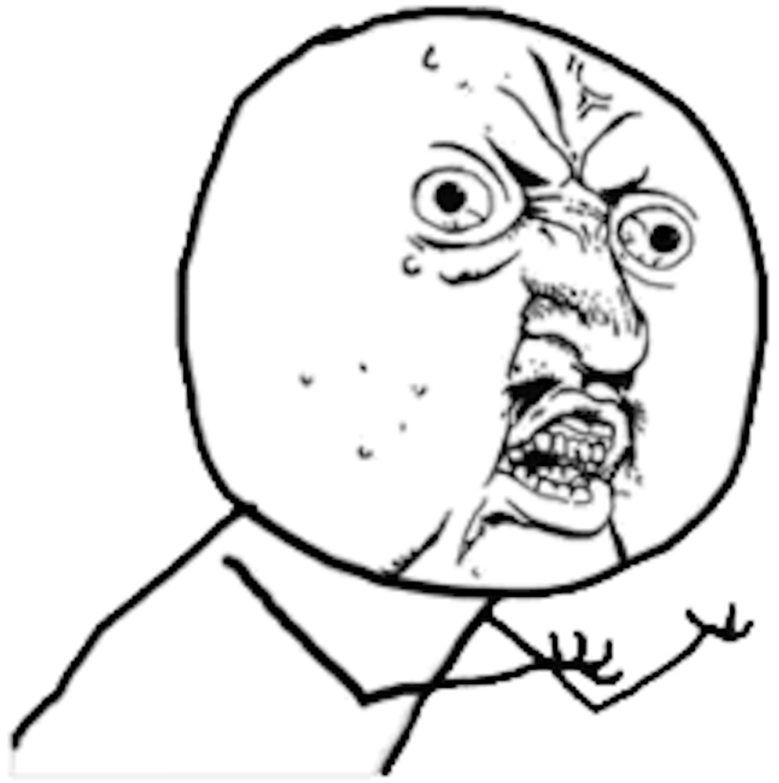
手淘iOS性能优化探索

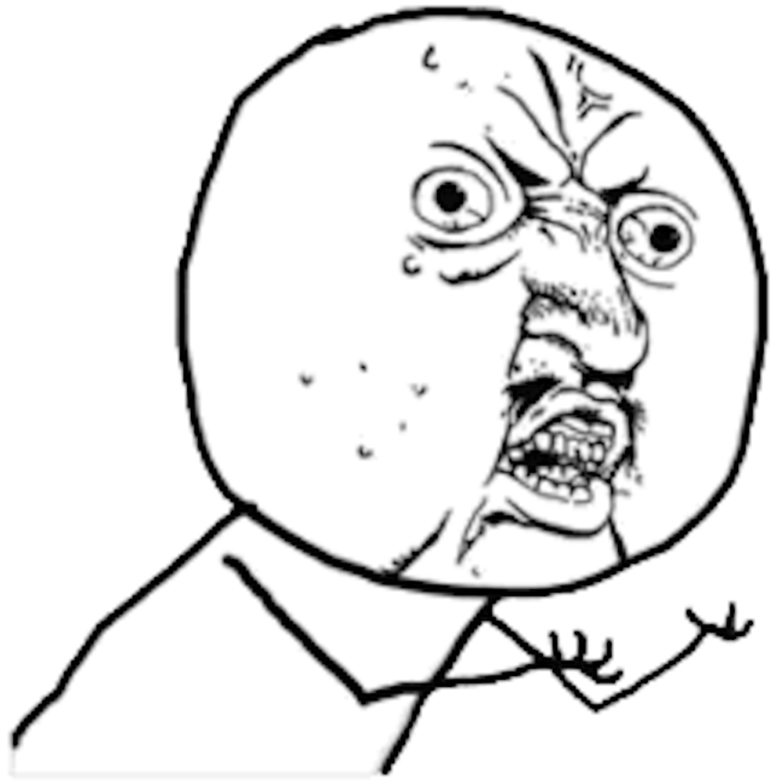
手淘基础架构 — 方颖（叁省）

淘宝网
Taobao.com

我们面对的每一天~~



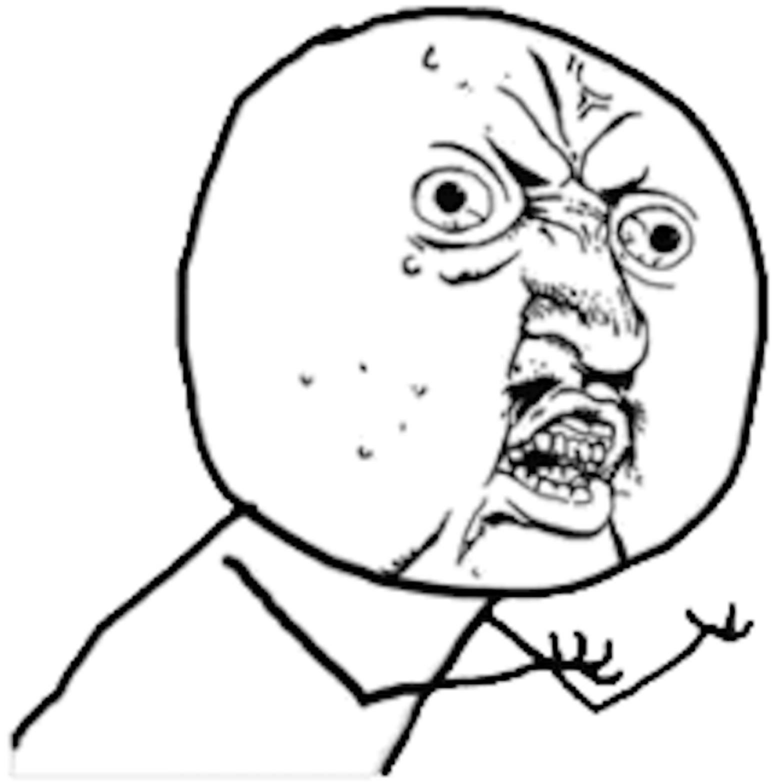
怎么一个版本一个版
本性能越来越差了~~~



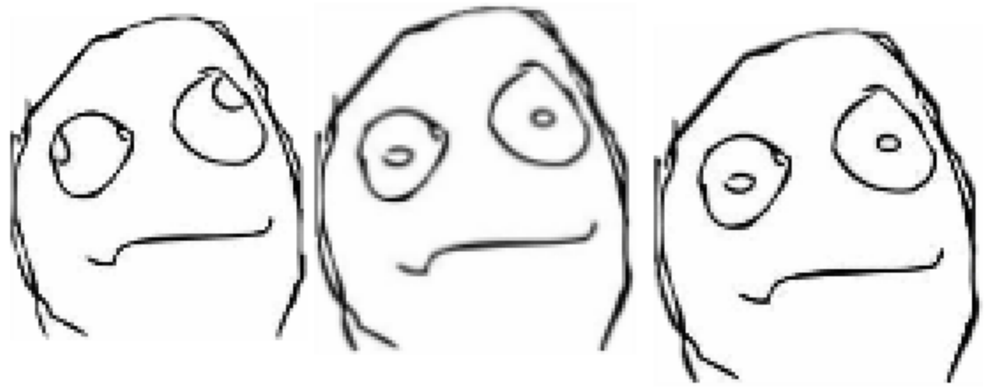
页面加载这么慢
都不知道吗~~~

不知道！

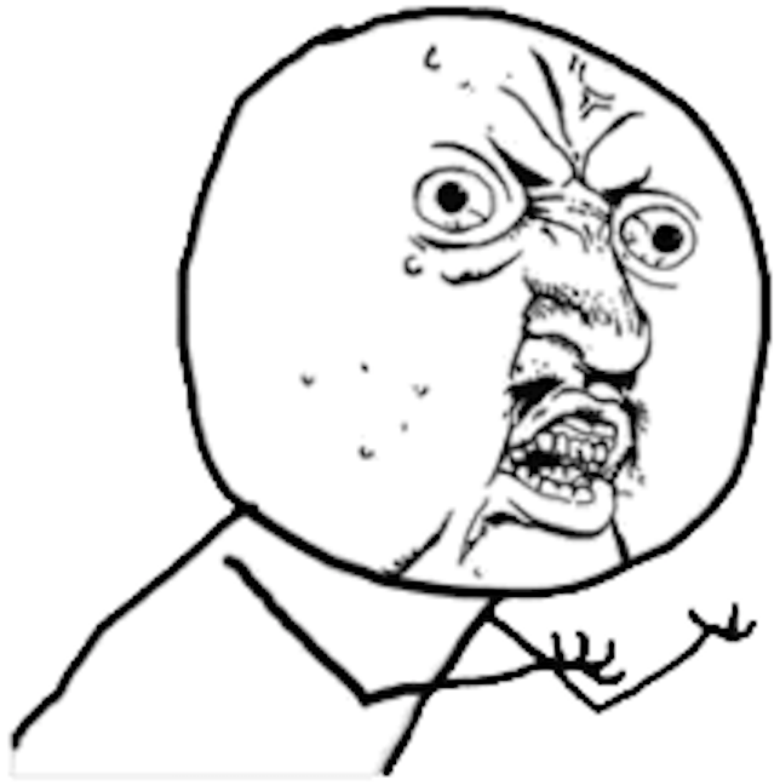
XXX~~~ XXX~~~
XXX~~~
~~~
XX~~~
~~~



线上页面加载数据怎么这么卡~~~
有很多客户投诉，页面划不动啊~~~

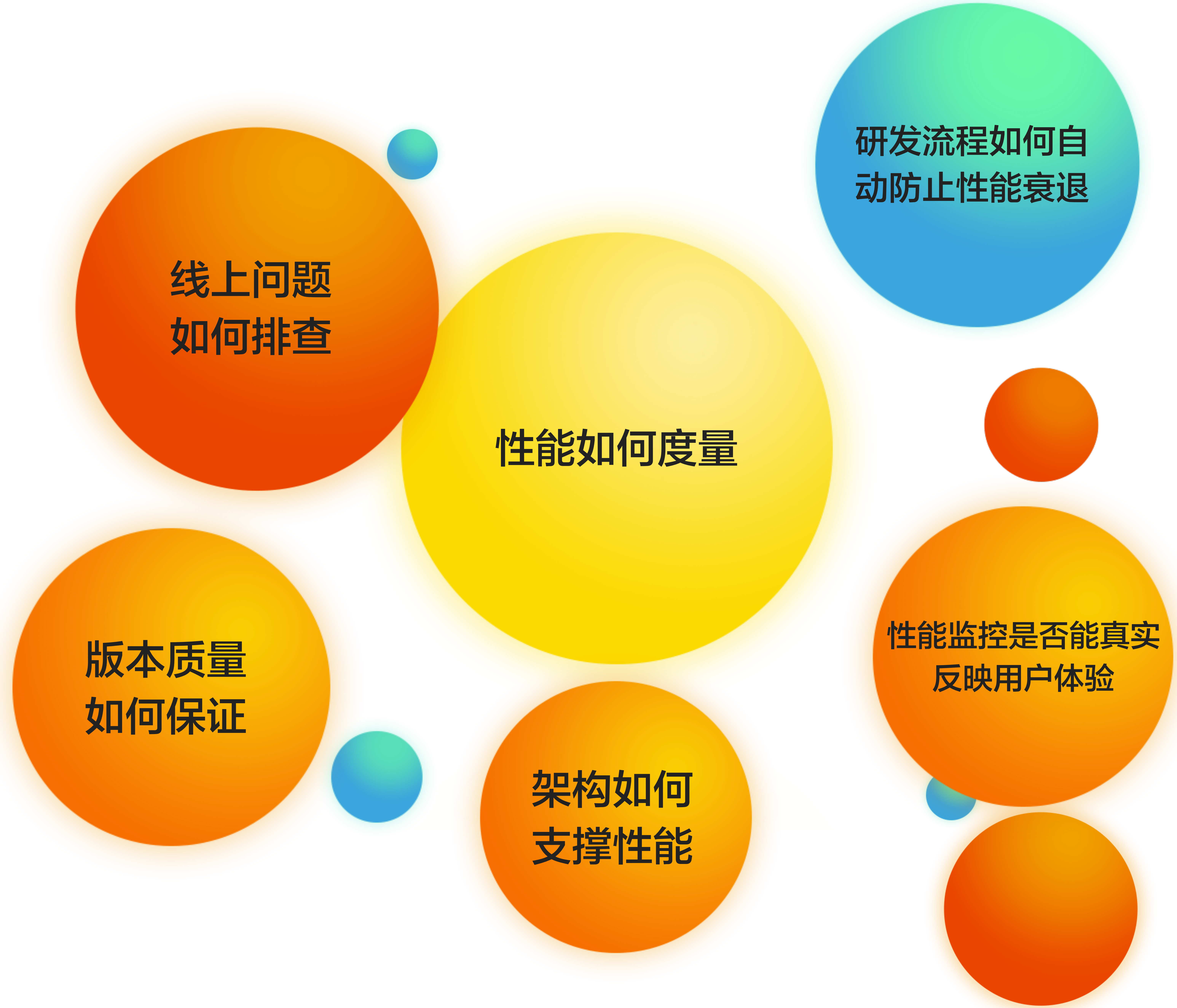


一脸懵逼~~~



启动不达标，不达标~~~

性能面对的问题



线上问题
如何排查

版本质量
如何保证

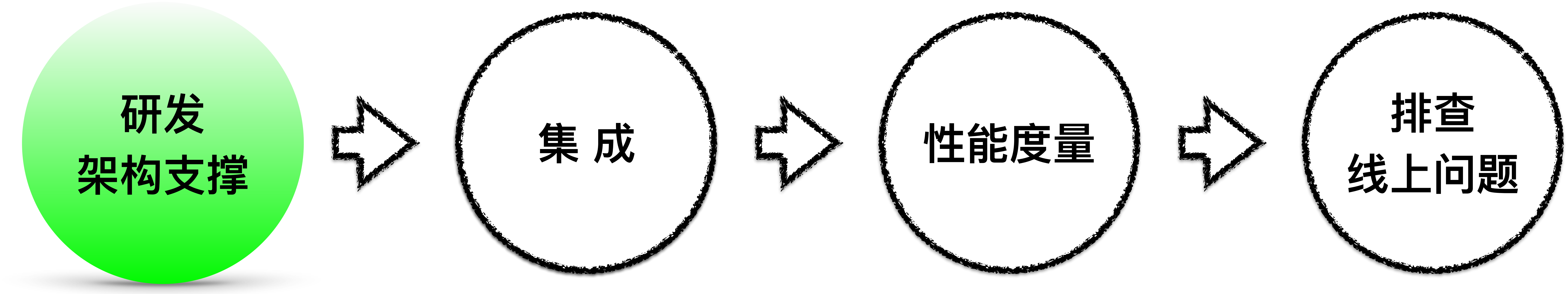
性能如何度量

架构如何
支撑性能

研发流程如何自
动防止性能衰退

性能监控是否能真实
反映用户体验

技术上从研发流程角度的思考



- App启动器

研发架构沉淀 — **App启动器设计目标**

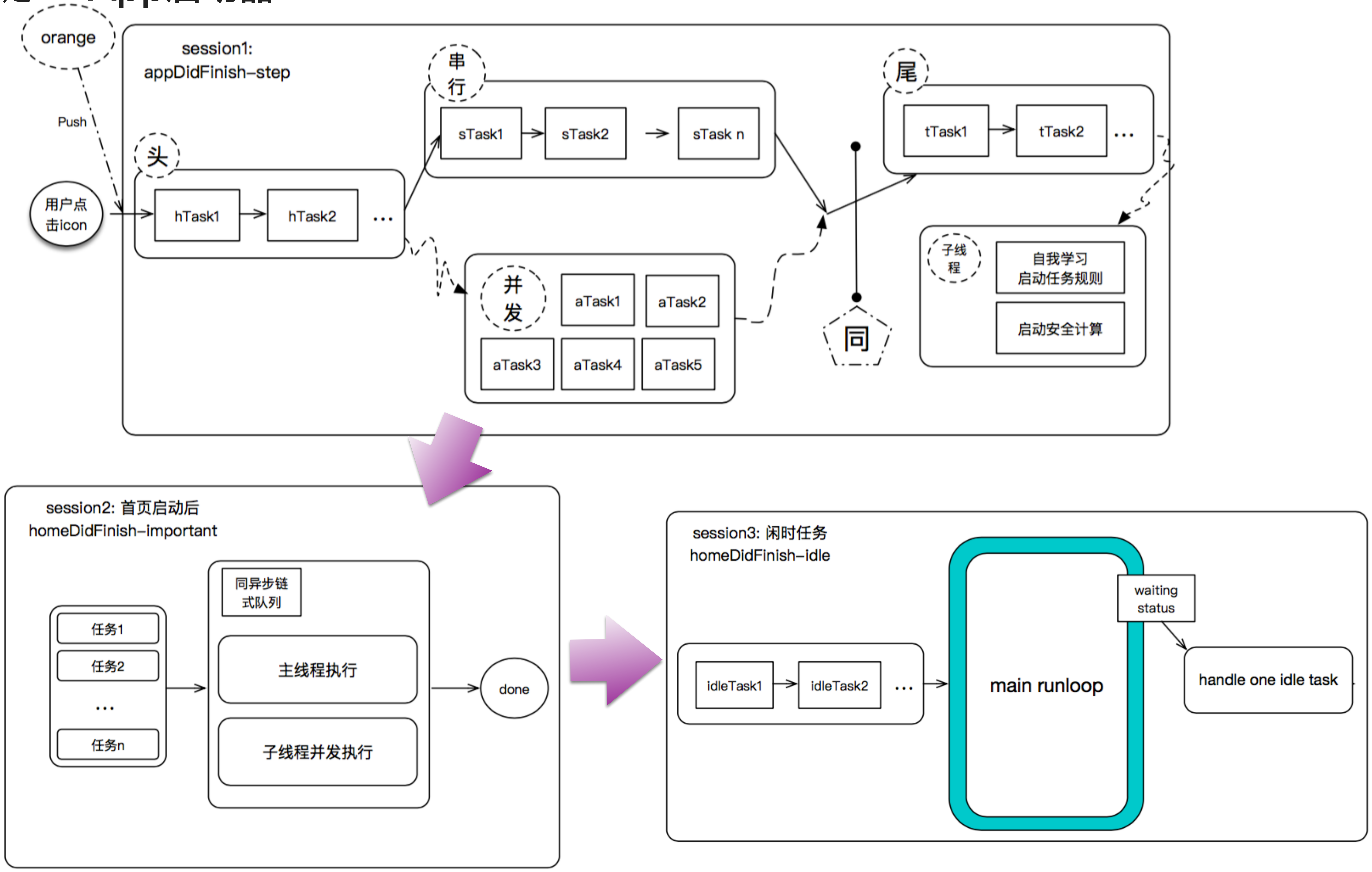
问题篇：

1. 启动过程任务数量多，并且复杂/凌乱
2. 版本持续迭代，启动任务任意增加，维护成本高
3. 启动性能不宜被管控，未知任务容易导致性能下降
4. 稳定性容易受到挑战，任意加入启动逻辑，可能造出闪退
5. 启动过程业务逻辑严重耦合

设计目标：

1. 采取配置信息，解决耦合问题，达到启动任务松耦合
2. 启动任务细粒子化，通过高并发设计、自学习最佳任务顺序，提高启动性能
3. 启动任务服务端可配置，保证线上问题服务端控制解决
4. 启动任务严格管控，业务任务接入需要接受审核

研发架构沉淀 — App启动器



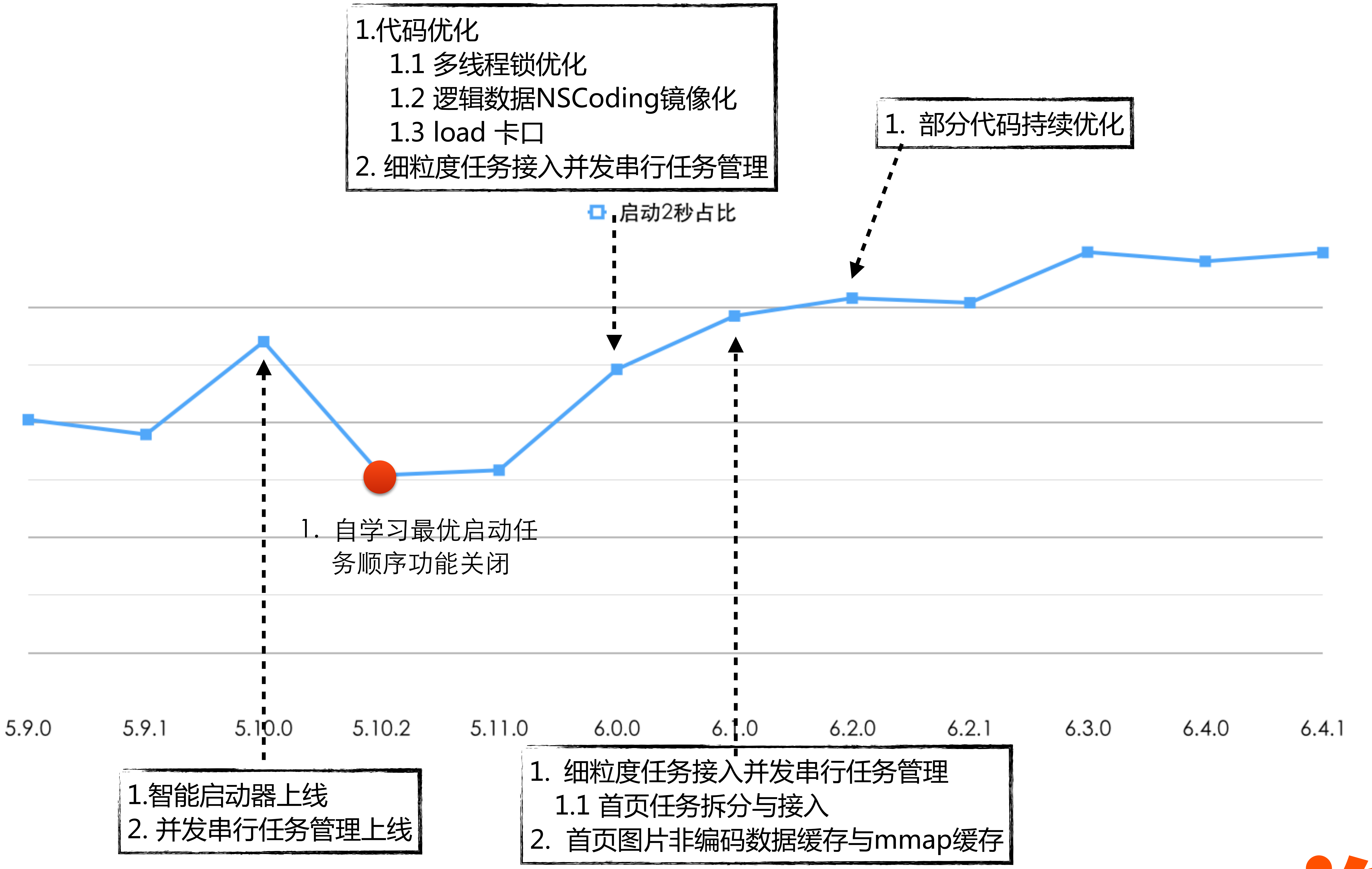
研发架构沉淀 — App启动器的效果

横轴:

