FRAPL

Next Generation Reverse Engineering Framework

Alex Hude

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Who we are

Alex Hude

- Melbourne, Australia
- Blackmagic Design
- Hardware, XNU
- Fried Apple team

Max Bazaliy

- Kyiv, Ukraine
- Lookout
- XNU, Linux, LLVM
- Fried Apple team

Modern Reverse Engineering

Static approach

- Disassemblers
- Code analyzers
- Decompilers
- IDA as a choice

Dynamic approach

- Debuggers
- Dynamic analyzers
- Code instrumentation
- Frida as a choice

Static analysis challenges

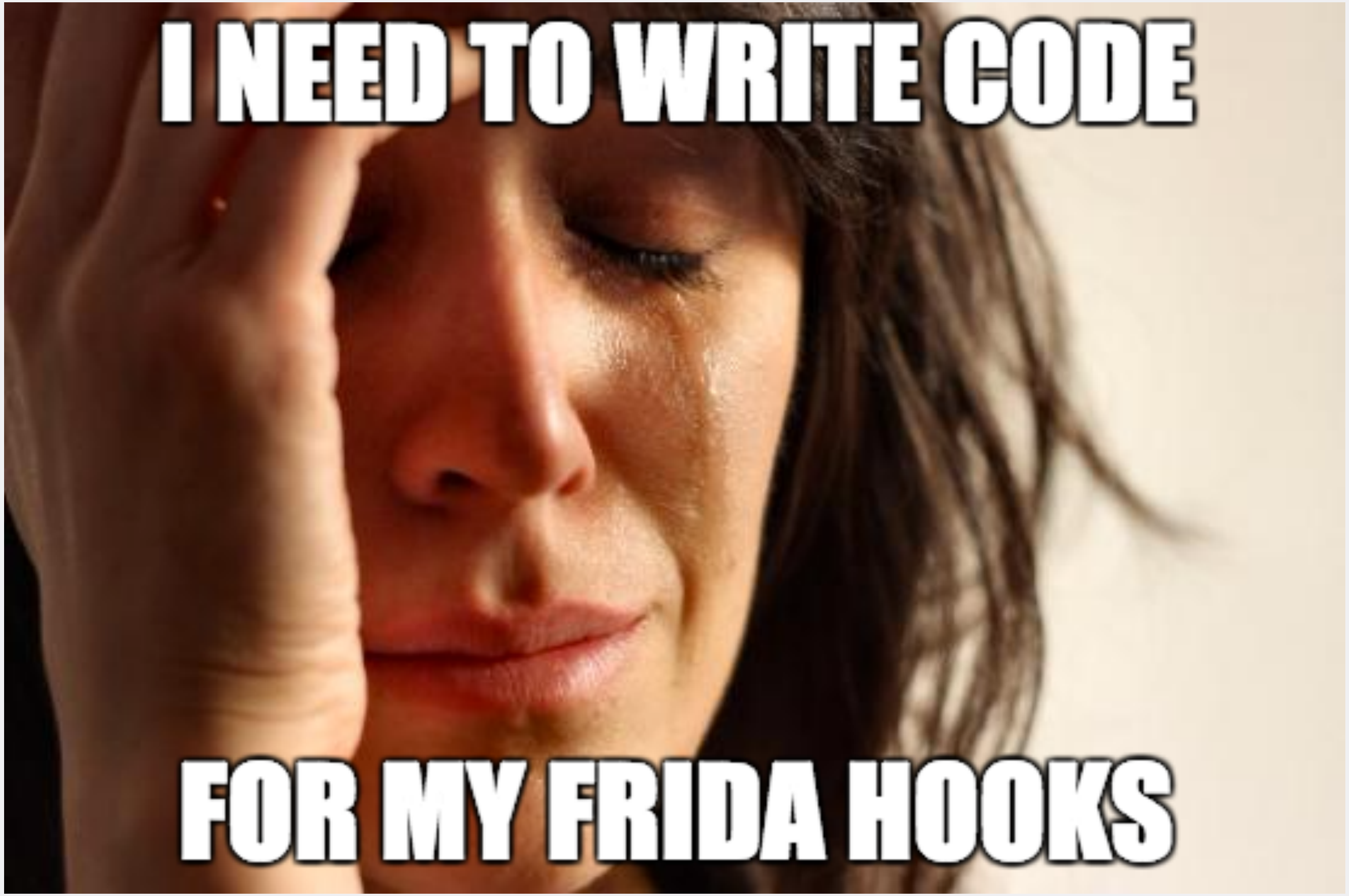
- Missed context (CPU registers, stack, memory)
- Hard to follow code execution flow (obfuscation)
- Hard to follow data flow (encryption)
- Hard to follow indirect function calls

Debugging challenges

- Anti debugging tricks
- Data loss during restarts
- Execution flow may be changed under debugging
- No way to hook/replace existing code easily

Dynamic instrumentation challenges

- Code disassembly still missed
- High learning curve
- Usually requires to write a lot of code
- Hard to maintain multiple things at a time


I NEED TO WRITE CODE
FOR MY FRIDA HOOKS

FRAPL

What is FRAPL ?

FRAPL

=

Frida scripts + FridaLink

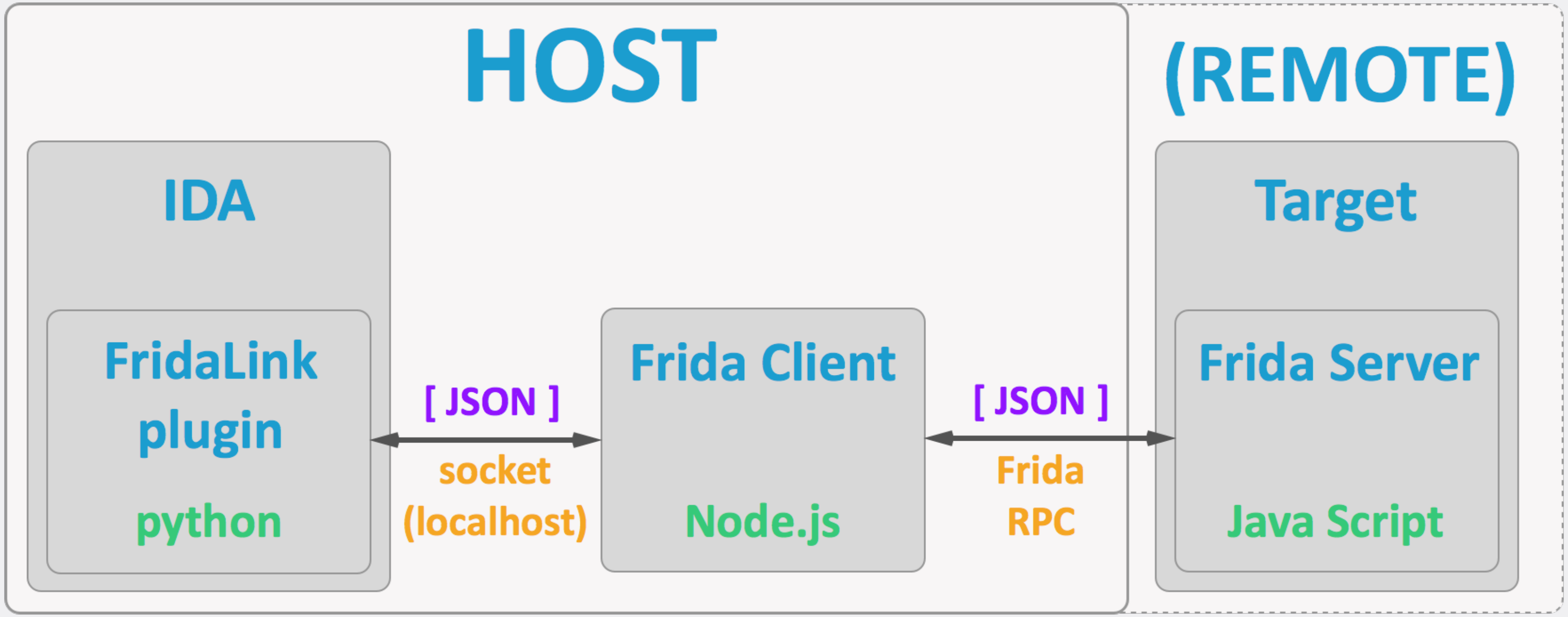
Frida Scripts

- Node.js client (attach, spawn, RPC, script loading)
- Node.js server script (RPC, GCD, iOS/macOS bindings)
- Common operations wrappers (objc hooks etc)
- Utility functions (memory dumps, logging)

