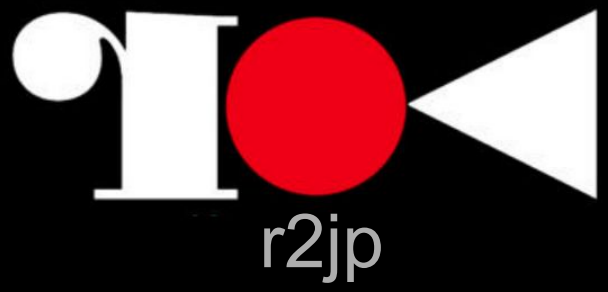


Unpacking the non-unpackable

@unixfreaxjp - r2con2018

malwaremustdie.org

Introduction

1. A security folk by day
   - Incident Response malware incident analyst support at a cyber emergency center in Japan
   - Advanced cyber threat research team member
   - FIRST.org member of SOC team
2. My community give-back:
   - Analysis write up in English (MMD blog +etc) & JP language
   - Moderator of a subreddit on Linux malware research
   - Lecturer for Linux malware on ICS threat in national events
3. Activity in radare2:
   - Introducing r2 in malware analysis & IR on national *& world-wide*
   - With help from pancake & national community we formed r2jp
   - I support mainstream to do tests, bug reports, ideas
   - The only lecturer teaches radare2 in All Japan Security Camp

Some facts you should know beforehand..

1. My background: Open Source believer, UNIX OS fanboy, FreeBSD user, UNIX Software debugger & Reverse Engineering
2. I may block you in twitter (but maybe my script does it, not me..)
   If you're the one, poke me here & let's see what we can do about that.
3. maijin, trufae, xvilka helps me a lot to catch up with recent radare..
4. The greatest decision in my life was:
   When I decided to run # *make uninstall* at radare2 dir in /usr/ports/ (as FreeBSD user) and switch to r2 Github version..
5. First r2 folks I met are:
   @zlowram, @trufae then @xvilka
6. Yes I also never find @trufae sleeps!

I never had chance to poke back to Paul, for his kind greets, pls allow me to poke him back..

Poke back to Paul, thanks & please put more screenshot of r2

Re:

My r2con2018 presentation highlights

1. My talk is about Linux binary packers and will explain how I handle them with my very basic radare2 skill.
2. I will try to share a practical methods in analyzing ITW packers, with approach from simple concept to complex one.
3. All methods are presented with screenshots and hopefully to finish within 30 minutes.. so I will be quick (sorry!) ping me afer for Q/A
4. I don't explain about:
   a. Windows OS binaries or other RE tool
   b. What is packers and how to basically (un)packed a binary
   c. How to spot the packed binary, yada yada..
5. Some warning about my presentation & my research
   a. I leaned radare myself via /usr/ports & helped GREATLY by r2 team to use r2!
   b. Mostly busy on handling incidents, so many stuff I want to write.. so little time
   c. If you can't see my twitter, you may didn’t see references I wrote in here before, it’s why I recaps them all now.. in the first part of this talk as the base.

Contents

1. Appetizer: Review on vanilla UPX packers, dissection & summary of several known packers I had researched.
   (this part contains basic info & a nice kickstart)
2. Some soup: Interesting ELF packers today (a good take-away for you)
3. Main course: Unknown packer I spotted ITW (non-unpackable one)

The concept of ELF unpacking will be shown in appetizer session, which will be used also in main course later, while before and on the “soup” session is adding you knowledge of various famous ELF packers ever seen and currently existed ones.

In the main course part I will show the dissection of a sample or two, (my) way to unpack it, and the alleged hidden motivation of why the original binaries are packed in this way...

Motto of the day

Q: I don't like ELF packers!
A: So do I, and no one does too, but…

“ FIRE UP YOUR R2 AND - EVERYTHING WILL BE OKAY! :) “

Part one - the appetizer

“ Dealing with the Vanilla UPX & details of other ELF packers I researched so far..“

Previous shares on ELF packers dissection

1. How I statically dealt with the custom UPX (aka Vanilla UPX)
2. ..and dynamic analysis on the above packers
3. ..and several ways on memory depacking (generally applied to all)

These has been shared either via my Twitter, YouTube or in Imgur (for them who can access it, due to OPSEC). BUT.. don't worry, let me sum them up on these first opening slides as appetizer..

....let's summing them up within one minute (...joke)

Vanilla ELF UPX 101 - in points & solution summary

1. Vanilla UPX 1st case - w/ UPX header rewriting method

   points are:

   - preventing the depacker command, the “-d”
   - making us believe this is not a UPX
   - they have no demerit by abusing headers, as long it runs well

   solution: Fixing the hex

2. Vanilla UPX 2nd case - w/ Source Code modification

   points are:

   - UPX is open source, we are all can see & can edit source code
   - Adding more "stuff" to UPX original packing (more routines etc)

   solution: Reading code then debugging it to modified code..

3. Other un-packing method if both two above doesn't work:

   - use radare2 to debug it,or brute it, or curse on it,
     and good luck!

...because you will maybe see this ELF

```
[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\
```

Anyone can tell what's wrong with this ELF?

The ELF header looks okay? (radare2)

```
sh-3.2$
sh-3.2$ r2 -nn sample
Module version mismatch /Users/rik/.local/share/radare2/plugins/core_pdd.dylib
 -- Don't feed the bugs! (except delicious stacktraces)!
[0x00000000]> pf.elf_header
      ident : 0x00000000 = .ELF....
       type : 0x00000010 = type (enum elf_type) = 0x2 ; ET_EXEC
    machine : 0x00000012 = machine (enum elf_machine) = 0x3 ; EM_386
    version : 0x00000014 = 0x00000001
      entry : 0x00000018 = 0x00c086b8
      phoff : 0x0000001c = 0x00000034
      shoff : 0x00000020 = 0x00000000
      flags : 0x00000024 = 0x00000000
     ehsize : 0x00000028 = 0x0034
  phentsize : 0x0000002a = 0x0020
      phnum : 0x0000002c = 0x0002
  shentsize : 0x0000002e = 0x0028
      shnum : 0x00000030 = 0x0000
   shstrndx : 0x00000032 = 0x0000
[0x00000000]>
```

Run: r2 -nn <sample> ; pf.elf_header

Check the header's values.. (elfdump)

```
e_ident: ELFCLASS32 ELFDATA2LSB ELFOSABI_LINUX
e_type: ET_EXEC
e_machine: EM_386
e_version: EV_CURRENT
e_entry: 0xc086b8
e_phoff: 52
e_shoff: 0
e_flags: 0
e_ehsize: 52
e_phentsize: 32
e_phnum: 2
e_shentsize: 40
e_shnum: 0
e_shstrndx: 0
```