手淘版本号

纵轴:

启动耗时2秒用户占比



1.代码优化
    1.1 多线程锁优化
    1.2 逻辑数据NSCoding镜像化
    1.3 load 卡口
2. 细粒度任务接入并发串行任务管理

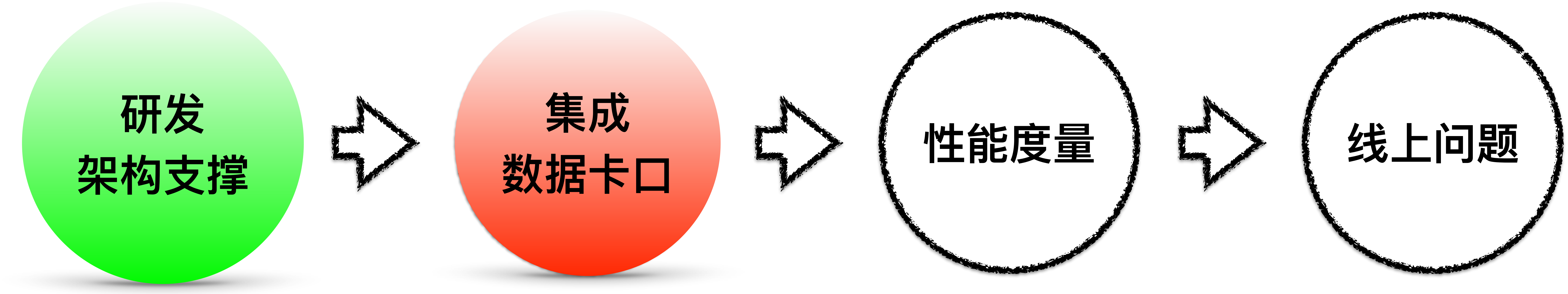
1. 部分代码持续优化

1. 自学习最优启动任务顺序功能关闭

1.智能启动器上线
2. 并发串行任务管理上线

1. 细粒度任务接入并发串行任务管理
    1.1 首页任务拆分与接入
2. 首页图片非编码数据缓存与mmap缓存

技术上从研发流程角度的思考



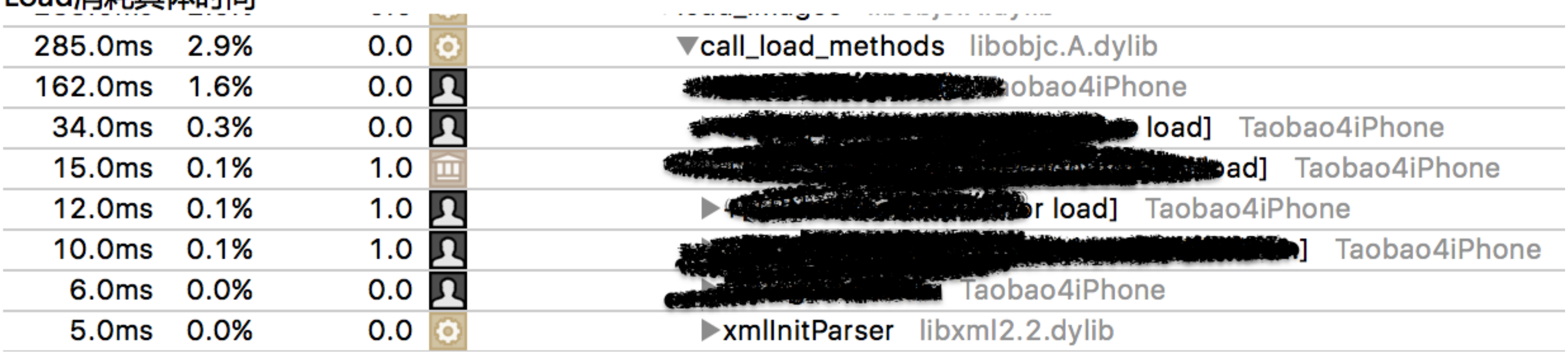
- API使用卡口
- 性能维度卡口

集成数据卡口 — **非最佳使用API卡口案例**

developer 在main之前的可以进行的处理

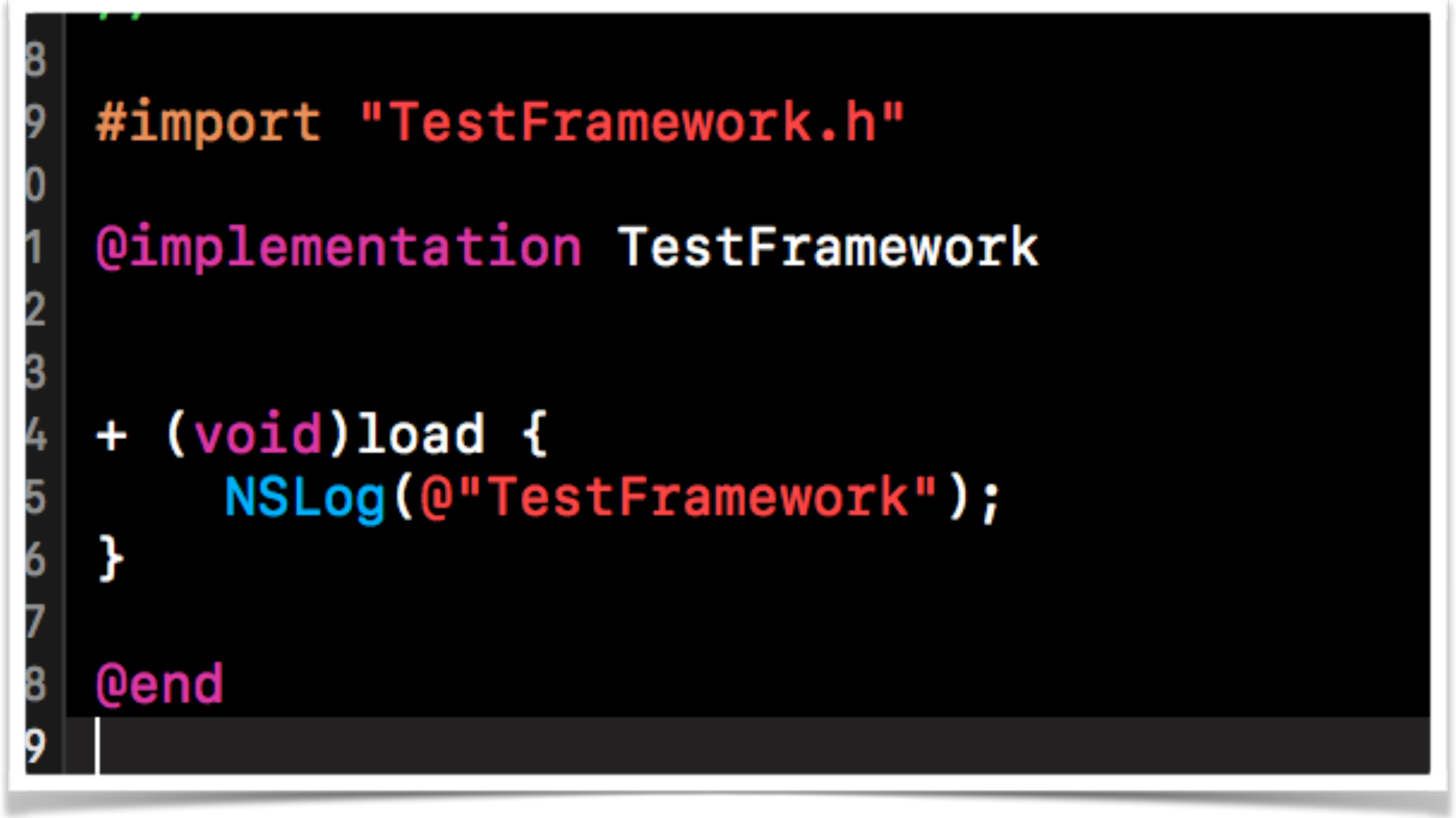
class load()
category load()
attribute((constructor)) 和
C++ generates initializer
for static allocated objects
Parse Image
Map Image
Rebase Image
Bind Image
Run Image Initializers
Call main()
Call
UIApplicationMain()
Call
WillFinishLaunch()
main 之前系统init
main 之后init

Load消耗具体时间

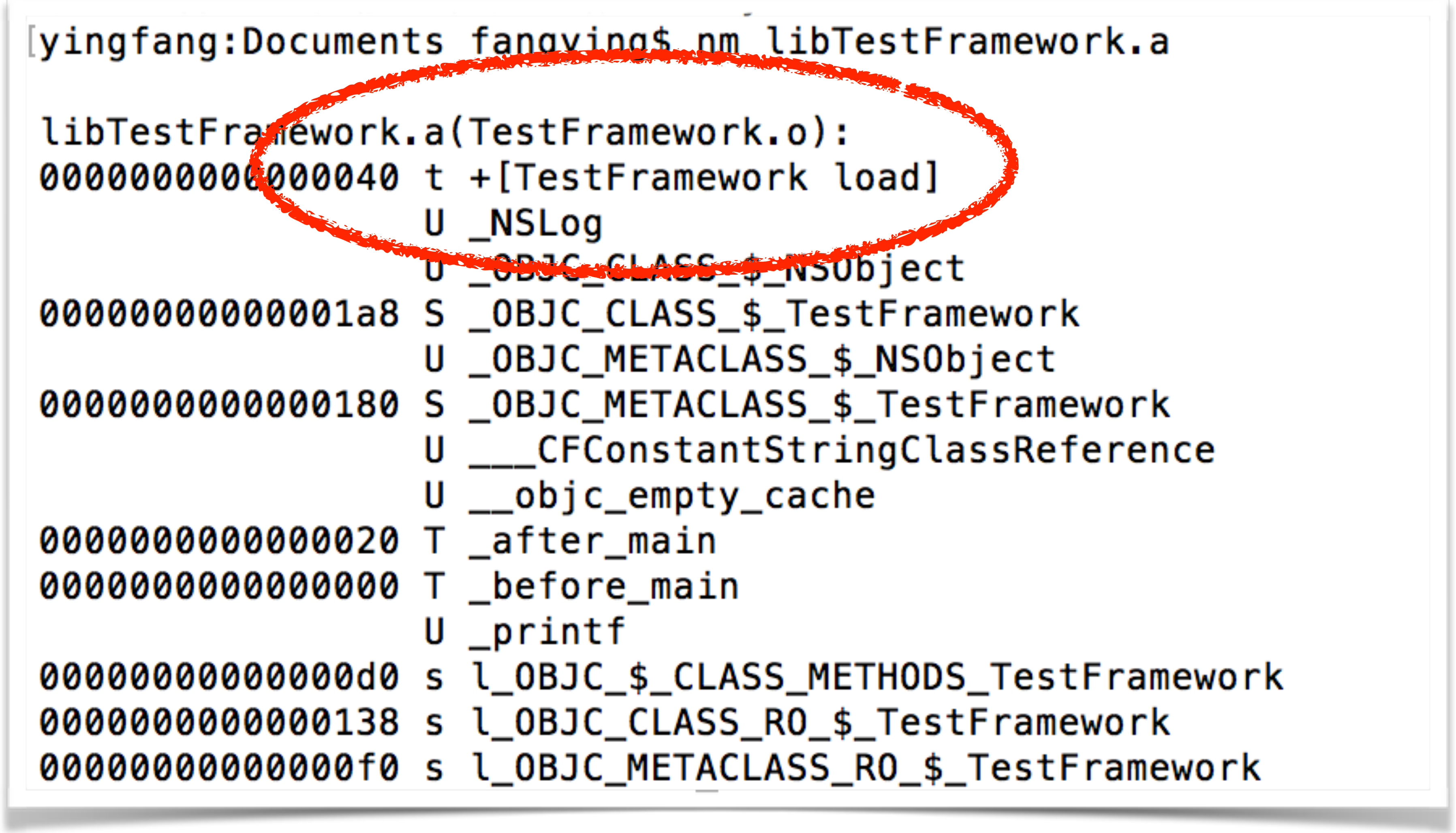


285.0ms	2.9%	0.0	⚙	▼call_load_methods libobjc.A.dylib
162.0ms	1.6%	0.0	👤	[redacted]obao4iPhone
34.0ms	0.3%	0.0	👤	[redacted] load] Taobao4iPhone
15.0ms	0.1%	1.0	🏛	[redacted]ad] Taobao4iPhone
12.0ms	0.1%	1.0	👤	▶[redacted]r load] Taobao4iPhone
10.0ms	0.1%	1.0	👤	[redacted]] Taobao4iPhone
6.0ms	0.0%	0.0	👤	[redacted] Taobao4iPhone
5.0ms	0.0%	0.0	⚙	▶xmlInitParser libxml2.2.dylib

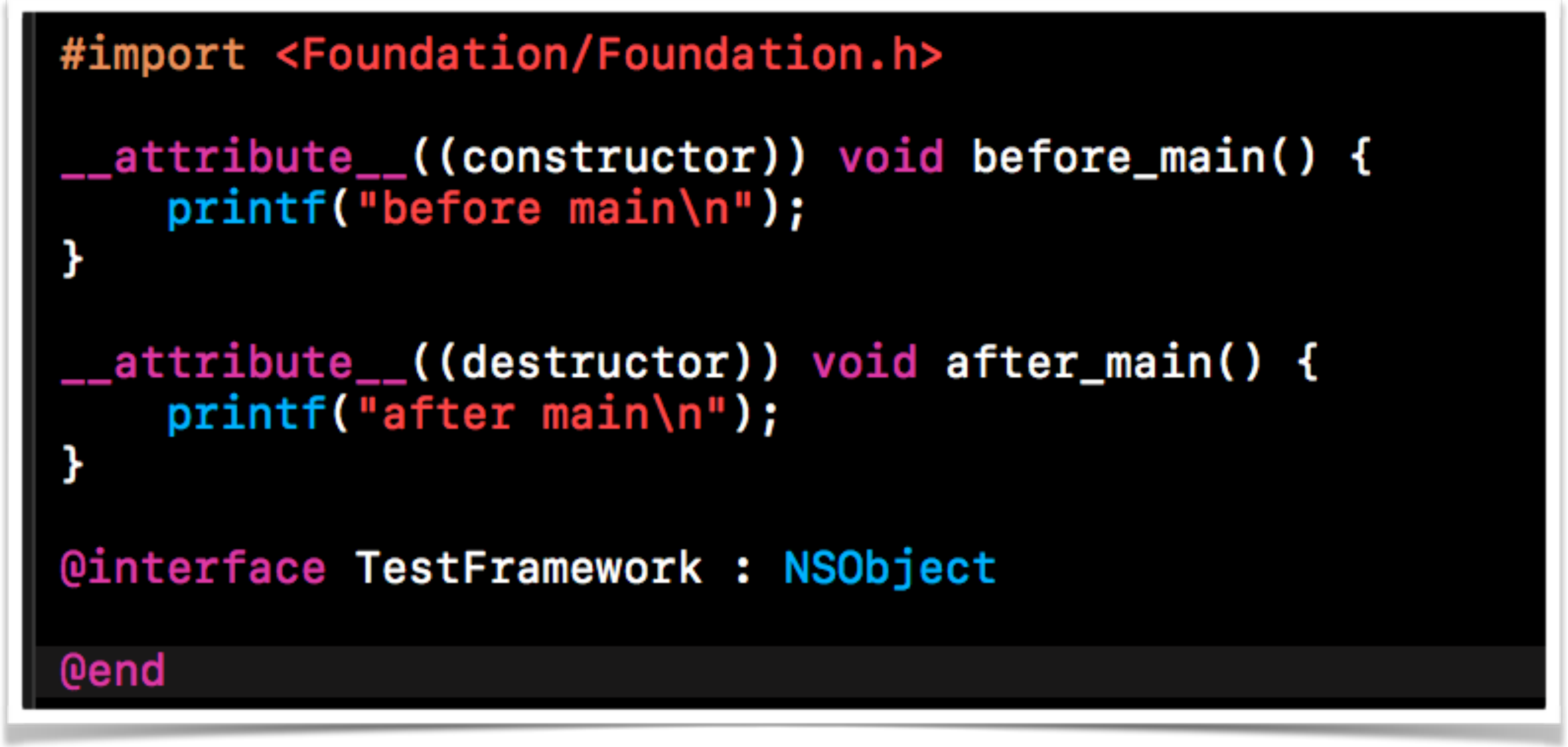
集成数据卡口 — 非最佳使用API卡口案例



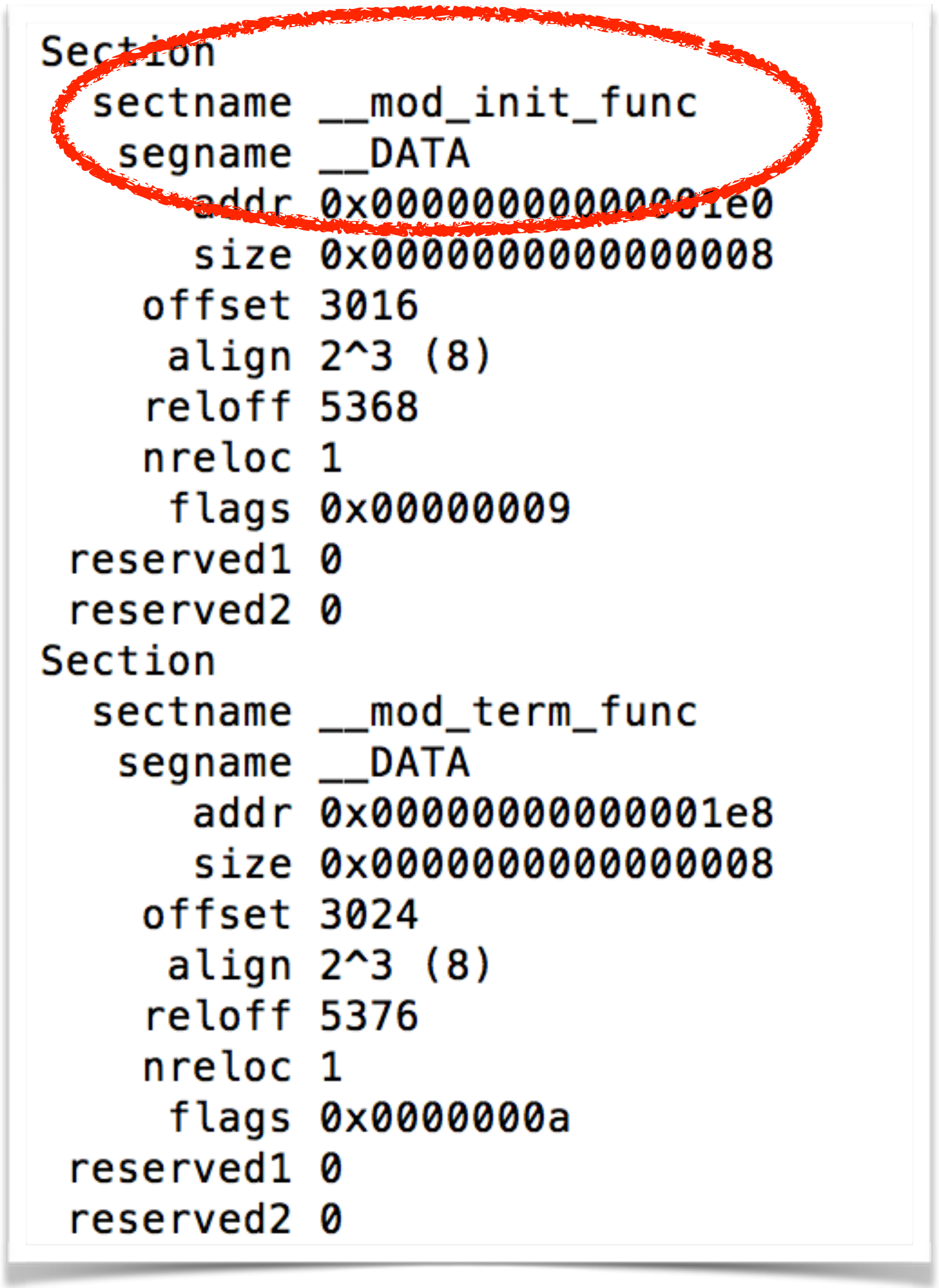
```objc
#import "TestFramework.h"

@implementation TestFramework


+ (void)load {
    NSLog(@"TestFramework");
}

@end