FridaLink

- IDA plugin that implements UI controls to Frida
- Socket protocol between IDA & Frida Client (JSON)
- RPC protocol for between Frida Client & Server (JSON)
- FridaLink.js (Frida script)

FridaLink architecture



FridaLink goals

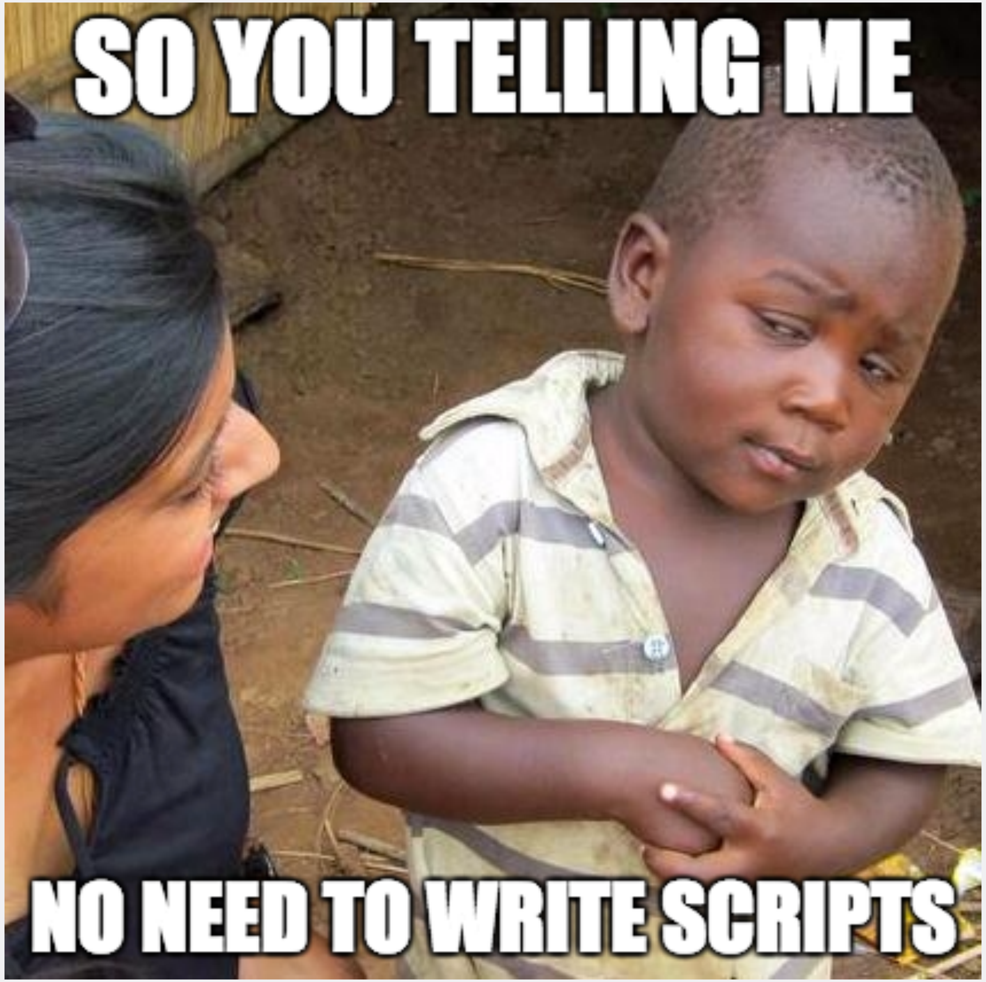
- Bring static analysis info from IDA to Frida
- Use dynamic info from Frida for IDA analysis
- Monitor runtime state directly from IDA
- Control Frida agent directly from IDA

FridaLink features

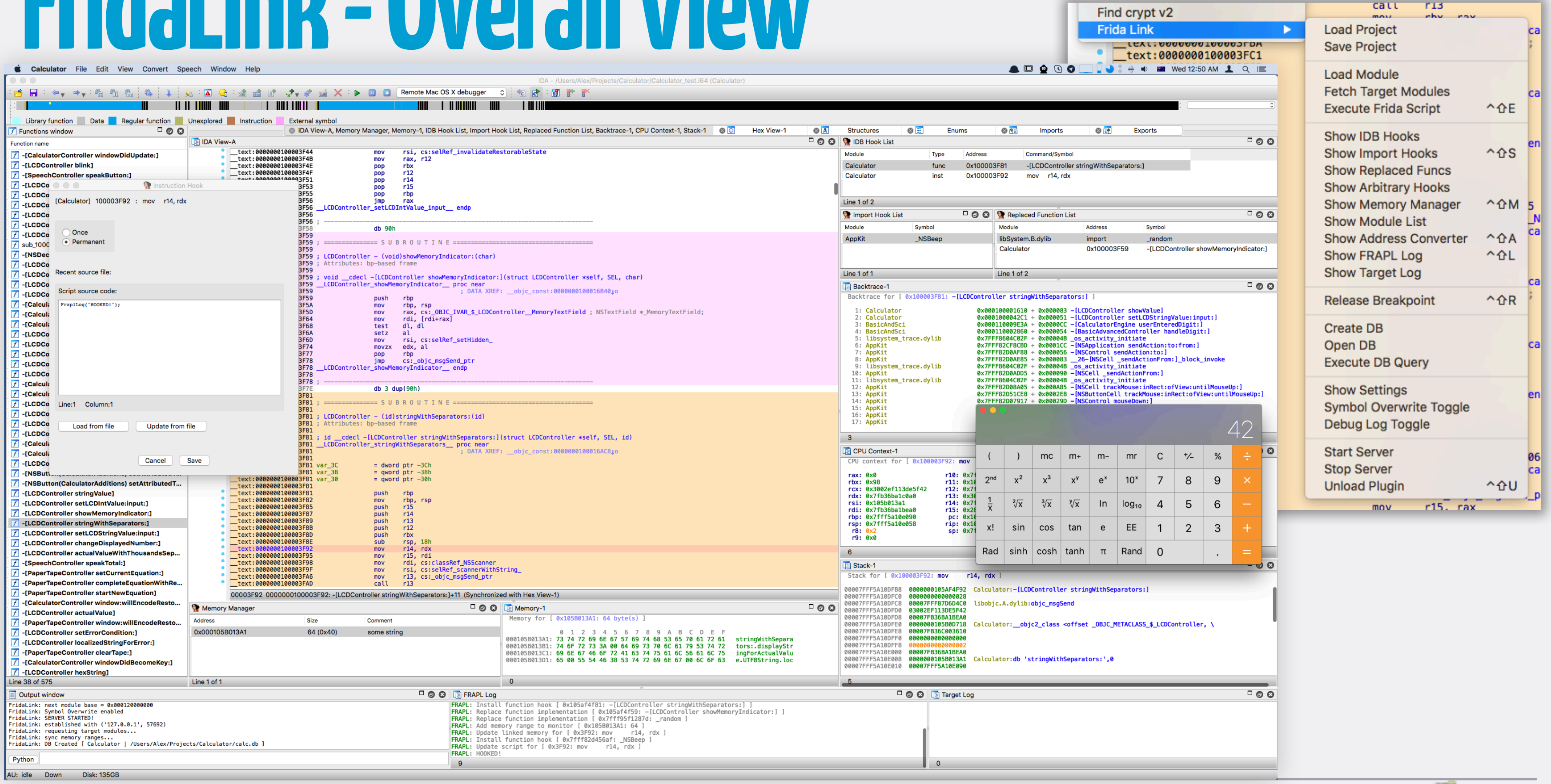
- Function/instruction hooks made easy
- Function replacement made easy
- Module loading made easy
- Custom scripts support

FridaLink features

- CPU context monitoring
- Memory monitoring
- SQLite database support
- Helpers and project save/restore


SO YOU TELLING ME
NO NEED TO WRITE SCRIPTS

FridaLink - Overall View



[Calculator] 100003F92 : mov r14, rdx

```
FrapLog("HOOKED!");
```

IDB Hook List

Module	Type	Address	Command/Symbol
Calculator	func	0x100003F81	-[LCDController stringWithSeparators:]
Calculator	inst	0x100003F92	mov r14, rdx

Import Hook List

Module	Symbol
AppKit	_NSBeep

Replaced Function List

Module	Address	Symbol
libSystem.B.dylib	import	_random
Calculator	0x100003F59	-[LCDController showMemoryIndicator:]

