The Python Bites your Apple

Fuzzing and exploiting OSX Kernel bugs

Flanker

KeenLab Tencent

XKungfoo Shanghai, April 2016

科恩实验室
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About me

Senior Security Researcher at KeenLab, Tencent

- Pwn2Own 2016 OSX Category Winner
- BlackHat, CanSecWest, HITCON, QCon Speaker
- *nix platform sandbox bypass and kernel exploitation
- Google Android Security Top Researchers Hall of Fame

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About KeenLab

- Former KeenTeam with all researchers move to Tencent and form KeenLab
- 8 Pwn2Own Champions
- Universal Rooting
- We're hiring!

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Objective of this talk

- Basic description of IOKit
- Kernel Zone Allocator and Fengshui Technique
- Introducing KitLib and distributed Fuzzer
- Introducing Kexthelper, a IDA plugin for OSX KEXT
- Case Studies

IOKit Security Background

What's IOKit

I/O Kit is a collection of system frameworks, libraries, tools, and other resources for creating device drivers in OS X

- Security researchers tend to refer it as Kernel drivers and frameworks written with IOKit and accessible via IOKit method calls

Why attacking IOKit

- IOKit drivers runs in Kernel space, some of them even reachable from browser sandbox for efficiency (Graphics).
- Huge number of drivers implemented
- Few access restrictions (compared to Android)

IOKit Security Background

IOService

Different services are exposed via IOKit. We can consult most of them in Hardware IO tools and ioreg.

- IOAccelerator
- IOHIDDevice
- IOPMrootDomain
- ...

IOKit Security Background

IOUserClient

External method calls are first routed via IOUserClient, triggered by mach_msg IPC

```
kern_return_t IOServiceOpen( io_service_t service, task_port_t owningTask, uint32_t type,
      io_connect_t *connect );
```

- When userspace openService is called, corresponding newUserClient at Kernel space is invoked
- Different types may map to different userClient
  - IOAccelerator
- May check caller's identity: is root? (OSX and iOS differ)
- IOServiceClose maps to clientClose in is_io_service_close (race condition here?)

IOKit Security Background

externalMethod

Method calls are dispatched through getTargetMethodForIndex and/or externalMethod

```
virtual IOExternalMethod * getTargetAndMethodForIndex(IOService ** targetP, UInt32 index );
virtual IOReturn     externalMethod(uint32_t selector, IOExternalMethodArguments *
      args,IOExternalMethodDispatch * dispatch, OSObject * target, void * reference)
```

- IOExternalMethodArguments is constructed in is_io_connect_method containing incoming parameter
- IOExternalMethod/IOExternalMethodDispatch specifies parameters constraint

IOKit Security Background

Calling conventions

- structureInput will be converted to descriptor if size >0x4000 in IOConnectCallMethod
- if size <0x4000 passes through inband buffer
- io_connect_method generate and send mach_msg
- of course we can directly call io_connect_method, bypass this constraint

libkern C++ Runtime

- Reduced set of C++
  - No Exception
  - No Multiple Inherience
  - No template
  - Custom implementation of RTTI
- OSMetaClass
  - OSMetaClass is defined by macros
  - Contains Name, size and father class for each corresponding class

IOKit Security Background

IOConnectCallMethod

```
kern_return_t
IOConnectCallMethod(
   mach_port_t connection,     // In
   uint32_t selector,    // In
   const uint64_t *input,      // In
   uint32_t inputCnt,    // In
   const void *inputStruct,    // In
   size_t      inputStructCnt, // In
   uint64_t *output,  // Out
   uint32_t *outputCnt,  // In/Out
   void    *outputStruct,  // Out
   size_t     *outputStructCntP) // In/Out
```

IOKit historical vulnerabilities

- Race condition (hottest) (CVE-2015-7084)
- Heap overflow
- UAF
- TOCTOU
- OOB write (Our P2O bug!)
- NULL dereference (not exploitable with SMAP and in sandbox)

Cons of traditional fuzzer

- written in C/C++, more time consuming
- error-prone, easy to make mistakes
- less supporting library
  - socket
  - logging
- not dynamically expandable due to language nature

Introducing Kitlib

```
io_connect_t t;
io_service_t svc =
      IOServiceGetMatchingService(kIOMasterPortDefault,
      IOServiceMatching("fuckliangchen"));
IOServiceOpen(svc, mach_task_self(), 0, &t);
uint32_t outputCnt = 0x100;
size_t outputStructCnt = 0x2000;
uint64_t* output = new uint64_t[outputCnt];
char* outputStruct = new
      char[outputStructCnt];

const uint32_t inputCnt = 0x100;
uint64_t input[inputCnt];
const size_t inputStructCnt = 0x2000;
char inputStruct[inputStructCnt];
IOConnectCallMethod(t, 0, input, inputCnt,
      inputStruct, inputStructCnt, output,
      &outputCnt, outputStruct,
      &outputStructCnt);
```

```
import kitlib
h = kitlib.openSvc('fuckliangchen', 0)
kitlib.callConnectMethod(h, [0L]*0x100,
      'a'*0x2000, 0x100, 0x2000)
```

What's Kitlib

- Kitlib is a Python wrapper for IOKit calls
- Internally written in C++ and Python, provides convenient functions for writing fuzzers, using SWIG and ctypes
- Performance cost is low

SWIG usage

- Define interfaces in header file (kitlib.h)
- C++ wrapper layer in cpp file (if needed) (kitlib.cpp)
- Writing wrapping code for argument convention from Python to C++ in glue file (kitlib.i)

Questions

- Memory management?
- Type conventions?