```



```
yingfang:Documents fangying$ nm libTestFramework.a

libTestFramework.a(TestFramework.o):
0000000000000040 t +[TestFramework load]
                 U _NSLog
                 U _OBJC_CLASS_$_NSObject
00000000000001a8 S _OBJC_CLASS_$_TestFramework
                 U _OBJC_METACLASS_$_NSObject
0000000000000180 S _OBJC_METACLASS_$_TestFramework
                 U ___CFConstantStringClassReference
                 U __objc_empty_cache
0000000000000020 T _after_main
0000000000000000 T _before_main
                 U _printf
00000000000000d0 s l_OBJC_$_CLASS_METHODS_TestFramework
0000000000000138 s l_OBJC_CLASS_RO_$_TestFramework
00000000000000f0 s l_OBJC_METACLASS_RO_$_TestFramework
```

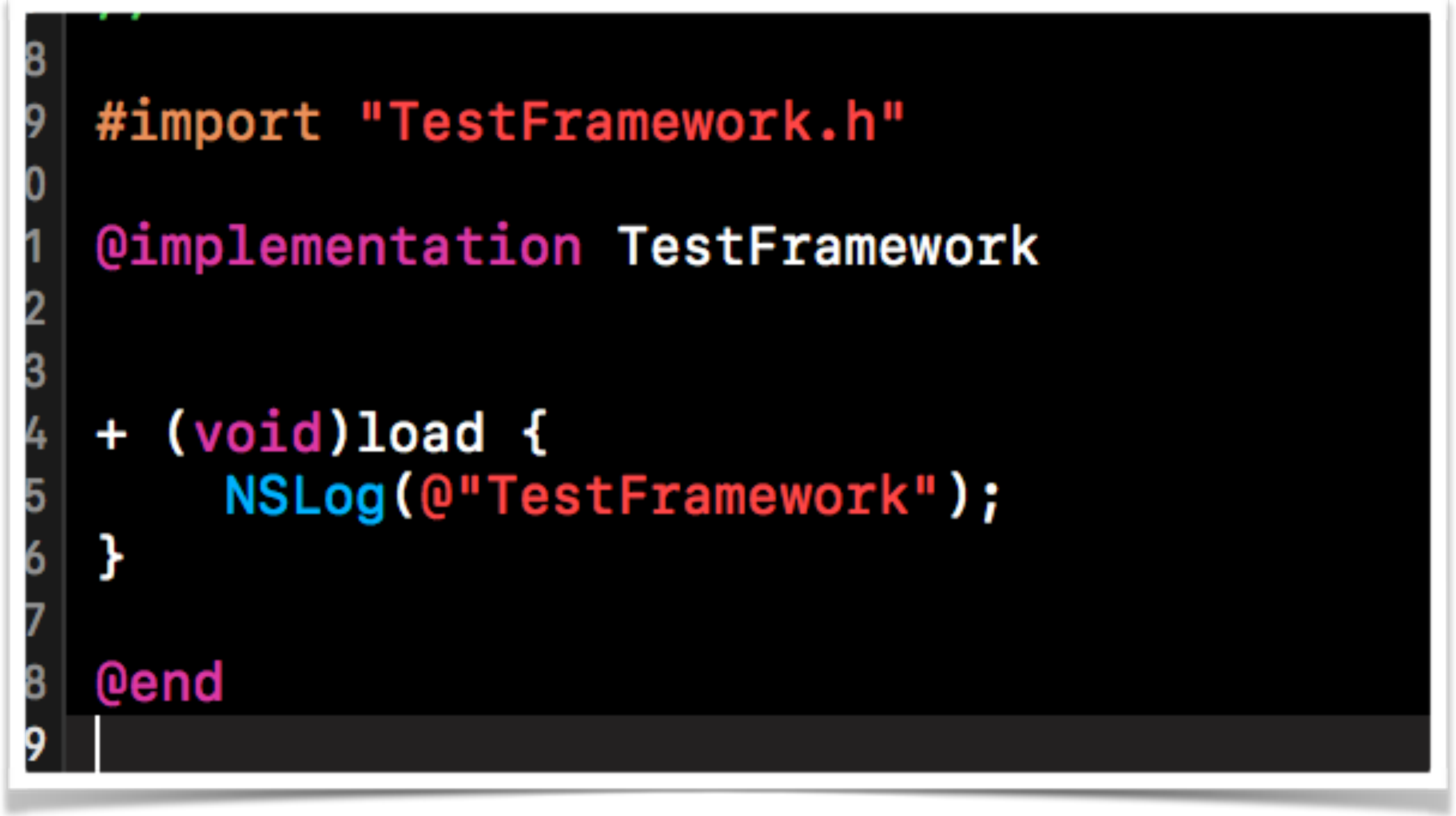


```objc
#import <Foundation/Foundation.h>

__attribute__((constructor)) void before_main() {
    printf("before main\n");
}

__attribute__((destructor)) void after_main() {
    printf("after main\n");
}

@interface TestFramework : NSObject

@end
```

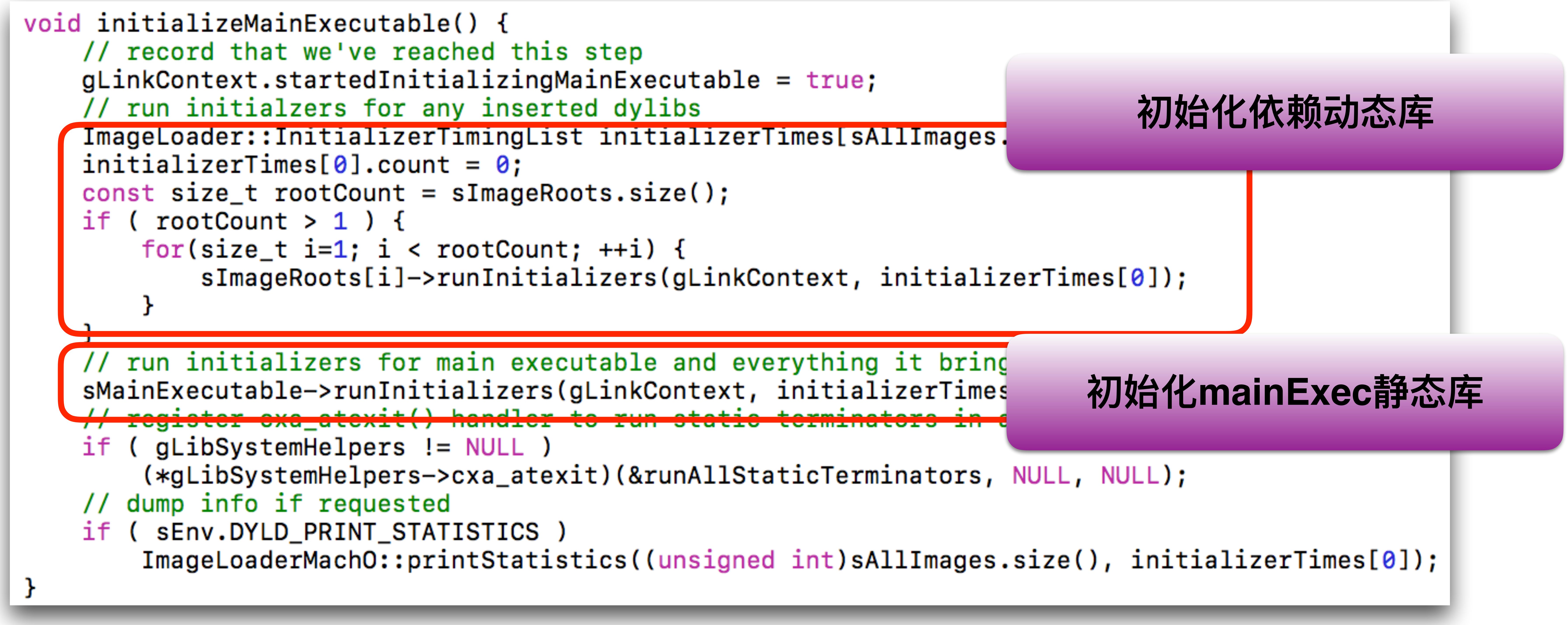


```
Section
  sectname __mod_init_func
   segname __DATA
      addr 0x00000000000001e0
      size 0x0000000000000008
    offset 3016
     align 2^3 (8)
    reloff 5368
    nreloc 1
     flags 0x00000009
 reserved1 0
 reserved2 0
Section
  sectname __mod_term_func
   segname __DATA
      addr 0x00000000000001e8
      size 0x0000000000000008
    offset 3024
     align 2^3 (8)
    reloff 5376
    nreloc 1
     flags 0x0000000a
 reserved1 0
 reserved2 0
```

集成数据卡口 — **非最佳使用API卡口案例**　　如何去统计和定位App load函数的耗时?



```
#import "TestFramework.h"

@implementation TestFramework


+ (void)load {
    NSLog(@"TestFramework");
}

@end
```

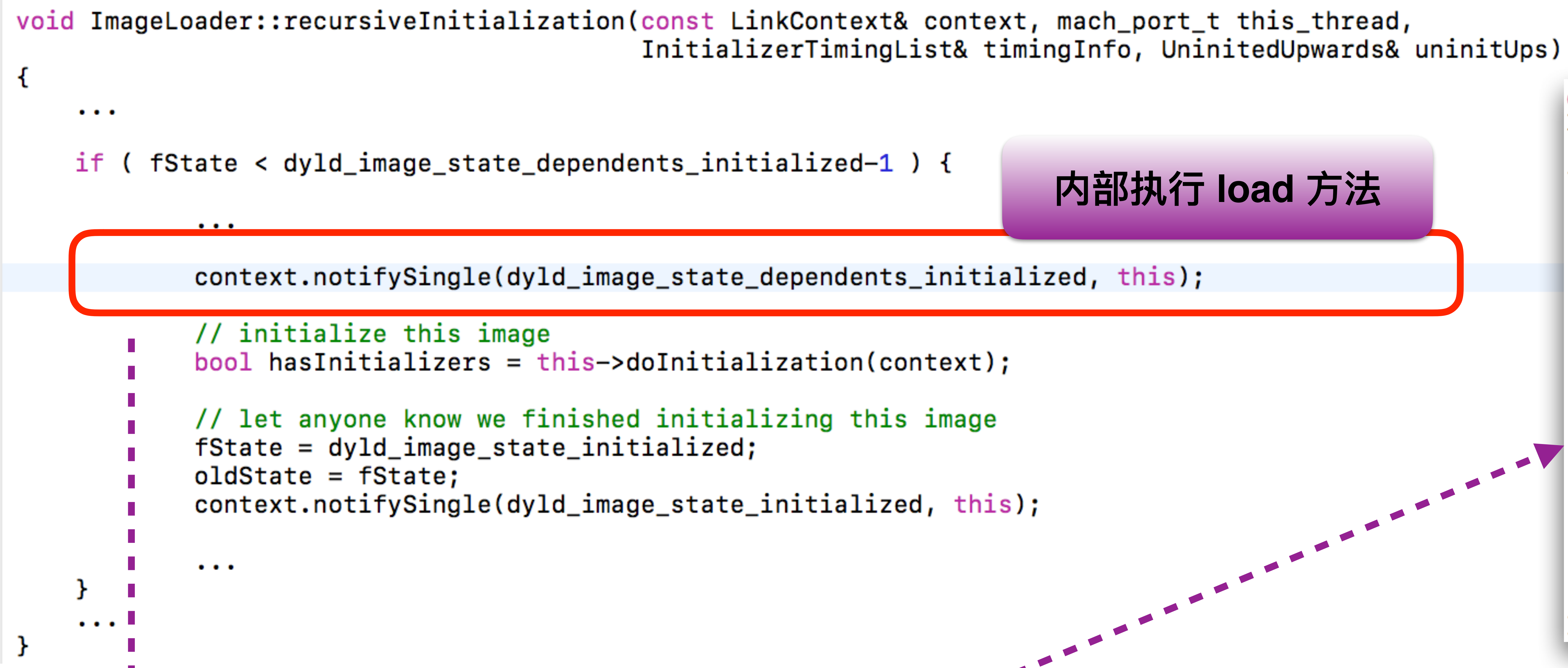


```
void initializeMainExecutable() {
    // record that we've reached this step
    gLinkContext.startedInitializingMainExecutable = true;
    // run initialzers for any inserted dylibs
    ImageLoader::InitializerTimingList initializerTimes[sAllImages.
    initializerTimes[0].count = 0;
    const size_t rootCount = sImageRoots.size();
    if ( rootCount > 1 ) {
        for(size_t i=1; i < rootCount; ++i) {
            sImageRoots[i]->runInitializers(gLinkContext, initializerTimes[0]);
        }
    }
    // run initializers for main executable and everything it bring
    sMainExecutable->runInitializers(gLinkContext, initializerTimes
    // register cxa_atexit() handler to run static terminators in
    if ( gLibSystemHelpers != NULL )
        (*gLibSystemHelpers->cxa_atexit)(&runAllStaticTerminators, NULL, NULL);
    // dump info if requested
    if ( sEnv.DYLD_PRINT_STATISTICS )
        ImageLoaderMachO::printStatistics((unsigned int)sAllImages.size(), initializerTimes[0]);
}
```

初始化依赖动态库

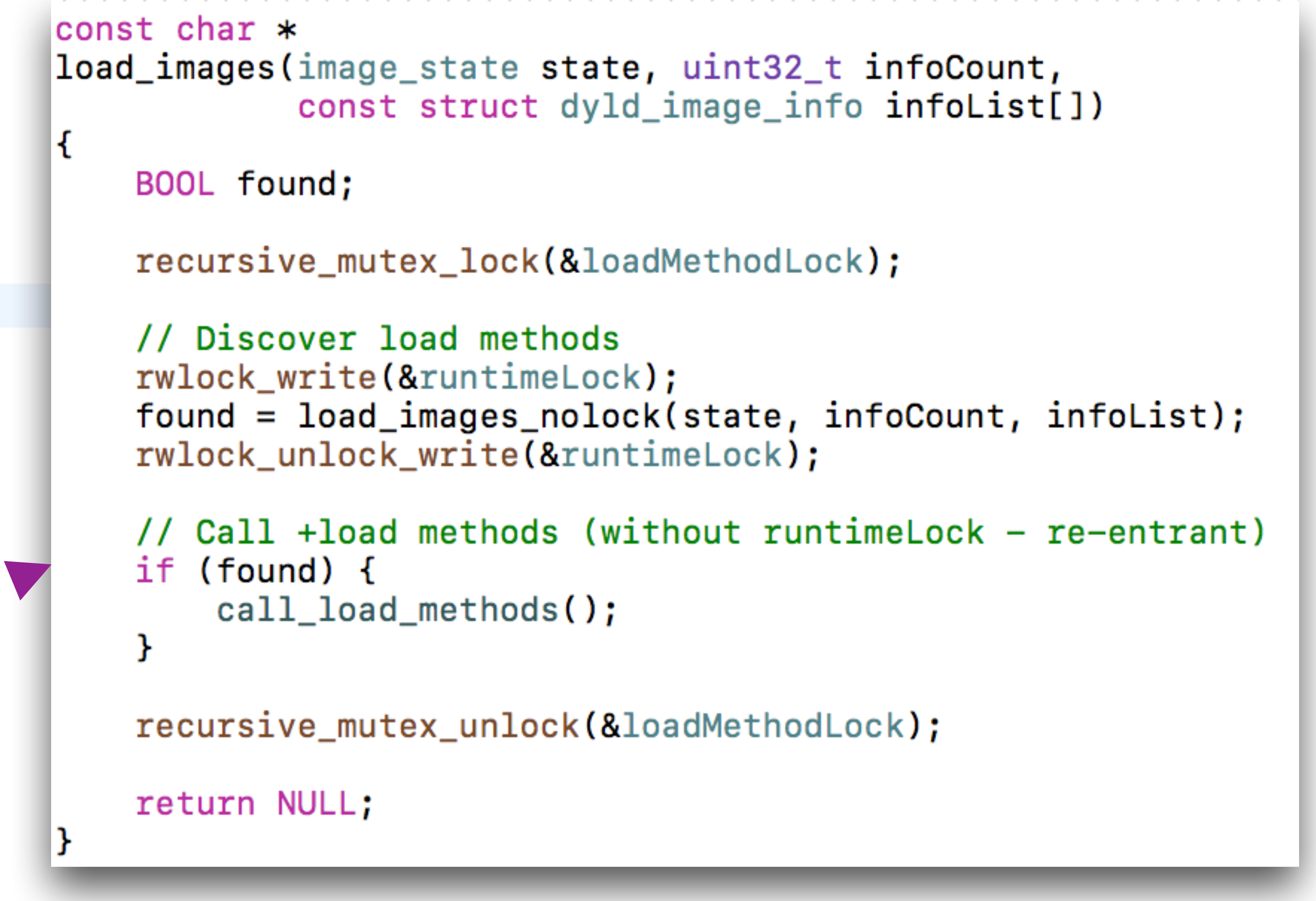
初始化mainExec静态库

集成数据卡口 — **非最佳使用API卡口案例**　　如何去统计和定位App load函数的耗时?

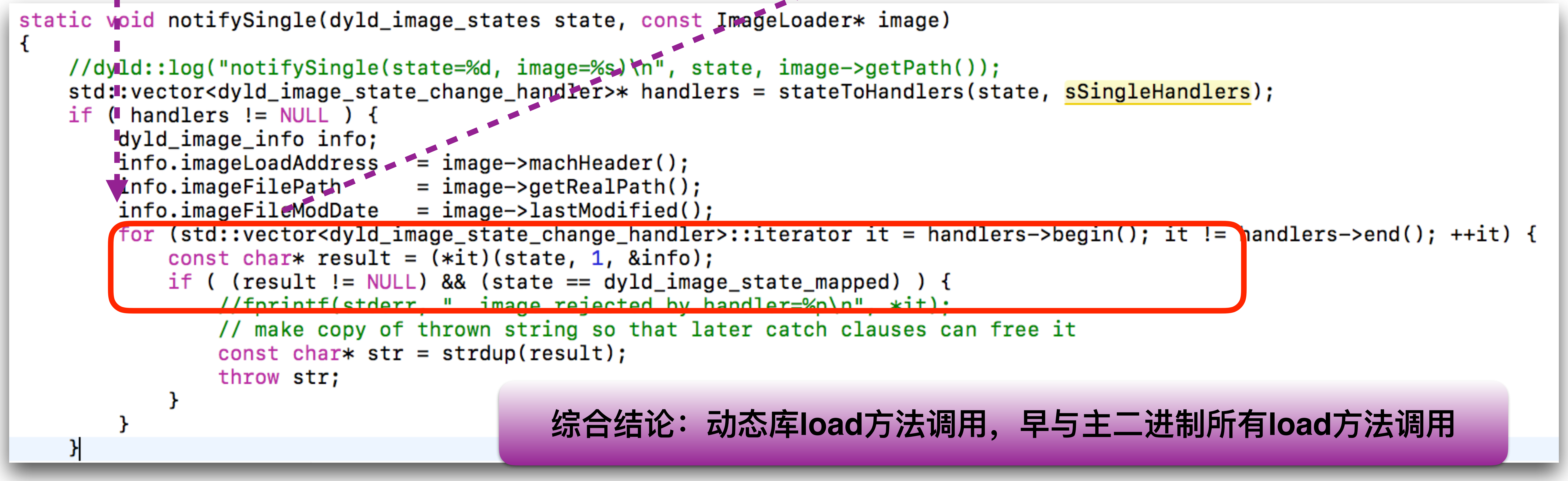


```
void ImageLoader::recursiveInitialization(const LinkContext& context, mach_port_t this_thread,
                                          InitializerTimingList& timingInfo, UninitedUpwards& uninitUps)
{
    ...

    if ( fState < dyld_image_state_dependents_initialized-1 ) {

            ...

            context.notifySingle(dyld_image_state_dependents_initialized, this);

            // initialize this image
            bool hasInitializers = this->doInitialization(context);

            // let anyone know we finished initializing this image
            fState = dyld_image_state_initialized;
            oldState = fState;
            context.notifySingle(dyld_image_state_initialized, this);

            ...
    }
    ...
}
```

