PLAY FUZZING MACHINE
hunting iOS/Osx kernel vulnerability automatically and Smartly

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About Me

- Lilang Wu
  - 4 years security experience
  - macOS/iOS malware/vulnerability
  - Fuzzing project
  - Twitter: @Lilang_Wu
  - BH USA 2019, 2018, BH EU 2018, HITB, CodeBlue
- Moony Li
  - 10 years security
  - MacOS/Android/iOS vulnerability
  - Vul hunt and exploit, SandBox dev
  - Twitter: @Flyic
  - BH 2019,2018,2016…

Agenda

- Static Analysis for Kernel Extensions Attack Interfaces
- Enhanced PassiveFuzz
- Vulnerabilities Found
- Conclusion

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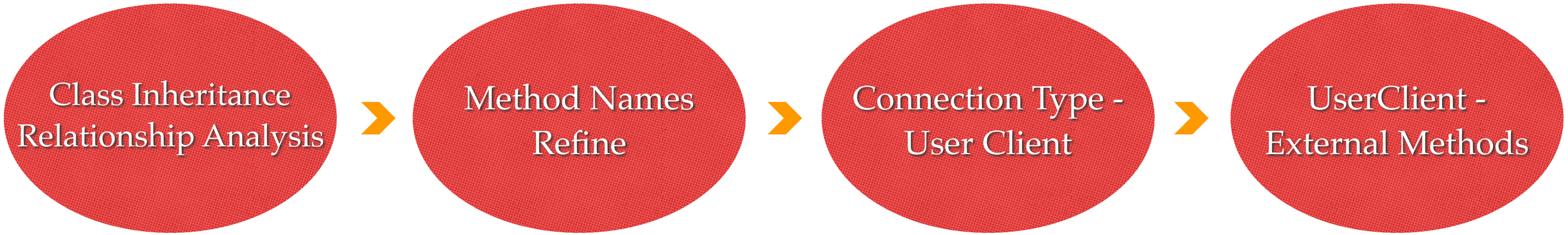
Kexts Interfaces Analysis Flow



Class Inheritance Relationship

- rdi/x0: instance of register Meta class
- rsi/x1: Meta class name
- rdx/x2: instance of parent Meta class
- rcx/w3: size of register Meta class instance

```
__GLOBAL__sub_I_IOAccelMemory_cpp proc near
                                        ; DATA XREF: __mod_init_func:0000000000590E0↓o
                push    rbp
                mov     rbp, rsp
                lea     rdi, __ZN13IOAccelMemory10gMetaClassE ; IOAccelMemory::gMetaClass
                lea     rsi, aIoaccelmemory ; "IOAccelMemory"
                mov     rdx, cs:__ZN8OSObject10gMetaClassE_0 ; OSObject::gMetaClass
                mov     ecx, 0A0h ; '
                call    __ZN11OSMetaClassC2EPKcPKS_j ; OSMetaClass::OSMetaClass(char const*,OSMetaClass const*,uint)
                lea     rax, off_59550
                mov     cs:__ZN13IOAccelMemory10gMetaClassE, rax ; IOAccelMemory::gMetaClass
                pop     rbp
                retn
__GLOBAL__sub_I_IOAccelMemory_cpp endp
```

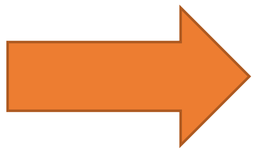
Method Name Refine

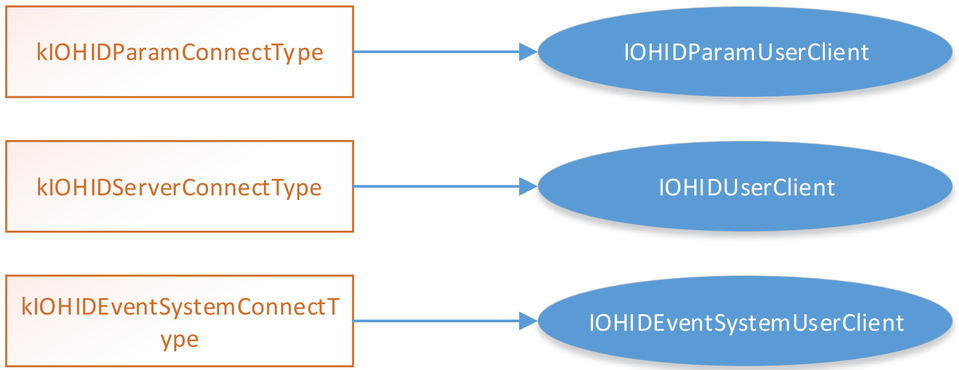
IOMobileFramebuffer ->IOService->IORegistryEntry->OSObject

Connection Type - UserClients

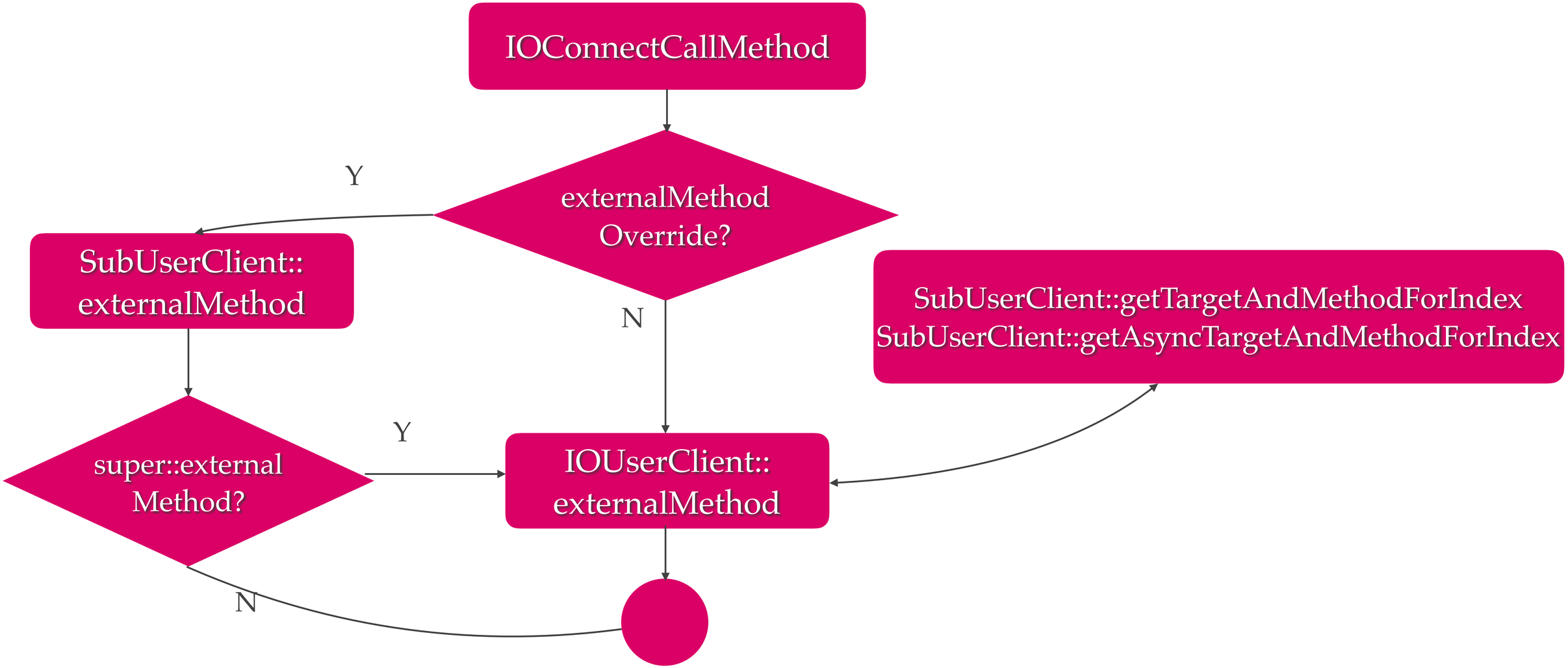
- Locate the newUserClient function address for IOServices
- Analyze the ASM instructions to enumerate the connection types
- Analyze the ASM instructions to get the corresponding user client for each connection type

```
do {
    if (type == kIOHIDParamConnectType) {
        if (eventsOpen) {
            newConnect = new IOHIDParamUserClient;
        } else {
            err = kIOReturnNotOpen;
            break;
        }
    }
    else if ( type == kIOHIDServerConnectType) {
        newConnect = new IOHIDUserClient;
    }
    else if ( type == kIOHIDStackShotConnectType ) {
        newConnect = new IOHIDStackShotUserClient;
    }
    else if ( type == kIOHIDEventSystemConnectType ) {
        newConnect = new IOHIDEventSystemUserClient;
    }
    else {
        err = kIOReturnUnsupported;
    }
```