Header file

Defining basic types

- mach_port_t
- mach_vm_address_t
- io_object_t
- io_service_t
- io_iterator_t

Define interfaces

```
mach_port_t openSvc(const char* svc_name, uint32_t type);
mach_port_t* openMultiSvc(const char* svc_name, uint32_t* typearr);
size_t getSvcCntForName(const char* svc_name);
bool svcAva(const char* svc_name,uint32_t type);
```

Glue file

Wraps functions

```
size_t getSvcCntForName(const char* svc_name)
{
    io_iterator_t iter;
    kern_return_t kr;
    io_service_t device;
    size_t ret = 0;

    kr = IOServiceGetMatchingServices(kIOMasterPortDefault, IOServiceMatching(svc_name), &iter);
    while ((device = IOIteratorNext(iter)))
    {
        ++ret;
        IOObjectRelease(device);
    }
    IOObjectRelease(iter);
    return ret;
}
```

Glue file

Wraps functions

```
unsigned int callConnectMethod(
                    mach_port_t   connection,     // In
                    uint32_t   selector,    // In
                    const uint64_t *input,       // In
                    uint32_t   inputCnt,    // In
                    const void     *inputStruct,     // In
                    size_t     inputStructCnt, // In
                    uint64_t  *output,   // Out
                    uint32_t  *outputCnt,   // In/Out
                    void    *outputStruct,  // Out
                    size_t    *outputStructCnt)
{    kern_return_t kt = IOConnectCallMethod((mach_port_t) connection, /* Connection  */
                                        selector,          /* Selector      */
                                        input, inputCnt,             /* input, inputCnt */
                                        inputStruct,       /* inputStruct   */
                                        inputStructCnt,            /* inputStructCnt */
                                        output, outputCnt, outputStruct, outputStructCnt); /*
                                              Output stuff */

    return kt;
}
```

Argument Wrapping

```
/*
 This function handles scalar input, translate the incoming python value, which is list,
 to native representation. Memory cleanup is needed afterwards
 */
%typemap(in) (const uint64_t *input, uint32_t inputCnt) {
    /* Check if is a list */
    if (PyList_Check($input)) {
        uint32_t size = PyList_Size($input);
        uint32_t i = 0;
        $2 = size;
        $1 = (uint64_t*) malloc(size * sizeof(uint64_t));
        for (i = 0; i < size; i++) {
            PyObject *o = PyList_GetItem($input,i);
            if (PyLong_Check(o)) {
                $1[i] = PyLong_AsUnsignedLongLong(o);
            }
            else {
                PyErr_SetString(PyExc_TypeError,"list must contain L numbers");
                free($1);
                return NULL;
            }
        }
    } else if ($input == Py_None) {
        $1 = NULL;
        $2 = 0;
    } else {
        PyErr_SetString(PyExc_TypeError,"not a list");
```

Argument wrapping

freeing memory

```
%typemap(freearg) (const uint64_t *input, uint32_t inputCnt) {
    free($1);
}
```

Call flow

- user Python code calls in SWIG auto-generated function
- SWIG auto-generated function calls user convention typemap code, mapping python types to C++ arguments $1 $2, etc
- SWIG auto-generated function passes $1 $2, etc into C++ glue code
- SWIG auto-generated function calls freearg code to free memory

Kitlib Implementation

Example source code

```
import kitlib
h = kitlib.openSvc('fuckliangchen', 0)
kitlib.callConnectMethod(h, [0L]*0x100, 'a'*0x2000, 0x100, 0x2000)
```

- inputScalar to list
- inputStruct to string/bytearray
- outputScalar/outputStruct maps to len
- output maps to tuple (retcode, outscalar, outstruct)

Problems for Kitlib1

- I'm lazy and I don't want to write wrapper for each interface
- Argument passing is immutable, cannot do TOCTOU fuzzing

Calling directly into library functions

ctypes

- For functions without need for wrapping we directly call ctypes
- Build-in mutable support (TOCTOU and race condition fuzzing)

Basic ctypes primitives

ctypes

- c_int, c_ulonglong, c_char_p
- create_string_buffer

Parsing KEXT for arguments

- static const IOExternalMethodDispath/IOExternalMethod array (parseable)
- dynamic routed via code (oops)

- for former we can automatically retrieve arguments via pattern matching
- Scan const-data section for matching
- Map class to arguments array

Example IOExternalMethodDispatch

```
__const:0000000000064BC0 ; IGAccelCLContext::attach(IOService *)::methodDescs
__const:0000000000064BC0 __ZZN16IGAccelCLContext6attachEP9IOServiceE11methodDescs db 0
__const:0000000000064BC0                                         ; DATA XREF:
      IGAccelCLContext::attach(IOService *)+16
__const:0000000000064BC1                 db    0
__const:0000000000064BC2                 db    0
__const:0000000000064BC3                 db    0
__const:0000000000064BC4                 db    0
__const:0000000000064BC5                 db    0
__const:0000000000064BC6                 db    0
__const:0000000000064BC7                 db    0
__const:0000000000064BC8                 dq offset
      __ZN16IGAccelCLContext15map_user_memoryEP22IntelCLMapUserMemoryInP23IntelCLMapUserMemoryOutyPy
      ; IGAccelCLContext::map_user_memory(IntelCLMapUserMemoryIn *,IntelCLMapUserMemoryOut
      *,ulong long,ulong long *)
__const:0000000000064BD0                 db    0
__const:0000000000064BD1                 db    0
__const:0000000000064BD2                 db    0
__const:0000000000064BD3                 db    0
__const:0000000000064BD4                 db    0
__const:0000000000064BD5                 db    0
__const:0000000000064BD6                 db    0
__const:0000000000064BD7                 db    0
__const:0000000000064BD8                 db    3
__const:0000000000064BD9                 db    0
__const:0000000000064BDA                 db    0
```