内部执行 load 方法



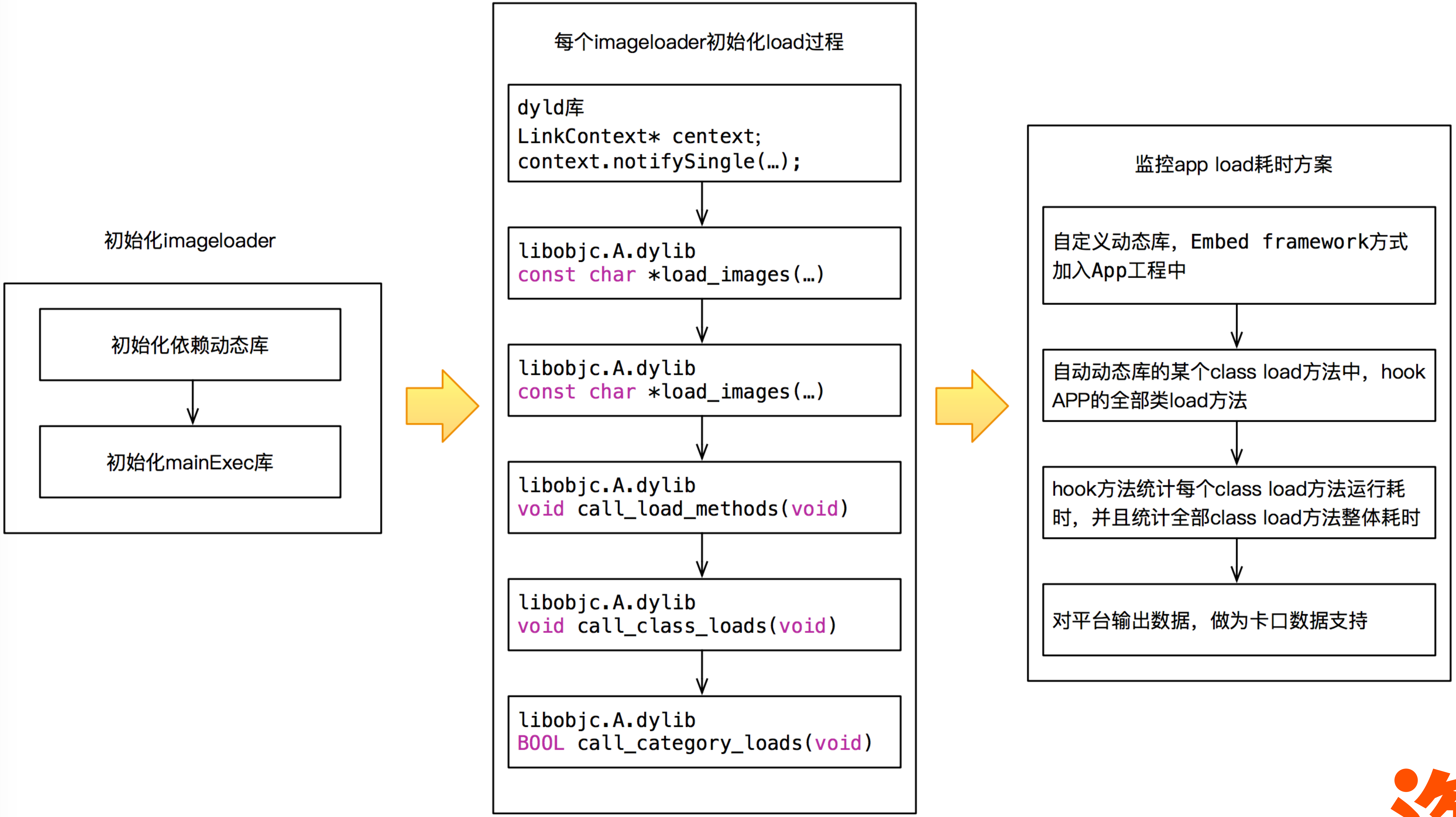
```
const char *
load_images(image_state state, uint32_t infoCount,
            const struct dyld_image_info infoList[])
{
    BOOL found;

    recursive_mutex_lock(&loadMethodLock);

    // Discover load methods
    rwlock_write(&runtimeLock);
    found = load_images_nolock(state, infoCount, infoList);
    rwlock_unlock_write(&runtimeLock);

    // Call +load methods (without runtimeLock - re-entrant)
    if (found) {
        call_load_methods();
    }

    recursive_mutex_unlock(&loadMethodLock);

    return NULL;
}
```



```
static void notifySingle(dyld_image_states state, const ImageLoader* image)
{
    //dyld::log("notifySingle(state=%d, image=%s)\n", state, image->getPath());
    std::vector<dyld_image_state_change_handler>* handlers = stateToHandlers(state, sSingleHandlers);
    if ( handlers != NULL ) {
        dyld_image_info info;
        info.imageLoadAddress   = image->machHeader();
        info.imageFilePath      = image->getRealPath();
        info.imageFileModDate   = image->lastModified();
        for (std::vector<dyld_image_state_change_handler>::iterator it = handlers->begin(); it != handlers->end(); ++it) {
            const char* result = (*it)(state, 1, &info);
            if ( (result != NULL) && (state == dyld_image_state_mapped) ) {
                //fprintf(stderr, "  image rejected by handler=%p\n", *it);
                // make copy of thrown string so that later catch clauses can free it
                const char* str = strdup(result);
                throw str;
            }
        }
    }
}
```

综合结论：动态库load方法调用，早与主二进制所有load方法调用

集成数据卡口 — **非最佳使用API卡口案例**　如何去统计和定位App load函数的耗时?



初始化imageloader

- 初始化依赖动态库
- 初始化mainExec库

每个imageloader初始化load过程

```
dyld库
LinkContext* centext;
context.notifySingle(…);
```

```
libobjc.A.dylib
const char *load_images(…)
```

```
libobjc.A.dylib
const char *load_images(…)
```

```
libobjc.A.dylib
void call_load_methods(void)
```

```
libobjc.A.dylib
void call_class_loads(void)
```

```
libobjc.A.dylib
BOOL call_category_loads(void)
```

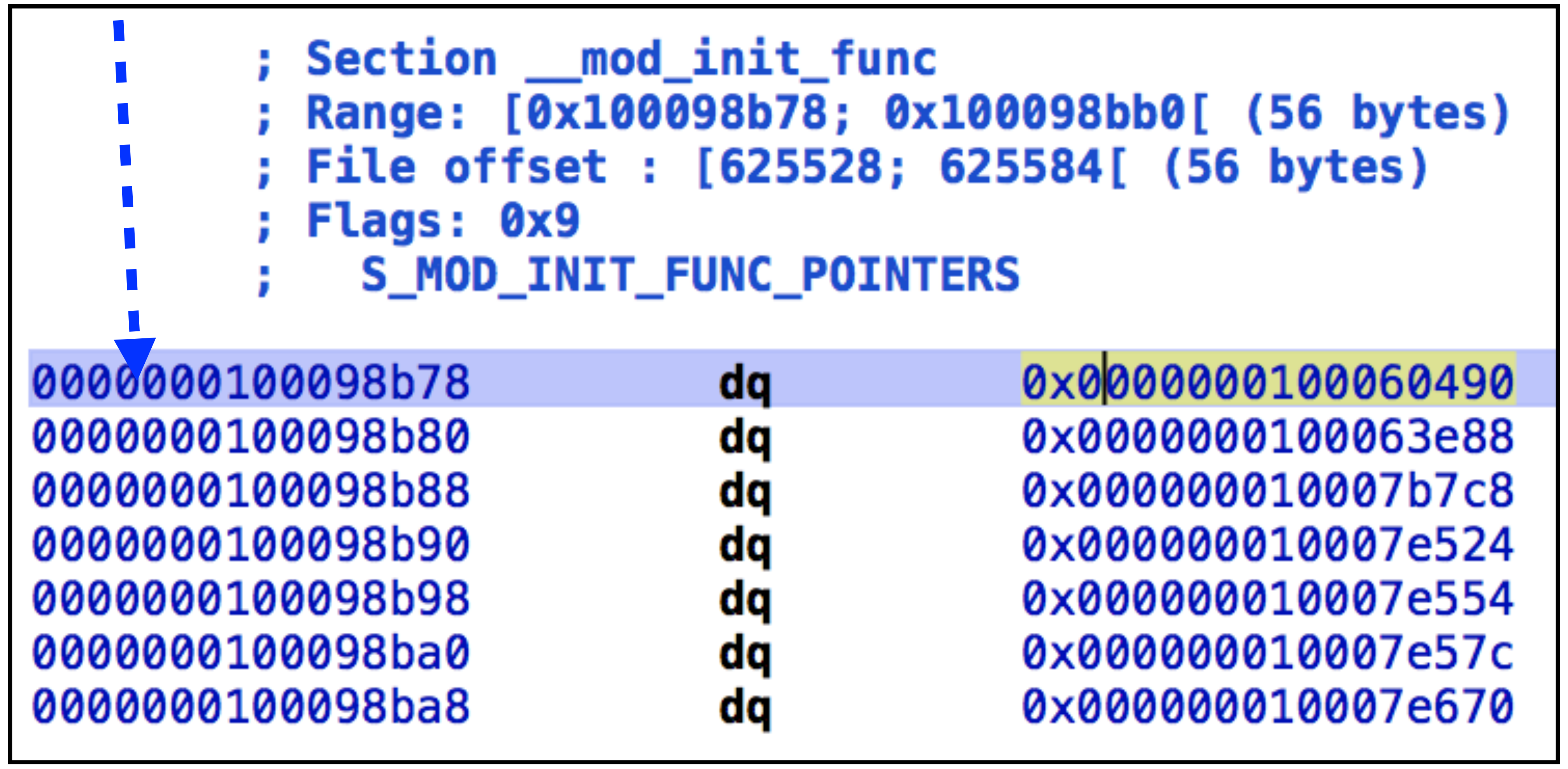
监控app load耗时方案

1. 自定义动态库，Embed framework方式加入App工程中
2. 自动动态库的某个class load方法中，hook APP的全部类load方法
3. hook方法统计每个class load方法运行耗时，并且统计全部class load方法整体耗时
4. 对平台输出数据，做为卡口数据支持

集成数据卡口 — **非最佳使用API卡口案例** 监控C++静态对象构造函数和__attribute_((constructor))的耗时?

```
void ImageLoaderMachO::doModInitFunctions(const LinkContext& context)
{
    if ( fHasInitializers ) {
        ...
        for (uint32_t i = 0; i < cmd_count; ++i) {
            if ( cmd->cmd == LC_SEGMENT_COMMAND ) {
                const struct macho_segment_command* seg = (struct macho_segment_command*)cmd;
                const struct macho_section* const sectionsStart = (struct macho_section*)((char*)seg + sizeof(struct macho_segment_command));
                const struct macho_section* const sectionsEnd = &sectionsStart[seg->nsects];
                for (const struct macho_section* sect=sectionsStart; sect < sectionsEnd; ++sect) {
                    const uint8_t type = sect->flags & SECTION_TYPE;
                    if ( type == S_MOD_INIT_FUNC_POINTERS ) {
                        Initializer* inits = (Initializer*)(sect->addr + fSlide);
                        const size_t count = sect->size / sizeof(uintptr_t);
                        for (size_t i=0; i < count; ++i) {
                            Initializer func = inits[i];
                            ...
                            func(context.argc, context.argv, context.envp, context.apple, &context.programVars);
                        }
                    }
                }
            }
            cmd = (const struct load_command*)(((char*)cmd)+cmd->cmdsize);
        }
    }
}
```

TYPE==S_MOD_INIT_FUNC_POINTERS
对应Mach-O文件中具体的section段

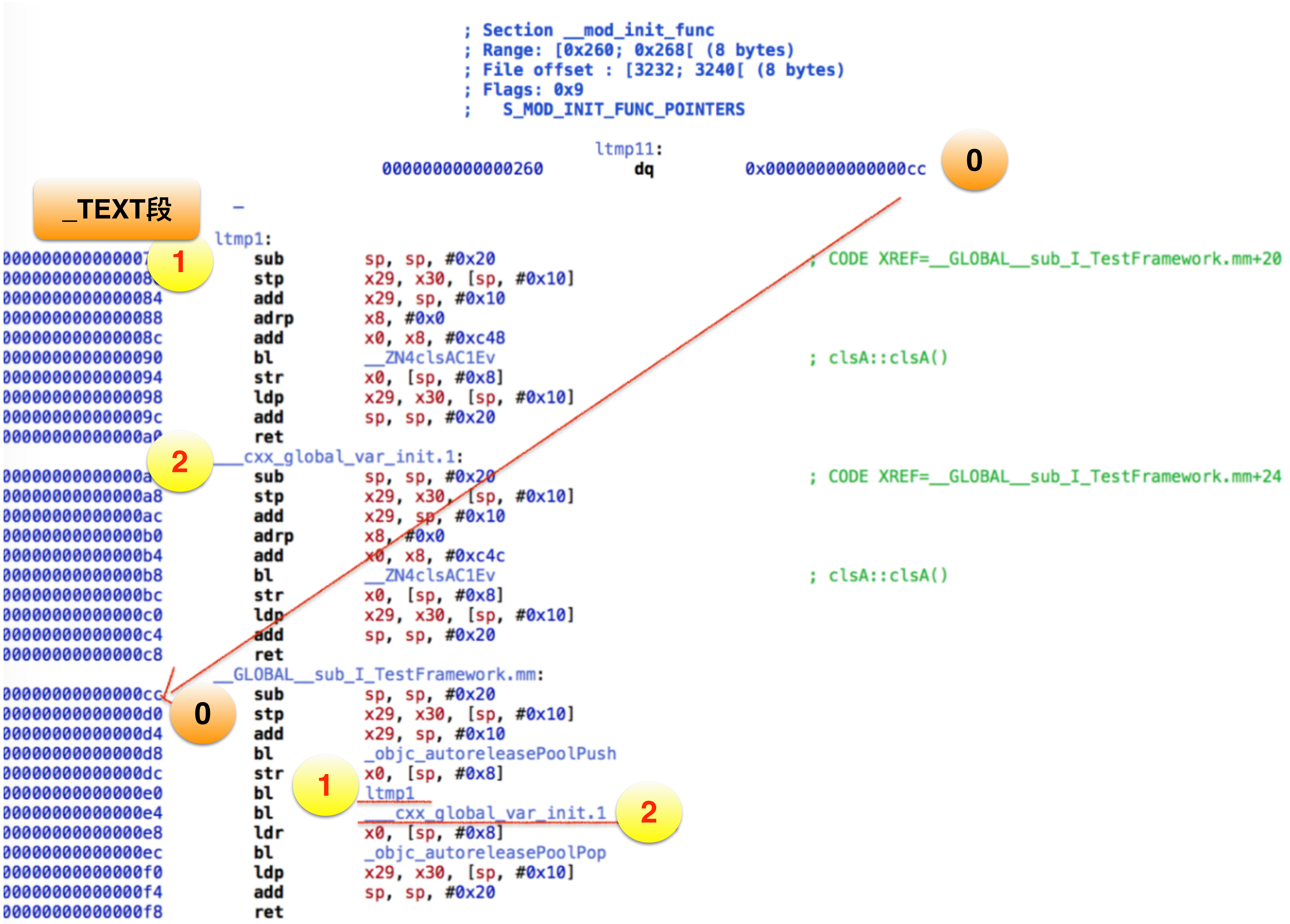


```
        ; Section __mod_init_func
        ; Range: [0x100098b78; 0x100098bb0[ (56 bytes)
        ; File offset : [625528; 625584[ (56 bytes)
        ; Flags: 0x9
        ;   S_MOD_INIT_FUNC_POINTERS

0000000100098b78        dq        0x0000000100060490
0000000100098b80        dq        0x0000000100063e88
0000000100098b88        dq        0x000000010007b7c8
0000000100098b90        dq        0x000000010007e524
0000000100098b98        dq        0x000000010007e554
0000000100098ba0        dq        0x000000010007e57c
0000000100098ba8        dq        0x000000010007e670
```

集成数据卡口 — **非最佳使用API卡口案例** 监控C++静态对象构造函数和__attribute_((constructor))的耗时?

实验1

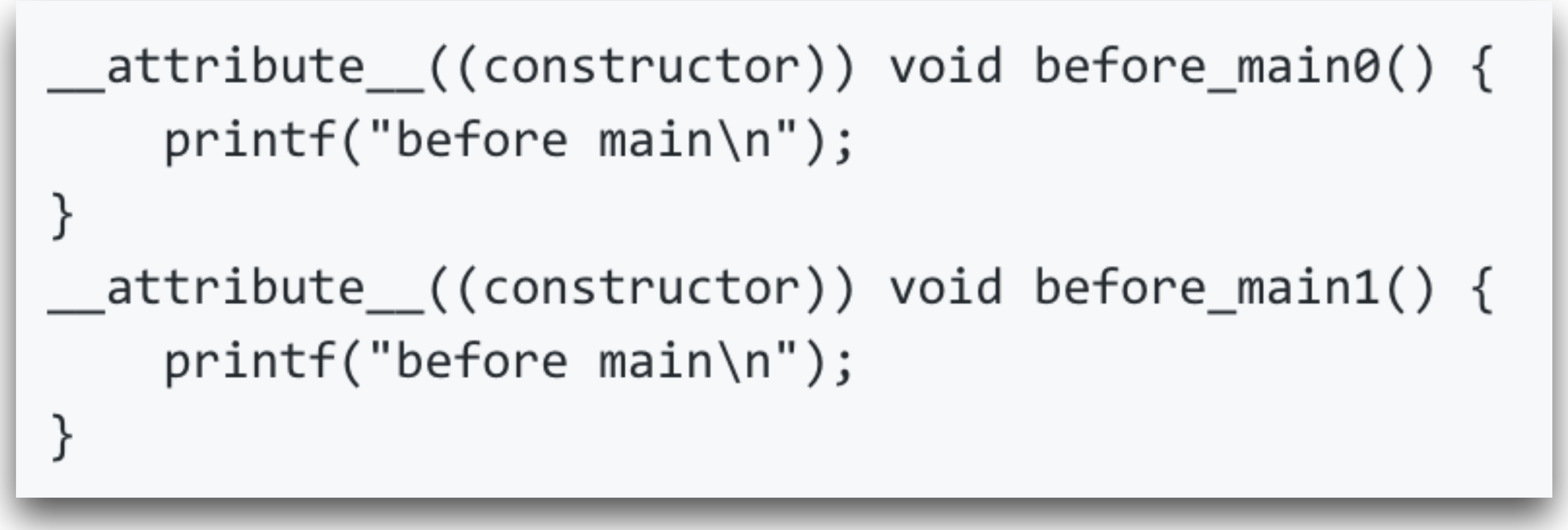
```
class clsA {
public:
    clsA();
    int a;
};
clsA::clsA() {
    a = 10;
}
static clsA objA;
clsA objB;
```



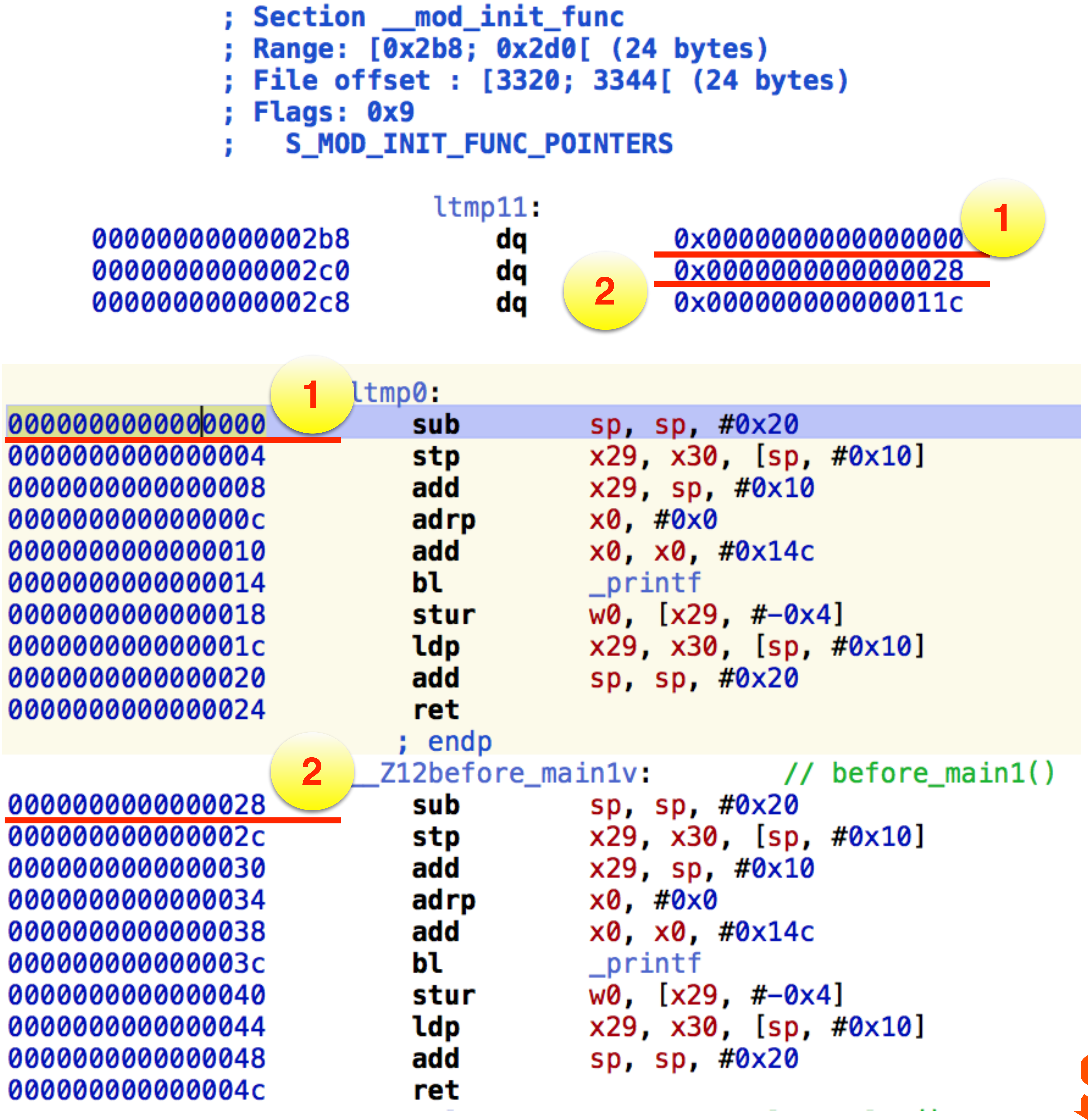
```
                              ; Section __mod_init_func
                              ; Range: [0x260; 0x268[ (8 bytes)
                              ; File offset : [3232; 3240[ (8 bytes)
                              ; Flags: 0x9
                              ;   S_MOD_INIT_FUNC_POINTERS

                                            ltmp11:
                    0000000000000260        dq          0x00000000000000cc

              -
         ltmp1:
000000000000007   sub     sp, sp, #0x20                      ; CODE XREF=__GLOBAL__sub_I_TestFramework.mm+20
00000000000008    stp     x29, x30, [sp, #0x10]
0000000000000084  add     x29, sp, #0x10
0000000000000088  adrp    x8, #0x0
000000000000008c  add     x0, x8, #0xc48
0000000000000090  bl      __ZN4clsAC1Ev                      ; clsA::clsA()
0000000000000094  str     x0, [sp, #0x8]
0000000000000098  ldp     x29, x30, [sp, #0x10]
000000000000009c  add     sp, sp, #0x20
00000000000000a0  ret
                __cxx_global_var_init.1:
00000000000000a   sub     sp, sp, #0x20                      ; CODE XREF=__GLOBAL__sub_I_TestFramework.mm+24
00000000000000a8  stp     x29, x30, [sp, #0x10]
00000000000000ac  add     x29, sp, #0x10
00000000000000b0  adrp    x8, #0x0
00000000000000b4  add     x0, x8, #0xc4c
00000000000000b8  bl      __ZN4clsAC1Ev                      ; clsA::clsA()
00000000000000bc  str     x0, [sp, #0x8]
00000000000000c0  ldp     x29, x30, [sp, #0x10]
00000000000000c4  add     sp, sp, #0x20
00000000000000c8  ret
               __GLOBAL__sub_I_TestFramework.mm:
00000000000000cc  sub     sp, sp, #0x20
00000000000000d0  stp     x29, x30, [sp, #0x10]
00000000000000d4  add     x29, sp, #0x10
00000000000000d8  bl      _objc_autoreleasePoolPush
00000000000000dc  str     x0, [sp, #0x8]
00000000000000e0  bl      ltmp1
00000000000000e4  bl      ___cxx_global_var_init.1
00000000000000e8  ldr     x0, [sp, #0x8]
00000000000000ec  bl      _objc_autoreleasePoolPop
00000000000000f0  ldp     x29, x30, [sp, #0x10]
00000000000000f4  add     sp, sp, #0x20
00000000000000f8  ret
```

集成数据卡口 — **非最佳使用API卡口案例** 监控C++静态对象构造函数和__attribute_((constructor))的耗时?