Use: BSD command elfdump to dump the ELF header

How about the program header entries? (radare2)

```
[[0x00000000]>
[[0x00000000]>
[[0x00000000]> s 0x34
[[0x00000034]> pf.elf_phdr
    type : 0x00000034 = type (enum elf_p_type) = 0x1 ; PT_LOAD
  offset : 0x00000038 = 0x00000000
   vaddr : 0x0000003c = 0x00c01000
   paddr : 0x00000040 = 0x00c01000
  filesz : 0x00000044 = 0x00008828
   memsz : 0x00000048 = 0x00008828
   flags : 0x0000004c = flags (enum elf_p_flags) = 0x5 ; PF_Read_Exec
   align : 0x00000050 = 0x00001000
[[0x00000034]>
[[0x00000034]> s 0x54
[[0x00000054]> pf.elf_phdr
    type : 0x00000054 = type (enum elf_p_type) = 0x1 ; PT_LOAD
  offset : 0x00000058 = 0x00000448
   vaddr : 0x0000005c = 0x0805f448
   paddr : 0x00000060 = 0x0805f448
  filesz : 0x00000064 = 0x00000000
   memsz : 0x00000068 = 0x00000000
   flags : 0x0000006c = flags (enum elf_p_flags) = 0x6 ; PF_Read_Write
   align : 0x00000070 = 0x00001000
[[0x00000054]>
 [0x00000054]>
```

Load sample with -nn; Goto 1st or 2nd header; Run: pf.elf_phdr

How about the program header entries? (elfdump)

```
entry: 0
    p_type: PT_LOAD
    p_offset: 0
    p_vaddr: 0xc01000
    p_paddr: 0xc01000
    p_filesz: 34856
    p_memsz: 34856
    p_flags: PF_X|PF_R
    p_align: 4096

entry: 1
    p_type: PT_LOAD
    p_offset: 1096
    p_vaddr: 0x805f448
    p_paddr: 0x805f448
    p_filesz: 0
    p_memsz: 0
    p_flags: PF_W|PF_R
    p_align: 4096
```

Use: BSD command elfdump to dump the ELF header

To do manual analysis of this ELF header in radare2 interface correctly

Run: / ELF; Seek for ELF magic; s <address> ; Run: pxa

```
[0x00c01000]> pxa
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F
            /s/hit0_0ehdr
0x00c01000  7f45 4c46 0101 0103 0000 0000 0000 0000  .ELF............ ; [02] -rw- s
0x00c01010  0200 0300 0100 0000 d08e c000 3400 0000  ............4...   size 52 nam
0x00c01020  0000 0000 0000 0000 3400 2000 0200 2800  ........4. ...(.
                        /section_end.ehdr
0x00c01030  0000 0000 0100 0000 0000 0000 0010 c000  ................
0x00c01040  0010 c000 d386 0000 d386 0000 0500 0000  ................
0x00c01050  0010 0000 0100 0000 d00f 0000 d0ef 0508  ................
0x00c01060  d0ef 0508 0000 0000 0000 0000 0600 0000  ................
0x00c01070  0010 0000 d9ba 2ad2 5550 5821 1008 0d0c  ......*.UPX!....
0x00c01080  0000 0000 8c08 0100 8c08 0100 b400 0000  ................
                                            /hit0_1
```

ELF header

pheadr entry 0

pheadr entry 1

UPX header

...and so many unlimited variations of these ELF too

```
0x00008001 hit0_0 .ELF(.
[0x00010e20]> s 0x00008000
[0x00008000]> x
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00008000  7f45 4c46 0101 0103 0000 0000 0000 0000  .ELF............
0x00008010  0200 2800 0100 0000 200e 0100 3400 0000  ..(..... ...4...
0x00008020  0000 0000 0200 0004 3400 2000 0200 2800  ........4. ...(.
0x00008030  0000 0000 0100 0000 0000 0000 0080 0000  ................
0x00008040  0080 0000 399f 0000 399f 0000 0500 0000  ....9...9.......
0x00008050  0080 0000 0100 0000 8830 0000 8830 0200  .........0...0..
0x00008060  8830 0200 0000 0000 0000 0000 0600 0000  .0..............
0x00008070  0080 0000 10a3 9fe1 7830 3000 3411 0d17  ........x00.4...
0x00008080  0000 0000 aa22 0200 aa22 0200 b400 0000  ....."..."......
0x00008090  5f00 0000 0e00 0000 1a03 003f 9145 8468  _..........?.E.h
0x000080a0  3bde dea6 0f23 f0d4 2419 baad 1bf9 c8c3  ;....#..$.......
0x000080b0  d157 bd75 1ebe 42af 2ab5 7eaf 1e22 04f6  .W.u..B.*.~.."..
0x000080c0  5930 d1cf 45f3 0071 9918 a740 d183 d47b  Y0..E..q...@...{
0x000080d0  6314 08f3 7b75 c7cd d3b6 7467 57b5 989c  c...{u....tgW...
0x000080e0  eb94 d5a6 20d5 fe17 9698 1fce 0661 1aff  .... ........a..
0x000080f0  e65e 7de9 2ed5 e0e8 7e01 0024 8b00 000e  .^}.....~..$....
[0x00008000]>
```

Anyone can tell what's wrong with this ELF?

Practise to read ELF(upx) headers w/ radare2 (default)

```
 -- Jingle sploits, jingle sploits, ropchain all the way.
[0x00010e20]> / ELF
Searching 3 bytes in [0x8000-0x11f39]
hits: 1
0x00008001 hit0_0 .ELF(.
[0x00010e20]> 0x00008000
[0x00008000]> pxa
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F
             /s/hit0_0ehdr
0x00008000  7f45 4c46 0101 0103 0000 0000 0000 0000  .ELF............
0x00008010  0200 2800 0100 0000 200e 0100 3400 0000  ..(..... ...4...
0x00008020  0000 0000 0200 0004 3400 2000 0200 2800  ........4. ...(.
                       /segment_end.ehdr
0x00008030  0000 0000 0100 0000 0000 0000 0080 0000  ................
0x00008040  0080 0000 399f 0000 399f 0000 0500 0000  ....9...9.......
0x00008050  0080 0000 0100 0000 8830 0000 8830 0200  .........0...0..
0x00008060  8830 0200 0000 0000 0000 0000 0600 0000  .0..............
0x00008070  0080 0000 10a3 9fe1 7830 3000 3411 0d17  ........x00.4...
0x00008080  0000 0000 aa22 0200 aa22 0200 b400 0000  ....."..."......
0x00008090  5f00 0000 0e00 0000 1a03 003f 9145 8468  _..........?.E.h
0x000080a0  3bde dea6 0f23 f0d4 2419 baad 1bf9 c8c3  ;....#..$.......
0x000080b0  d157 bd75 1ebe 42af 2ab5 7eaf 1e22 04f6  .W.u..B.*.~.."..
```