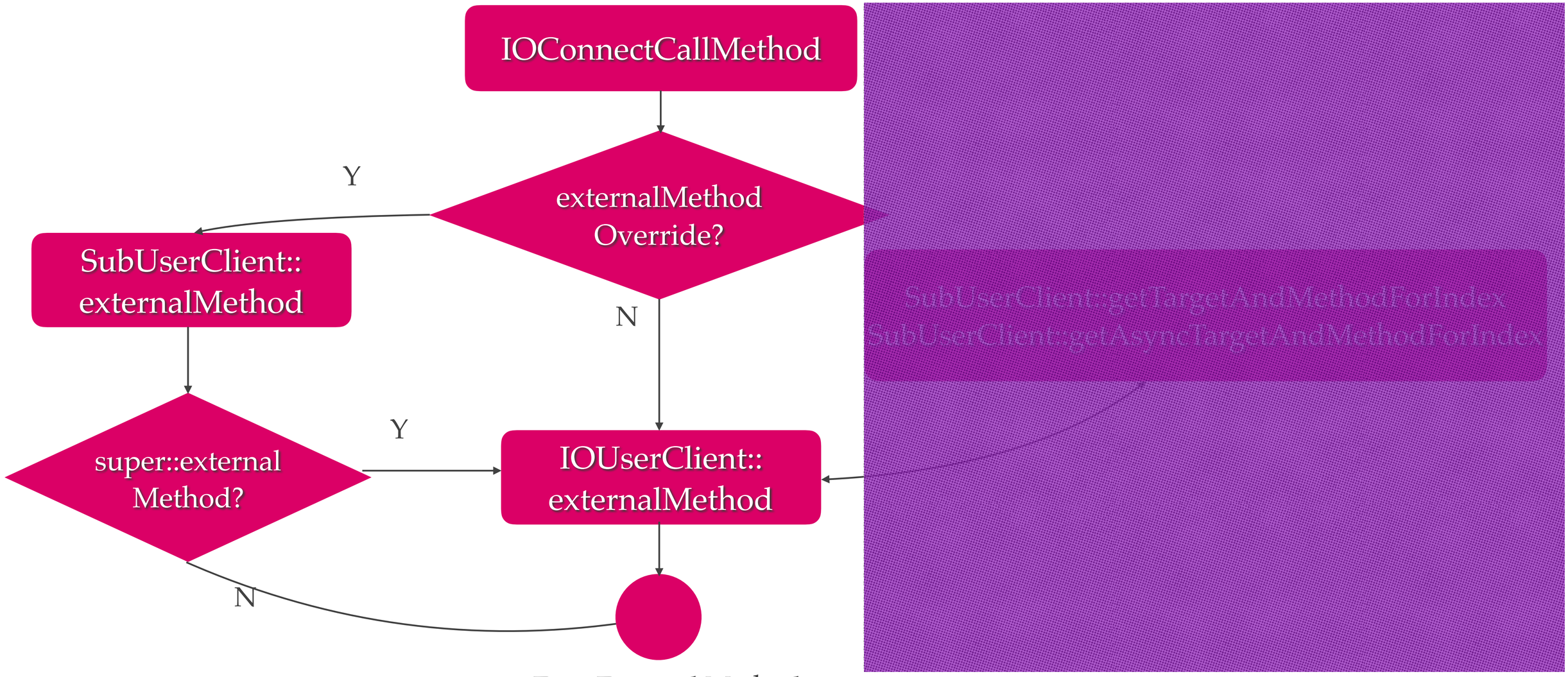




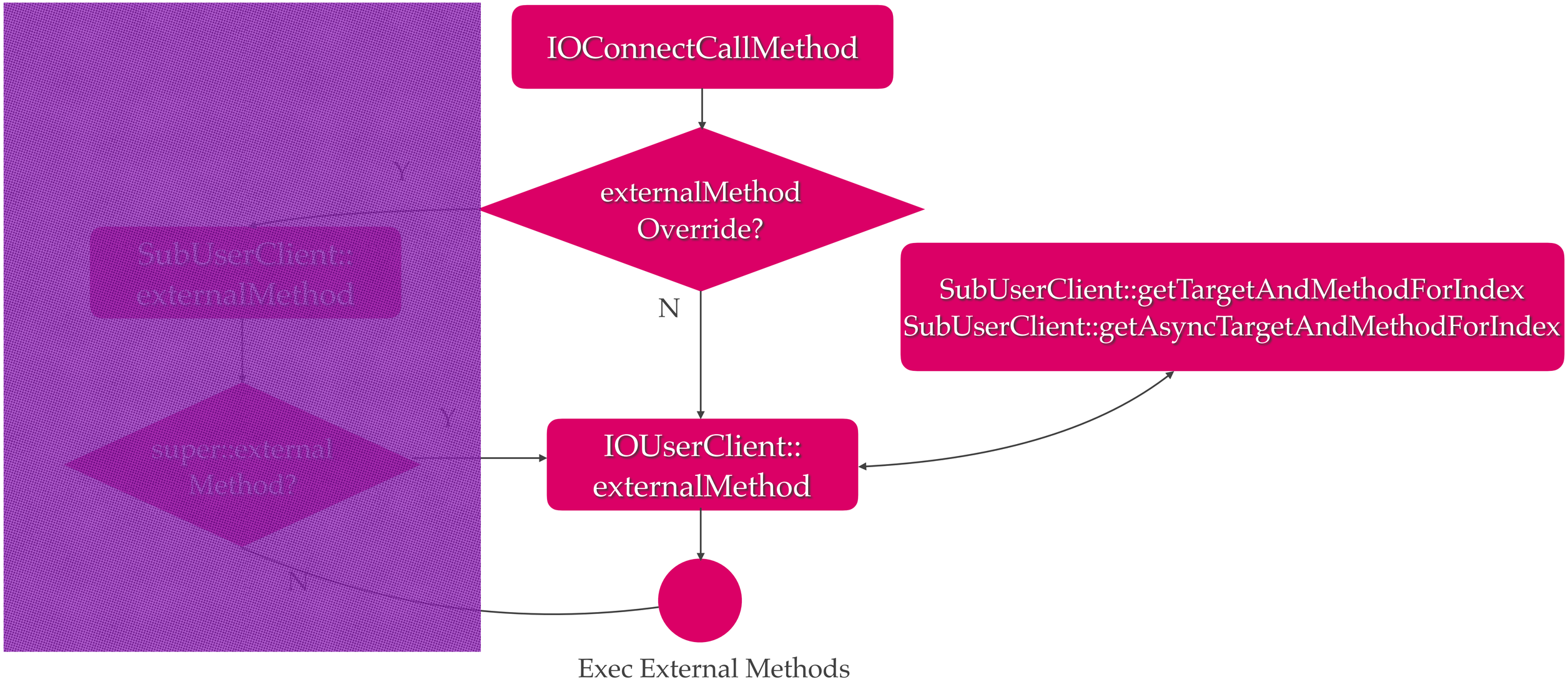
UserClient - External Methods



UserClient - External Methods



UserClient - External Methods



Two Graceful Implementation(1/3)

```
struct IOExternalMethodDispatch
{
    IOExternalMethodAction function;
    uint32_t        checkScalarInputCount;
    uint32_t        checkStructureInputSize;
    uint32_t        checkScalarOutputCount;
    uint32_t        checkStructureOutputSize;
};
```

```
IOReturn IOHIDEventServiceUserClient::externalMethod(
                                uint32_t                    selector,
                                IOExternalMethodArguments * arguments,
                                IOExternalMethodDispatch *  dispatch,
                                OSObject *                  target,
                                void *                      reference)
{
    if (selector < (uint32_t) kIOHIDEventServiceUserClientNumCommands)
    {
        dispatch = (IOExternalMethodDispatch *) &sMethods[selector];

        if (!target)
            target = this;
    }

        return super::externalMethod(selector, arguments, dispatch, target, re
}
```

Two Graceful Implementation(3/3)

```
//===========================================================================
// IOHIDEventServiceUserClient::sMethods
//===========================================================================
const IOExternalMethodDispatch IOHIDEventServiceUserClient::sMethods[kIOHIDEventServiceUserClientNumCommands] = {
    { //    kIOHIDEventServiceUserClientOpen
        (IOExternalMethodAction) &IOHIDEventServiceUserClient::_open,
        1, 0,
    0, 0
    },
    { //    kIOHIDEventServiceUserClientClose
        (IOExternalMethodAction) &IOHIDEventServiceUserClient::_close,
        1, 0,
    0, 0
    },
    { //    kIOHIDEventServiceUserClientCopyEvent
        (IOExternalMethodAction) &IOHIDEventServiceUserClient::_copyEvent,
        2, -1,
    0, -1
    },
    { //    kIOHIDEventServiceUserClientSetElementValue
        (IOExternalMethodAction) &IOHIDEventServiceUserClient::_setElementValue,
        3, 0,
    0, 0
    },
};
```

Two Graceful Implementation(2/3)

```
struct IOExternalMethod
{
    IOService *   object;
    IOMethod    func;
    IOOptionBits flags;
    IOByteCount   count0;
    IOByteCount   count1;
};
```

```
IOExternalMethod * IOI2CInterfaceUserClient::getTargetAndMethodForIndex(
    IOService ** targetP, UInt32 index )
{
    static const IOExternalMethod methodTemplate[] = {
                /* 0 */  { NULL, (IOMethod) &IOI2CInterfaceUserClient::extAcquireBus,
                           kIOUCScalarIScalar0, 0, 0 },
                /* 1 */  { NULL, (IOMethod) &IOI2CInterfaceUserClient::extReleaseBus,
                           kIOUCScalarIScalar0, 0, 0 },
                /* 3 */  { NULL, (IOMethod) &IOI2CInterfaceUserClient::extIO,
                           kIOUCStructIStruct0, 0xffffffff, 0xffffffff },
            };

    if (index >= (sizeof(methodTemplate) / sizeof(methodTemplate[0])))
        return (NULL);

    *targetP = this;
    return ((IOExternalMethod *)(methodTemplate + index));
}
```