实验2



```
__attribute__((constructor)) void before_main0() {
    printf("before main\n");
}
__attribute__((constructor)) void before_main1() {
    printf("before main\n");
}
```

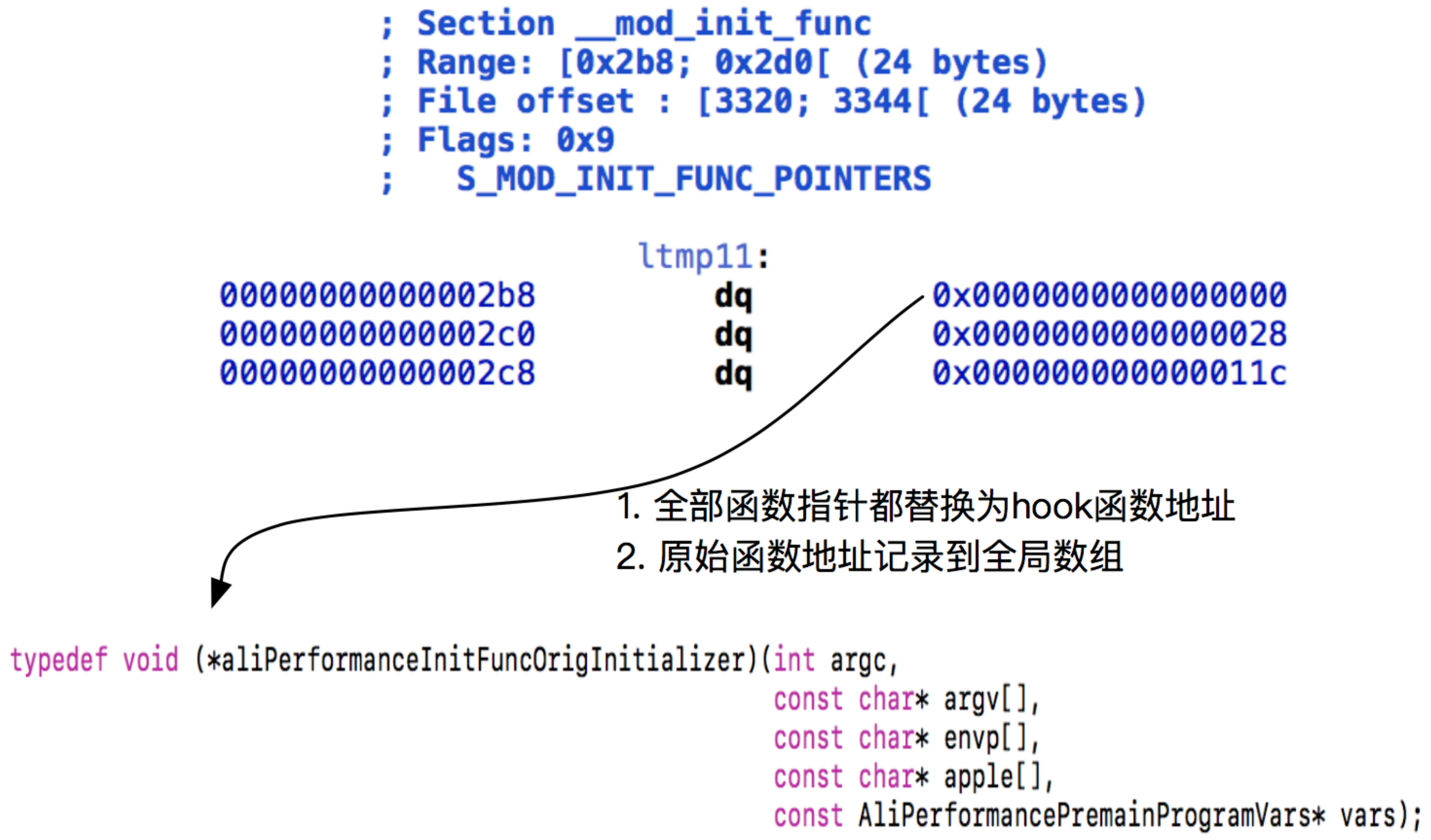


```
; Section __mod_init_func
; Range: [0x2b8; 0x2d0[ (24 bytes)
; File offset : [3320; 3344[ (24 bytes)
; Flags: 0x9
;   S_MOD_INIT_FUNC_POINTERS

                    ltmp11:
00000000000002b8         dq         0x0000000000000000
00000000000002c0         dq         0x0000000000000028
00000000000002c8         dq         0x000000000000011c

                    ltmp0:
0000000000000000         sub        sp, sp, #0x20
0000000000000004         stp        x29, x30, [sp, #0x10]
0000000000000008         add        x29, sp, #0x10
000000000000000c         adrp       x0, #0x0
0000000000000010         add        x0, x0, #0x14c
0000000000000014         bl         _printf
0000000000000018         stur       w0, [x29, #-0x4]
000000000000001c         ldp        x29, x30, [sp, #0x10]
0000000000000020         add        sp, sp, #0x20
0000000000000024         ret
                        ; endp
                    __Z12before_main1v:        // before_main1()
0000000000000028         sub        sp, sp, #0x20
000000000000002c         stp        x29, x30, [sp, #0x10]
0000000000000030         add        x29, sp, #0x10
0000000000000034         adrp       x0, #0x0
0000000000000038         add        x0, x0, #0x14c
000000000000003c         bl         _printf
0000000000000040         stur       w0, [x29, #-0x4]
0000000000000044         ldp        x29, x30, [sp, #0x10]
0000000000000048         add        sp, sp, #0x20
000000000000004c         ret
```

实验结论:

- __attribute__((constructor))修饰函数的个数与section __mod_init_func端funciton pointers个数一致
- C++静态对象构造函数虽然无法统计出每个具体函数的耗时，但是可以统计出具体对应某个.o中全部静态对象构造函数的耗时
- Section __mod_init_func是在**DATA段**（该段可以动态修改），function pointers指向的区域是**TEXT段**（该段无权限修改）

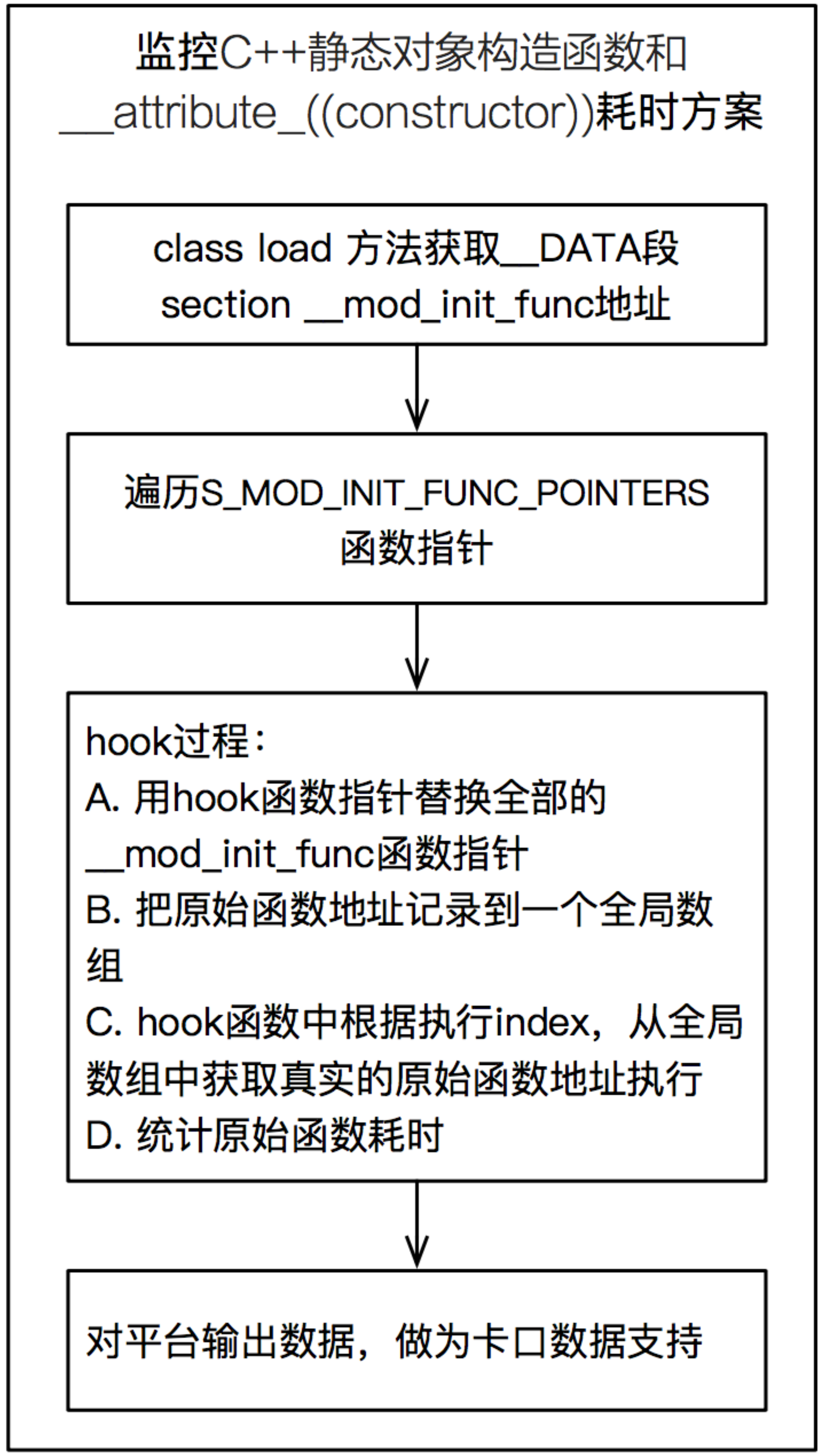
集成数据卡口 — **非最佳使用API卡口案例** 监控C++静态对象构造函数和__attribute_((constructor))的耗时?



```
; Section __mod_init_func
; Range: [0x2b8; 0x2d0[ (24 bytes)
; File offset : [3320; 3344[ (24 bytes)
; Flags: 0x9
;   S_MOD_INIT_FUNC_POINTERS

                        ltmp11:
00000000000002b8             dq         0x0000000000000000
00000000000002c0             dq         0x0000000000000028
00000000000002c8             dq         0x000000000000011c
```

1. 全部函数指针都替换为hook函数地址
2. 原始函数地址记录到全局数组

```
typedef void (*aliPerformanceInitFuncOrigInitializer)(int argc,
                                                       const char* argv[],
                                                       const char* envp[],
                                                       const char* apple[],
                                                       const AliPerformancePremainProgramVars* vars);
```



监控C++静态对象构造函数和__attribute_((constructor))耗时方案

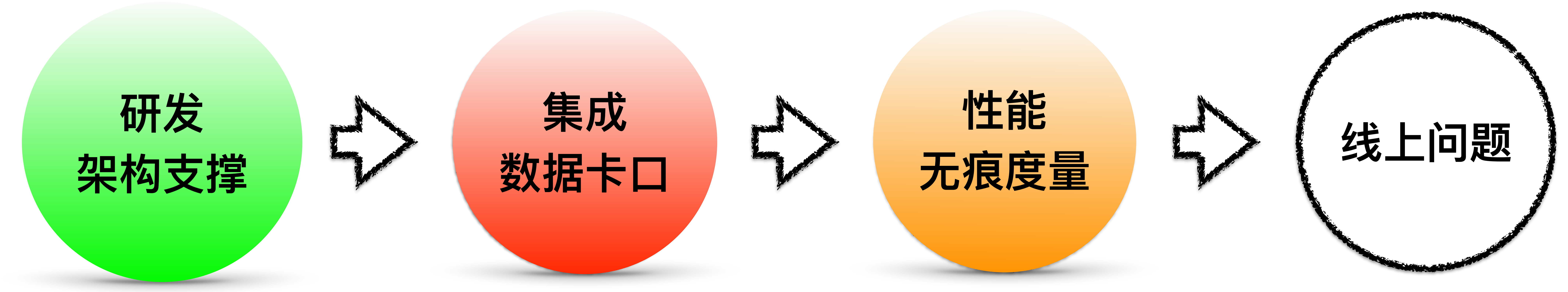
class load 方法获取__DATA段 section __mod_init_func地址

遍历S_MOD_INIT_FUNC_POINTERS 函数指针

hook过程：
A. 用hook函数指针替换全部的__mod_init_func函数指针
B. 把原始函数地址记录到一个全局数组
C. hook函数中根据执行index，从全局数组中获取真实的原始函数地址执行
D. 统计原始函数耗时

对平台输出数据，做为卡口数据支持

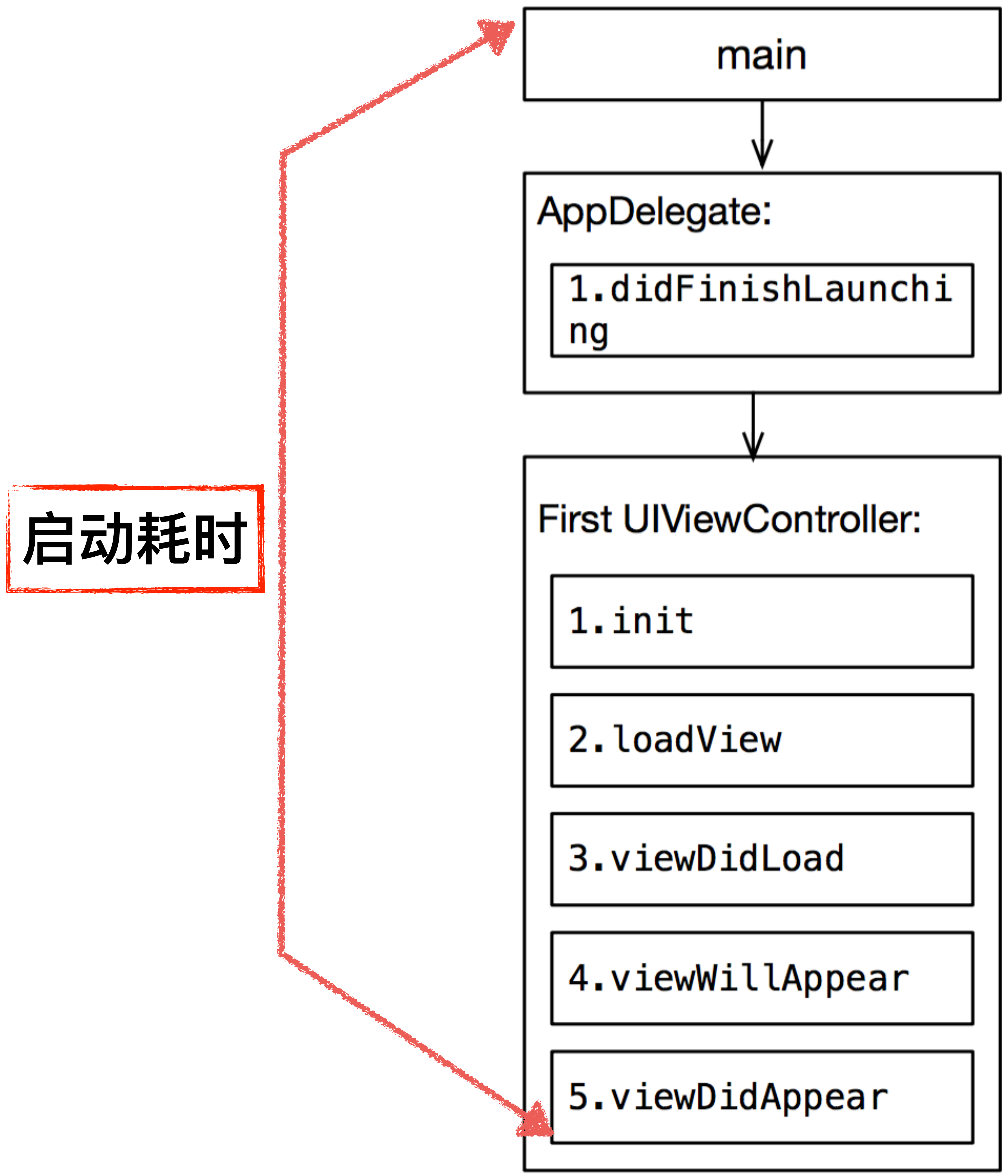
技术上从研发流程角度的思考



- **启动&页面加载监控**
- FPS监控
- 内存监控
- CPU监控

无痕性能度量SDK — **常见页面加载耗时度量**

图1：App启动过程



main

AppDelegate:

1.didFinishLaunching

First UIViewController:

1.init

2.loadView

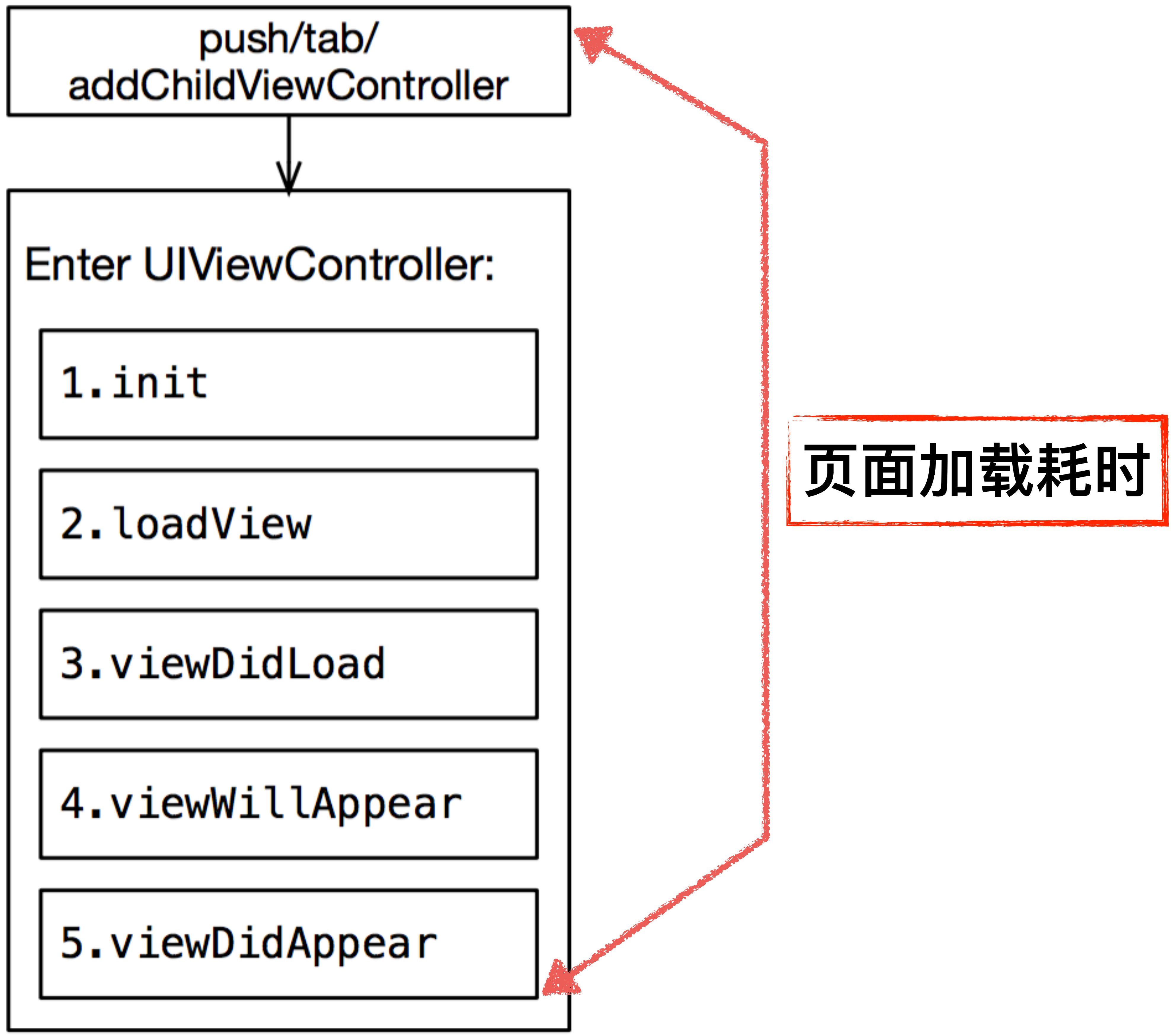
3.viewDidLoad

4.viewWillAppear

5.viewDidAppear

启动耗时

图2：页面加载过程



push/tab/
addChildViewController

Enter UIViewController:

1.init

2.loadView

3.viewDidLoad

4.viewWillAppear

5.viewDidAppear

页面加载耗时

快看！
Duang
Duang~~

无痕性能度量SDK — main函数前系统做了啥?

developer 在main之前的可以进行的处理

class load()
category load()

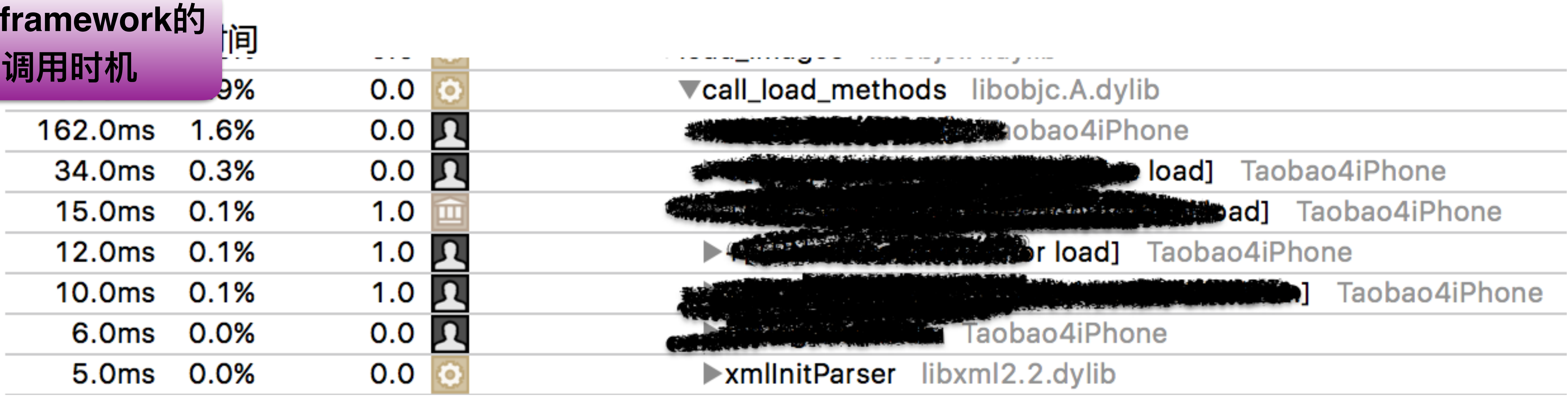
attribute((constructor)) 和
C++ generates initializer
for static allocated objects

Parse Image | Map Image | Rebase Image | Bind Image | Run Image Initializers | Call main() | Call UIApplicationMain() | Call WillFinishLaunch()

main 之前系统init

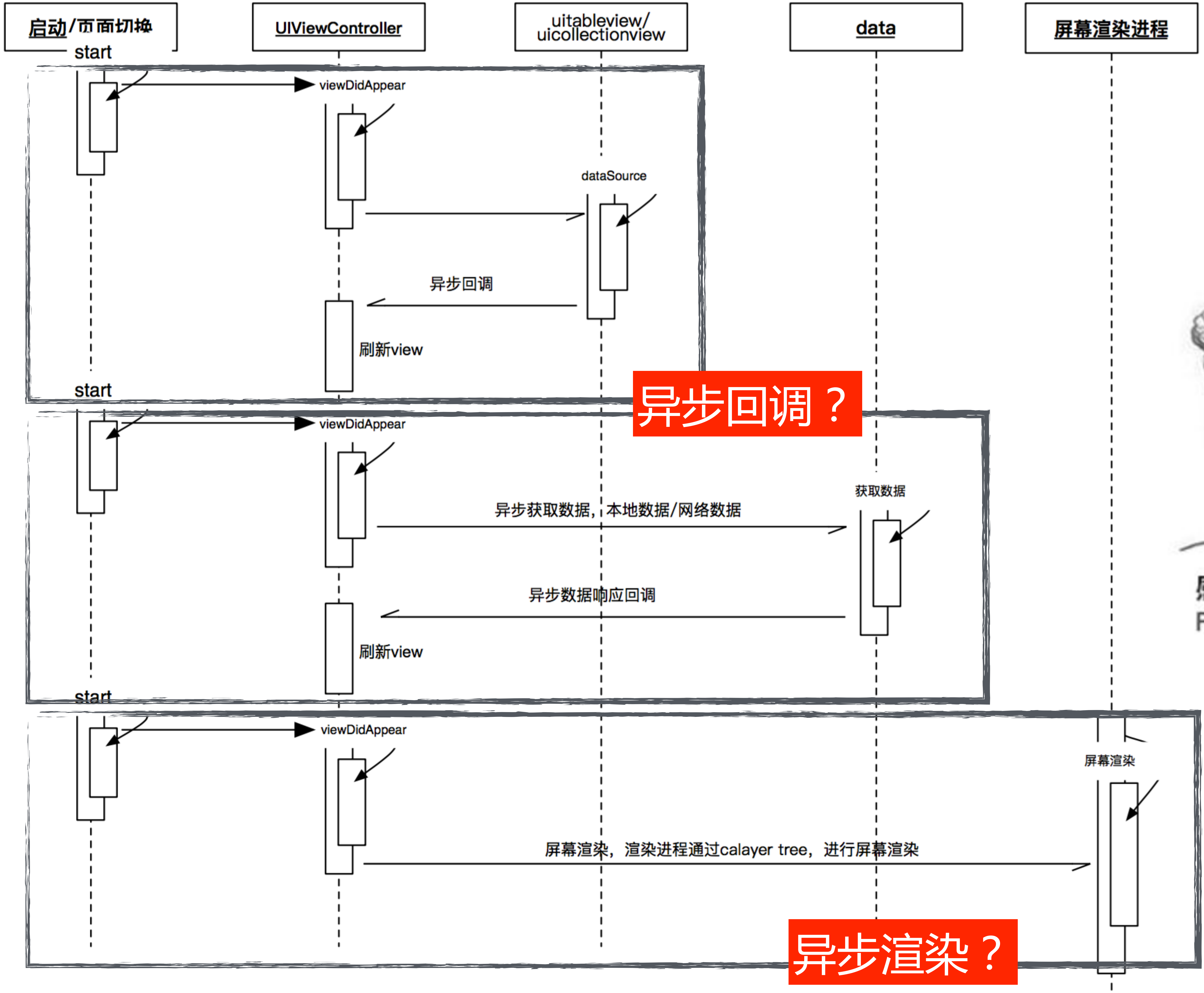
main 之后init

app启动起点：动态framework的 class load方法调用时机



```
        间
        9%      0.0      ▼call_load_methods  libobjc.A.dylib
162.0ms  1.6%   0.0        [redacted]obao4iPhone
 34.0ms  0.3%   0.0        [redacted] load]  Taobao4iPhone
 15.0ms  0.1%   1.0        [redacted]ad]  Taobao4iPhone
 12.0ms  0.1%   1.0         ▶[redacted]r load]  Taobao4iPhone
 10.0ms  0.1%   1.0        [redacted]]  Taobao4iPhone
  6.0ms  0.0%   0.0        [redacted]Taobao4iPhone
  5.0ms  0.0%   0.0         ▶xmlInitParser  libxml2.2.dylib
```

无痕性能度量SDK — viewDidAppear后页面展示了吗?

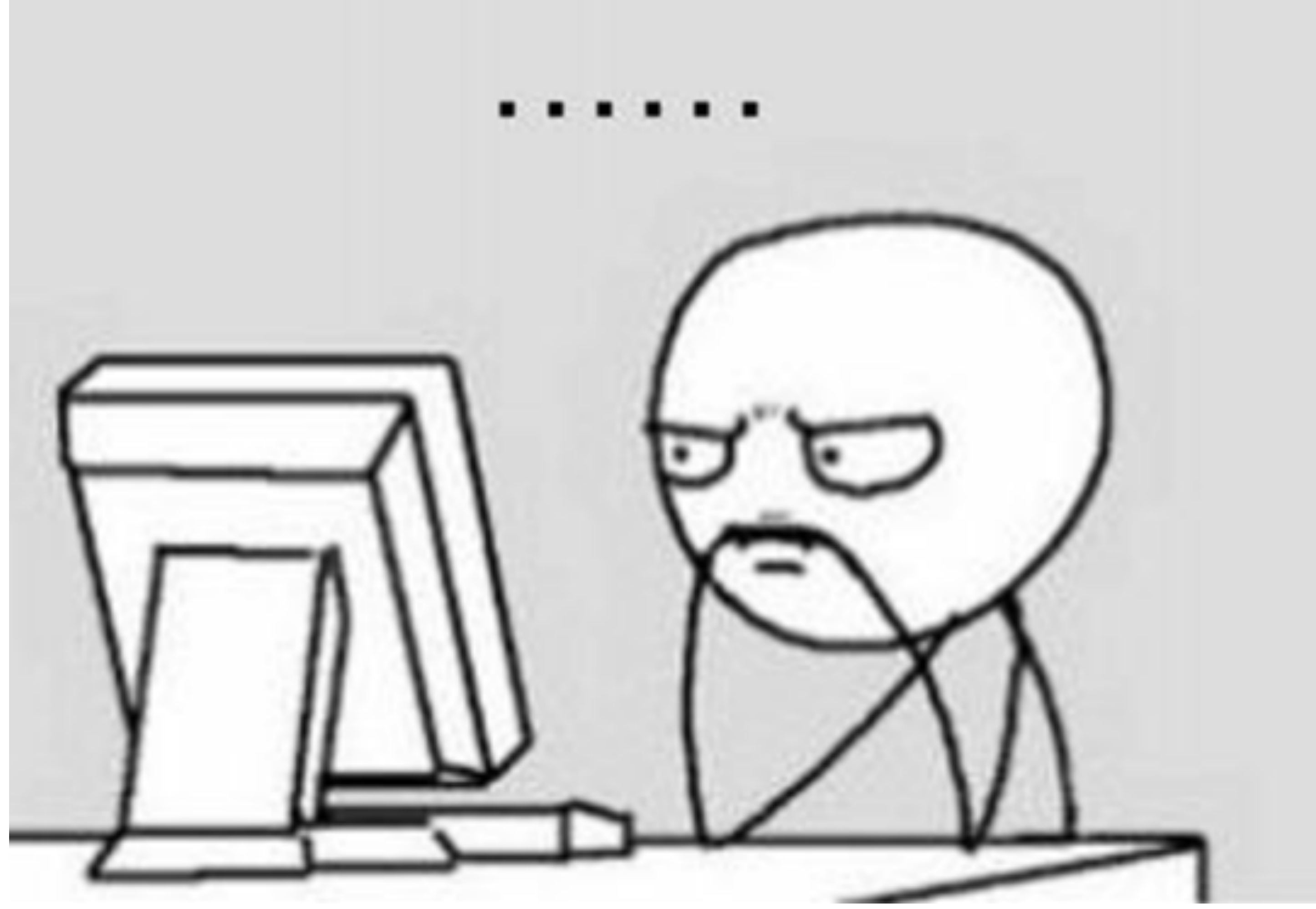


异步回调？

异步渲染？

无痕性能度量SDK — **用户真正看到页面是啥时候呢?**

如何才能判断屏幕渲染完成？？？



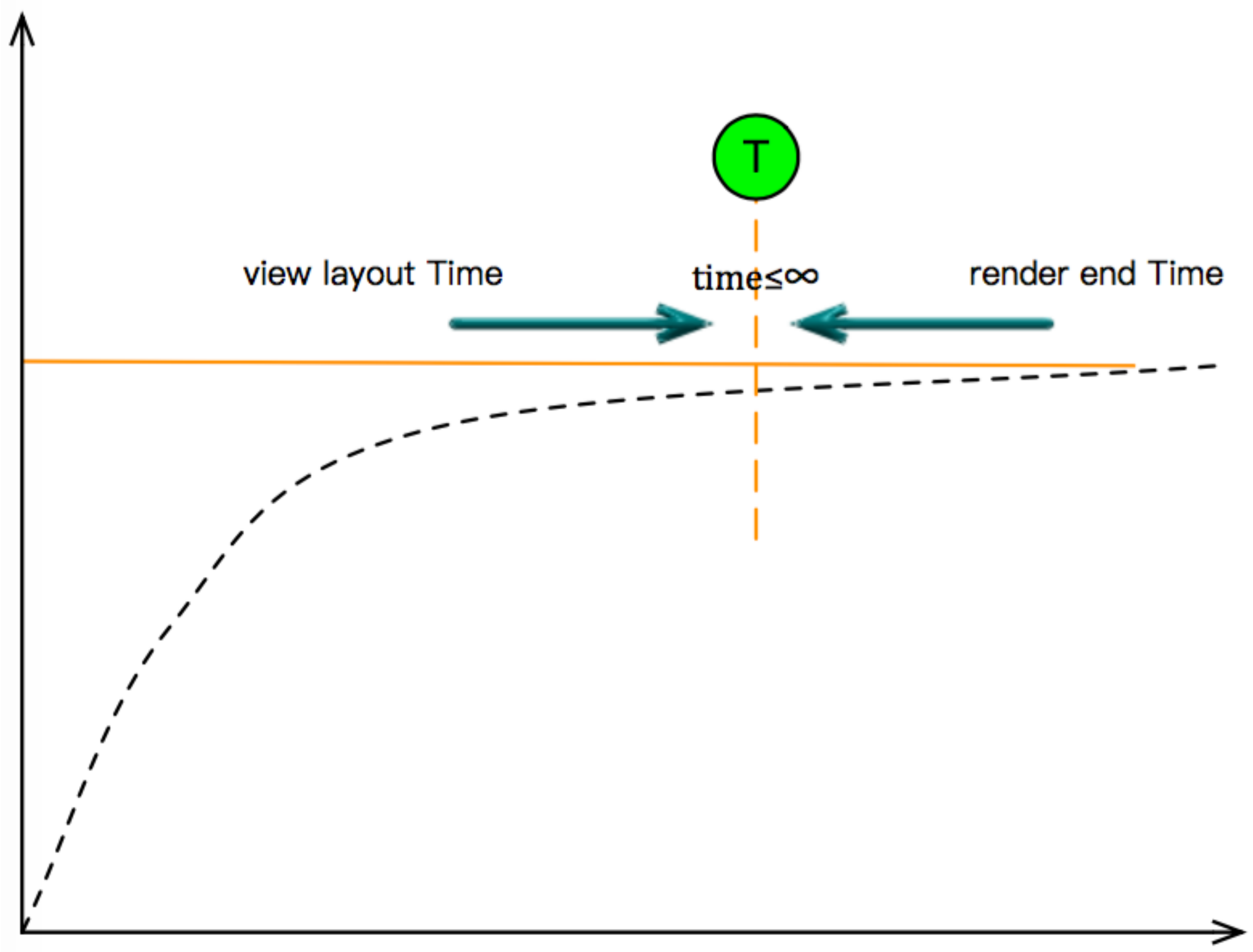
是否能间接获取出屏幕渲染完成时间？？？

无痕性能度量SDK — **基于用户体验页面加载完成度量思路**

理论方法论:

☛ 双向极限逼近法则

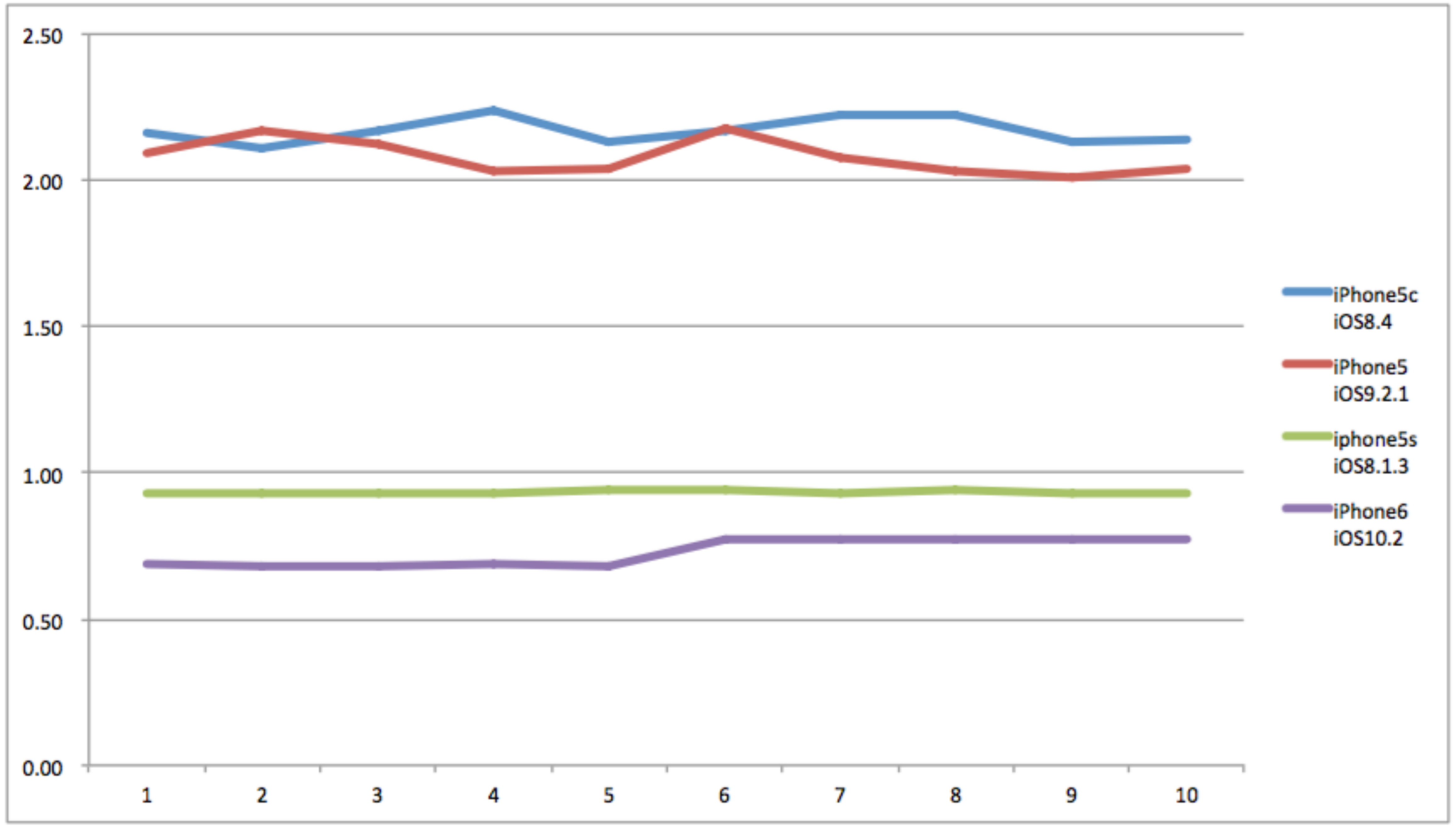
T(target) = |Time(forward), Time(backward)| ≤ ∞