Practise to read ELF(upx) headers with radare2 -n

```
[0x00000000]> s 0x0; pf.elf_phdr
    type : 0x00000000 = type (enum elf_p_type) = 0x464c457f
  offset : 0x00000004 = 0x03010101
   vaddr : 0x00000008 = 0x00000000
   paddr : 0x0000000c = 0x00000000
  filesz : 0x00000010 = 0x00280002
   memsz : 0x00000014 = 0x00000001
   flags : 0x00000018 = flags (enum elf_p_flags) = 0x10e20
   align : 0x0000001c = 0x00000034
[0x00000000]> s 0x34; pf.elf_phdr
    type : 0x00000034 = type (enum elf_p_type) = 0x1 ; PT_LOAD
  offset : 0x00000038 = 0x00000000
   vaddr : 0x0000003c = 0x00008000
   paddr : 0x00000040 = 0x00008000
  filesz : 0x00000044 = 0x00009f39
   memsz : 0x00000048 = 0x00009f39
   flags : 0x0000004c = flags (enum elf_p_flags) = 0x5 ; PF_Read_Exec
   align : 0x00000050 = 0x00008000
[0x00000034]> s 0x54; pf.elf_phdr
    type : 0x00000054 = type (enum elf_p_type) = 0x1 ; PT_LOAD
  offset : 0x00000058 = 0x00003088
   vaddr : 0x0000005c = 0x00023088
   paddr : 0x00000060 = 0x00023088
  filesz : 0x00000064 = 0x00000000
   memsz : 0x00000068 = 0x00000000
   flags : 0x0000006c = flags (enum elf_p_flags) = 0x6 ; PF_Read_Write
   align : 0x00000070 = 0x00008000
[0x00000054]> px 100 @ 0x74
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000074  10a3 9fe1 7830 3000 3411 0d17 0000 0000  ....x00.4.......
0x00000084  aa22 0200 aa22 0200 b400 0000 5f00 0000  ."..."......_...
0x00000094  0e00 0000 1a03 003f 9145 8468 3bde dea6  .......?.E.h;...
0x000000a4  0f23 f0d4 2419 baad 1bf9 c8c3 d157 bd75  .#..$........W.u
0x000000b4  1ebe 42af 2ab5 7eaf 1e22 04f6 5930 d1cf  ..B.*.~.."..Y0..
```

ELF HEADER

PROGRAM HEADER 0

PROGRAM HEADER 1

UPX HEADERS

...checking whether the values are correct (elfdump)

```
e_ident: ELFCLASS32 ELFDATA2LSB ELFOSABI_LINUX
e_type: ET_EXEC
e_machine: EM_ARM
e_version: EV_CURRENT
e_entry: 0x10e20
e_phoff: 52
e_shoff: 0
e_flags: 67108866
e_ehsize: 52
e_phentsize: 32
e_phnum: 2
e_shentsize: 40
e_shnum: 0
e_shstrndx: 0
```

```
entry: 0
    p_type: PT_LOAD
    p_offset: 0
    p_vaddr: 0x8000
    p_paddr: 0x8000
    p_filesz: 40761
    p_memsz: 40761
    p_flags: PF_X|PF_R
    p_align: 32768

entry: 1
    p_type: PT_LOAD
    p_offset: 12424
    p_vaddr: 0x23088
    p_paddr: 0x23088
    p_filesz: 0
    p_memsz: 0
    p_flags: PF_W|PF_R
    p_align: 32768
```

Use: BSD command elfdump to dump the ELF header

Back to the question:

" So, what is wrong with those files? "

Motto of the day

Remember our motto of the day:

“ FIRE UP YOUR R2!

+ ..HAVE FAITH! DON’T GIVE UP ! "

Remember this pic when dealing with Vanilla UPX

```
$ hexdump -C ./cat-upx|head -15
00000000  7f 45 4c 46 01 01 01 03  00 00 00 00 00 00 00 00  |.ELF............|
00000010  02 00 03 00 01 00 00 00  48 65 c0 00 34 00 00 00  |........He..4...|
00000020  00 00 00 00 00 00 00 00  34 00 20 00 02 00 28 00  |........4. ...(.|
00000030  00 00 00 00 01 00 00 00  00 00 00 00 00 10 c0 00  |................|
00000040  00 10 c0 00 38 5d 00 00  38 5d 00 00 05 00 00 00  |....8]..8]......|
00000050  00 10 00 00 01 00 00 00  28 07 00 00 28 57 05 08  |........(...(W..|
00000060  28 57 05 08 00 00 00 00  00 00 00 00 06 00 00 00  |(W..............|
00000070  00 10 00 00 a7 b1 30 fd  55 50 58 21 f8 07 0d 0c  |......0.UPX!....|
00000080  00 00 00 00 ac c6 00 00  ac c6 00 00 54 01 00 00  |............T...|
00000090  bd 00 00 00 02 00 00 00  7f 3f 64 f9 7f 45 4c 46  |.........?d..ELF|
000000a0  01 00 02 00 03 00 0d 1c  a1 04 db 6f b3 dd 08 34  |...........o...4|
```

UPX HEADER

Elf file type is EXEC (Executable file)
Entry point 0xc06548
There are 2 program headers, starting at offset 52
Program Headers:

Type	Offset	VirtAddr	PhysAddr	FileSiz	MemSiz	Flg	Align
LOAD	0x000000	0x00c01000	0x00c01000	0x05d38	0x05d38	R E	0x1000
LOAD	0x000728	0x08055728	0x08055728	0x00000	0x00000	RW	0x1000

Magic

e_ident: ELFCLASS32 ELFDATA2LSB ELFOSABI_LINUX
e_type: ET_EXEC
e_machine: EM_386
e_version: EV_CURRENT
e_entry: 0xc06548
e_phoff: 52
e_shentsize: 40
e_shstrndx: 0
e_shoff: 0
e_flags: 0
e_ehsize: 52
e_phentsize: 32
e_phnum: 2
e_shnum: 0