Parse Method

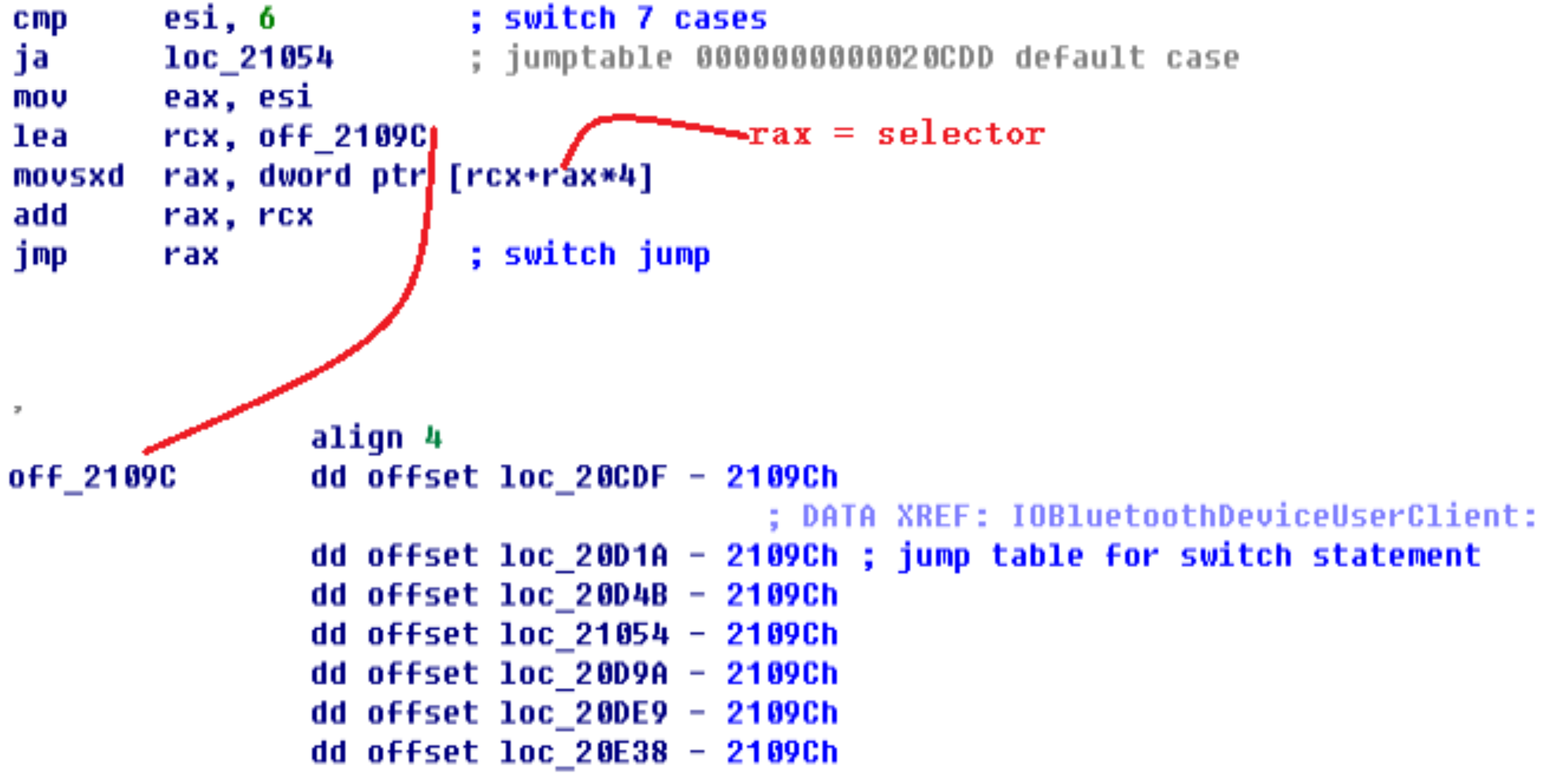
- Parse "Symbol Table“ section
- Search Constant Array name, shown as "String Table Index“
- Start with “__ZZN” or “__ZN”
- Locate the address, shown as "value"

```
String Table Index      __ZZN23IOFramebufferUserClient14externalMethodEjP25IOExternalMethodArgumentsP24IOExternalMethodDispatchP8OSObjectPvE14methodTemplate
Type
0E                      N_SECT
Section Index           7 (__DATA,__const)
Description
Value                   205360 ($+41072)
```

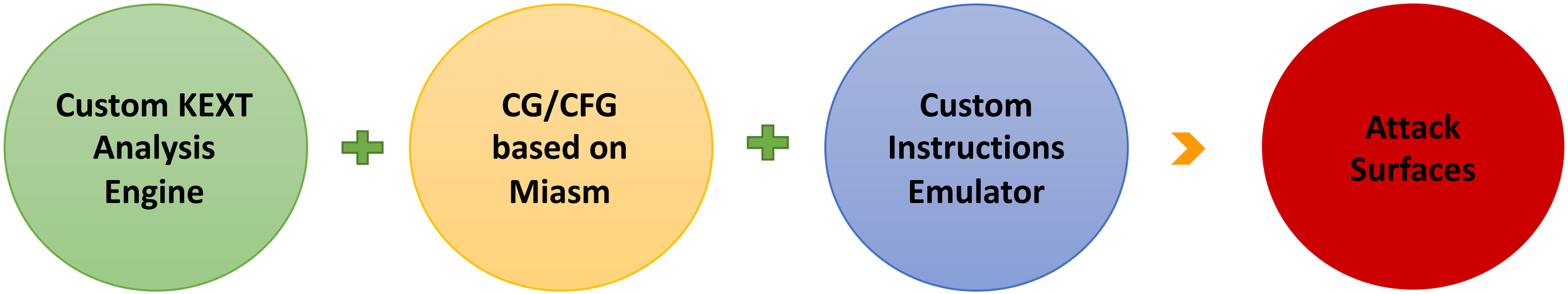
```
000627A0  0000C05F              String Table Index      __ZN18IOHIDLibUserClient8sMethodsE
000627A4  0F                    Type
                                0E                      N_SECT
                                01                      N_EXT
000627A5  08                    Section Index           8 (__DATA,__const)
000627A6  0000                  Description
000627A8  0000000000042F10      Value                   274192 ($+11216)
```

The Ugly Implementation

- Locate the address of override externalMethod Function
- Analyze the ASM instructions to get selector and external methods



Analyze the ASM Instructions



Custom KEXTs Analysis Engine

- MachOHeader(object)
  - __init__(self, fh, offset, size)
  - get_driver_list(self)
  - __parser_driver_dict(self, bundle)
  - macho_get_vmaddr(self, segname, sectname)
  - macho_get_fileaddr(self, segname, sectname)
  - macho_get_size(self, segname, sectname)
  - macho_get_loadcmds(self)
  - memcpy(self, start_fileaddr, size)
  - get_mem_from_vmaddr(self, anchor_f, anchor_vm, src_vm)
  - get_memStr_from_vmaddr(self, anchor_f, anchor_vm, src_vm
  - get_memStr_from_f(self, file_off)
  - get_f_from_vm(self, anchor_f, anchor_vm, src_vm)
  - get_vm_from_f(self, anchor_f, anchor_vm, src_f)
  - get_prelinkf_from_vm(self, src_vm)
  - get_prelinkvm_from_f(self, anchor_vm, anchor_f, src_f)
  - MH_MAGIC
  - endian
  - fh
  - kernel_header
  - mach_header
  - offset
  - prelink_offset
  - size
  - sizediff

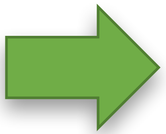
- KernelMachO(object)
  - __init__(self, filename=None, base_addr=0xffffff007004(
  - load(self, fh)
  - load_fat(self, fh)
  - load_header(self, fh, offset, size)
  - get_section_addrs(self)
  - get_other_addrs(self)
  - get_driver_list(self)
  - extract_kext(self, bundleID=None, dir=None)
  - __construct_kext(self, bundle, offset, prelink_offset, dir)
  - __dump_kext_data(self, fd, fh_offset, data_size, fd_offset)
  - __parser_driver_dict(self, bundle)
  - base_addr
  - driver_list_notprelink
  - driver_list_prelink
  - fat
  - filename
  - headers