After parsing

```
_const:0000000000064BC0 ; IGAccelCLContext::attach(IOService *)::methodDescs
__const:0000000000064BC0 __ZZN16IGAccelCLContext6attachEP9IOServiceE11methodDescs
      IOExternalMethod <0, \
__const:0000000000064BC0                                        ; DATA XREF:
      IGAccelCLContext::attach(IOService *)+16
__const:0000000000064BC0                                  offset
      __ZN16IGAccelCLContext15map_user_memoryEP22IntelCLMapUserMemoryInP23IntelCLMapUserMemoryOutyPy,\
      ; IGAccelCLContext::map_user_memory(IntelCLMapUserMemoryIn *,IntelCLMapUserMemoryOut
      *,ulong long,ulong long *)
__const:0000000000064BC0                                  0, 3, 0FFFFFFFFh, 0FFFFFFFFh>
__const:0000000000064BF0                       IOExternalMethod <0, \ ;
      IGAccelCLContext::unmap_user_memory(IntelCLUnmapUserMemoryIn *,ulong long)
__const:0000000000064BF0                                  offset
      __ZN16IGAccelCLContext17unmap_user_memoryEP24IntelCLUnmapUserMemoryIny,\
__const:0000000000064BF0                                  0, 4, 0, 0FFFFFFFFh>
```

Example: IOExternalMethodDispatch matching

- +0 points to TEXT or zero
- +8, +16, +24 reasonable integers (NO TEXT pointing)

Example: Vtable matching

- Reference from constructor
- +8, +16, ... all points to TEXT section or EXTERN(UNDEF) section

Pseudo Algo

```
matchers = [IOExternalMethodDispatchMatcher, VtableMatcher, IOExternalMethodMatcher]
for matcher in matchers:
    if matcher.isSectionBegin(const_data_section):
        matcher.deflateToList(section, offset)
        break

map userclient with arguments
scan newUserClient for service-userclient mappings
add father's userclient to children service
scan constructor for service size
scan for offset access to determine field offset

Construct vtable as a structure S, set vt(offset 0, size 8) type to S*
```

Restoring object structure

- Scanning MetaClass function for object's size
- Create the object's whole vtable area as a struct
- Setting +0(8) field as vt and type to previous struct pointer

Restoring object structure(cont.)

```
//...
__text:0000000000048079          mov     r14, rdi
__text:000000000004807C          movzx   eax, word ptr [rbx+22h]
__text:0000000000048080          cmp     eax, 3
__text:0000000000048083          jnz     loc_48122
__text:0000000000048089          cmp     qword ptr [rbx], 0
__text:000000000004808D          jz      loc_48129
//...
__text:00000000000480A6          cmp     rax, rcx
__text:00000000000480A9          jnb     short loc_48129
__text:00000000000480AB          mov     rax, [r14]
__text:00000000000480AE          mov     rdi, r14
__text:00000000000480B1          mov     rsi, rbx
__text:00000000000480B4          call    qword ptr [rax+9E8h]
__text:00000000000480BA          mov     rdi, [r14+1030h]
__text:00000000000480C1          mov     rax, [rdi]
__text:00000000000480C4          mov     esi, [r15+8]
__text:00000000000480C8          shl     rsi, 6
__text:00000000000480CC          add     rsi, [r14+610h]
__text:00000000000480D3          call    qword ptr [rax+140h]
__text:00000000000480D9          inc     dword ptr [rbx+2Ch]
__text:00000000000480DC          cmp     byte ptr [rbx+30h], 0
__text:00000000000480E0          jz      short loc_480F8
__text:00000000000480E2          mov     eax, [r15+8]
__text:00000000000480E6          mov     rcx, [r14+608h]
```

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Restoring object structure(cont.)