Backtrace-1

```
Backtrace for [ 0x100003F81: -[LCDController stringWithSeparators:] ]

 1: Calculator              0x000100001610 + 0x000083 -[LCDController showValue]
 2: Calculator              0x0001000042C1 + 0x000051 -[LCDController setLCDStringValue:input:]
 3: BasicAndSci             0x000110009E3A + 0x0000CC -[CalculatorEngine userEnteredDigit:]
 4: BasicAndSci             0x000110002860 + 0x000054 -[BasicAdvancedController handleDigit:]
 5: libsystem_trace.dylib   0x7FFF8604C02F + 0x00004B _os_activity_initiate
 6: AppKit                  0x7FFF82CF8CBD + 0x0001CC -[NSApplication sendAction:to:from:]
 7: AppKit                  0x7FFF82D0AF88 + 0x000056 -[NSControl sendAction:to:]
 8: AppKit                  0x7FFF82D0AE85 + 0x000083 __26-[NSCell _sendActionFrom:]_block_invoke
 9: libsystem_trace.dylib   0x7FFF8604C02F + 0x00004B _os_activity_initiate
10: AppKit                  0x7FFF82D0ADD5 + 0x000090 -[NSCell _sendActionFrom:]
11: libsystem_trace.dylib   0x7FFF8604C02F + 0x00004B _os_activity_initiate
12: AppKit                  0x7FFF82D08A05 + 0x000A85 -[NSCell trackMouse:inRect:ofView:untilMouseUp:]
13: AppKit                  0x7FFF82D51CE8 + 0x0002E8 -[NSButtonCell trackMouse:inRect:ofView:untilMouseUp:]
14: AppKit                  0x7FFF82D07917 + 0x00029D -[NSControl mouseDown:]
15: AppKit
16: AppKit
17: AppKit
```

Stack-1

```
Stack for [ 0x100003F92: mov     r14, rdx ]

00007FFF5A10DFB8  0000000105AF4F92  Calculator:-[LCDController stringWithSeparators:]
00007FFF5A10DFC0  0000000000000028
00007FFF5A10DFC8  00007FFF87D6D4C0  libobjc.A.dylib:objc_msgSend
00007FFF5A10DFD0  03002EF113DE5F42
00007FFF5A10DFD8  00007FB36BA1BEA0
00007FFF5A10DFE0  0000000105B0D718  Calculator:__objc2_class <offset _OBJC_METACLASS_$_LCDController, \
00007FFF5A10DFE8  00007FB36C003610
00007FFF5A10DFF0  0000000000000000
00007FFF5A10DFF8  0000000000000002
00007FFF5A10E000  00007FB36BA1BEA0
00007FFF5A10E008  0000000105B013A1  Calculator:db 'stringWithSeparators:',0
00007FFF5A10E010  00007FFF5A10E090
```

00003F92 000000100003F92: -[LCDController stringWithSeparators:]+11 (Synchronized with Hex View-1)

Memory Manager

Address	Size	Comment
0x000105B013A1	64 (0x40)	some string

Memory-1

```
Memory for [ 0x105B013A1: 64 byte(s) ]

               0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
000105B013A1: 73 74 72 69 6E 67 57 69 74 68 53 65 70 61 72 61   stringWithSepara
000105B013B1: 74 6F 72 73 3A 00 64 69 73 70 6C 61 79 53 74 72   tors:.displayStr
000105B013C1: 69 6E 67 46 6F 72 41 63 74 75 61 6C 56 61 6C 75   ingForActualValu
000105B013D1: 65 00 55 54 46 38 53 74 72 69 6E 67 00 6C 6F 63   e.UTF8String.loc
```

Output window

```
FridaLink: next module base = 0x000120000000
FridaLink: Symbol Overwrite enabled
FridaLink: SERVER STARTED!
FridaLink: established with ('127.0.0.1', 57692)
FridaLink: requesting target modules...
FridaLink: sync memory ranges...
FridaLink: DB Created [ Calculator | /Users/Alex/Projects/Calculator/calc.db ]
```

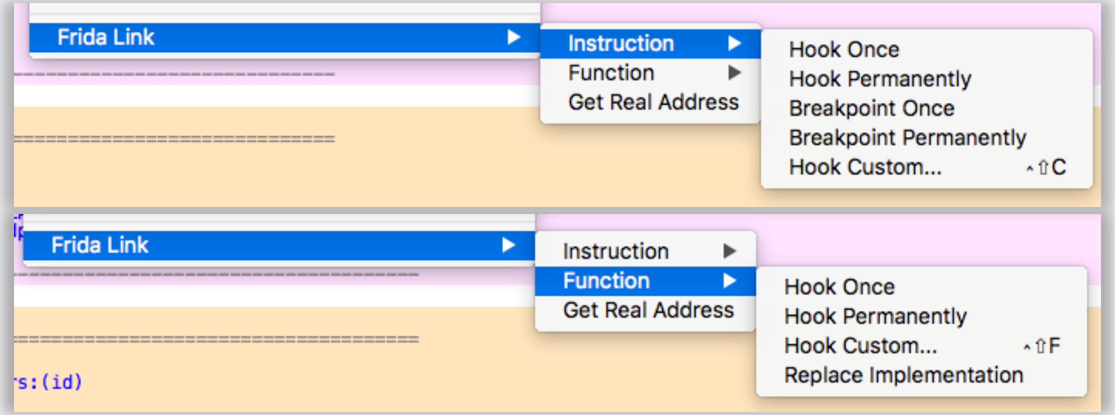
FRAPL Log

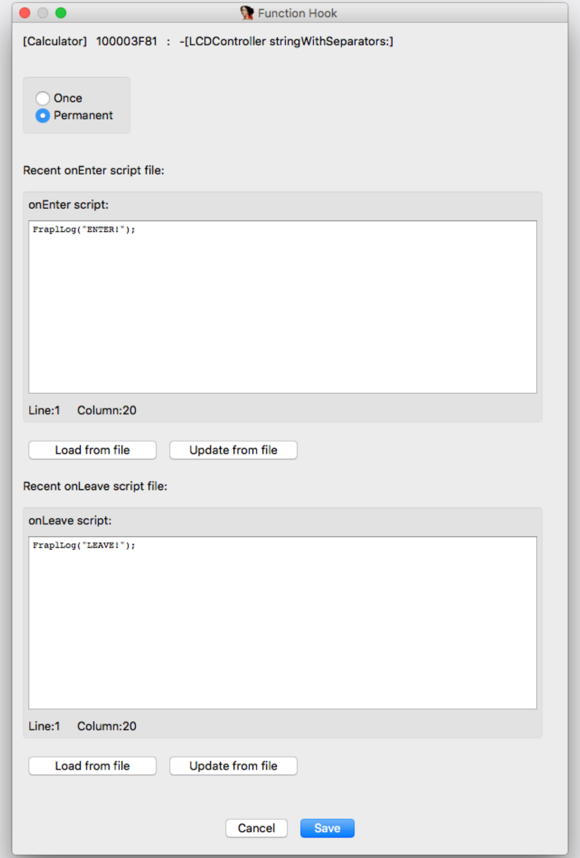
```
FRAPL: Install function hook [ 0x105af4f81: -[LCDController stringWithSeparators:] ]
FRAPL: Replace function implementation [ 0x105af4f59: -[LCDController showMemoryIndicator:] ]
FRAPL: Replace function implementation [ 0x7fff95f1287d: _random ]
FRAPL: Add memory range to monitor [ 0x105B013A1: 64 ]
FRAPL: Update linked memory for [ 0x3F92: mov     r14, rdx ]
FRAPL: Install function hook [ 0x7fff82d456af: _NSBeep ]
FRAPL: Update script for [ 0x3F92: mov     r14, rdx ]
FRAPL: HOOKED!
```

AU: idle   Down   Disk: 135GB

FridaLink – Hooks

- Instruction hooks
- Instruction breakpoints (hook with wait)
- IDB (local) function hooks
- Import function hooks




Function Hook

[Calculator] 100003F81 : -[LCDController stringWithSeparators:]

Once [✓ Permanent]

Recent onEnter script file:

onEnter script:

```
FraplLog("ENTER!");
```

Line:1 Column:20

Recent onLeave script file:

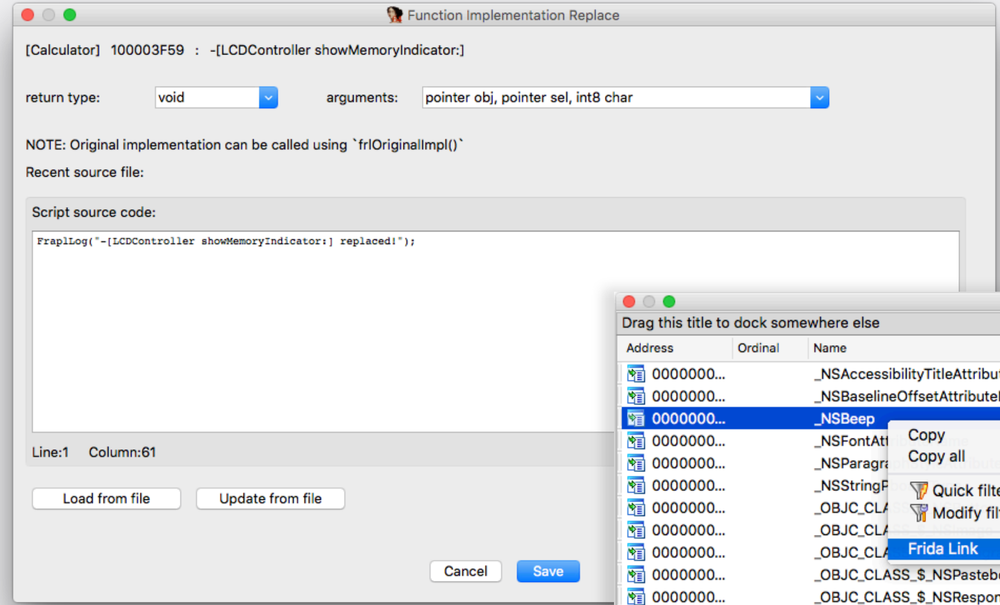
onLeave script:

```
FraplLog("LEAVE!");
```

Line:1 Column:20

FridaLink – Function Replacement

Replace local function



Function Implementation Replace

[Calculator] 100003F59 : -[LCDController showMemoryIndicator:]

return type: void   arguments: pointer obj, pointer sel, int8 char

NOTE: Original implementation can be called using `frlOriginalImpl()`

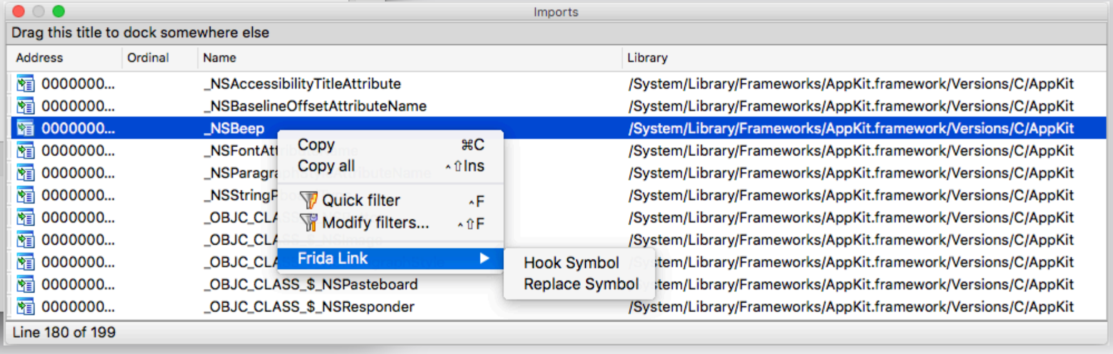
Recent source file:

Script source code:

```
FraplLog("-[LCDController showMemoryIndicator:] replaced!");
```

Line:1   Column:61

Replace Import function



Imports

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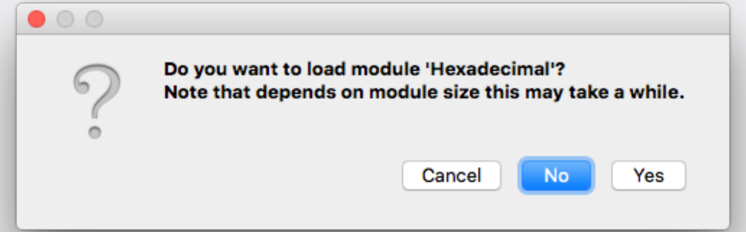
Address	Ordinal	Name	Library
0000000...		_NSAccessibilityTitleAttribute	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_NSBaselineOffsetAttributeName	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_NSBeep	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_NSFontAtt	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_NSParagra	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_NSStringP	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_OBJC_CLA	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_OBJC_CLA	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_OBJC_CLA	tem/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_OBJC_CLASS_$_NSPasteboard	tem/Library/Frameworks/AppKit.framework/Versions/C/AppKit
0000000...		_OBJC_CLASS_$_NSResponder	/System/Library/Frameworks/AppKit.framework/Versions/C/AppKit

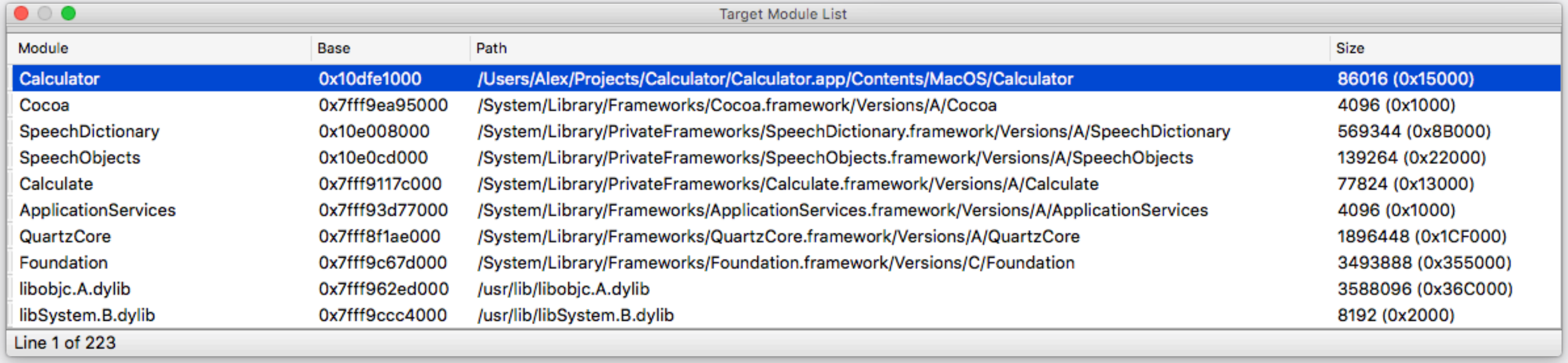
Line 180 of 199

FridaLink – Module Loading

- Automatic (on backtrace)
- Manual



Do you want to load module 'Hexadecimal'?
Note that depends on module size this may take a while.