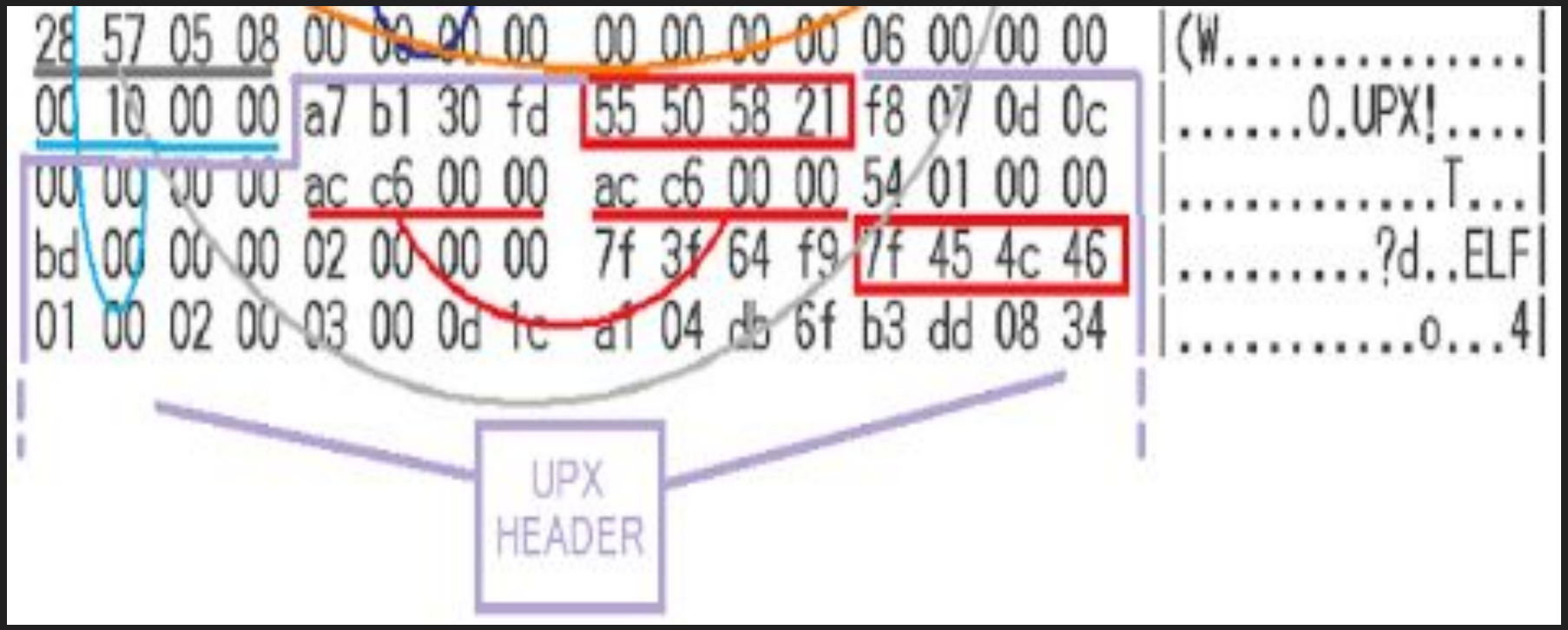
ENTRY 0x0	ENTRY 0x1
p_type: 1 (PT_LOAD)	p_type: 1 (PT_LOAD)
p_offset: 0	p_offset: 1832 (0x0728)
p_vaddr: 0xc01000	p_vaddr: 0x8055728
p_paddr: 0xc01000	p_paddr: 0x8055728
p_filesz: 23864(0x5d38)	p_filesz: 0
p_memsz: 23864 (0x5d38)	p_memsz: 0
p_flags: PF_X|PF_R (0x5)	p_flags: PF_W|PF_R (0x6)
p_align: 4096(0x1000)	p_align: 4096(0x1000)

Every Vanilla UPX can not get around these ELF binary rules and program header table entries rules.

Understanding this is importtant in analyzing packers.

..above image is for ELF UPX x86_32, use this concept to recognize the headers for the other architecture too, then write your own image.

Especially this part, the one that has to be correctly written for decompressing an ELF UPX



..and (hopefully) all will be okay :)

Fixing the headers i.e.:

```
0x00c01070  0010 0000 d9ba 2ad2 5550 5821 1008 0d0c  ......*.UPX!....
0x00c01080  0000 0000 8c08 0100 8c08 0100 b400 0000  ................
0x00c01090  7200 0000 0200 0000 7f3f 64f9 7f45 4c46  r........?d..ELF
0x00c010a0  0100 0200 0300 0d94 8104 fe6f b3dd 0834  ...........o...4
0x00c010b0  0734 061b 0b20 0004 0028 000f 000e 005f  .4... ...(.....
0x00c010c0  fbb5 c92d 8023 0313 ea0a 0305 7dee ce7e  ...-.#......}..~
```

```
0x00c01090  7200 0000 0200 0000 7f3f 64f9 7f45 4c46  r........?d..ELF
0x00c010a0  0100 0200 0300 0d94 8104 fe6f b3dd 0834  ...........o...4
0x00c010b0  0734 061b 0b20 0004 0028 000f 000e 005f  .4... ...(....._
[0x00c01000]> q
[[redacted]/malware/temp/028/[redacted]/005]$ upx -d pty2
                       Ultimate Packer for eXecutables
                          Copyright (C) 1996 - 2013
UPX 3.91        Markus Oberhumer, Laszlo Molnar & John Reiser   Sep 30th 2013

        File size         Ratio      Format      Name
   --------------------   ------   -----------   -----------
     69241 <-     34916   50.43%  netbsd/elf386  pty2

Unpacked 1 file.
```

What if things are still gone wrong?

```
[0x00000000]> # in here..
[0x00000000]> px @0x59!0x1
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000059  0d                                       .
[0x00000000]> # If you see this blob....
[0x00000000]> px @0x58!0x2
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000058  680d                                     h.
[0x00000000]> # it is not suppose to be the same as:
[0x00000000]> px @0x5C!0x2
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x0000005c  680d                                     h.
[0x00000000]> #This bit was faked:
[0x00000000]> px @0x59!0x1
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000059  0d                                       .
[0x00000000]> # so putting the correct bit together will restore the ELF
[0x00000000]> # however if one doesn't know the orig ELF form it is impo-
[0x00000000]> #ssible.. what to do?
[0x00000000]> #
```

Note from pancake: To be more readable please use @0x5c!1

..and (hopefully) all will be okay :)

Brute it!

```
[0x00cfce38]>
[0x00cfce38]>
[0x00cfce38]> px @0x59!0x1
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000059  0d                                       .
[0x00cfce38]> # patch it..
[0x00cfce38]> oo+; s 0x59; px 1; wx 00; px 1
File stdin-dep reopened in read-write mode
Warning: Cannot initialize section headers
Warning: Cannot initialize strings table
Warning: Cannot initialize dynamic strings
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000059  0d                                       .
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000059  00                                       .
```

Video: https://www.youtube.com/watch?v=72JpU95aDLg

.and (hopefully) all will be okay :)

Vanilla UPX - Fixing the hacked source code

FACTS:

- ELF packed with UPX and the headers looks okay
- Can NOT be decompress even all are in correct places.