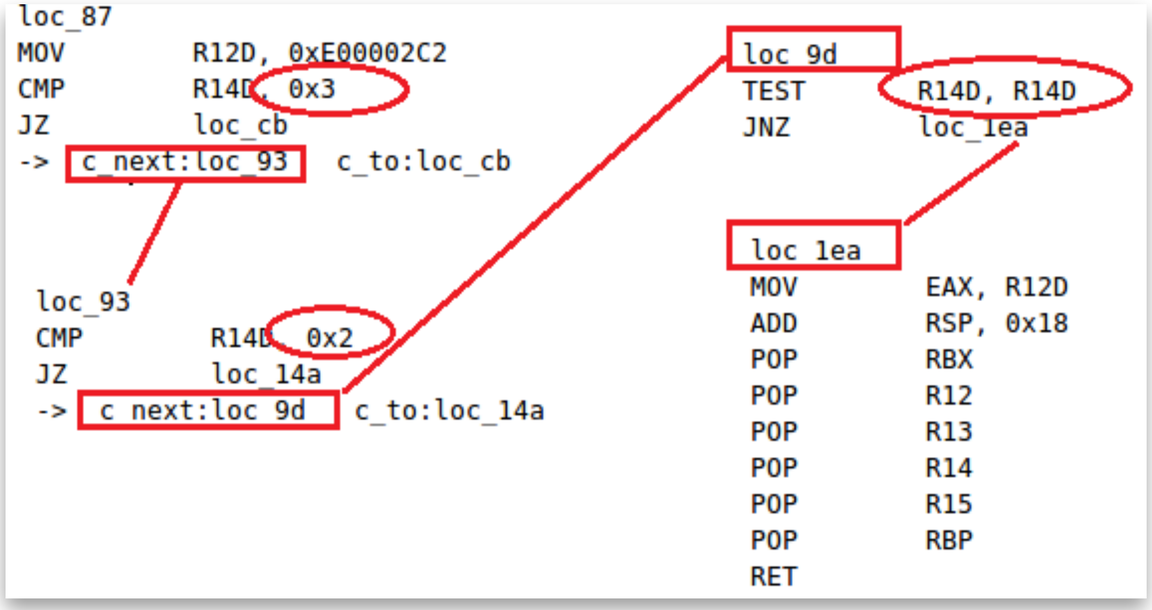
- OSMetaClass(object)
  - __init__(self)
  - IOExternalAsyncMethod
  - IOExternalMethod
  - IOExternalMethodDispatch
  - can_ser_open
  - can_ser_open_type
  - class_name
  - class_self_addr
  - class_size
  - class_super_addr
  - class_super_list
  - class_super_name
  - extends_list
  - externalMethod_f
  - externalMethod_vm
  - getAsyncTargetAndMethodForIndex_f
  - getAsyncTargetAndMethodForIndex_vm
  - getTargetAndMethodForIndex_f
  - getTargetAndMethodForIndex_vm
  - getTargetAndTrapForIndex_f
  - getTargetAndTrapForIndex_vm
  - havePublishedResource
  - instance_list
  - is_ioeam
  - is_ioem
  - is_ioemd
  - metaclass_list
  - metaclass_vt_f
  - metaclass_vt_vm
  - newUserClient_f
  - newUserClient_vm
  - object_vt_f

Generate CFG using Miasm

AppleHDAEngine::newUserClient(, , type,)

```
loc_2C1F1:                              ; CODE XREF: AppleHDA
                mov     r12d, 0E00002C2h
                cmp     r14d, 3
                jz      short loc_2C235
                cmp     r14d, 2
                jz      loc_2C2B4
                test    r14d, r14d
                jnz     loc_2C354
                mov     rax, cs:off_920E0
                xor     ecx, ecx
                mov     rdi, r13
                mov     rsi, r15
                mov     rdx, [rbp-40h]
                mov     r8, [rbp-30h]
                call    qword ptr [rax+788h]
                mov     r12d, eax
                jmp     loc_2C354
; ---------------------------------------------------------------------------

loc_2C235:                              ; CODE XREF: AppleHDA
                lea     rax, __ZN24AppleHDAEngineUserClient9
                mov     rdi, [rax]
                mov     rax, [rdi]
                call    qword ptr [rax+88h]
```

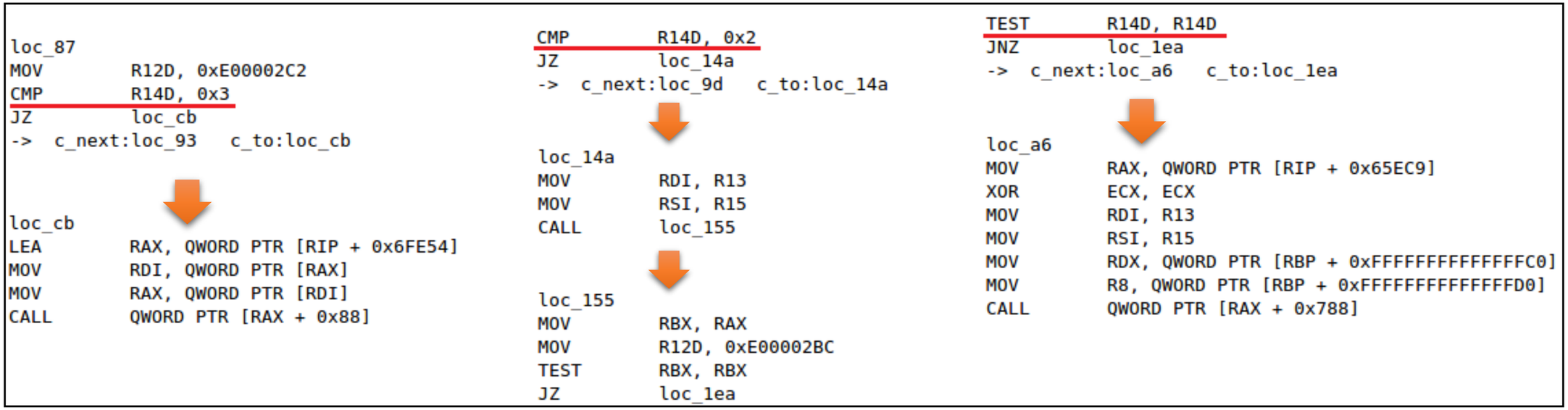




https://github.com/cea-sec/miasm

Analysis key paths based on CFG

- Key Paths based on Key registers
  - RCX register in “newUserClient“ function
  - RSI register in “externalMethod“ function
  - Tracking data flow between registers, as shown below, RCX move to R14D register



Custom Instruction Emulator

- ARM Emulator
  - adrp/adr, add, mov/mov
- nX86_64 Emulator
  - lea, mov, call, cmp, jz, je…

```
if not cmp(mnemonic, "str"):
    reg_num = insn.op_count(CS_OP_REG)
    if reg_num == 1:
        continue
    f_reg = get_first_reg(insn)
    if f_reg == arm64_const.ARM64_REG_XZR or f_reg == arm64
                f_reg == arm64_const.ARM64_REG_WZR:
        continue
    s_reg = get_second_reg(insn)

    if s_reg:
        s_reg_v = get_actual_value_by_regN(s_reg)
        if not (s_reg_v and s_reg_v == meta_class.class_sel
            continue
    else:
        continue

    f_reg_v_vm = get_actual_value_by_regN(f_reg)
    if iskext:
        f_reg_v_f = k_header.get_prelinkf_from_vm(f_reg_v_v
    else:
        f_reg_v_f = k_header.get_f_from_vm(each_mif_f, each

    parse_const_func(k_header, meta_class, f_reg_v_vm,
                     f_reg_v_f, iskext)
```

```
def get_single_IMM(insn):
    seg_num = insn.op_count(CS_OP_IMM)
    if seg_num > 1:
        print "Extract: too much imm reg!"
    if seg_num != 1:
        print "Extract: no imm reg found!"
    return to_x(insn.op_find(CS_OP_IMM, 1).value.imm)

def get_mem_op_offset(insn):
    mem_num = insn.op_count(CS_OP_MEM)
    if mem_num >= 1:
        offset = insn.op_find(CS_OP_MEM, 1).mem.disp
        return offset

def get_mem_op_reg(insn):
    mem_num = insn.op_count(CS_OP_MEM)
    if mem_num >= 1:
        offset = insn.op_find(CS_OP_MEM, 1).mem.base
        return offset

def get_first_reg(insn):
    return insn.op_find(CS_OP_REG, 1).value.reg


def get_second_reg(insn):
    return insn.op_find(CS_OP_REG, 2).value.reg
```

```
if not cmp(mnemonic, "bl"):
    if insn.op_count(CS_OP_IMM):
        bl_addr_vm = get_single_IMM(insn)
        meta_class = OSMetaClass()
        if bl_addr_vm == OSMetaClass_OSMetaClass_VMaddr:
            #meta_class = OSMetaClass()

  = get_actual_value_by_regN(arm64_const.ARM64_REG_X0)
  = get_actual_value_by_regN(arm64_const.ARM64_REG_X1)
r = get_actual_value_by_regN(arm64_const.ARM64_REG_X2)
  = get_actual_value_by_regN(arm64_const.ARM64_REG_X3)

ddr:
= k_header.get_memStr_from_vmaddr(each_mif_f, each_mif_vm, meta_class.class_name_addr)
class_name,
r = meta_cl
class_name,
 meta_class

= "unknow c
ss

6)
m_vm(each_m
r(k_header,

"L") == OSM

 = get_actu
 = get_actu
r = get_act
t_actual_va

ddr:
= k_header.

class_name,
r = meta_cl
class_name,
 meta_class

= "unknow classname"
```

```
from capstone import x86_const


class x_reg_manager(object):

    def __init__(self):
        self.x = [1]*234
        for i in range(234):
            self.x[i] = 0


    def get_actual_value_by_regN(self, reg):
        #global x0
        return self.x[reg]



    def set_actual_value_by_regN(self, reg, reg_val):
        self.x[reg] = reg_val
```