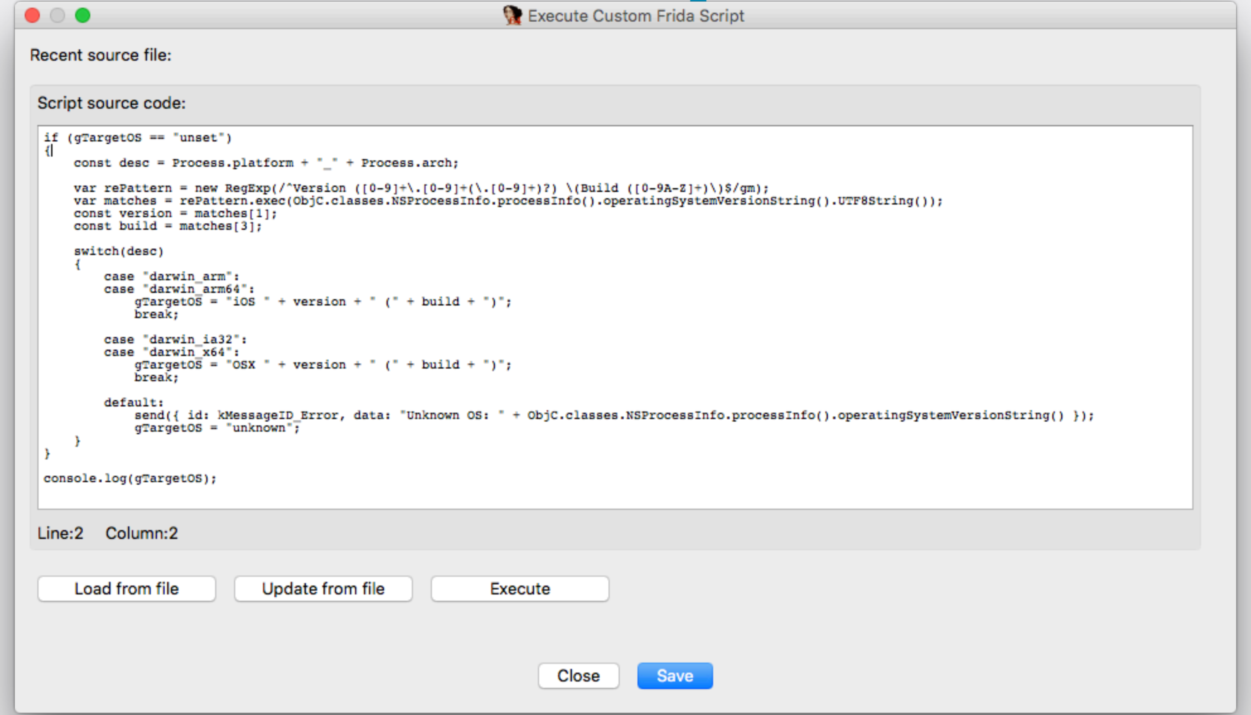


Target Module List

Module	Base	Path	Size
Calculator	0x10dfe1000	/Users/Alex/Projects/Calculator/Calculator.app/Contents/MacOS/Calculator	86016 (0x15000)
Cocoa	0x7fff9ea95000	/System/Library/Frameworks/Cocoa.framework/Versions/A/Cocoa	4096 (0x1000)
SpeechDictionary	0x10e008000	/System/Library/PrivateFrameworks/SpeechDictionary.framework/Versions/A/SpeechDictionary	569344 (0x8B000)
SpeechObjects	0x10e0cd000	/System/Library/PrivateFrameworks/SpeechObjects.framework/Versions/A/SpeechObjects	139264 (0x22000)
Calculate	0x7fff9117c000	/System/Library/PrivateFrameworks/Calculate.framework/Versions/A/Calculate	77824 (0x13000)
ApplicationServices	0x7fff93d77000	/System/Library/Frameworks/ApplicationServices.framework/Versions/A/ApplicationServices	4096 (0x1000)
QuartzCore	0x7fff8f1ae000	/System/Library/Frameworks/QuartzCore.framework/Versions/A/QuartzCore	1896448 (0x1CF000)
Foundation	0x7fff9c67d000	/System/Library/Frameworks/Foundation.framework/Versions/C/Foundation	3493888 (0x355000)
libobjc.A.dylib	0x7fff962ed000	/usr/lib/libobjc.A.dylib	3588096 (0x36C000)
libSystem.B.dylib	0x7fff9ccc4000	/usr/lib/libSystem.B.dylib	8192 (0x2000)

Line 1 of 223

FridaLink – Custom Scripts

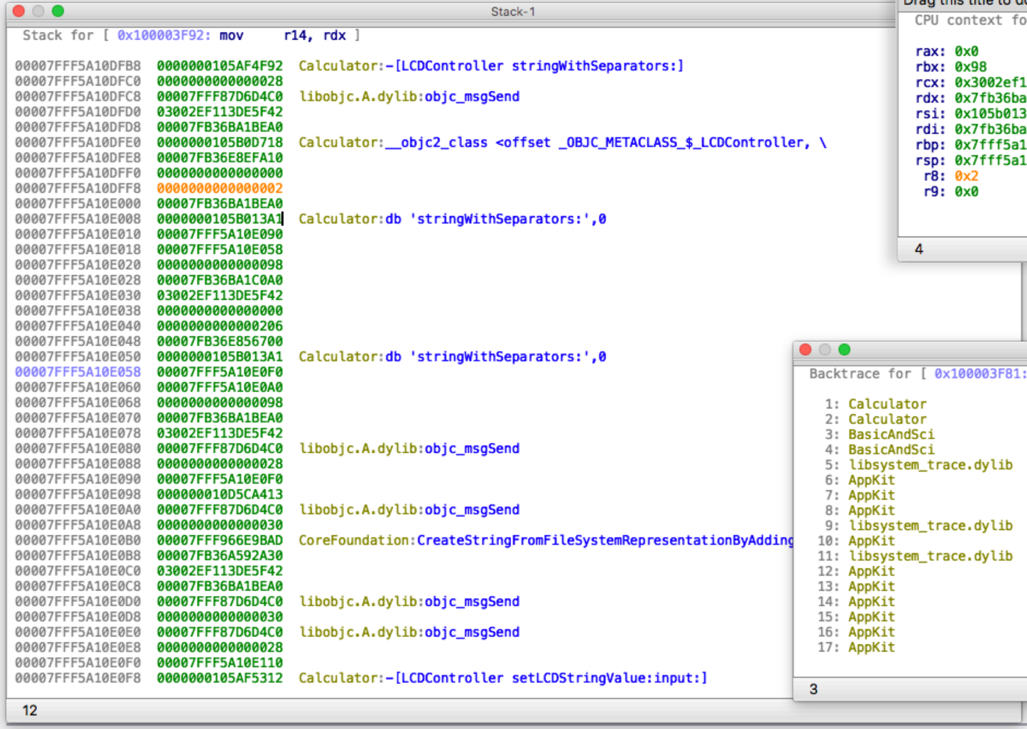


```
if (gTargetOS == "unset")
{
    const desc = Process.platform + "_" + Process.arch;

    var rePattern = new RegExp(/^Version ([0-9]+\.[0-9]+(\.[0-9]+)?) \(Build ([0-9A-Z]+)\)$/gm);
    var matches = rePattern.exec(ObjC.classes.NSProcessInfo.processInfo().operatingSystemVersionString().UTF8String());
    const version = matches[1];
    const build = matches[3];

    switch(desc)
    {
        case "darwin_arm":
        case "darwin_arm64":
            gTargetOS = "iOS " + version + " (" + build + ")";
            break;

        case "darwin_ia32":
        case "darwin_x64":
            gTargetOS = "OSX " + version + " (" + build + ")";
            break;

        default:
            send({ id: kMessageID_Error, data: "Unknown OS: " + ObjC.classes.NSProcessInfo.processInfo().operatingSystemVersionString() });
            gTargetOS = "unknown";
    }
}

console.log(gTargetOS);
```