- Scanning functions and perform forward-flow analysis on registers starting RDI
- Retriving MOV/LEA offset and do addStructMember

```
__int64 __fastcall IGAccelCLContext::process_token_SetFence(__int64 this, __int64 a2)
{
  __int64 v2; // r15@3
  __int64 result; // rax@6
  unsigned int v4; // esi@7

  if ( *(_WORD *)(a2 + 34) != 3 )
  {
    v4 = -5;
    return IOAccelContext2::setContextError((IOAccelContext2 *)this, v4);
  }
  if ( !*(_QWORD *)a2
    || (v2 = *(_QWORD *)(a2 + 24), (unsigned __int64)*(unsigned int *)(v2 + 8) << 6 >=
          *(unsigned int *)(this + 1600)) )
  {
    v4 = -2;
    return IOAccelContext2::setContextError((IOAccelContext2 *)this, v4);
  }
  (*(void (__cdecl **)(__int64))(*(_QWORD *)this + 2536LL))(this);
  (*(void (__fastcall **)(_QWORD, unsigned __int64))(**(_QWORD **)(this + 4144) + 320LL))(
    *(_QWORD *)(this + 4144),
    *(_QWORD *)(this + 1552) + ((unsigned __int64)*(unsigned int *)(v2 + 8) << 6));
  ++*(_DWORD *)(a2 + 44);
  if ( *(_BYTE *)(a2 + 48) )
    *(_DWORD *)(*(_QWORD *)(this + 1544) + 16LL * *(unsigned int *)(v2 + 8)) = 0;
  *(_BYTE *)(this + 4154) = 1;
  result = (*(__int64 (__fastcall **)(__int64, __int64))(*(_QWORD *)this + 2528LL))(this, a2);
  *(_BYTE *)(this + 4154) = 0;
  return result;
}
```

```
__int64 __fastcall IGAccelCLContext::process_token_SetFence(IGAccelCLContext *this, __int64 a2)
{
  __int64 v2; // r15@3
  __int64 result; // rax@6
  unsigned int v4; // esi@7

  if ( *(_WORD *)(a2 + 34) != 3 )
  {
    v4 = -5;
    return IOAccelContext2::setContextError((IOAccelContext2 *)this, v4);
  }
  if ( !*(_QWORD *)a2
    || (v2 = *(_QWORD *)(a2 + 24), (unsigned __int64)*(unsigned int *)(v2 + 8) << 6 >=
          LODWORD(this->field_640)) )
  {
    v4 = -2;
    return IOAccelContext2::setContextError((IOAccelContext2 *)this, v4);
  }
  ((void (__cdecl *)(IGAccelCLContext
        *))this->vt->__ZN16IGAccelCLContext16endCommandStreamER24IOAccelCommandStreamInfo)(this);
  (*(void (__fastcall **)(__int64, unsigned __int64))(*(_QWORD *)this->field_1030 + 320LL))(
    this->field_1030,
    *(_QWORD *)&this->gap610[0] + ((unsigned __int64)*(unsigned int *)(v2 + 8) << 6));
  ++*(_DWORD *)(a2 + 44);
  if ( *(_BYTE *)(a2 + 48) )
    *(_DWORD *)(this->field_608 + 16LL * *(unsigned int *)(v2 + 8)) = 0;
  this->field_103a = 1;
  result = ((__int64 (__fastcall *)(IGAccelCLContext *,
        __int64))this->vt->__ZN16IGAccelCLContext18beginCommandStreamER24IOAccelCommandStreamInfo)(
             this,
             a2);
  this->field_103a = 0;
```

Running fuzzer

- retriving metadata for all kexts and store using pickle
  - idc.Batch
- Set up multiple VM on fuzzing server
- add fuzzer as start-up item, load pickle and record progress

Fuzzing outcome

- Heap overflow in AppleXXX (CVE-2016-?)
- Race condition in IOXXX (CVE-2016-?)
- Double free in AppleXXX (CVE-2016-?)
- Integer overflow in IOXXX (CVE-2016-?)
- NULL pointer dereferences in IOXXX (CVE-2016-?)
- .....(more waiting disclosure)

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A hidden ignored attack surface in IOKit

oops, Apple hasn't fixed it yet, will disclose later.

Infoleak in AppleBDWGraphics/IntelHD5000 via racecondition

- IGAccelCLContext/IGAccelGLContext provides interface via externalMethod for mapping/unmapping user memory, passed in mach_vm_address_t
- Ian Beer and us both discovered a race condition in unmapping user memory, which lead to code execution
- Apple fixes this issue by adding a lock in un_map_usermemory (the delete operation), but its incomplete.