SOLUTION:

- Debug until point where the decompressor error come up
- Find how the error behavior is and seek which variable is causing it
- Go to the official UPX source code to see if it is correctly coded that way
- Diff it, see how it is patched and adjust the source code, recompile the UPX and try to decompress with the new fixed source code

Vanilla UPX - Fixing the hacked source code

```
upx      CALL  ioctl(0x2,TIOCGETA,0xbfbfdad0)
upx      RET   ioctl 0
upx      CALL  write(0x2,0xbfbfdb3c,0x5)
upx      GIO   fd 2 wrote 5 bytes
"upx: "
upx      RET   write 5
upx      CALL  write(0x2,0xbfbfdb3c,0x15)
upx      GIO   fd 2 wrote 21 bytes
"./daemon.armv4l.mod: "
upx      RET   write 21/0x15
upx      CALL  write(0x2,0xbfbfdf6c,0x27)
upx      GIO   fd 2 wrote 39 bytes
"CantUnpackException: header corrupted 2"
upx      RET   write 39/0x27
upx      CALL  write(0x2,0x81b8640,0x1)
upx      GIO   fd 2 wrote 1 byte
```

Output of the ktrace read in kdump (on BSD)

Vanilla UPX - Fixing the hacked source code

```
upx      RET   ioctl 0
upx      CALL  write(0x2,0xbfbfdb3c,0x5)
upx
upx
upx
upx
upx
upx
upx
upx
upx
upx
upx
upx
upx
upx
upx
```

```
89e5          mov ebp, esp
53            push ebx      ; prep ebx for hdr
83ec04        sub esp, 4
8b5d08        mov ebx, dword [ebp+arg_2]
8b4304        mov eax, dword [ebx + 4]
85c0          test eax, eax
7860          js 0x80af611
8b03          mov eax, dword [ebx]
85c0          test eax, eax
785a          js 0x80af611
from 0x080af61f (fcn.080af5a0)
83f803        cmp eax, 3
ba18000000    mov edx, 0x18 ; where it failed
7e1f          jle 0x80af5e0
```

Analyze (r2) reasons why the error occured ...

Vanilla UPX - Fixing the hacked source code

```
upx      RET    ioctl 0
upx      CALL   write(0x2,0xbfbfdb3c,0x5)
```

```
89e5          mov ebp, esp
53            push ebx      ; prep ebx for hdr
83ec04        sub esp, 4
```

```
const upx_bytep p = buf + boff;
version = p[4];
format = p[5];
method = p[6];
level = p[7];
filter_cto = 0;

const int size = getPackHeaderSize();
if (boff + size <= 0 || boff + size > blen)
throwCantUnpack("header corrupted 2");
```

Check which UPX source was tweaked..

More explanation in: https://imgur.com/a/3mgZm/

Vanilla UPX - Fixing the hacked source code

```
upx      RET    ioctl 0
upx      CALL   write(0x
upx      89e5
upx      53
upx      83ec04
upx
upx
upx
```

Vanilla UPX - Fixing the hacked source code

In this example the malware

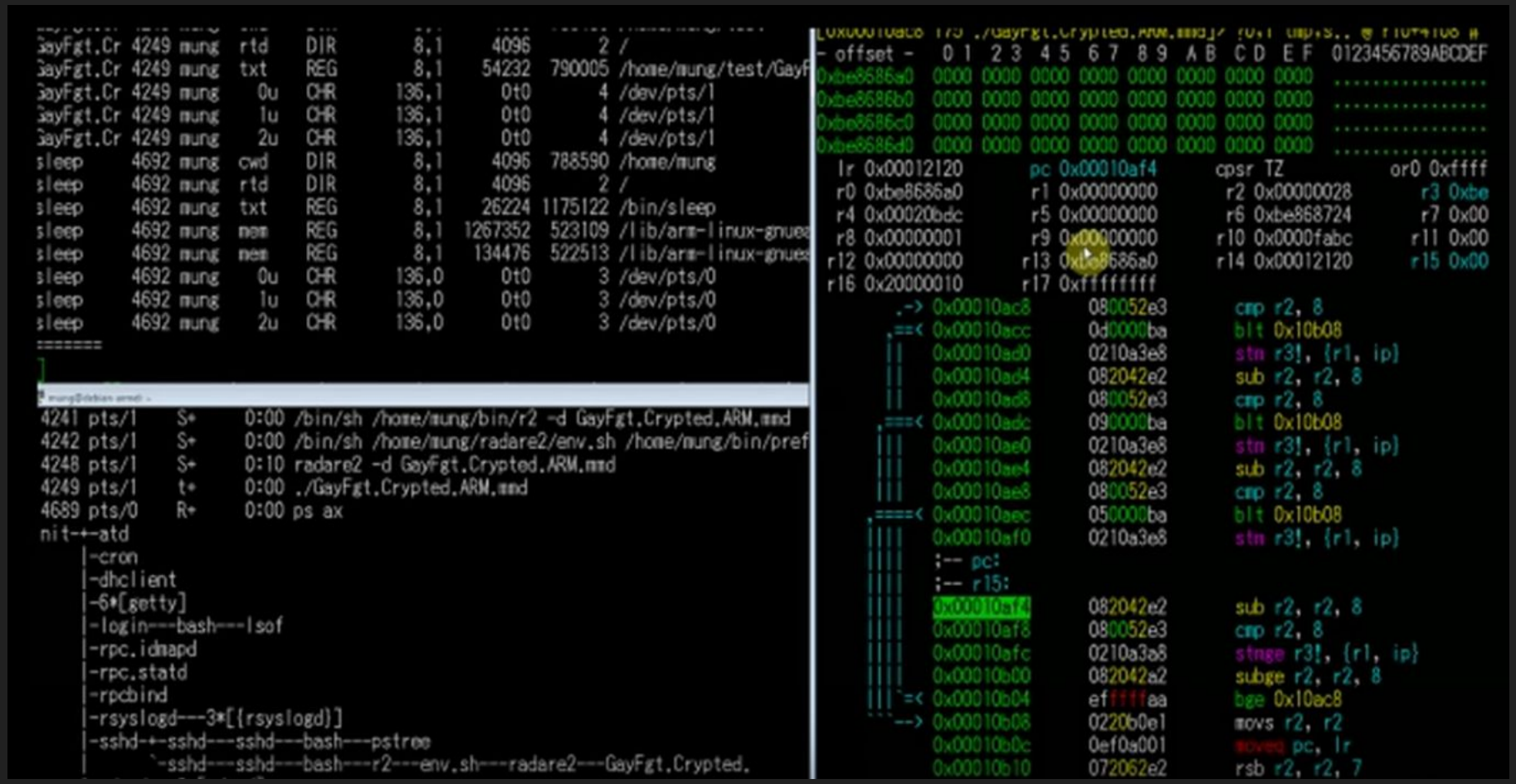
Solution:
Adjust the C code to the tweaked one & recompile upx, then use -d to unpack.