Execute custom script dialog

FridaLink – CPU Context Monitoring

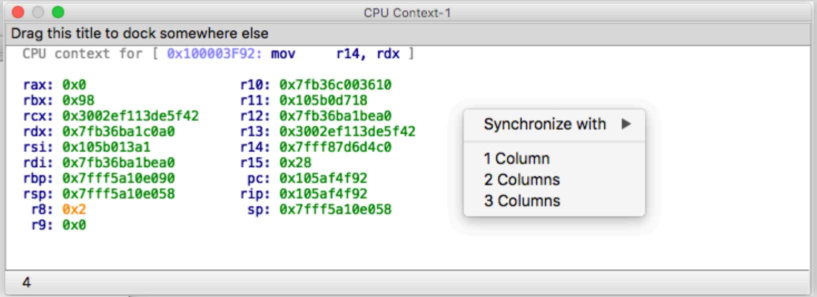
Stack


Stack-1

```
 Stack for [ 0x100003F92: mov     r14, rdx ]

00007FFF5A10DFB8  0000000105AF4F92  Calculator:-[LCDController stringWithSeparators:]
00007FFF5A10DFC0  0000000000000028
00007FFF5A10DFC8  00007FFF87D6D4C0  libobjc.A.dylib:objc_msgSend
00007FFF5A10DFD0  03002EF113DE5F42
00007FFF5A10DFD8  00007FB36BA1BEA0
00007FFF5A10DFE0  0000000105B0D718  Calculator:__objc2_class <offset _OBJC_METACLASS_$_LCDController, \
00007FFF5A10DFE8  00007FB36E8EFA10
00007FFF5A10DFF0  0000000000000000
00007FFF5A10DFF8  0000000000000002
00007FFF5A10E000  00007FB36BA1BEA0
00007FFF5A10E008  0000000105B013A1  Calculator:db 'stringWithSeparators:',0
00007FFF5A10E010  00007FFF5A10E090
00007FFF5A10E018  00007FFF5A10E058
00007FFF5A10E020  0000000000000098
00007FFF5A10E028  00007FB36BA1C0A0
00007FFF5A10E030  03002EF113DE5F42
00007FFF5A10E038  0000000000000000
00007FFF5A10E040  0000000000000206
00007FFF5A10E048  00007FB36E856700
00007FFF5A10E050  0000000105B013A1  Calculator:db 'stringWithSeparators:',0
00007FFF5A10E058  00007FFF5A10E0F0
00007FFF5A10E060  00007FFF5A10E0A0
00007FFF5A10E068  0000000000000098
00007FFF5A10E070  00007FB36BA1BEA0
00007FFF5A10E078  03002EF113DE5F42
00007FFF5A10E080  00007FFF87D6D4C0  libobjc.A.dylib:objc_msgSend
00007FFF5A10E088  0000000000000028
00007FFF5A10E090  00007FFF5A10E0F0
00007FFF5A10E098  000000010D5CA413
00007FFF5A10E0A0  00007FFF87D6D4C0  libobjc.A.dylib:objc_msgSend
00007FFF5A10E0A8  0000000000000030
00007FFF5A10E0B0  00007FFF966E9BAD  CoreFoundation:CreateStringFromFileSystemRepresentationByAdding
00007FFF5A10E0B8  00007FB36A592A30
00007FFF5A10E0C0  03002EF113DE5F42
00007FFF5A10E0C8  00007FB36BA1BEA0
00007FFF5A10E0D0  00007FFF87D6D4C0  libobjc.A.dylib:objc_msgSend
00007FFF5A10E0D8  0000000000000030
00007FFF5A10E0E0  00007FFF87D6D4C0  libobjc.A.dylib:objc_msgSend
00007FFF5A10E0E8  0000000000000028
00007FFF5A10E0F0  00007FFF5A10E110
00007FFF5A10E0F8  0000000105AF5312  Calculator:-[LCDController setLCDStringValue:input:]
```

12

CPU context

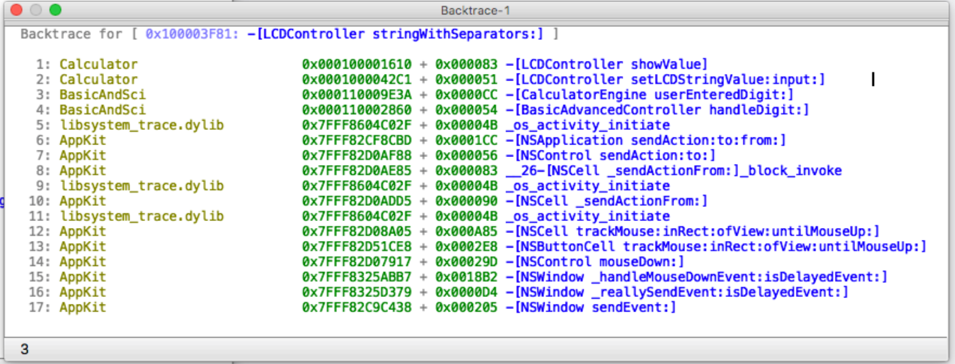

CPU Context-1

Drag this title to dock somewhere else

```
 CPU context for [ 0x100003F92: mov     r14, rdx ]

 rax: 0x0                 r10: 0x7fb36c003610
 rbx: 0x98                r11: 0x105b0d718
 rcx: 0x3002ef113de5f42   r12: 0x7fb36ba1bea0
 rdx: 0x7fb36ba1c0a0      r13: 0x3002ef113de5f42
 rsi: 0x105b013a1         r14: 0x7fff87d6d4c0
 rdi: 0x7fb36ba1bea0      r15: 0x28
 rbp: 0x7fff5a10e090       pc: 0x105af4f92
 rsp: 0x7fff5a10e058      rip: 0x105af4f92
  r8: 0x2                  sp: 0x7fff5a10e058
  r9: 0x0
```

4

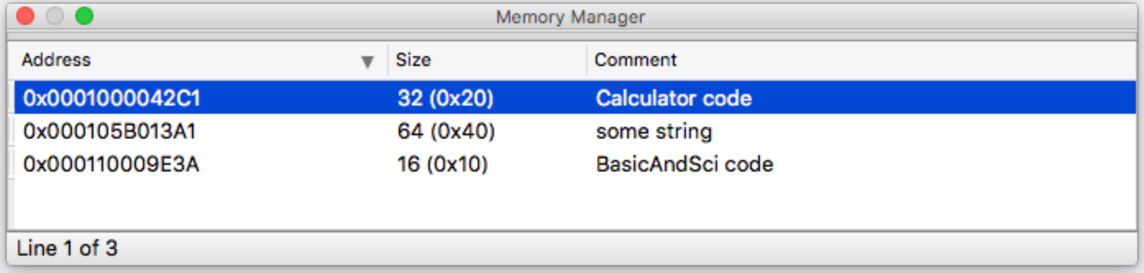
Backtrace


Backtrace-1

```
 Backtrace for [ 0x100003F81: -[LCDController stringWithSeparators:] ]

  1: Calculator                0x000100001610 + 0x000083 -[LCDController showValue]
  2: Calculator                0x0001000042C1 + 0x000051 -[LCDController setLCDStringValue:input:]
  3: BasicAndSci               0x000110009E3A + 0x0000CC -[CalculatorEngine userEnteredDigit:]
  4: BasicAndSci               0x000110002860 + 0x000054 -[BasicAdvancedController handleDigit:]
  5: libsystem_trace.dylib     0x7FFF8604C02F + 0x00004B _os_activity_initiate
  6: AppKit                    0x7FFF82CF8CBD + 0x0001CC -[NSApplication sendAction:to:from:]
  7: AppKit                    0x7FFF82D0AF88 + 0x000056 -[NSControl sendAction:to:]
  8: AppKit                    0x7FFF82D0AE85 + 0x000083 __26-[NSCell _sendActionFrom:]_block_invoke
  9: libsystem_trace.dylib     0x7FFF8604C02F + 0x00004B _os_activity_initiate
 10: AppKit                    0x7FFF82D0ADD5 + 0x000090 -[NSCell _sendActionFrom:]
 11: libsystem_trace.dylib     0x7FFF8604C02F + 0x00004B _os_activity_initiate
 12: AppKit                    0x7FFF82D08A05 + 0x000A85 -[NSCell trackMouse:inRect:ofView:untilMouseUp:]
 13: AppKit                    0x7FFF82D51CE8 + 0x0002E8 -[NSButtonCell trackMouse:inRect:ofView:untilMouseUp:]
 14: AppKit                    0x7FFF82D07917 + 0x00029D -[NSControl mouseDown:]
 15: AppKit                    0x7FFF8325ABB7 + 0x0018B2 -[NSWindow _handleMouseDownEvent:isDelayedEvent:]
 16: AppKit                    0x7FFF8325D379 + 0x0000D4 -[NSWindow _reallySendEvent:isDelayedEvent:]
 17: AppKit                    0x7FFF82C9C438 + 0x000205 -[NSWindow sendEvent:]
```

3

FridaLink – Memory Monitoring

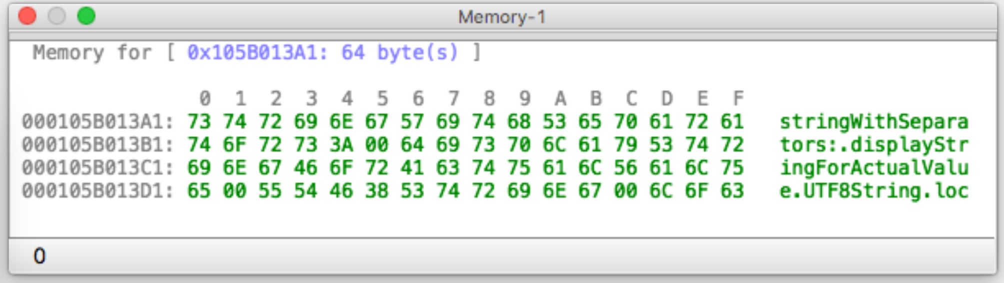


Memory Manager

Address	Size	Comment
0x0001000042C1	32 (0x20)	Calculator code
0x000105B013A1	64 (0x40)	some string
0x000110009E3A	16 (0x10)	BasicAndSci code