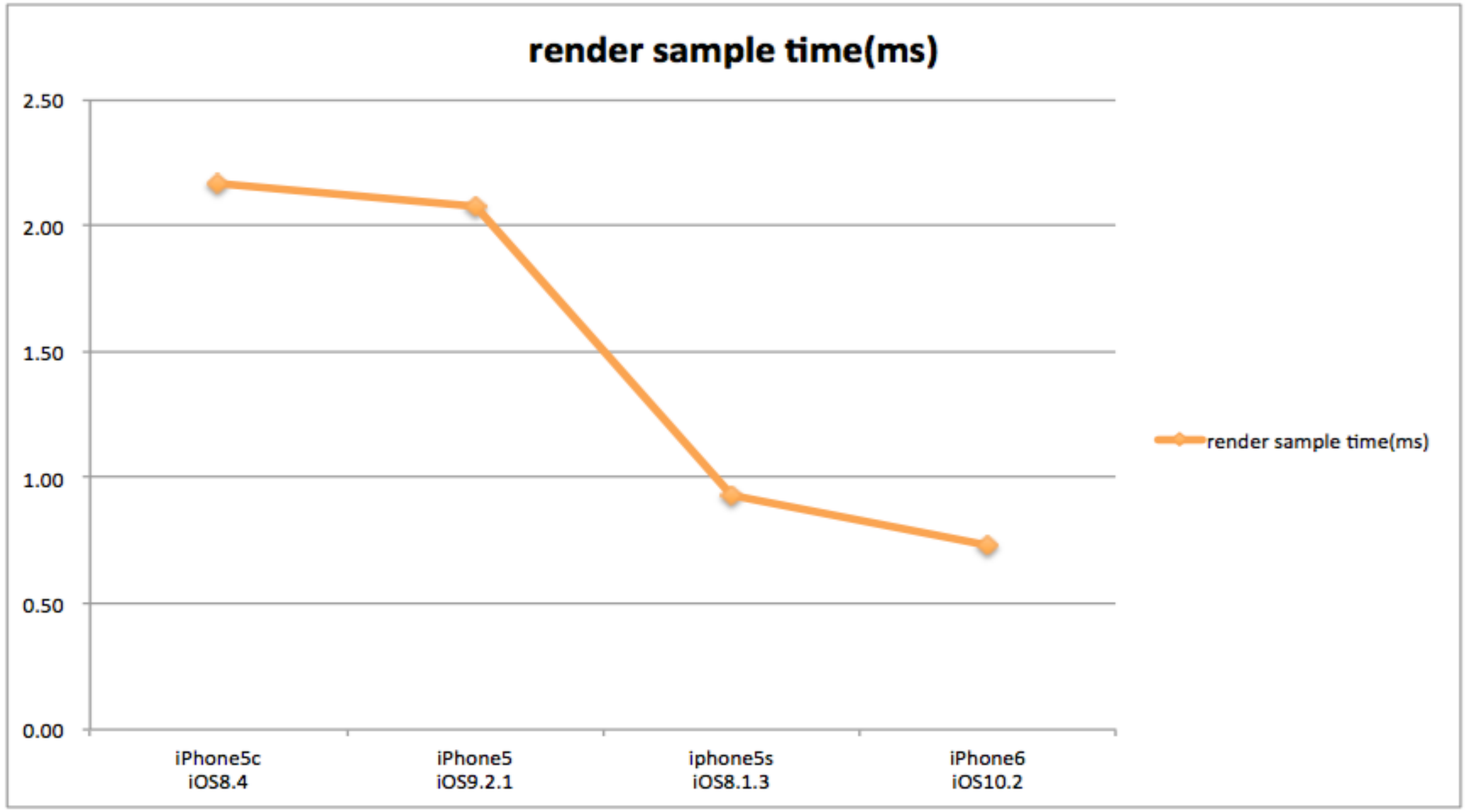
无痕性能度量SDK — **屏幕渲染采样耗时测试数据**

真实实验数据：

☛ 渲染结果采样耗时

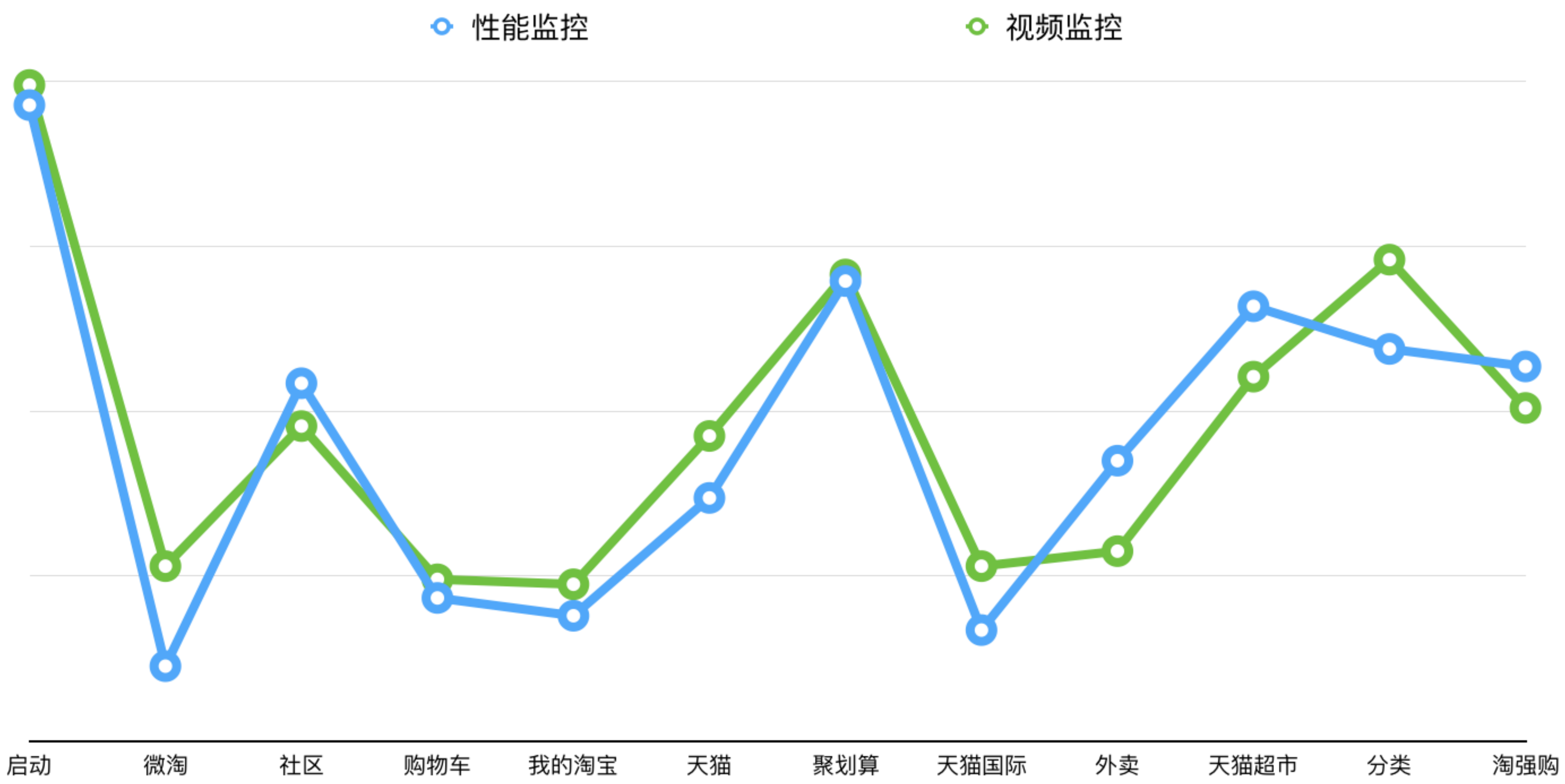


不同机型10次实验数据结果图

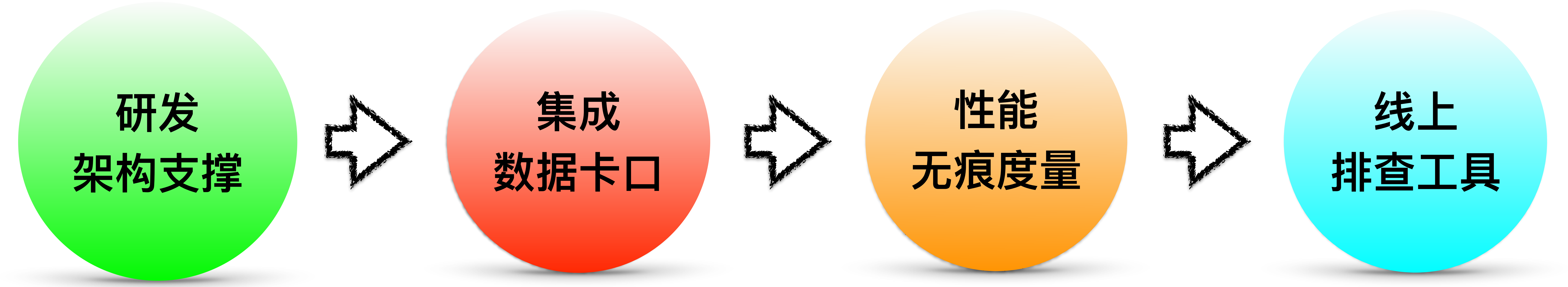


不同机型1次实验数据结果图

无痕性能度量SDK — **基于用户体验页面加载度量方式的测试结果**



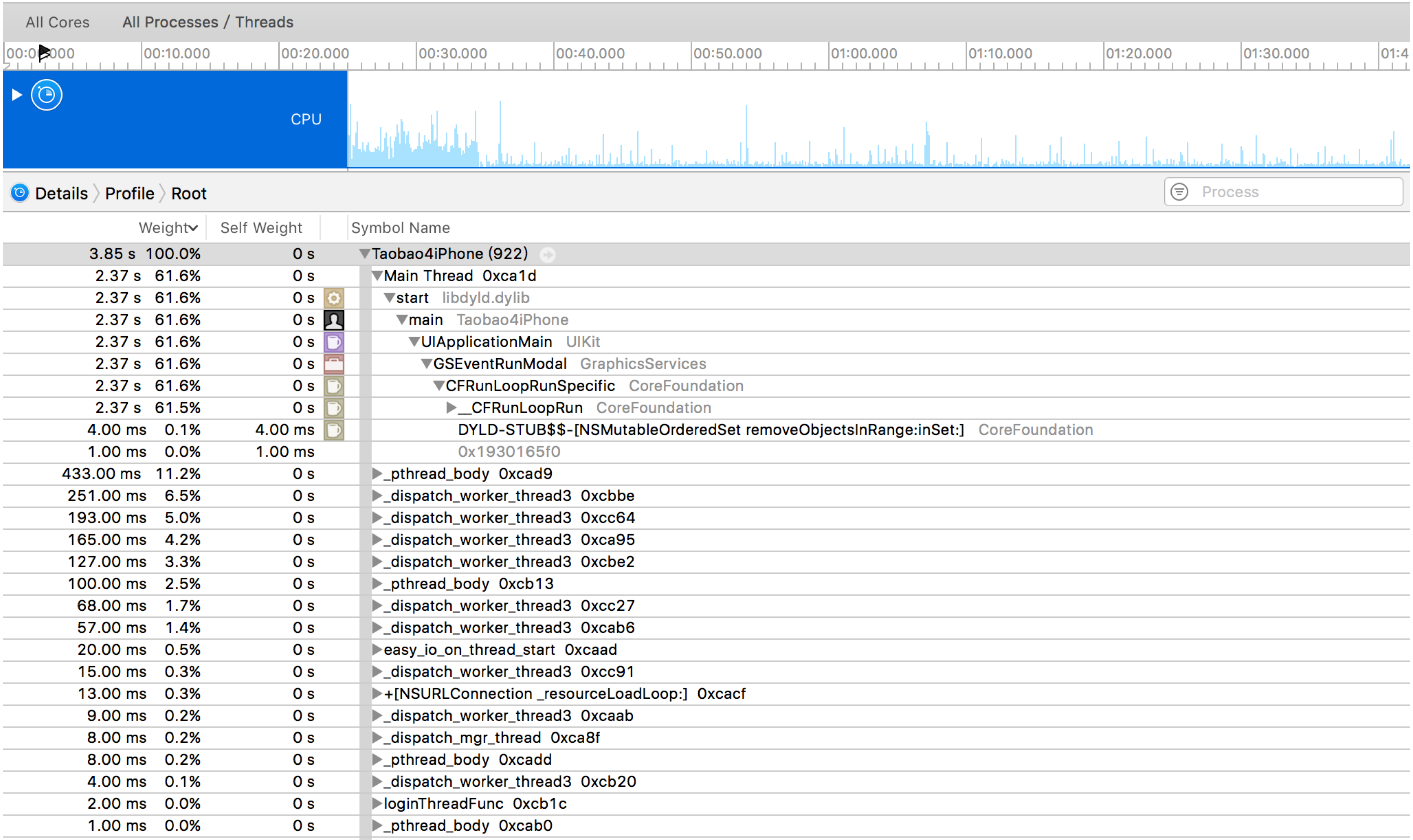
技术上从研发流程角度的思考



- 主线程卡顿监控
- instrument 工具

线上性能排查工具—instrument苹果给开发人员的神器

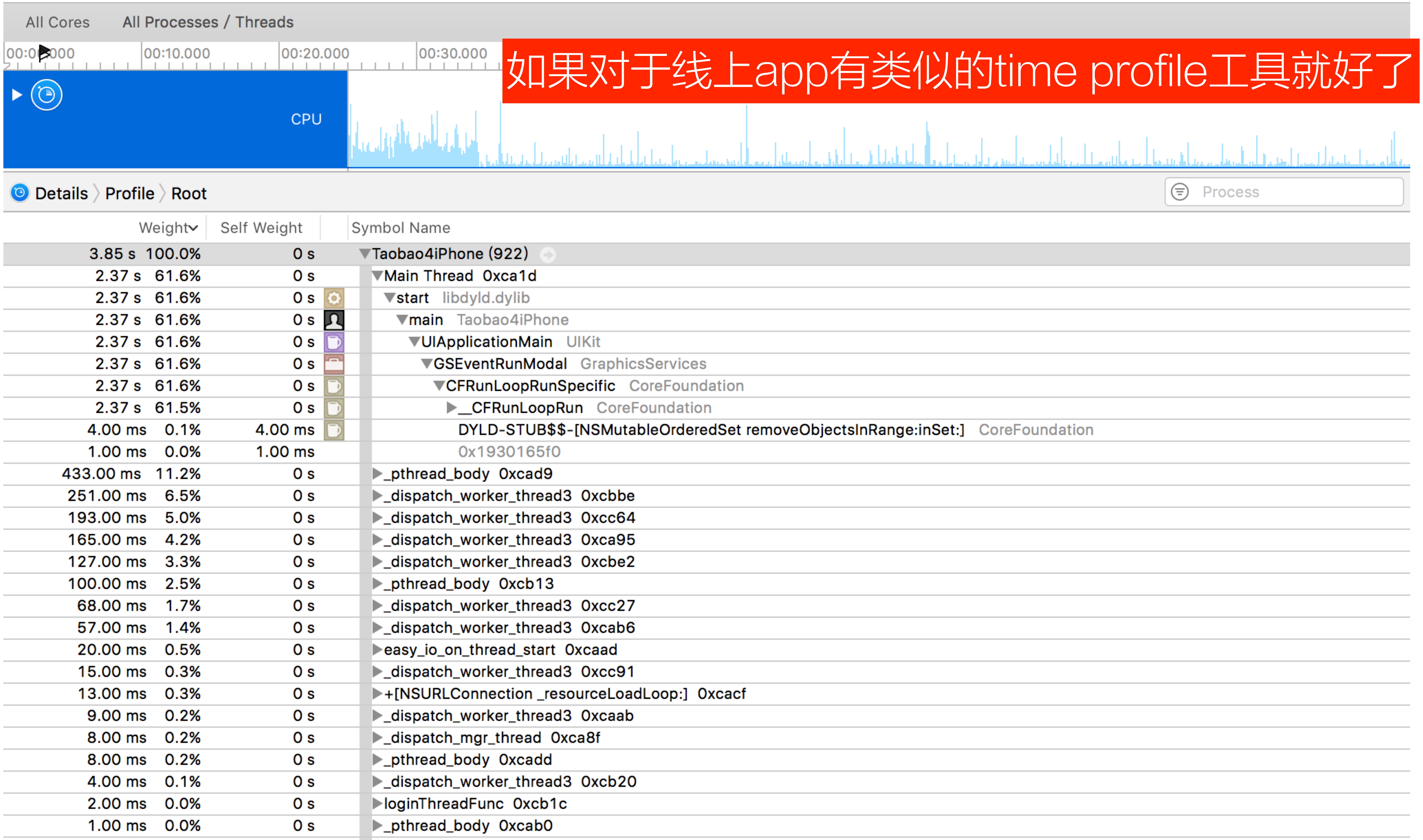
To a force of English



Weight		Self Weight	Symbol Name
3.85 s	100.0%	0 s	▼Taobao4iPhone (922)
2.37 s	61.6%	0 s	▼Main Thread 0xca1d
2.37 s	61.6%	0 s	▼start libdyld.dylib
2.37 s	61.6%	0 s	▼main Taobao4iPhone
2.37 s	61.6%	0 s	▼UIApplicationMain UIKit
2.37 s	61.6%	0 s	▼GSEventRunModal GraphicsServices
2.37 s	61.6%	0 s	▼CFRunLoopRunSpecific CoreFoundation
2.37 s	61.5%	0 s	▶__CFRunLoopRun CoreFoundation
4.00 ms	0.1%	4.00 ms	DYLD-STUB$$-[NSMutableOrderedSet removeObjectsInRange:inSet:] CoreFoundation
1.00 ms	0.0%	1.00 ms	0x1930165f0
433.00 ms	11.2%	0 s	▶_pthread_body 0xcad9
251.00 ms	6.5%	0 s	▶_dispatch_worker_thread3 0xcbbe
193.00 ms	5.0%	0 s	▶_dispatch_worker_thread3 0xcc64
165.00 ms	4.2%	0 s	▶_dispatch_worker_thread3 0xca95
127.00 ms	3.3%	0 s	▶_dispatch_worker_thread3 0xcbe2
100.00 ms	2.5%	0 s	▶_pthread_body 0xcb13
68.00 ms	1.7%	0 s	▶_dispatch_worker_thread3 0xcc27
57.00 ms	1.4%	0 s	▶_dispatch_worker_thread3 0xcab6
20.00 ms	0.5%	0 s	▶easy_io_on_thread_start 0xcaad
15.00 ms	0.3%	0 s	▶_dispatch_worker_thread3 0xcc91
13.00 ms	0.3%	0 s	▶+[NSURLConnection _resourceLoadLoop:] 0xcacf
9.00 ms	0.2%	0 s	▶_dispatch_worker_thread3 0xcaab
8.00 ms	0.2%	0 s	▶_dispatch_mgr_thread 0xca8f
8.00 ms	0.2%	0 s	▶_pthread_body 0xcadd
4.00 ms	0.1%	0 s	▶_dispatch_worker_thread3 0xcb20
2.00 ms	0.0%	0 s	▶loginThreadFunc 0xcb1c
1.00 ms	0.0%	0 s	▶_pthread_body 0xcab0

线上性能排查工具—instrument苹果给开发人员的神器

To a force of English



如果对于线上app有类似的time profile工具就好了

Weight		Self Weight	Symbol Name
3.85 s	100.0%	0 s	▼Taobao4iPhone (922)
2.37 s	61.6%	0 s	▼Main Thread 0xca1d
2.37 s	61.6%	0 s	▼start libdyld.dylib
2.37 s	61.6%	0 s	▼main Taobao4iPhone
2.37 s	61.6%	0 s	▼UIApplicationMain UIKit
2.37 s	61.6%	0 s	▼GSEventRunModal GraphicsServices
2.37 s	61.6%	0 s	▼CFRunLoopRunSpecific CoreFoundation
2.37 s	61.5%	0 s	▶__CFRunLoopRun CoreFoundation
4.00 ms	0.1%	4.00 ms	DYLD-STUB$$-[NSMutableOrderedSet removeObjectsInRange:inSet:] CoreFoundation
1.00 ms	0.0%	1.00 ms	0x1930165f0
433.00 ms	11.2%	0 s	▶_pthread_body 0xcad9
251.00 ms	6.5%	0 s	▶_dispatch_worker_thread3 0xcbbe
193.00 ms	5.0%	0 s	▶_dispatch_worker_thread3 0xcc64
165.00 ms	4.2%	0 s	▶_dispatch_worker_thread3 0xca95
127.00 ms	3.3%	0 s	▶_dispatch_worker_thread3 0xcbe2
100.00 ms	2.5%	0 s	▶_pthread_body 0xcb13
68.00 ms	1.7%	0 s	▶_dispatch_worker_thread3 0xcc27
57.00 ms	1.4%	0 s	▶_dispatch_worker_thread3 0xcab6
20.00 ms	0.5%	0 s	▶easy_io_on_thread_start 0xcaad
15.00 ms	0.3%	0 s	▶_dispatch_worker_thread3 0xcc91
13.00 ms	0.3%	0 s	▶+[NSURLConnection _resourceLoadLoop:] 0xcacf
9.00 ms	0.2%	0 s	▶_dispatch_worker_thread3 0xcaab
8.00 ms	0.2%	0 s	▶_dispatch_mgr_thread 0xca8f
8.00 ms	0.2%	0 s	▶_pthread_body 0xcadd
4.00 ms	0.1%	0 s	▶_dispatch_worker_thread3 0xcb20
2.00 ms	0.0%	0 s	▶loginThreadFunc 0xcb1c
1.00 ms	0.0%	0 s	▶_pthread_body 0xcab0

线上性能排查工具—**自制instrument的思路**

To a force of English

dump
dump全部线程栈信息
App运行时间轴...
dump
dump
dump
dump
dump
dump
dump
dump
x ms
服务端指定采样周期
服务端指令启动
instrument
instrument
周期采样线程信息
线程栈信息
数据去重拟合
数据信息上传
服务平台
服务平台
处理&排查问题

线上性能排查工具—tbinstrument 淘宝的instrument

To a force of English

100
80
60
40
20
0
CPU使用率(%)
0 (ms)
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
[2567]
[4355]
[4611]
[5379]
[11011] com.apple.uikit.eventfetch–thread
[16647]
[19715]
[24327]
[24579]
[24835]
[25091]
[25347]
[25603]
[25859]
[27399]

线上性能排查工具—tbinstrument 淘宝的instrument

To a force of English

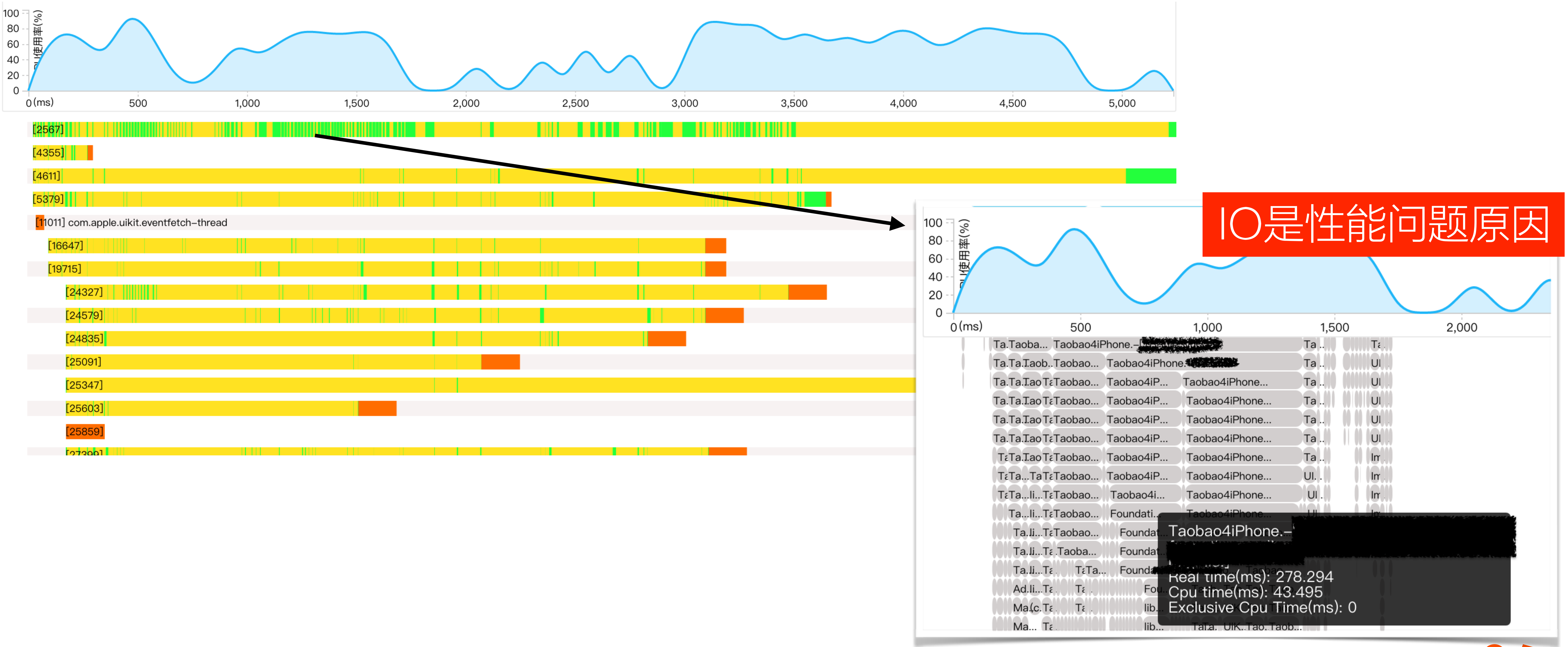
100
80
60
40
20
0
CPU使用率(%)
0 (ms)
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
[2567]
[4355]
[4611]
[5379]
[11011] com.apple.uikit.eventfetch–thread
[16647]
[19715]
[24327]
[24579]
[24835]
[25091]
[25347]
[25603]
[25859]
[27399]
libsystem_pthread.dylib.start_wqthread
libsystem_pthread.dylib._pthread...
libsystem_kernel.dylib.__workq_k...
(context switch)
libsystem_pthread....
libsystem_kernel.d...
libsystem_pthre...
libdispatch.dyl...
Foundation.<red...
Taobao4iPhone.–...
CoreFoundation....
CFNetwork...
libsystem_pthread.dylib._pthread_wqthread...
libsystem_kernel.dylib.__workq_kernreturn...