When things goes south?
Check again..

```
10 if (boff + size <= 0 || boff + size > blen)
11 throwCantUnpack("header corrupted 2");
```

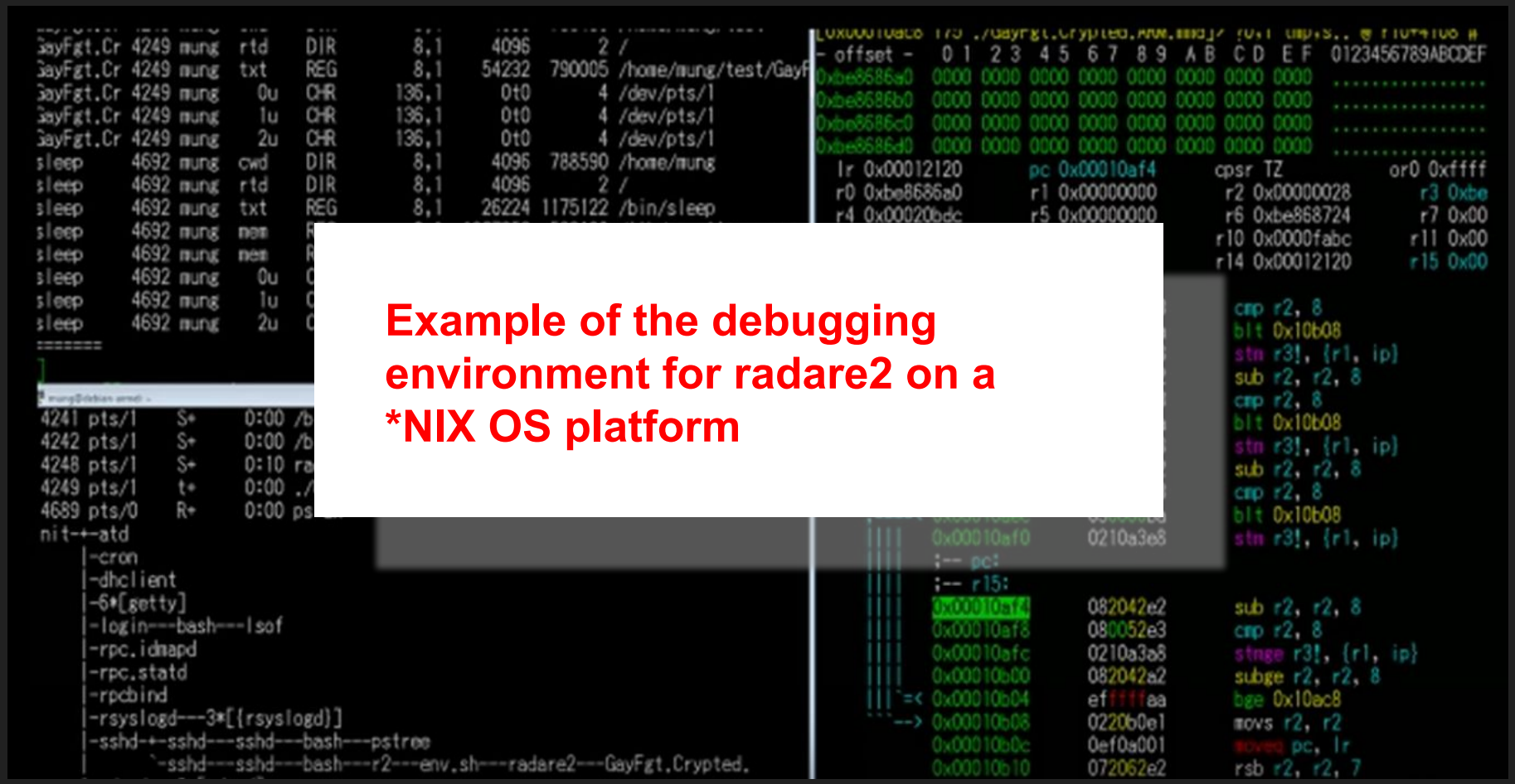
More explanation in: https://imgur.com/a/3mgZm/