Operation Procedure

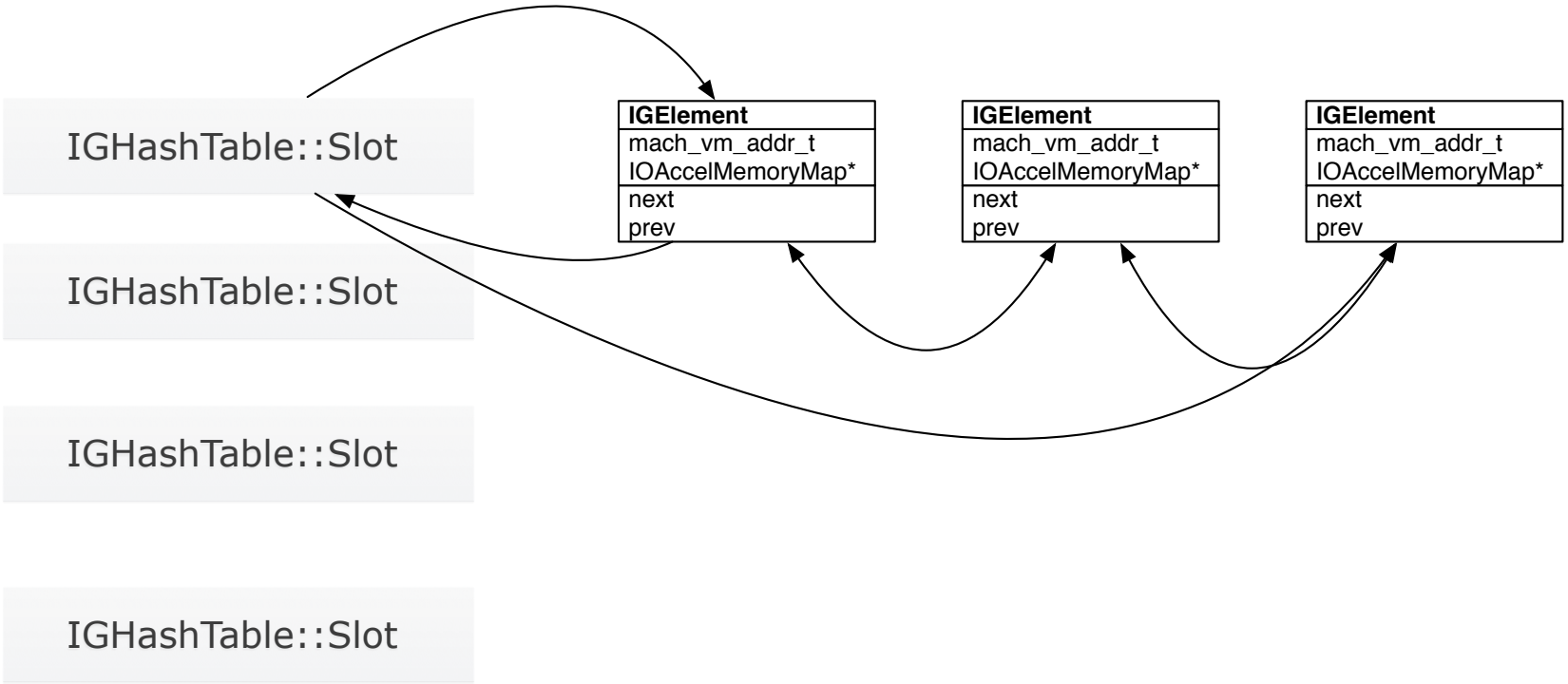
MAP_USER_MEMORY

- contains
  - index slot using hash function
  - iterate the list for matching
- add
  - Append item to corresponding slot list

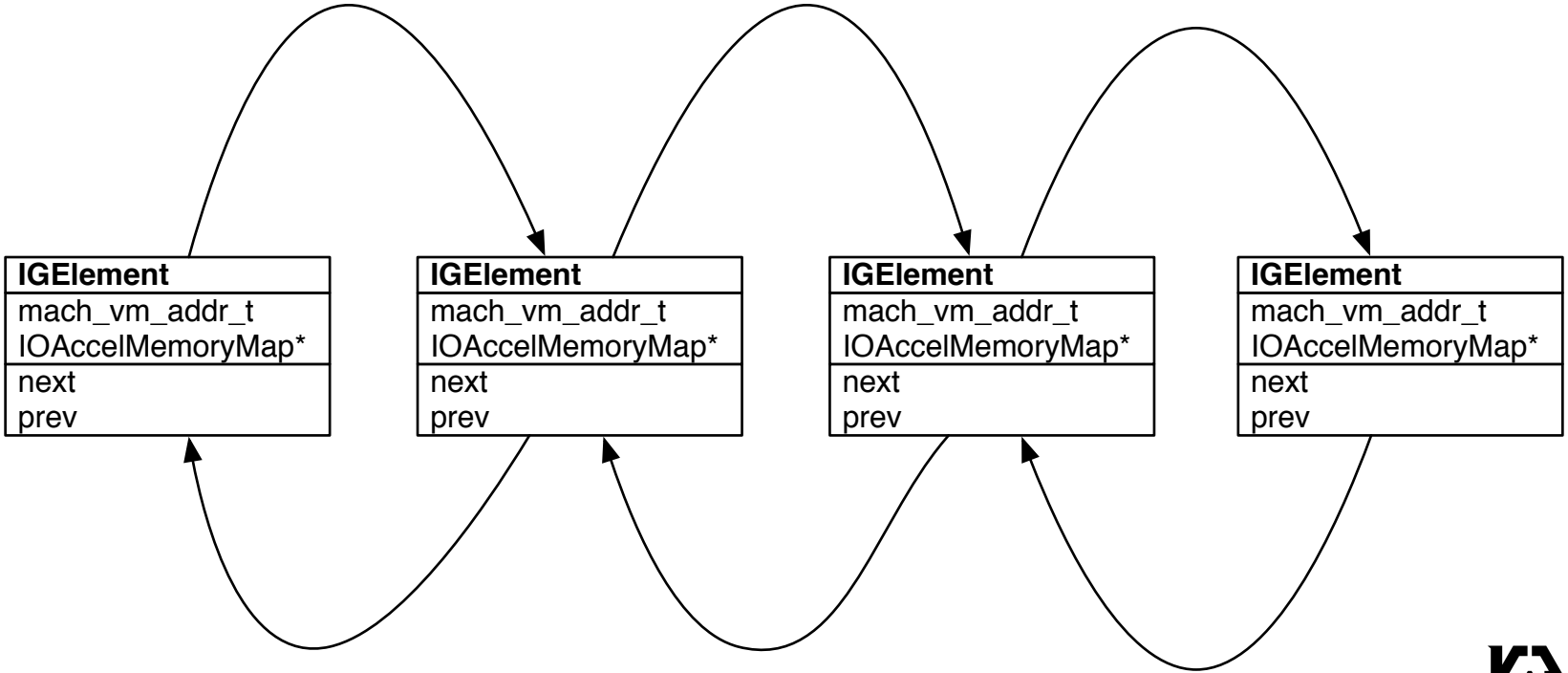
UNMAP_USER_MEMORY

- contains
- get
- remove (get a object ptr and call virtual function)
  - Update head and tail when appropriate
  - Update prev-¿next and next-¿prev