Attack Interfaces

AppleHDAEngine::newUserClient

```
_____________________________________________________

index   CanOpen TOpenType       ServiceName                                  extends
  4     True      0       AppleHDAEngineOutput                             IOAudioEngine::gMetaClass-->AppleHDAEngine-->AppleHDAEngineOutput
 86     True      0       AppleHDAEngine                                   IOAudioEngine::gMetaClass-->AppleHDAEngine

_____________________________________________________

ServiceName         OpenType          UserClient
AppleHDAEngine      0x3               AppleHDAEngineUserClient::metaClass
AppleHDAEngine      0x2               DspFuncUserClient::Create(IOAudioEngine*, task*)
```

AppleHDAEngineUserClient::externalMethod

```
-------------------------------------------------------------------------------------------------------------------
selector      cSIC            cSIS            cSOC            cSOS      func_name
  0              2               0               0            4095      AppleHDAEngineUserClient::getState
  1              2            4095               0               0      AppleHDAEngineUserClient::setState
  2              0               0               0               0      AppleHDAEngineUserClient::resetDSPToPropertyList
  3              1               0               1               0      AppleHDAEngineUserClient::isPortPresent
  4              0               0               6               0      AppleHDAEngineUserClient::getHardwareVolume
  5              1               0               0               0      AppleHDAEngineUserClient::setHardwareVolume
  6              0               0              16               0      AppleHDAEngineUserClient::getActiveSpatialChannels
  7              0               0               3               0      AppleHDAEngineUserClient::getAudioSnoopEnabled
  8              3               0               0               0      AppleHDAEngineUserClient::setAudioSnoopEnabled
  9              2               0               0               0      AppleHDAEngineUserClient::setSpatialChannelMute

Process finished with exit code 0
```

Shortage

- KEXTs are closed source, many method strings are stripped
- Function call usually use *(object_ptr + offset) type

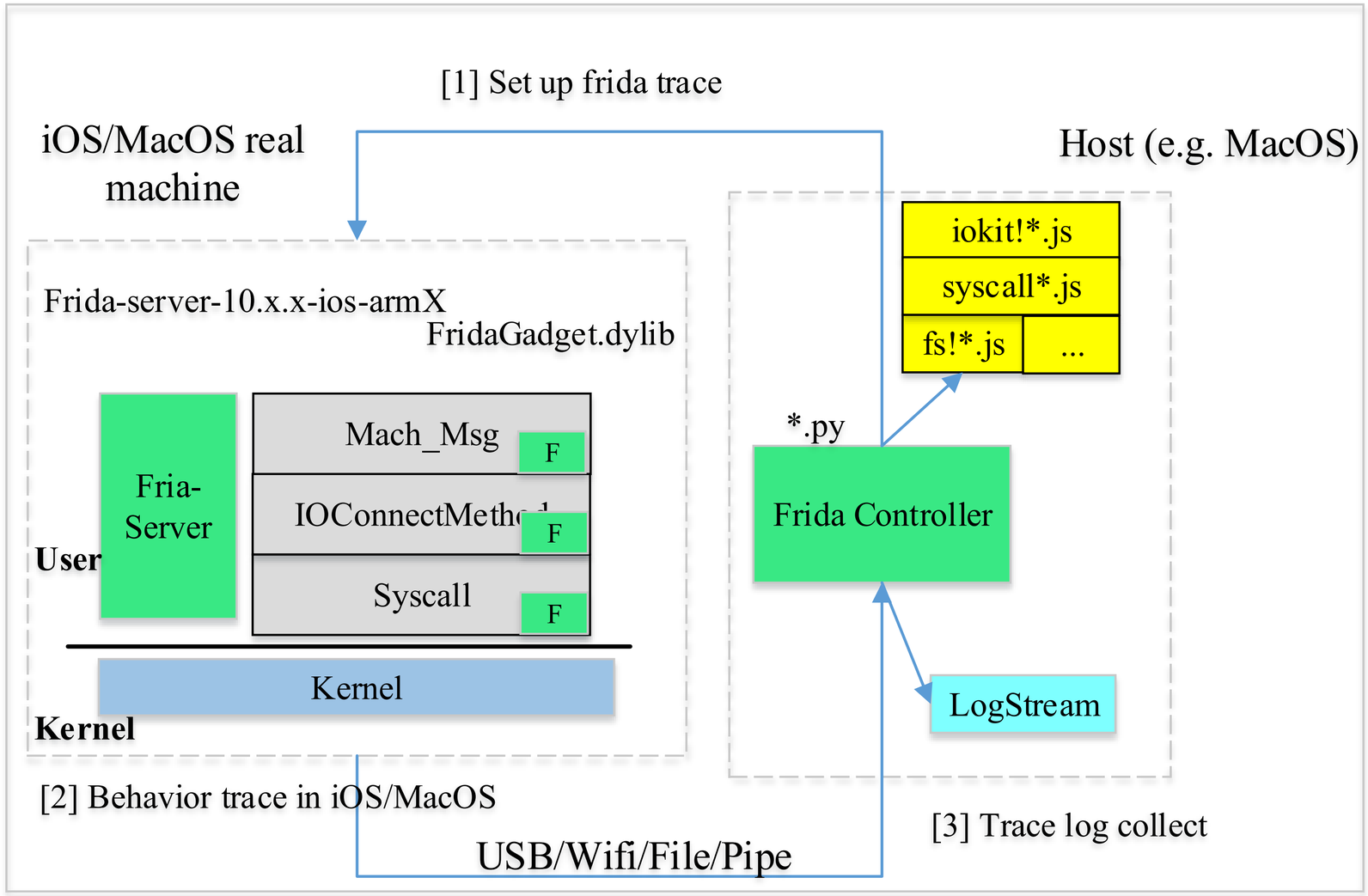
```
v20 = (*(int (__fastcall **)(IORegistryEntry *, __int64, AMDRadeonX4000_AMDAccelResource *, _QWORD, _QWORD, _QWORD))(*(_QWORD *)this_ptr + 0xB70LL))(
        this_ptr,
        v2,
        accelResource_offset8,
        0LL,
        *((_QWORD *)this_ptr + 594),
        0LL);                           // AMDRadeonX4000_AMDSIGLContext::bindResource(IOAccelCommandStreamInfo &,IOAccelResource2 *,bool,IOAccelChannel2 *
```

LLDB Debug is your choose

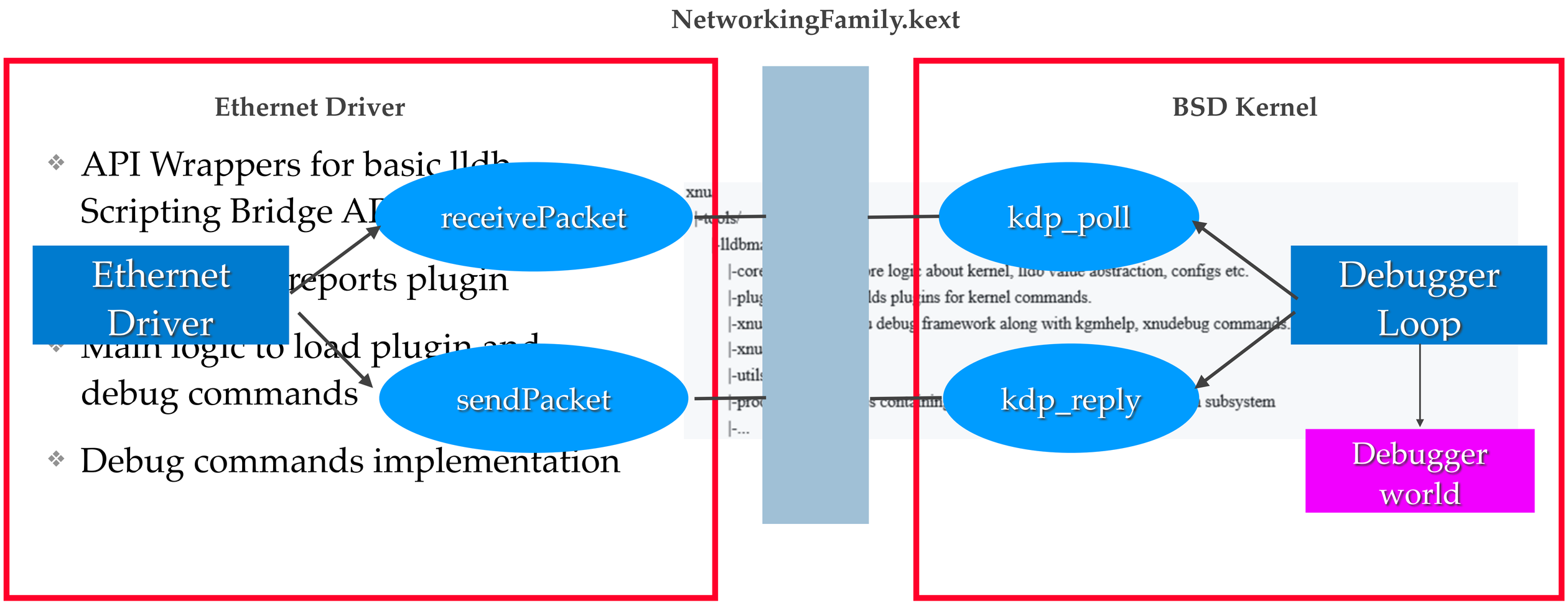
Comparison of dynamic trace

	User Trace	Kernel Trace	Embedded in OS	Any priviledge?	Support script?	Performance	Platform
Frida	Yes	No	No	Root or Repack	Yes	Middle	iOS/Osx
Dtrace	No	Yes	Yes	Root	Yes	High	Osx
lldb	Yes	Yes	Yes	Root	Yes	Low	iOS/Osx
Kernel hook	---	Yes	No	Root	No	Middle	Osx