Vanilla UPX - On memory un-packing with r2



Video: https://www.youtube.com/watch?v=ad6kvL834Wk

Vanilla UPX - On memory un-packing with r2



Video: https://www.youtube.com/watch?v=ad6kvL834Wk

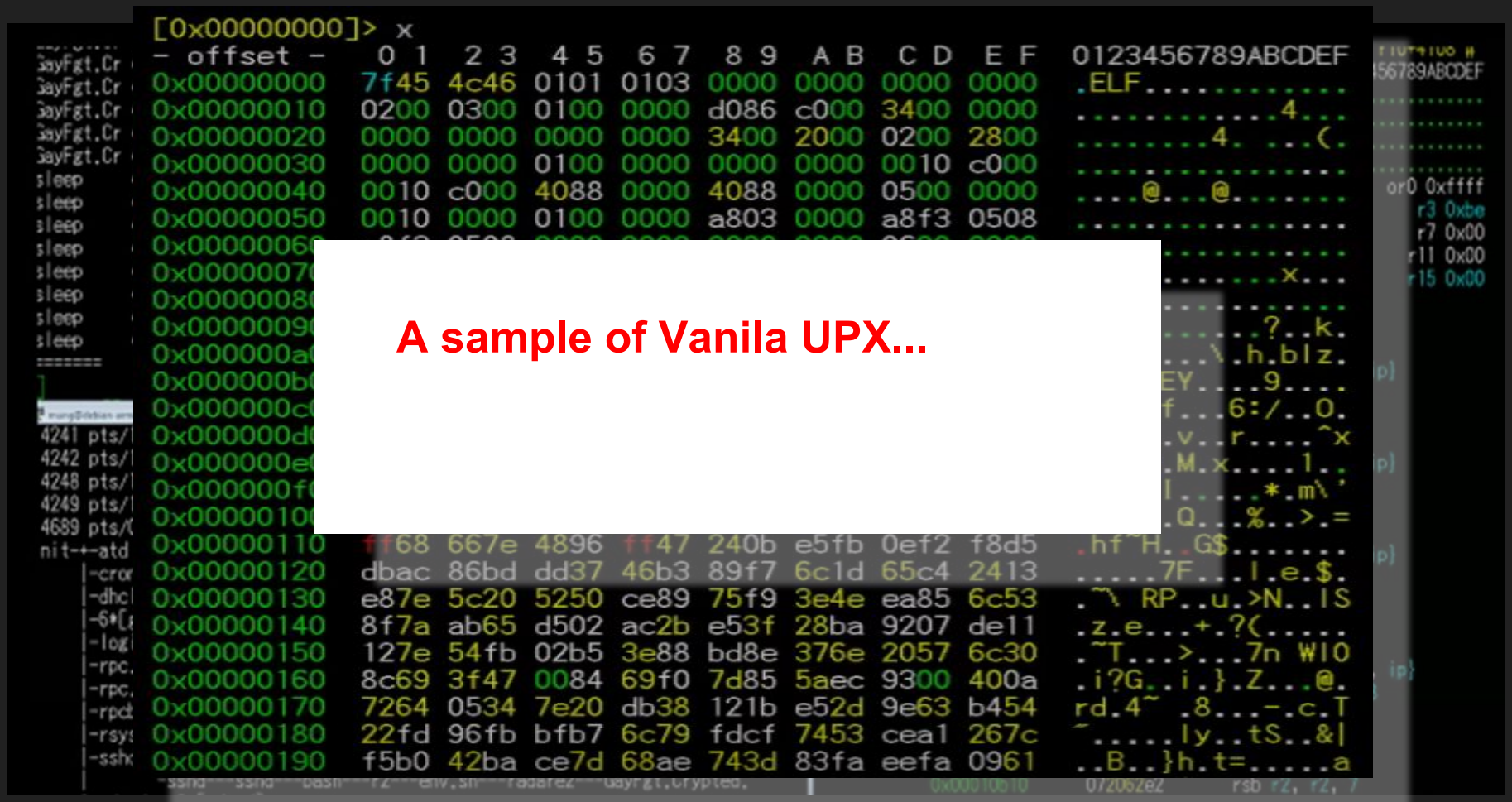
Vanilla UPX - On memory un-packing with r2

```
[0x00000000]> x
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00000000  7f45 4c46 0101 0103 0000 0000 0000 0000  .ELF............
0x00000010  0200 0300 0100 0000 d086 c000 3400 0000  ............4...
0x00000020  0000 0000 0000 0000 3400 2000 0200 2800  ........4. ...(.
0x00000030  0000 0000 0100 0000 0000 0000 0010 c000  ................
0x00000040  0010 c000 4088 0000 4088 0000 0500 0000  ....@...@.......
0x00000050  0010 0000 0100 0000 a803 0000 a8f3 0508  ................
0x00000060  a8f3 0508 0000 0000 0000 0000 0600 0000  ................
0x00000070  0010 0000 2efa 01da 0a00 0000 7811 0d0c  ............x...
0x00000080  0000 0000 139a 0100 139a 0100 9400 0000  ................
0x00000090  5400 0000 0e00 0000 1803 003f 91d0 6b8f  T..........?..k.
0x000000a0  492f fa6a e407 9a89 5c84 6898 626c 7a90  I/.j....\.h.blz.
0x000000b0  6576 b262 b445 59d8 fdb4 db39 8908 dc2e  ev.b.EY....9....
0x000000c0  9eb2 c6b9 1466 15c9 c636 3a2f 0c01 4f90  .....f...6:/..O.
0x000000d0  869b b1b8 dbdc 76ca c872 a2f6 8ce0 5e78  ......v..r....^x
0x000000e0  29bc 789a 641b 4ddb 78f5 8490 9431 0100  ).x.d.M.x....1..
0x000000f0  3974 0000 0e49 0600 1803 002a a36d 5c27  9t...I.....*.m\'
0x00000100  81a8 155f 95c7 510b 1f16 25de cb3e b13d  ...._..Q...%..>.=
0x00000110  ff68 667e 4896 ff47 240b e5fb 0ef2 f8d5  .hf~H..G$.......
0x00000120  dbac 86bd dd37 46b3 89f7 6c1d 65c4 2413  .....7F...l.e.$.
0x00000130  e87e 5c20 5250 ce89 75f9 3e4e ea85 6c53  .~\ RP..u.>N..lS
0x00000140  8f7a ab65 d502 ac2b e53f 28ba 9207 de11  .z.e...+.?(.....
0x00000150  127e 54fb 02b5 3e88 bd8e 376e 2057 6c30  .~T...>...7n Wl0
0x00000160  8c69 3f47 0084 69f0 7d85 5aec 9300 400a  .i?G..i.}.Z...@.
0x00000170  7264 0534 7e20 db38 121b e52d 9e63 b454  rd.4~ .8...-.c.T
0x00000180  22fd 96fb bfb7 6c79 fdcf 7453 cea1 267c  ".....ly..tS..&|
0x00000190  f5b0 42ba ce7d 68ae 743d 83fa eefa 0961  ..B..}h.t=.....a
```

