_worker_thread3 0 _dispatch_worker_thread3 0	x8906 x8907	Running Running Runnable	CPU 0 CPU 1 n/a	
93 47 47	mach_kernel Graphasaurus (419) Graphasaurus (419)	0x711f _dispatch_worker_thread3 0 _dispatch_worker_thread3 0	x8906 x8907	Running Running Runnable	CPU 0 CPU 1 n/a	

Ν	E



	00:01.400	00:02.100	00:02.800	00:03.	500	00:04.200	00:04.900
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Gr	lispatch_worker_thre aphasaurus (419)	ead3 0x8907					
× M	ain Thread 0x88e8						
	User Interactive	Load (10ms)		ender die offensel	Abddel offer		
📼 Detail	Is > Active Threads	S				In:	strument Detail
Detail Priority~	Is Active Threads Process	s Thread			State	Core	strument Detail
Detail Priority~ 93	Is > Active Threads Process mach_kernel	S Thread 0x711f			State Running	Core CPU 0	strument Detail
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NEW



	00:01.400	0:02.100	00:02.800	00:0	3.500	00:0	04.200	00:04.900	00
	lispatch_worker_threa aphasaurus (419)	.d3 0x8906							
	lispatch_worker_threa aphasaurus (419)	.d3 0x8907							
A M	ain Thread 0x88e8								
ШН	User Interactive L	oad (10ms)		and the start of					
\checkmark									
Detail	s > Active Threads						🕘 Ins	trument Detail	
Detail Priority~	Is Active Threads Process	Thread			S	tate	Core	trument Detail	
Detai Priority~ 93	Is Active Threads Process mach_kernel	Thread 0x711f			S	tate unning	Core CPU 0	trument Detail	
Detai Priority~ 93 47	Is Active Threads Process mach_kernel Graphasaurus (419)	Thread 0x711f _dispato	h_worker_thread3	0x8906	S	tate unning unning	Core CPU 0 CPU 1	trument Detail	
Detai Priority~ 93 47 47	Is Active Threads Process mach_kernel Graphasaurus (419) Graphasaurus (419)	Thread 0x711f _dispato _dispato	:h_worker_thread3 :h_worker_thread3	0x8906 0x8907	S R R R	tate unning unning unnable	Core CPU 0 CPU 1 n/a	trument Detail	
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NEW



User Interactive Load Average









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First Third [20161 - 20285] First Second	
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Fou Fifth (30099-30318) Fourth Second Fo	L L
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econd First First [30048 - 30314] First I Fo First	

Demo Priorities

Joe Grzywacz

1	00:03.456	00:03.460	6 6 1	00:03.464	00):03.468
	_dispatch_worker_ Graphasaurus (454)	thread3 0xe24f				•
	_dispatch_worker_ Graphasaurus (454)	thread3 0xe25d				S
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			0x0 0x	U Render	Graph Start: (0)	x3 0x0 0x
		Points				
Q	Details > KDebug Int	erval Signposts I	by Code			
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W	* All *		3,443	12.29 s	1.33 μs	3.57 n
			2 4 4 2	10.00 -	1.00.00	2 5 7 -

rocess / Name	Count	~	Duration	Min Duration	Avg Duration	Std Dev Du	Max Durati	0
▼ * All *		3,443	12.29 s	1.33 μs	3.57 ms	3.46 ms	18.83 ms	
▼ Graphasaurus (454)		3,443	12.29 s	1.33 μs	3.57 ms	3.46 ms	18.83 ms	S
GenTooltips		1,060	2.73 s	<mark>1.33 μs</mark>	2.57 ms	2.61 ms	18.83 ms	
UpdateGraph		1,060	879.86 ms	461.71 μs	830.06 μs	401.43 μs	2.72 ms	
RenderGraph		1,059	5.33 s	3.95 ms	5.03 ms	489.68 μs	8.00 ms	1
CADisplayLink		264	3.36 s	10.46 ms	12.73 ms	758.19 μs	14.61 ms	
								- 3

00:03.480 00:03.472 00:03.476 00:03.484 110 S •••• S GenTo... GenT... U... RenderGraph Start: (0x0 0x0 0x0... U. RenderGraph Start: (0x2 0x0... tips... CADisplayLink Start: (0x0 0x0 0x3de 0x0), End: (0x0 0x0 0x0 0x0) UpdateGrap... RenderGraph Start: (0x1 0x... U... RenderGraph Start: (0x3 0x0 0x0... Tooltips Start: (0x... \odot Instrument Detail



00:03.456 00:03	460	ç i i l	00:03.464	00	:03.468	00:03	3.472	a 6 1	00:03.476		00:03.4	80	00:03	8.484
_dispatch_worker_thread3 Graphasaurus (454)	3 0xe24f				•		5							6
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V Graphasaurus (454)		3,443	12.29 s	1.33 µs	3.57 ms	3.46 ms	18.83	ms						S
GenTooltips		1,060	2.73 s	1.33 µs	2.57 ms	2.61 ms	18.83	ms						
UpdateGraph		1,060	879.86 ms	461.71 μs	830.06 µs	401.43 μs	2.72	ms						
RenderGraph		1,059	5.33 s	3.95 ms	5.03 ms	489.68 µs	8.00	ms						
CADisplayLink		264	3.36 s	10.46 ms	12.73 ms	758.19 μs	14.61	ms						2



iority∽	Process	Thread	State	Core
45	Graphasaurus (454)	_dispatch_worker_thread3 0xe25c	Running	CPU 1
38	Graphasaurus (454)	_dispatch_worker_thread3 0xe251	Running	CPU 0
31	locationd (68)	_dispatch_worker_thread3 0xe039	Preempted	n/a
4	Graphasaurus (454)	_dispatch_worker_thread3 0xe24f	Runnable	n/a