Frida Hook in User Mode



lldb Kernel Debugging



lldb Kernel Debugging

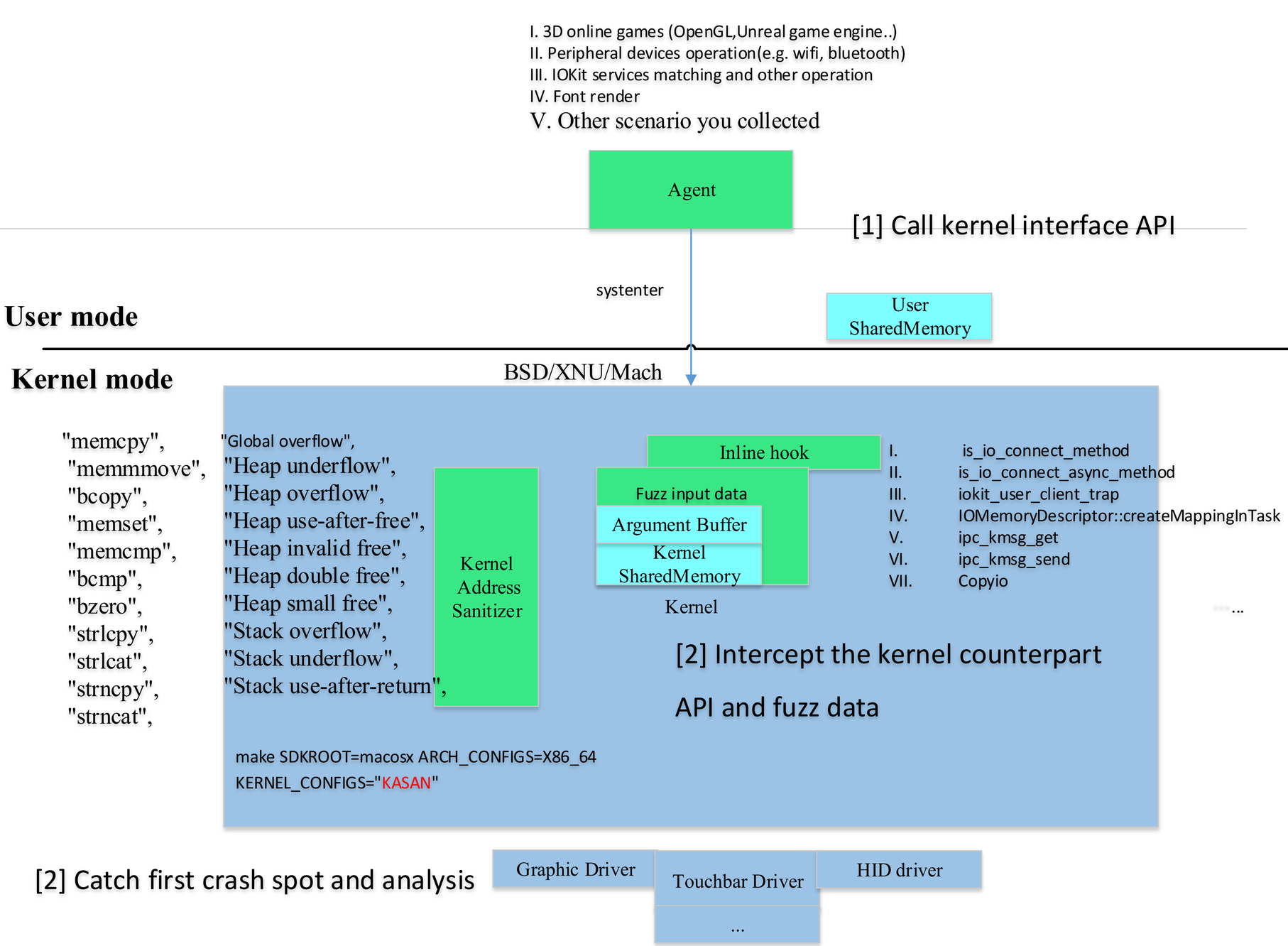
	System mode support	Scriptable	Control Grain	Execution control	Cross platform
DTrace	Kernel	Yes	API	No/View only	Easy
Frida	User	Yes	Instruction	Yes	Easy
Inline hook	Both	No	Instruction	Yes	Middle
LLDB control	Both	Yes	Instruction	Yes	Easy

Agenda

- Static Analysis for Kernel Extensions Attack Interfaces
- Enhanced PassiveFuzz
- Vulnerabilities Found
- Conclusion

PassiveFuzz

- Inline HOOK
- Probe Installation
- Mutation
- KASAN
- Agent
- Automation



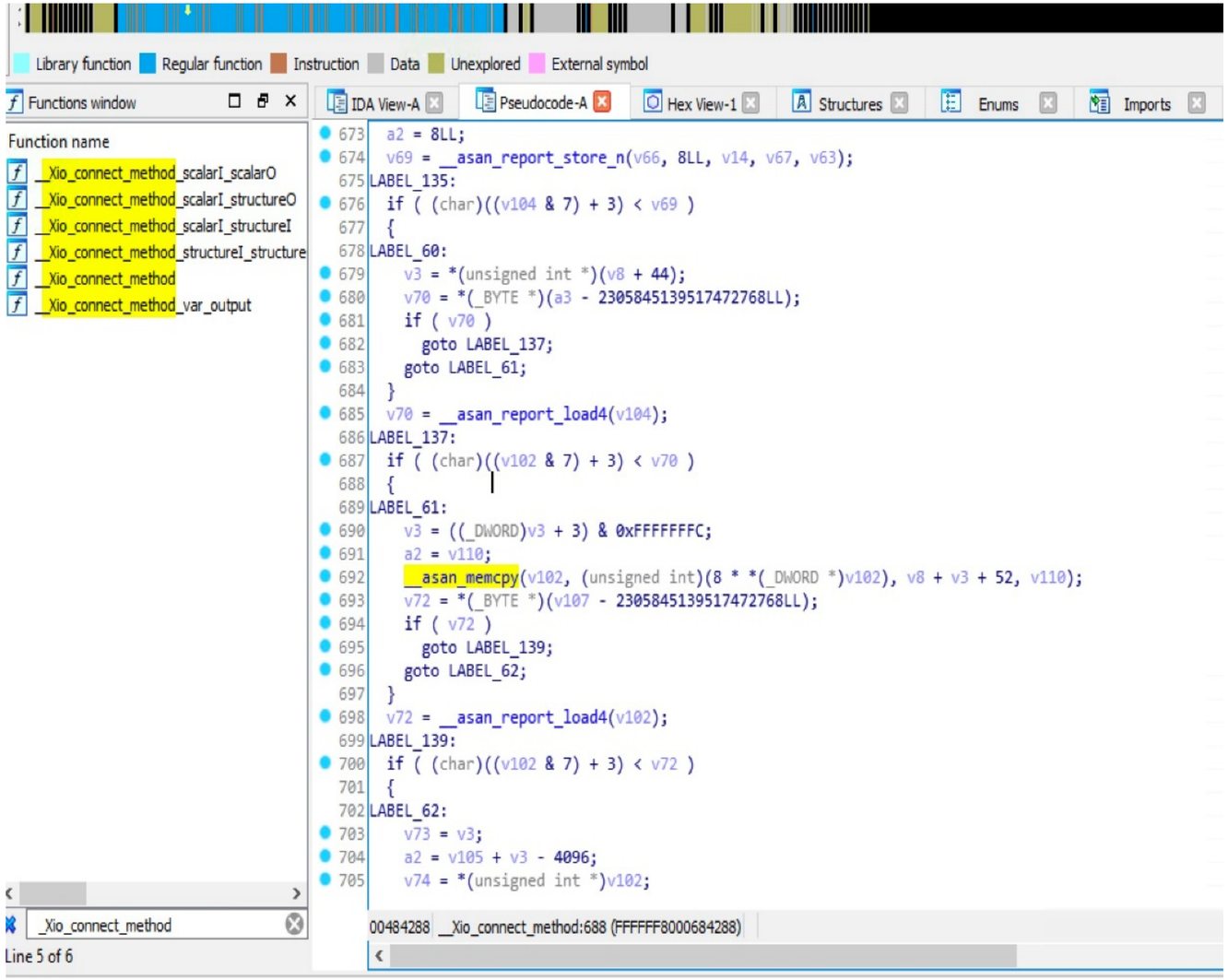
https://conference.hitb.org/hitbsecconf2019ams/materials/D1T2%20-%20Fresh%20Apples%20-%20Researching%20New%20Attack%20Interfaces%20on%20iOS%20and%20OSX%20-%20Moony%20Li%20&%20Lilang%20Wu.pdf