CoreText.<redacted>
Real time(ms): 150.888
Cpu time(ms): 0.037
Exclusive Cpu Time(ms): 0.037

线上性能排查工具 — tbinstrument 案例

To a force of English

- 排查问题case A



IO是性能问题原因

Taobao4iPhone.– [redacted]

Real time(ms): 278.294
Cpu time(ms): 43.495
Exclusive Cpu Time(ms): 0

线上性能排查工具 — tbinstrument 案例

To a force of English

- 排查问题case B

80
60
40
20
0
CPU使用率(%)
0 (ms)
500
1,000
1,500
2,000
2,500
3,000
3,500
[2567]
[5123]
[6147]
[6659]
[7171]
[5899]
[8459]
[8963]
[9219]
[9475]
[9731]
[14083] com.apple.uikit.eventfetch–thread
[21507]
[24835]
[27655]
[31499]
[31747] WebThread

主线程CPU消耗低？？

子线程CPU消耗高？？

线上性能排查工具 — tbinstrument 案例

To a force of English

- 排查问题case B

CPU使用率(%)
80
60
40
20
0
0 (ms)
500
1,000
1,500
2,
3,500
[2567]
[5123]
[6147]
[6659]
[7171]
[5899]
[8459]
[8963]
[9219]
[9475]
[9731]
[14083] com.apple.uikit.eventfetch–thread
[21507]
[24835]
[27655]
[31499]
[31747] WebThread
libobjc.A...
libdispatch.dylib._disp...
libdispatch.dylib.<reda...
libdispatch.dylib.<re...
[redacted]

主线程正常函数调用，耗时比一般耗时都要高

子线程有大量运行时函数调用，每个耗时都比正常使用要高。由于大量调用导致整体耗时很高，并且占用比较大的CPU

```
libobjc.A.dylib.imp_implementationWithBlock
Real time(ms): 38.115
Cpu time(ms): 0.101
Exclusive Cpu Time(ms): 0
```

```
libobjc.A.dylib.class_replaceMethod
Real time(ms): 24.307
Cpu time(ms): 0.177
Exclusive Cpu Time(ms): 0
```

```
libobjc.A.dylib.method_exchangeImplementatio
ns
Real time(ms): 17.149
Cpu time(ms): 9.942
Exclusive Cpu Time(ms): 0
```

线上性能排查工具 — **tbinstrument 案例**

To a force of English

- 排查问题case B　　OC方法消息分发 objc_msgSend内部有**runtimeLock**锁

```
/********************************************
 * id         objc_msgSend(id self,
 *            SEL op,
 *            ...)
 *
 * On entry: a1 is the message receiver,
 *            a2 is the selector
 ********************************************

    ENTRY objc_msgSend
# check whether receiver is nil
    teq      a1, #0
    beq      LMsgSendNilReceiver

# save registers and load receiver's class f
    stmfd    sp!, {a4,v1,r9}
    ldr      v1, [a1, #ISA]

# receiver is non-nil: search the cache
    CacheLookup a2, v1, LMsgSendCacheMiss

# cache hit (imp in ip) and CacheLookup retu
    ldmfd    sp!, {a4,v1,r9}
    bx       ip

# cache miss: go search the method lists
LMsgSendCacheMiss:
    ldmfd    sp!, {a4,v1,r9}
    b    objc_msgSend_uncached

LMsgSendNilReceiver:
    mov      a2, #0
    bx       lr

LMsgSendExit:
    END_ENTRY objc_msgSend
```

```
    STATIC_ENTRY objc_msgSend_uncached

# Push stack frame
    stmfd    sp!, {a1-a4,r7,lr}
    add      r7, sp, #16

# Load class and selector
    ldr a3, [a1, #ISA]        /* class = receiver->isa  *
                       /* selector already in a2 */
                       /* receiver already in a1 */

# Do the lookup
    MI_CALL_EXTERNAL(_class_lookupMethodAndLoadCache3)
    MOVE     ip, a1

# Prep for forwarding, Pop stack frame and call imp
    teq v1, v1         /* set nonstret (eq) */
    ldmfd    sp!, {a1-a4,r7,lr}
    bx   ip
```

```
**********************************************************************/
IMP _class_lookupMethodAndLoadCache3(id obj, SEL sel, Class cls)
{
    return lookUpMethod(cls, sel, YES/*initialize*/, NO/*cache*/, obj);
}
```

```
IMP lookUpMethod(Class cls, SEL sel, BOOL initialize, BOOL cache, id inst)
{
    Class curClass;
    IMP methodPC = NULL;

    // realize, +initialize, and any special early exit
    ...

    // The lock is held to make method-lookup + cache-fill atomic
    // with respect to method addition. Otherwise, a category could
    // be added but ignored indefinitely because the cache was re-filled
    // with the old value after the cache flush on behalf of the category.
 retry:
    lockForMethodLookup();

    //去获取真实的IMP

 done:
    unlockForMethodLookup();

    // paranoia: look for ignored selectors with non-ignored implementations
    assert(!(ignoreSelector(sel)  &&  methodPC != (IMP)&_objc_ignored_method));

    return methodPC;
}
```

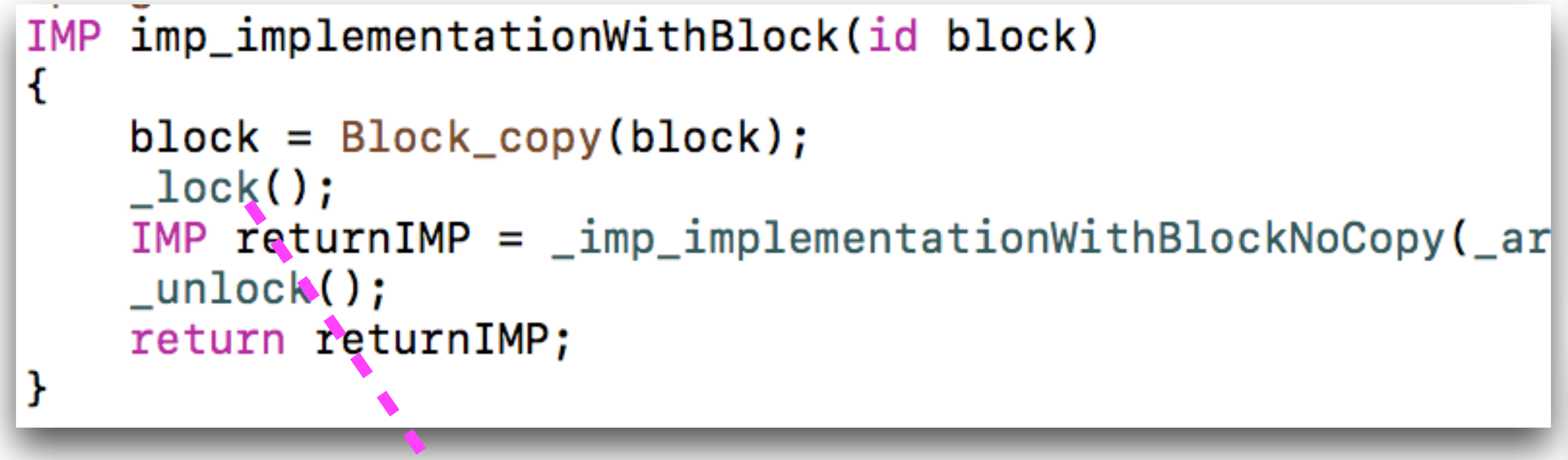
```
void lockForMethodLookup(void)
{
    rwlock_read(&runtimeLock);
}
void unlockForMethodLookup(void)
{
    rwlock_unlock_read(&runtimeLock);
}
```

runtimeLock 全局锁

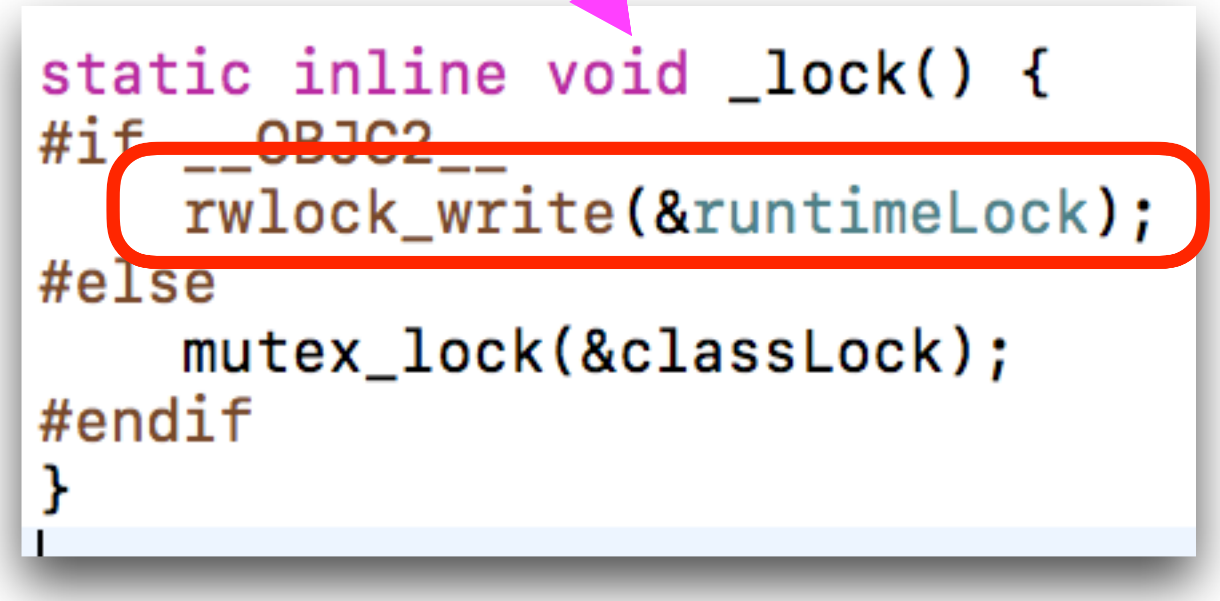
线上性能排查工具 — **tbinstrument 案例**

To a force of English

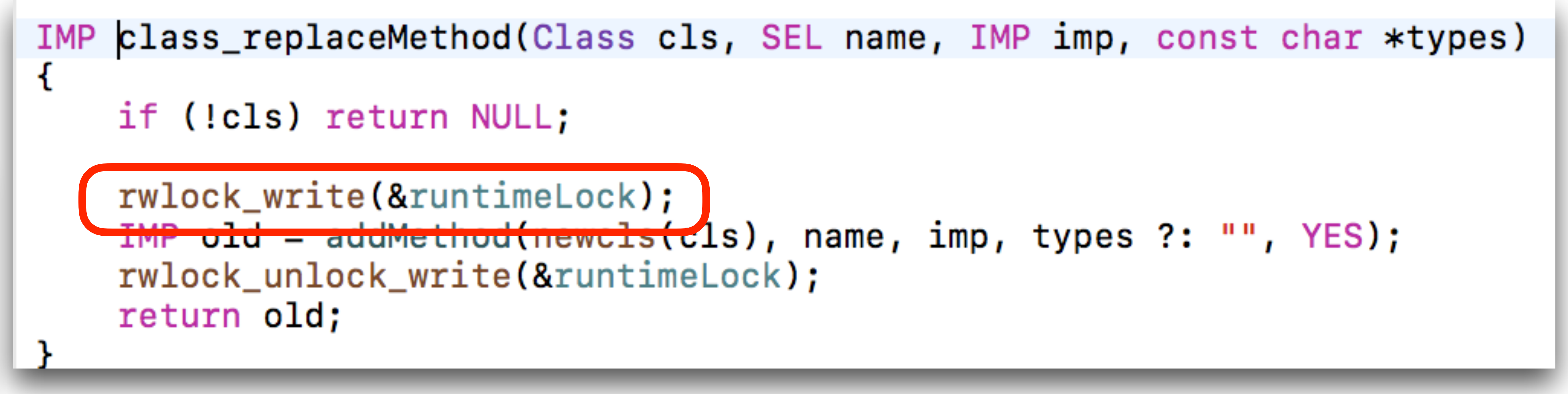
- 排查问题case B　　OC runtime相关函数内部执行，也有**runtimeLock**锁



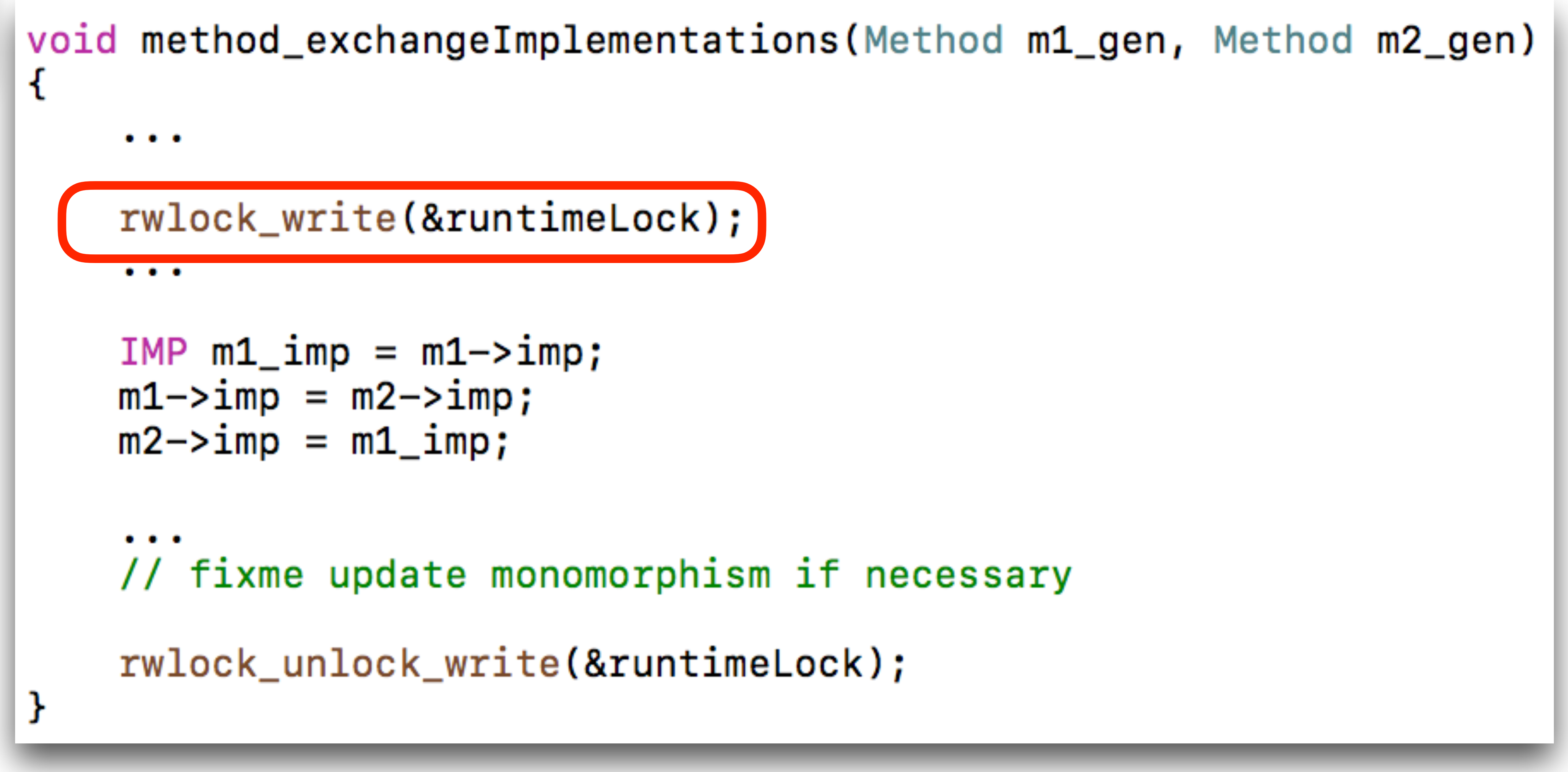
```
IMP imp_implementationWithBlock(id block)
{
    block = Block_copy(block);
    _lock();
    IMP returnIMP = _imp_implementationWithBlockNoCopy(_ar
    _unlock();
    return returnIMP;
}
```



```
static inline void _lock() {
#if __OBJC2__
    rwlock_write(&runtimeLock);
#else
    mutex_lock(&classLock);
#endif
}
```



```
IMP class_replaceMethod(Class cls, SEL name, IMP imp, const char *types)
{
    if (!cls) return NULL;

    rwlock_write(&runtimeLock);
    IMP old = addMethod(newcls(cls), name, imp, types ?: "", YES);
    rwlock_unlock_write(&runtimeLock);
    return old;
}
```



```
void method_exchangeImplementations(Method m1_gen, Method m2_gen)
{
    ...

    rwlock_write(&runtimeLock);
    ...

    IMP m1_imp = m1->imp;
    m1->imp = m2->imp;
    m2->imp = m1_imp;

    ...
    // fixme update monomorphism if necessary

    rwlock_unlock_write(&runtimeLock);
}
```

线上性能排查工具 — tbinstrument 案例

To a force of English

- 排查问题case B

80
60
40
20
0
CPU使用率(%)
0 (ms)
500
1,000
1,500
2,000
2,500
3,000
3,500
[2567]
[5123]
[6147]
[6659]
[7171]
[5899]
[8459]
[8963]
[9219]
[9475]
[9731]
[14083] com.apple.uikit.eventfetch-thread
[21507]
[24835]
[27655]
[31499]
[31747] WebThread

主线程CPU消耗低？？

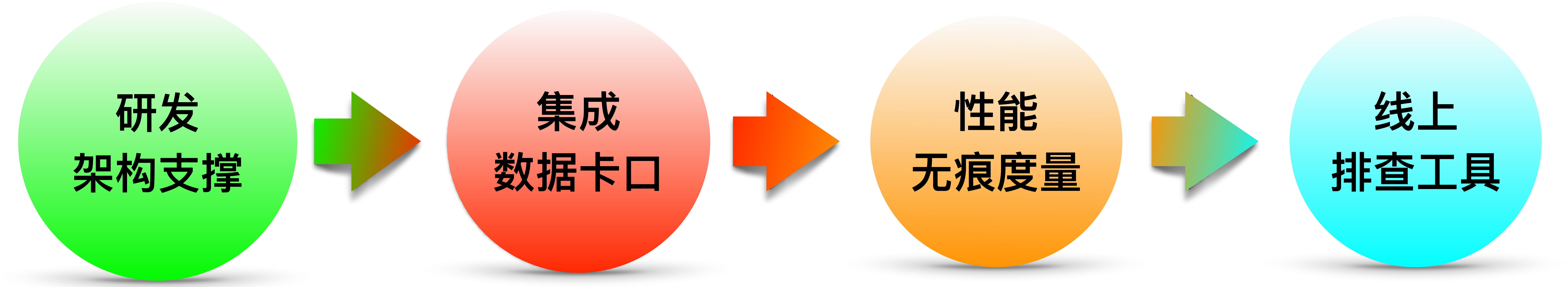
子线程CPU消耗高？？

结论：runtimeLock 全局锁导致性能瓶颈

A. 主线程正常函数调用，运行时oc基于objc_msgSend 消息方法内部遇到runtimeLock锁

B. 子线程oc runtime api频发循环调用，runtime api内部遇到runtimeLock锁

技术上从研发流程角度的思考



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Thanks!