The IGHashTable structure



The LinkedList connecting elements with same hash values



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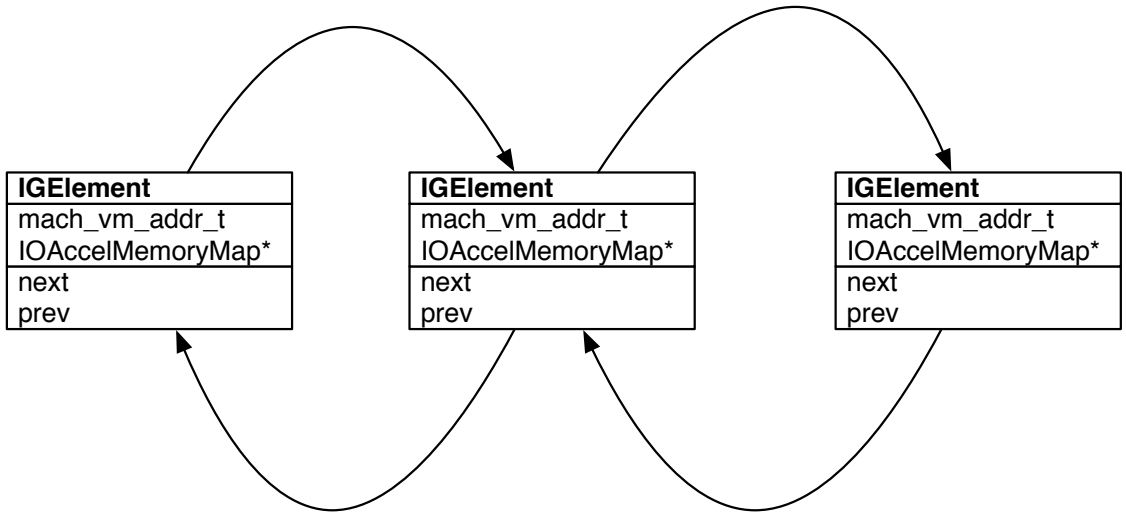
The normal idea that failes (Ian Beer one)

The ideal situation is both threads passes hash table::contains, and when one is retrieving IOAccelMemoryMap* after get returns valid pointer, the other frees it and we control the pointer



However in reality more frequently they do passes contains but thread 1 will remove it before thread 2 do get and thread 2 hit a null pointer dereference

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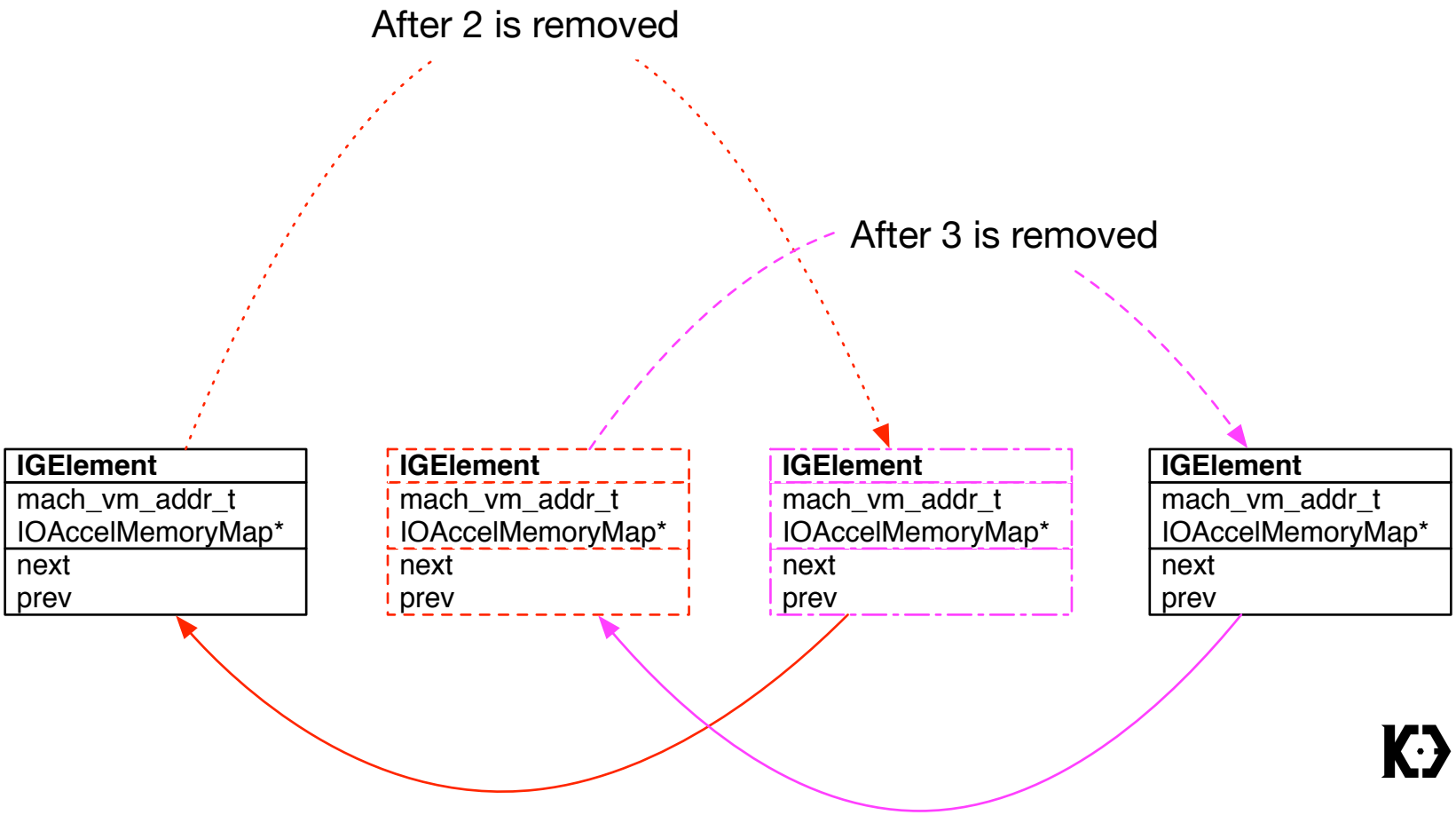
The advanced racing by us