KSAN in XNU kernel

- make SDKROOT=macosx ARCH_CONFIGS=X86_64 KERNEL_CONFIGS="KASAN“

- /System/Library/Kernenls/kernel*

-



https://conference.hitb.org/hitbsecconf2019ams/materials/D1T2%20-%20Fresh%20Apples%20-%20Researching%20New%20Attack%20Interfaces%20on%20iOS%20and%20OSX%20-%20Moony%20Li%20&%20Lilang%20Wu.pdf

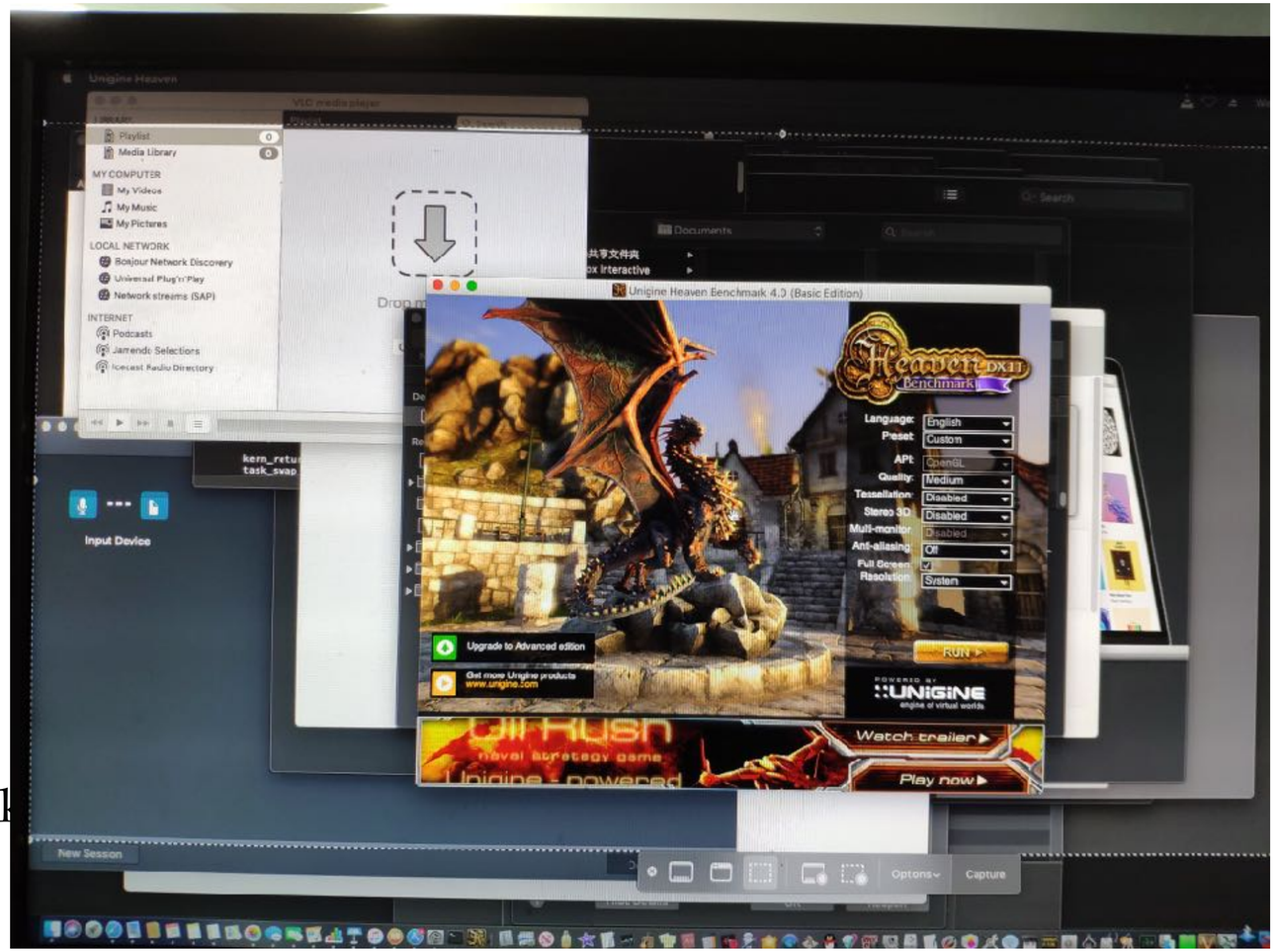
Crash Monitor

- Embedded lldb toolset is powe
- Fruitful python plugin
-

```
#
def diagnoseOnce(targetIP):
    settingSymbolResult = settingSymbols()
    remoteResult = kdpRemote(targetIP)
    if not checkKdpRemoteConnected():
        return

    btResult = getCallStack()
    conAddr = getConnectionAddrFromBt(btResult)
    showObjResult = showObject(conAddr)
    objName = getObjNameFromShowObj(showObjResult)
    selector = getSelectorFromBt(btResult)
    disResult = getDisAssemble()
    regsResult = getRegs()

    kdpRemote(targetIP)
    coreResult = sendCore(dumpServerIP, coreName)
    doDetach()
    monitorFileUntilDone(coreFilePath)

    print("diagnoseOnce exit")

def startRFCLoopInterface(debugger, targetIP, result, internal_dict):
    counter = 0
    while True:
        try:
            diagnoseOnce()
        except Exception as e:
            print (colored("[ERROR] " + str(e), "red"))
            traceback.print_exc()
        counter = counter + 1
        #break

# And the initialization code to add your commands
def __lldb_init_module(debugger, internal_dict):
    debugger.HandleCommand('command script add rfc -f remoteFuzzController.startRFCLoopInterface')
```

Data Generating on Target Machine

- Purpose
  - Touch more deep code coverage
- Methodology
  - Generating valid data and code execution (with context)
- Implementation
  - Apple Script based app test
  - Enrich kinds of corpuses around attack interface
  - Browser, 3D game engine, benchmark …as you think
-



Data Generating Tricks

- Embedded Apple Script is powerful
- Automatic app test
- Timely reboot from kernel
  - In case of kernel hang but not crash

```
void doReboot()
{

    fnPEHaltRestart  afnPEHaltRestart = NULL;
    fnhalt_all_cpus afnhalt_all_cpus = NULL;
    afnPEHaltRestart = (fnPEHaltRestart) solve_kernel_symbol(&g_kernel_info,"PEHaltRestart");
    afnPEHaltRestart(kPERestartCPU);
    afnhalt_all_cpus = (fnhalt_all_cpus)solve_kernel_symbol(&g_kernel_info,"halt_all_cpus");
    afnhalt_all_cpus(TRUE);
}
void watchdogTimelyRebootThread(__unused void *arg, __unused wait_result_t wr)
{
    unsigned int nCountSeconds = (unsigned int)arg;
    struct timespec ts = { nCountSeconds, 0 };
    int error = 0;
    lck_mtx_lock(watch_dogt_timely_reboot_mutex);
    while (1) {

        fnIOSleep aIOSleep = (fnIOSleep)solve_kernel_symbol(&g_kernel_info, API_SYMBOL_IO_SLEEP);
        aIOSleep(nCountSeconds*1000);
        printf("[DEBUG] doReboot: end...\n");
        doReboot();
        //doCheck();
    }
}

kern_return_t startWatdogForTimelyReboot(unsigned int nCountSeconds)
{
    printf("[DEBUG] startWatdogForTimelyReboot (%d): begin...\n",nCountSeconds);
    kern_return_t kr =  KERN_SUCCESS;
    watch_dogt_timely_reboot_grp = lck_grp_alloc_init("startWatdogForTimelyReboot", LCK_GRP_ATTR_NULL);
    watch_dogt_timely_reboot_mutex = lck_mtx_alloc_init(watch_dogt_timely_reboot_grp, LCK_ATTR_NULL);
    kr = kernel_thread_start(watchdogTimelyRebootThread, (void *)nCountSeconds, &tWatchdogThreadHandle);
    printf("[DEBUG] startWatdogForTimelyReboot (%d): end...\n",nCountSeconds);
    return kr;
```

```
StartupFuzzingSource()
{
    echo "[StartupFuzzingSource]: begin..."
    startTimelyRebootDriver $sleepSecondsOfSession

    for counter in $(seq 1 999999)
    do
        #Test vm
        openAnyFolder "/Users/user/Desktop/VM/CDOS_VB/CDOS*/*.vbox"
        openAnyFolder "/Users/user/Desktop/VM/CDOS_VM/CDOS*/*.vmx"
        openAnyFolder "/Users/user/Desktop/VM/osx*/*.vmx"

        #External device test zone
        faceTimeTest
        VLCTest

        #Safari browser test zone
        safariTest

        #Game engine test zone
        heavenBenchMarkTest
        valleyBenchMarkTest
        heavenBenchMarkTest
        #Misc test zone
        openAnyFolder "/Applications/*"
        openAnyFolder "/Users/user/Downloads/*"
        openAnyFolder "/Applications/Utilities/*"
        sleep $sleepSecondsInFuzz

        if [ "$counter" -ge "$counterToReboot" ]
        then
            echo "now reboot"
            rebootNow
        fi
    done
    echo "[StartupFuzzingSource]: end..."
}
```

```
commonTestApp()
{
    appName=$1
    #appName="FaceTime"
    sudo killall -9 $appName
    osascript -e 'on run {appNameArg}' -e "quit app appNameArg" -e 'end run' $appName

    osascript -e 'on run {appNameArg}' -e "tell application  appNameArg to activate" -e 'end run' $appName
    echo "[commonTestApp]:\tfuzz FaceTime done..."
}
```