Line 1 of 3

Memory manger

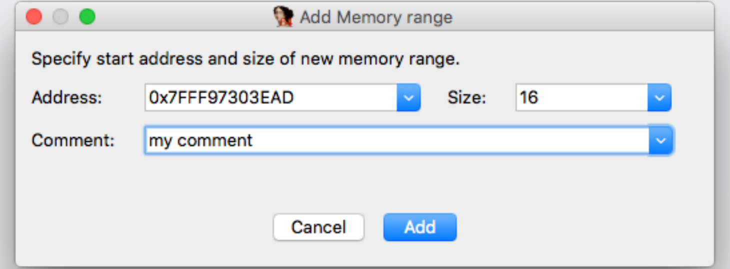


Memory-1

```
Memory for [ 0x105B013A1: 64 byte(s) ]

              0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
000105B013A1: 73 74 72 69 6E 67 57 69 74 68 53 65 70 61 72 61   stringWithSepara
000105B013B1: 74 6F 72 73 3A 00 64 69 73 70 6C 61 79 53 74 72   tors:.displayStr
000105B013C1: 69 6E 67 46 6F 72 41 63 74 75 61 6C 56 61 6C 75   ingForActualValu
000105B013D1: 65 00 55 54 46 38 53 74 72 69 6E 67 00 6C 6F 63   e.UTF8String.loc
```

0

Memory content



Add Memory range

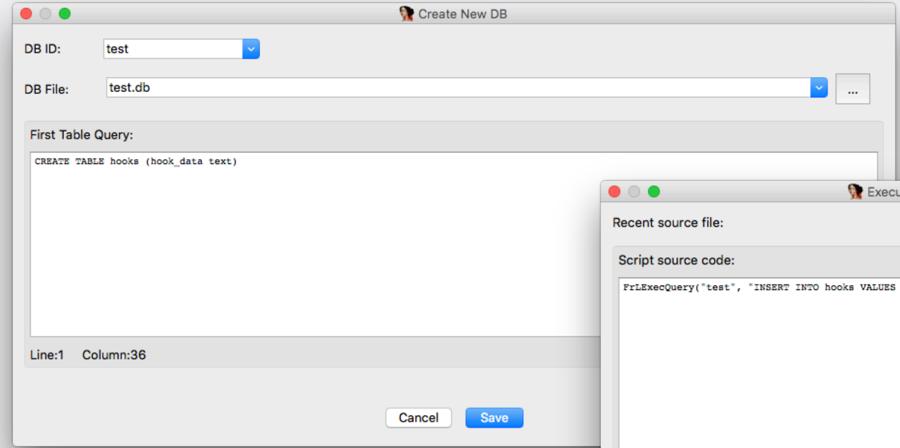
Specify start address and size of new memory range.

Address: 0x7FFF97303EAD Size: 16

Comment: my comment

Add new memory watchpoint

FridaLink – SQLite Support



DB ID: test

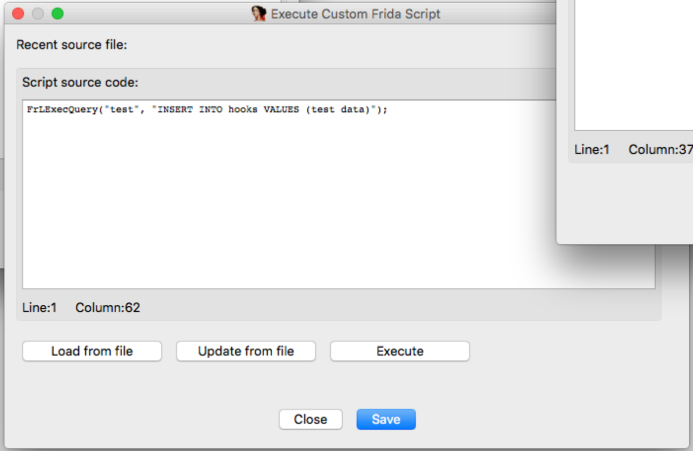
DB File: test.db

First Table Query:

```
CREATE TABLE hooks (hook_data text)
```

Line:1 Column:36

Set up DB



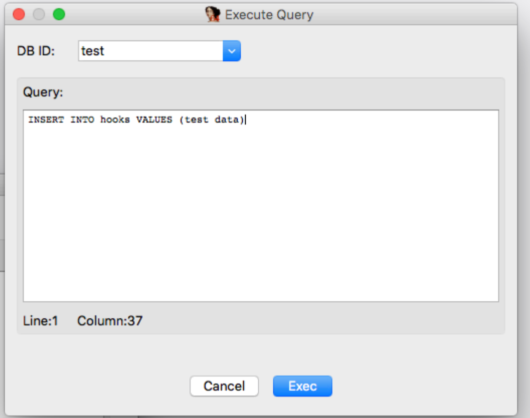
Recent source file:

Script source code:

```
FrLExecQuery("test", "INSERT INTO hooks VALUES (test data)");
```

Line:1 Column:62

Load script



DB ID: test

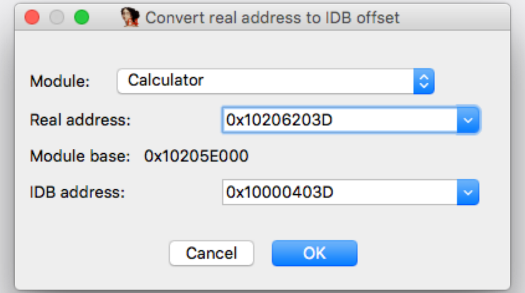
Query:

```
INSERT INTO hooks VALUES (test data)
```

Line:1 Column:37

Query execution

FridaLink – Helpers and more



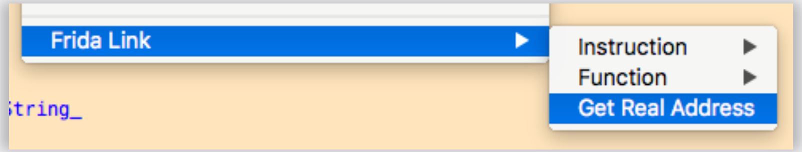
Convert real address to IDB offset

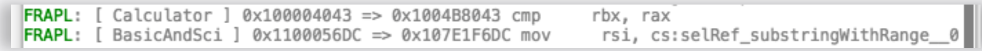
Module: Calculator

Real address: 0x10206203D

Module base: 0x10205E000

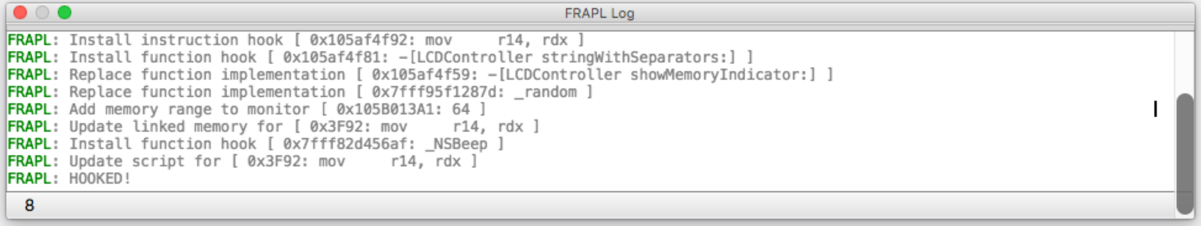
IDB address: 0x10000403D





```
FRAPL: [ Calculator ] 0x100004043 => 0x1004B8043 cmp     rbx, rax
FRAPL: [ BasicAndSci ] 0x1100056DC => 0x107E1F6DC mov     rsi, cs:selRef_substringWithRange__0
```

Address converter



FRAPL Log

```
FRAPL: Install instruction hook [ 0x105af4f92: mov     r14, rdx ]
FRAPL: Install function hook [ 0x105af4f81: -[LCDController stringWithSeparators:] ]
FRAPL: Replace function implementation [ 0x105af4f59: -[LCDController showMemoryIndicator:] ]
FRAPL: Replace function implementation [ 0x7fff95f1287d: _random ]
FRAPL: Add memory range to monitor [ 0x105B013A1: 64 ]
FRAPL: Update linked memory for [ 0x3F92: mov     r14, rdx ]
FRAPL: Install function hook [ 0x7fff82d456af: _NSBeep ]
FRAPL: Update script for [ 0x3F92: mov     r14, rdx ]
FRAPL: HOOKED!
```