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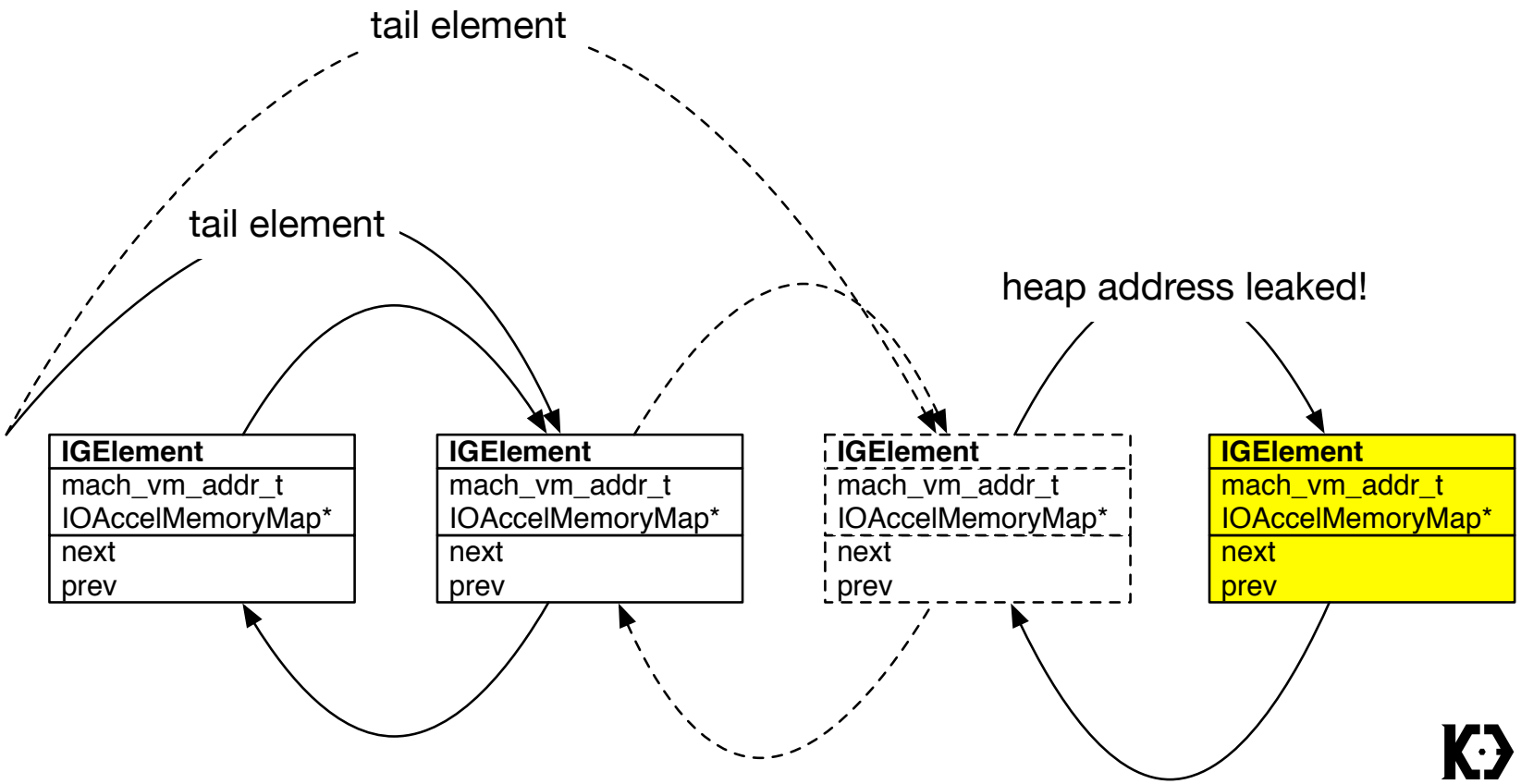
The new vulnerability