Details > Active Threads									
Priority~	Process	Thread		State	Core				
45	Graphasaurus (454)	_dispatch_worker_thread3	0xe25d	Running	CPU 1				
38	Graphasaurus (454)	_dispatch_worker_thread3	0xe251	Running	CPU 0				
31	locationd (68)	_dispatch_worker_thread3	0xe039	Preempted	n/a				
4	Graphasaurus (454)	_dispatch_worker_thread3	0xe24f	Runnable	n/a				

Attribute of blocks, queues, threads Constrains the priority range Throttles I/O Throttles CPU frequency

Virtual Memory Faults

Affect performance Worse under a load Manageable

System Trace Has the tools



Details Narrative

Timestamp^	Narrative
00:04.352.664	Virtual memory Copy On Write took 3.79 µs
00:04.352.670	Virtual memory Copy On Write took 3.67 µs
00:04.352.675	Virtual memory Copy On Write took 4.00 µs
00:04.352.681	Virtual memory Copy On Write took 5.04 µs
00:04.352.688	Virtual memory Copy On Write took 4.29 µs
00:04.352.694	Virtual memory Copy On Write took 3.75 µs
00:04.352.700	Virtual memory Copy On Write took 3.83 µs
00:04.352.706	Virtual memory Copy On Write took 4.25 µs
00:04.352.712	Virtual memory Copy On Write took 4.58 µs
00:04.352.718	Virtual memory Copy On Write took 4.21 µs
00:04.352.724	Virtual memory Copy On Write took 3.75 µs
00:04.352.730	Virtual memory Copy On Write took 4.08 µs



回

System Trace Has the tools

Dui	ration	Self Durati	Symbol Name
178.12 ms	95.4%	0 s	▼Graphasaurus (41
175.59 ms	94.1%	0 s	Copy On Write
2.45 ms	1.3%	0 s	Zero Fill
78.96 μs	0.0%	0 s	▼Page Cache Hit
78.96 μs	0.0%	0 s	Main Thread C
78.96 µs	0.0%	0 s	Start libdyld
78.96 µs	0.0%	0 s	
78.96 µs	0.0%	0 s	UIApplica
78.96 μs	0.0%	0 s	▼-[UIApp
78.96 μs	0.0%	0 s	GSEve
78.96 μs	0.0%	0 s	◯ ▼CFR
78.96 μs	0.0%	0 s	
78.96 μs	0.0%	0 s	
78.96 μs	0.0%	0 s	
72.96 μs	0.0%	0 s	
72.96 μs	0.0%	0 s	
72.96 µs	0.0%	0 s	
72.96 µs	0.0%	0 s	
72.96 µs	0.0%	0 s	
72.96 µs	0.0%	0 s	
72.96 µs	0.0%	0 s	
72.96 µs	0.0%	0 s	

19) 🕤 0x88e8 d.dylib ohasaurus ationMain UIKit olication _run] UIKit entRunModal GraphicsServices unLoopRunSpecific CoreFoundation CFRunLoopRun CoreFoundation _CFRunLoopDoSource1 CoreFoundation CFRUNLOOP_IS_CALLING_OUT_TO_A_SOURCE1_PERFORM_FUN migHelperRecievePortCallout AppSupport XReceivedStatusBarDataAndActions UlKit UIStatusBarReceivedStatusBarDataAndActions UIKit w-[UIStatusBar statusBarServer:didReceiveStatusBarData:wit -[UIStatusBarForegroundView setStatusBarData:actions:a ▼-[UIStatusBarForegroundView _setStatusBarData:actions

•[UIStatusBarLayoutManager updateItemsWithData:ac

-[UIStatusBarLayoutManager _updateItemView:withD

Fault on Access

Allocations are quick First access causes fault

Resolved Inline No explicit call Access any byte in the page Just-in-time mapping to physical memory

Mitigation

Mitigation

Absorb them

- Leave room for faulting in your budget
- More resilient under a load

Mitigation

Absorb them

- Leave room for faulting in your budget
- More resilient under a load
- Fault pages on a background thread
- dispatch_async
- Avoids stutters when showing new content

Summary

Companion to the Time Profiler Applications that scale well under heavy loads Try it out on your app Many new features in Instruments 8

More Information https://developer.apple.com/wwdc16/411

Related Sessions

Optimizing App Startup Time

Using Time Profiler in Intruments

Concurrent Programming with GCD in Sw

	Mission	Wednesday 10:00AM
	Nob Hill	Friday 3:00PM
/ift 3	Pacific Heights	Friday 4:00PM



System Trace Q&A Lab

Xcode Open Hours

Profiling and Debugging Lab

Xcode Open Hours

Fort Mason	Thursday 10:00PM
Developer Tools Lab C	Thursday 12:00PM
Developer Tools Lab C	Friday 3:00PM
Developer Tools Lab B	Friday 3:00PM