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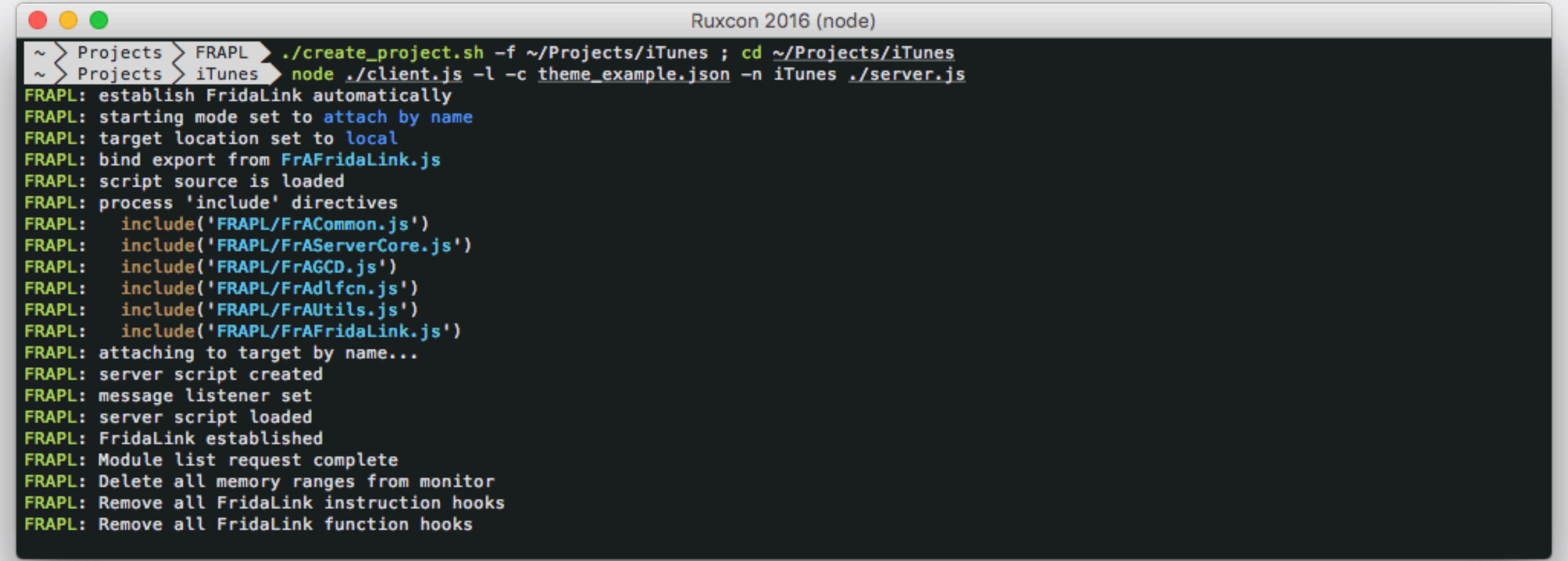
FRAPL logs

Getting Started

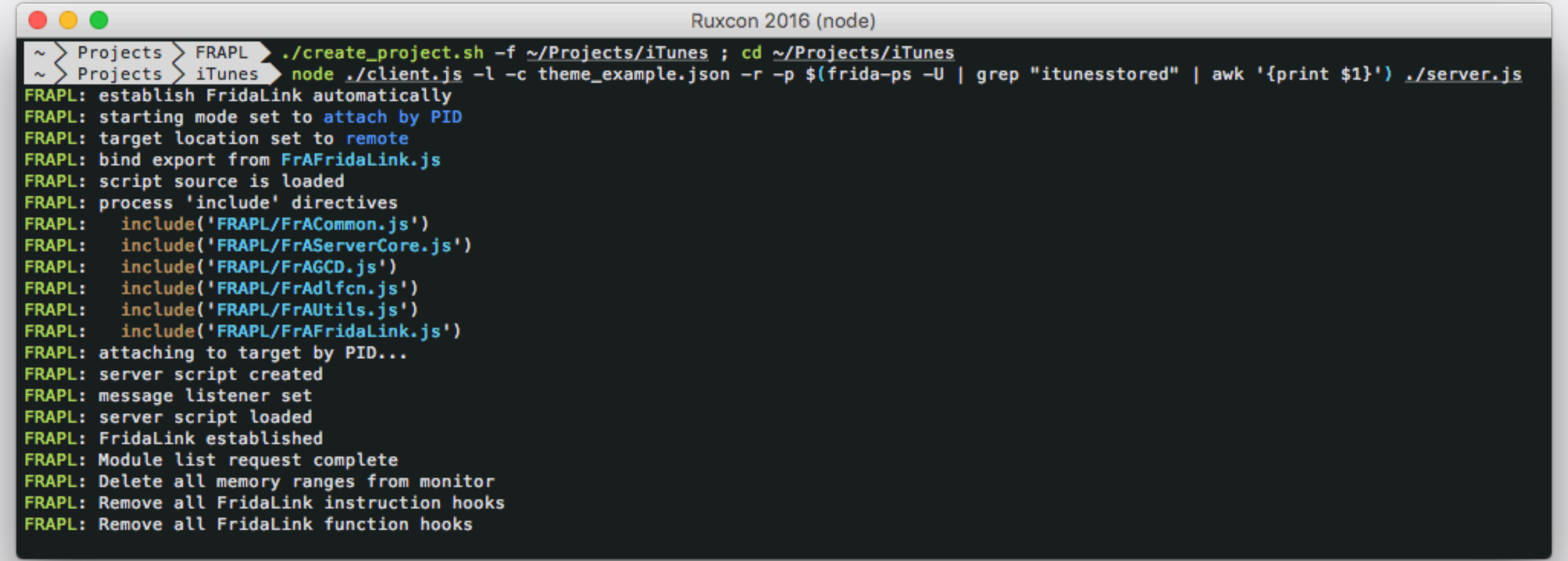
1. Load FridaLink.py into IDA
2. Create project using create_project.sh
3. Run client with node

macOS Application Demo


Ruxcon 2016 (node)

```
~ > Projects > FRAPL > ./create_project.sh -f ~/Projects/iTunes ; cd ~/Projects/iTunes
~ > Projects > iTunes > node ./client.js -l -c theme_example.json -n iTunes ./server.js
FRAPL: establish FridaLink automatically
FRAPL: starting mode set to attach by name
FRAPL: target location set to local
FRAPL: bind export from FrAFridaLink.js
FRAPL: script source is loaded
FRAPL: process 'include' directives
FRAPL:   include('FRAPL/FrACommon.js')
FRAPL:   include('FRAPL/FrAServerCore.js')
FRAPL:   include('FRAPL/FrAGCD.js')
FRAPL:   include('FRAPL/FrAdlfcn.js')
FRAPL:   include('FRAPL/FrAUtils.js')
FRAPL:   include('FRAPL/FrAFridaLink.js')
FRAPL: attaching to target by name...
FRAPL: server script created
FRAPL: message listener set
FRAPL: server script loaded
FRAPL: FridaLink established
FRAPL: Module list request complete
FRAPL: Delete all memory ranges from monitor
FRAPL: Remove all FridaLink instruction hooks
FRAPL: Remove all FridaLink function hooks
```

iOS Application Demo



Ruxcon 2016 (node)

```
~ > Projects > FRAPL > ./create_project.sh -f ~/Projects/iTunes ; cd ~/Projects/iTunes
~ > Projects > iTunes > node ./client.js -l -c theme_example.json -r -p $(frida-ps -U | grep "itunesstored" | awk '{print $1}') ./server.js
FRAPL: establish FridaLink automatically
FRAPL: starting mode set to attach by PID
FRAPL: target location set to remote
FRAPL: bind export from FrAFridaLink.js
FRAPL: script source is loaded
FRAPL: process 'include' directives
FRAPL:   include('FRAPL/FrACommon.js')
FRAPL:   include('FRAPL/FrAServerCore.js')
FRAPL:   include('FRAPL/FrAGCD.js')
FRAPL:   include('FRAPL/FrAdlfcn.js')
FRAPL:   include('FRAPL/FrAUtils.js')
FRAPL:   include('FRAPL/FrAFridaLink.js')
FRAPL: attaching to target by PID...
FRAPL: server script created
FRAPL: message listener set
FRAPL: server script loaded
FRAPL: FridaLink established
FRAPL: Module list request complete
FRAPL: Delete all memory ranges from monitor
FRAPL: Remove all FridaLink instruction hooks
FRAPL: Remove all FridaLink function hooks
```

WEN ETA RELES ??

eta son

https://github.com/FriedAppleTeam

Future plans

- Kernel support
- Windows support ?
- Android support ?
- Hack the planet!

Questions

@getorix

@mbazaliy

special thanks to

@in7egral