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Unmap frees the element while map is still traversing

```
*** Panic Report ***
panic(cpu 0 caller 0xffffff80165ce40a): Kernel trap at 0xffffff80165c4e90, type 13=general protection, registers:
CR0: 0x000000008001003b, CR2: 0xffffff81210ea000, CR3: 0x00000001b8fd30b7, CR4: 0x00000000003627e0
RAX: 0x0000000000000001, RBX: 0xdeadbeefdeadbeef, RCX: 0x0000000000000059, RDX: 0x0000000000000008
RSP: 0xffffff9122e3bae0, RBP: 0xffffff9122e3bae0, RSI: 0xffffff803197ee34, RDI: 0xdeadbeefdeadbeef
R8:  0x0000000000000004, R9:  0x0000000caca00d2a, R10: 0x8000000caca00d2a, R11: 0x000a0d200caca000
R12: 0xffffff803197ee34, R13: 0x00000000e00002c2, R14: 0xffffff803197ee34, R15: 0xffffff80323fd600
RFL: 0x0000000000010202, RIP: 0xffffff80165c4e90, CS:  0x0000000000000008, SS:  0x0000000000000010
Fault CR2: 0xffffff81210ea000, Error code: 0x0000000000000000, Fault CPU: 0x0, PL: 0

Backtrace (CPU 0), Frame : Return Address
0xffffff80f8808c50 : 0xffffff80164dab12 mach_kernel : _panic + 0xe2
0xffffff80f8808cd0 : 0xffffff80165ce40a mach_kernel : _kernel_trap + 0x91a
0xffffff80f8808eb0 : 0xffffff80165ec273 mach_kernel : _return_from_trap + 0xe3
0xffffff80f8808ed0 : 0xffffff80165c4e90 mach_kernel : _memcmp + 0x10
0xffffff9122e3bae0 : 0xffffff7f989e71d4 com.apple.driver.AppleIntelBDWGraphics :
__ZNK11IGHashTableIyP16IGAccelMemoryMap12IGHashTraitsIyE25IGIOMallocAllocatorPolicyE8containsERKy + 0x42
0xffffff9122e3bb00 : 0xffffff7f989e56cc com.apple.driver.AppleIntelBDWGraphics :
__ZN16IGAccelCLContext15map_user_memoryEP22IntelCLMapUserMemoryInP23IntelCLMapUserMemoryOutyPy + 0x66
0xffffff9122e3bb50 : 0xffffff8016ae1592 mach_kernel : _shim_io_connect_method_structureI_structureO + 0x122
0xffffff9122e3bb80 : 0xffffff8016ae220a mach_kernel :
__ZN12IOUserClient14externalMethodEjP25IOExternalMethodArgumentsP24IOExternalMethodDispatchP8OSObjectPv + 0x34a
0xffffff9122e3bbe0 : 0xffffff8016adf277 mach_kernel : _is_io_connect_method + 0x1e7
0xffffff9122e3bd20 : 0xffffff8016597cc0 mach_kernel : _iokit_server + 0x5bd0
0xffffff9122e3be30 : 0xffffff80164df283 mach_kernel : _ipc_kobject_server + 0x103
```

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Overwriting free'd element's next pointer

```
Anonymous UUID:       D09DE92C-8710-4673-953D-BACF9F5B3C09

Thu Mar 24 01:34:03 2016

*** Panic Report ***
panic(cpu 2 caller 0xffffff800931f92b): "a freed zone element has been modified in zone kalloc.32: expected 0xdeadbeefdeadbeef but
found 0xffffff8029eb73a0, bits changed 0x2152416ff746cd4f, at offset 16 of 32 in element 0xffffff8029eb7440, cookies
0x3f0011330a841290 0x53521934cf94203"@/Library/Caches/com.apple.xbs/Sources/xnu/xnu-3248.40.184/osfmk/kern/zalloc.c:503
Backtrace (CPU 2), Frame : Return Address
0xffffff810b7a2a80 : 0xffffff80092dab12 mach_kernel : _panic + 0xe2
0xffffff810b7a2b00 : 0xffffff800931f92b mach_kernel : _zone_find_largest + 0x8fb
0xffffff810b7a2c30 : 0xffffff800983ca36 mach_kernel : __ZN6OSData16initWithCapacityEj + 0x66
0xffffff810b7a2c50 : 0xffffff800983cab0 mach_kernel : __ZN6OSData13initWithBytesEPKvj + 0x30
0xffffff810b7a2c80 : 0xffffff800983cc4e mach_kernel : __ZN6OSData9withBytesEPKvj + 0x6e
0xffffff810b7a2cb0 : 0xffffff800985d475 mach_kernel : __Z21OSUnserializeXMLparsePv + 0x13f5
0xffffff810b7a3d40 : 0xffffff800985db76 mach_kernel : __Z16OSUnserializeXMLPKcPP8OSString + 0xc6
0xffffff810b7a3d70 : 0xffffff80098de1da mach_kernel : _is_io_service_open_extended + 0xfa
0xffffff810b7a3de0 : 0xffffff80093977a1 mach_kernel : _iokit_server + 0x56b1
0xffffff810b7a3e30 : 0xffffff80092df283 mach_kernel : _ipc_kobject_server + 0x103
0xffffff810b7a3e60 : 0xffffff80092c28b8 mach_kernel : _ipc_kmsg_send + 0xb8
0xffffff810b7a3ea0 : 0xffffff80092d2665 mach_kernel : _mach_msg_overwrite_trap + 0xc5
0xffffff810b7a3f10 : 0xffffff80093b8bda mach_kernel : _mach_call_munger64 + 0x19a
0xffffff810b7a3fb0 : 0xffffff80093eca96 mach_kernel : _hndl_mach_scall64 + 0x16

BSD process name corresponding to current thread: fuckaddremovebdw
Boot args: keepsyms=1

Mac OS version:
15E65

Kernel version:
```

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Questions?

- Wanna join us? mail resume to i@flanker017.me!
- Weibo: @flanker_017

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Credits

- Liang Chen
- Marco Grassi
- Wushi

Thanks!

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