Agenda

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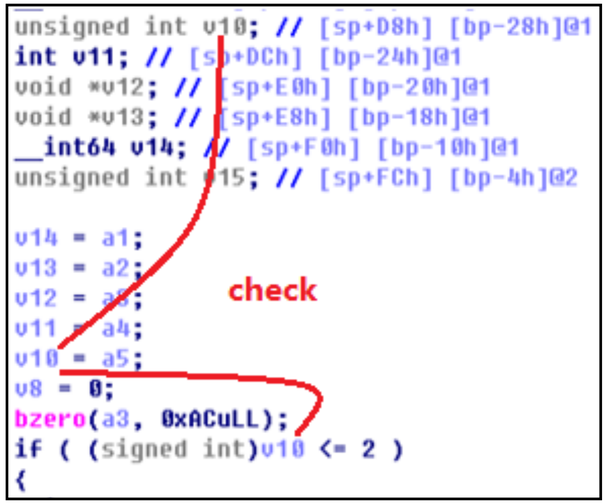
CVE-2018-4462

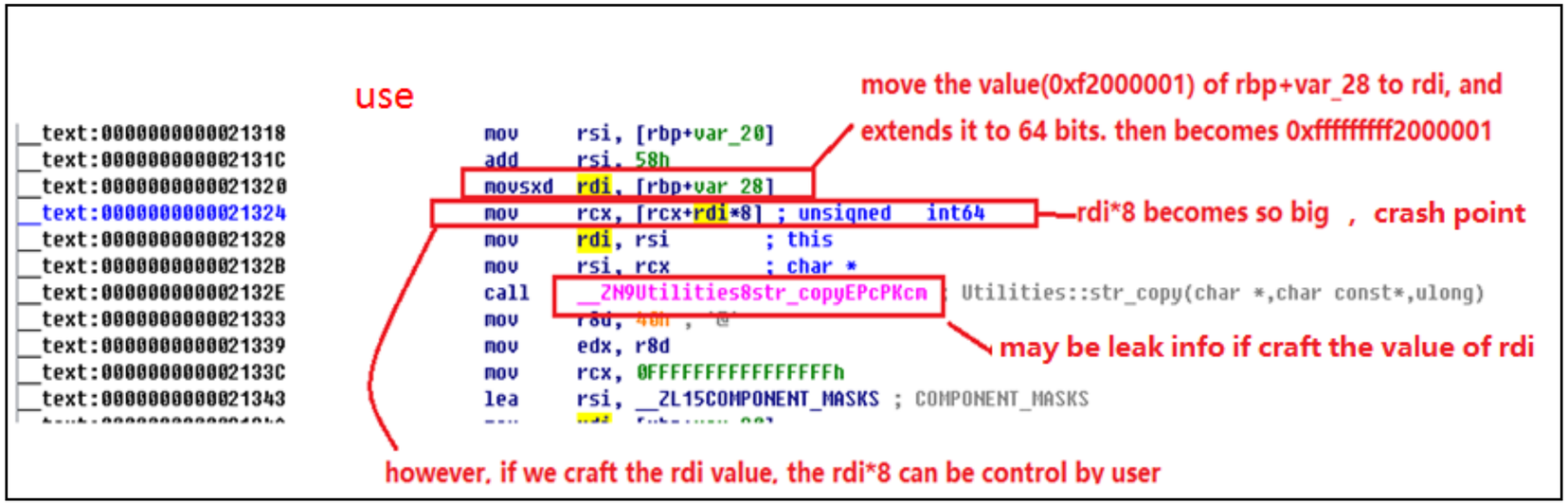
- Integer overflow vulnerability in AMDFramebuffer driver

```
(lldb) bt
* thread #1, stop reason = signal SIGSTOP
  * frame #0: 0xffffff7f8d91e324 AMDFramebuffer`AMDFramebuffer::getPixelInformationFromTiming(AtiDetailedTimingInformation const&, IOPixelInformation*, int, int) + 388
    frame #1: 0xffffff7f8d91e180 AMDFramebuffer`AMDFramebuffer::getPixelInformation(int, int, IOPixelInformation*) + 112
    frame #2: 0xffffff7f8d91e0a5 AMDFramebuffer`AMDFramebuffer::getPixelInformation(int, int, int, IOPixelInformation*) + 101
    frame #3: 0xffffff7f8b42223d IOGraphicsFamily`IOFramebuffer::extGetPixelInformation(target=0xffffff869e59f000, reference=<unavailable>, args=<unavailable>) at IOFrame
    frame #4: 0xffffff800aa4c478 kernel.development`IOUserClient::externalMethod(this=<unavailable>, selector=<unavailable>, args=0xffffffa756c8b988, dispatch=0xffffff7f8
0000) at IOUserClient.cpp:5335 [opt]
    frame #5: 0xffffff7f8b437d0b IOGraphicsFamily`IOFramebufferUserClient::externalMethod(this=0xffffff80b8810800, selector=1, args=0xffffffa756c8b988, dispatch=<unavaila
amebufferUserClient.cpp:380 [opt]
    frame #6: 0xffffff800aa553cf kernel.development`::is_io_connect_method(connection=0xffffff80b8810800, selector=1, scalar_input=<unavailable>, scalar_inputCnt=<unavai
put=0, ool_input_size=0, inband_output="", inband_outputCnt=0xffffff80ac2e2e0c, scalar_output=0xffffffa756c8bcb0, scalar_outputCnt=0xffffffa756c8bcac, ool_output=0, ool_
]
    frame #7: 0xffffff7f8e6c854b pasive_kernel_fuzz`trampline_is_io_connect_method(connection=0xffffff80b8810800, selector=1, scalar_input=0xffffff80b8b81e10, scalar_inpu
_input_size=0, inband_output="", inband_outputCnt=0xffffff80ac2e2e0c, scalar_output=0xffffffa756c8bcb0, scalar_outputCnt=0xffffffa756c8bcac, ool_output=0, ool_output_size
    frame #8: 0xffffff800a3f2bd4 kernel.development`_Xio_connect_method(InHeadP=<unavailable>, OutHeadP=0xffffff80ac2e2de0) at device_server.c:8379 [opt]
    frame #9: 0xffffff800a2c450d kernel.development`ipc_kobject_server(request=0xffffff80b8b81d70, option=<unavailable>) at ipc_kobject.c:359 [opt]
    frame #10: 0xffffff800a29124a kernel.development`ipc_kmsg_send(kmsg=0xffffff80b8b81d70, option=3, send_timeout=0) at ipc_kmsg.c:1822 [opt]
    frame #11: 0xffffff800a2b024f kernel.development`mach_msg_overwrite_trap(args=<unavailable>) at mach_msg.c:546 [opt]
    frame #12: 0xffffff7f8e6d81d7 pasive_kernel_fuzz`trampline_mach_msg_overwrite_trap(args=0xffffffa756c8bf08) at mach_msg_overwrite_trap_trampline.c:131
    frame #13: 0xffffff800a42cb09 kernel.development`mach_call_munger64(state=0xffffff80ac13de20) at bsd_i386.c:573 [opt]
    frame #14: 0xffffff800a25b466 kernel.development`hndl_mach_scall64 + 22
```

Root Cause

frame #0: 0xffffff7f8d91e324 AMDFramebuffer`AMDFramebuffer::**getPixelInformationFromTiming**(AtiDetailedTimingInformation const&, IOPixelInformation*, int, int) + 388
AMDFramebuffer`AMDFramebuffer::getPixelInformationFromTiming:
-> 0xffffff7f8d91e324 <+388>: movq (%rcx,%rdi,8), %rcx ——— a)
0xffffff7f8d91e328 <+392>: movq %rsi, %rdi
0xffffff7f8d91e32b <+395>: movq %rcx, %rsi
0xffffff7f8d91e32e <+398>: **callq 0xffffff7f8ccbcfe0** ; **Utilities::str_copy**(char*, char const*, unsigned long)
(lldb) register read rcx
rcx = 0xffffff7f8d926030 AMDFramebuffer::getPixelInformationFromTiming(AtiDetailedTimingInformation const&, IOPixelInformation*, int, int)::PIXEL_ENCODINGS
(lldb) register read rdi
rdi = 0xffffffff2000001





Agenda

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Conclusion

- Introduce a method to analyze the attack surfaces of kernel extensions, then introduce an enhanced passive fuzz architecture on Apple system. Finally, we study one CVE case hunt by our fuzzer

Questions?

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