Video: https://www.youtube.com/watch?v=ad6kvL834Wk

https://www.youtube.com/watch?v=E8gN_XUTCxM

Vanilla UPX - On memory un-packing with r2



Video: https://www.youtube.com/watch?v=ad6kvL834Wk

https://www.youtube.com/watch?v=E8gN_XUTCxM

```
0x08055712  2f6e 756c 6c20 323e 2631 2026 0000 6b69  /null 2>&1 &..ki
0x08055722  6c6c 616c 6c20 2d39 206d 6970 7365 6c20  llall -9 mipsel
0x08055732  3e20 2f64 6576 2f6e 756c 6c20 323e 2631  > /dev/null 2>&1
0x08055742  2026 0000 0000 6b69 6c6c 616c 6c20 2d39   &....killall -9
0x08055752  2070 6f77 6572 7063 203e 202f 6465 762f   powerpc > /dev/
0x08055762  6e75 6c6c 2032 3e26 3120 2600 0000 6b69  null 2>&1 &...ki
0x08055772  6c6c 616c 6c20 2d39 2070 7063 203e 202f  llall -9 ppc > /
0x08055782  6465 762f 6e75 6c6c 2032 3e26 3120 2600  dev/null 2>&1 &.
0x08055792  0000 6b69 6c6c 616c 6c20 2d39 2064 6165  ..killall -9 dae
0x080557a2  6d6f 6e2e 6172 6d76 346c 2e6d 6f64 203e  mon.armv4l.mod >
0x080557b2  202f 6465 762f 6e75 6c6c 2032 3e26 3120   /dev/null 2>&1
0x080557c2  2600 6b69 6c6c 616c 6c20 2d39 2064 6165  &.killall -9 dae
0x080557d2  6d6f 6e2e 6936 3836 2e6d 6f64 203e 202f  mon.i686.mod > /
0x080557e2  6465 762f 6e75 6c6c 2032 3e26 3120 2600  dev/null 2>&1 &.
0x080557f2  0000 6b69 6c6c 616c 6c20 2d39 2064 6165  ..killall -9 dae
0x08055802  6d6f 6e2e 6d69 7073 2e6d 6f64 203e 202f  mon.mips.mod > /
0x08055802  6d6f 6e2e 6d69 7073 2e6d 6f64 203e 202f  mon.mips.mod > /
0x08055812  6465 762f 6e75 6c6c 2032 3e26 3120 2600  dev/null 2>&1 &.
0x08055822  0000 6b69 6c6c 616c 6c20 2d39 2064 6165  ..killall -9 dae
0x08055832  6d6f 6e2e 6d69 7073 656c 2e6d 6f64 203e  mon.mipsel.mod >
0x08055842  202f 6465 762f 6e75 6c6c 2032 3e26 3120   /dev/null 2>&1
0x08055852  2600 726d 202d 7266 202f 746d 702f 2e78  &.rm -rf /tmp/.x
0x08055862  732f 2a20 3e20 2f64 6576 2f6e 756c 6c20  s/* > /dev/null
0x08055872  323e 2631 2026 0000 0000 6970 7461 626c  2>&1 &....iptabl
0x08055882  6573 202d 4120 494e 5055 5420 2d70 2074  es -A INPUT -p t
0x08055892  6370 202d 2d64 706f 7274 2032 3220 2d6a  cp --dport 22 -j
0x080558a2  2044 524f 5020 3e20 2f64 6576 2f6e 756c   DROP > /dev/nul
0x080558b2  6c20 323e 2631 2026 0000 6970 7461 626c  l 2>&1 &..iptabl
0x080558c2  6573 202d 4120 494e 5055 5420 2d70 2074  es -A INPUT -p t
```

Video: https://www.youtube.com/watch?v=ad6kvL834Wk

https://www.youtube.com/watch?v=E8gN_XUTCxM

```
0x08055712  2f6e 756c 6c20 323e 2631 2026 0000 6b69  /null 2>&1 &..ki
0x08055722  6c6c 616c 6c20 2d39 206d 6970 7365 6c20  llall -9 mipsel
0x08055732  3e20 2f64 6576 2f6e 756c 6c20 323e 2631  > /dev/null 2>&1
0x08055742  2026 0000 0000 6b69 6c6c 616c 6c20 2d39   &....killall -9
0x08055752  2070 6f77 6572 7063 203e 202f 6465 762f   powerpc > /dev/
0x08055762  6e75 6c6c 2032 3e26 3120 2600 0000 6b69  null 2>&1 &...ki
0x08055772  6c6c 616c 6c20 2d39 2070 7063 203e 202f  llall -9 ppc > /
0x08055782  6465 762f 6e75 6c6c 2032 3e26 3120 2600  dev/null 2>&1 &.
0x08055792  0000 6b69 6c6c 616c 6c20 2d39 2064 6165  ..killall -9 dae
0x080557a2  6d6f 6e2e 6172 6d76 346c 2e6d 6f64 203e  mon.armv4l.mod >
0x080557b2  202f 6465 762f 6e75 6c6c 2032 3e26 3120   /dev/null 2>&1
0x080557c2  2600 6b69 6c6c 616c 6c20 2d39 2064 6165  &.killall -9 dae
0x080557d2  6c                                       on.i686.mod > /
0x080557e2  64                                       ev/null 2>&1 &.
0x080557f2  00                                       killall -9 dae
0x08055802  6c                                       on.mips.mod > /
0x08055802  6c                                       on.mips.mod > /
0x08055812  64                                       ev/null 2>&1 &.
0x08055822  00                                       killall -9 dae
0x08055832  6c                                       on.mipsel.mod >
0x08055842  20                                       /dev/null 2>&1
0x08055852  2600 726d 202d 7266 202f 746d 702f 2e78  &.rm -rf /tmp/.x
0x08055862  732f 2a20 3e20 2f64 6576 2f6e 756c 6c20  s/* > /dev/null
0x08055872  323e 2631 2026 0000 0000 6970 7461 626c  2>&1 &....iptabl
0x08055882  6573 202d 4120 494e 5055 5420 2d70 2074  es -A INPUT -p t
0x08055892  6370 202d 2d64 706f 7274 2032 3220 2d6a  cp --dport 22 -j
0x080558a2  2044 524f 5020 3e20 2f64 6576 2f6e 756c   DROP > /dev/nul
0x080558b2  6c20 323e 2631 2026 0000 6970 7461 626c  l 2>&1 &..iptabl
0x080558c2  6573 202d 4120 494e 5055 5420 2d70 2074  es -A INPUT -p t
```

The unpacked ELF on memory

Video: https://www.youtube.com/watch?v=ad6kvL834Wk

https://www.youtube.com/watch?v=E8gN_XUTCxM

HOWTO:

- Let the unpack goes to where you can breakpoint the result safely, “db” the address, “dc” to the bp. Get into the unpacked bin.
- Seek the base address to where the unpacked data will be executable, to fix the bin later..
- Check the length properly, it is sometimes longer than actual sample
- Go to the unpacked ELF header first byte of MAGIC (at 7f454c46), or use “/ ELF” to seek.
- Use WTF to dump the depacked file

Video: https://www.youtube.com/watch?v=ad6kvL834Wk

https://www.youtube.com/watch?v=E8gN_XUTCxM

(to be added…)

Several Vanilla UPX samples to practise

Binaries info:

1. 8046e04564dc0b8d0e5a37358d6a8dfe
   ELF 32-bit LSB executable, ARM, version 1 (ARM), statically linked, stripped

2. 7980ffb3ad788b73397ce84b1aadf99b
   ELF 32-bit LSB executable, MIPS, MIPS-I version 1 (SYSV), statically linked, stripped

Motto of the day

..SO EVERYTHING IS A "BYTE”
OKAY NOW! :)

This is how you should feel:

Yay, we can beat some Vanillas..

Other ELF packers I researched so far..

Summarizing:

1. BurnEye (good for practise, has crypted password protection, basic of packing in ELF, Open source/Leaked Source?)
2. ElfEncrypter/ElfJunk (virtualize then obfuscate..and obfuscate, has password protection, Open source)
3. Shiva (The first anti reversing packer I tested, a bit old but one of best I guess, not seeing this anymore ITW, except older samples, hard to dissect with only static analysis)
4. VMProtect (Use Virtual Machine, Obfuscation code, Highly used of Junk Assembly, With several anti debugging, please read official web site for more, currently I am on watch this packer)

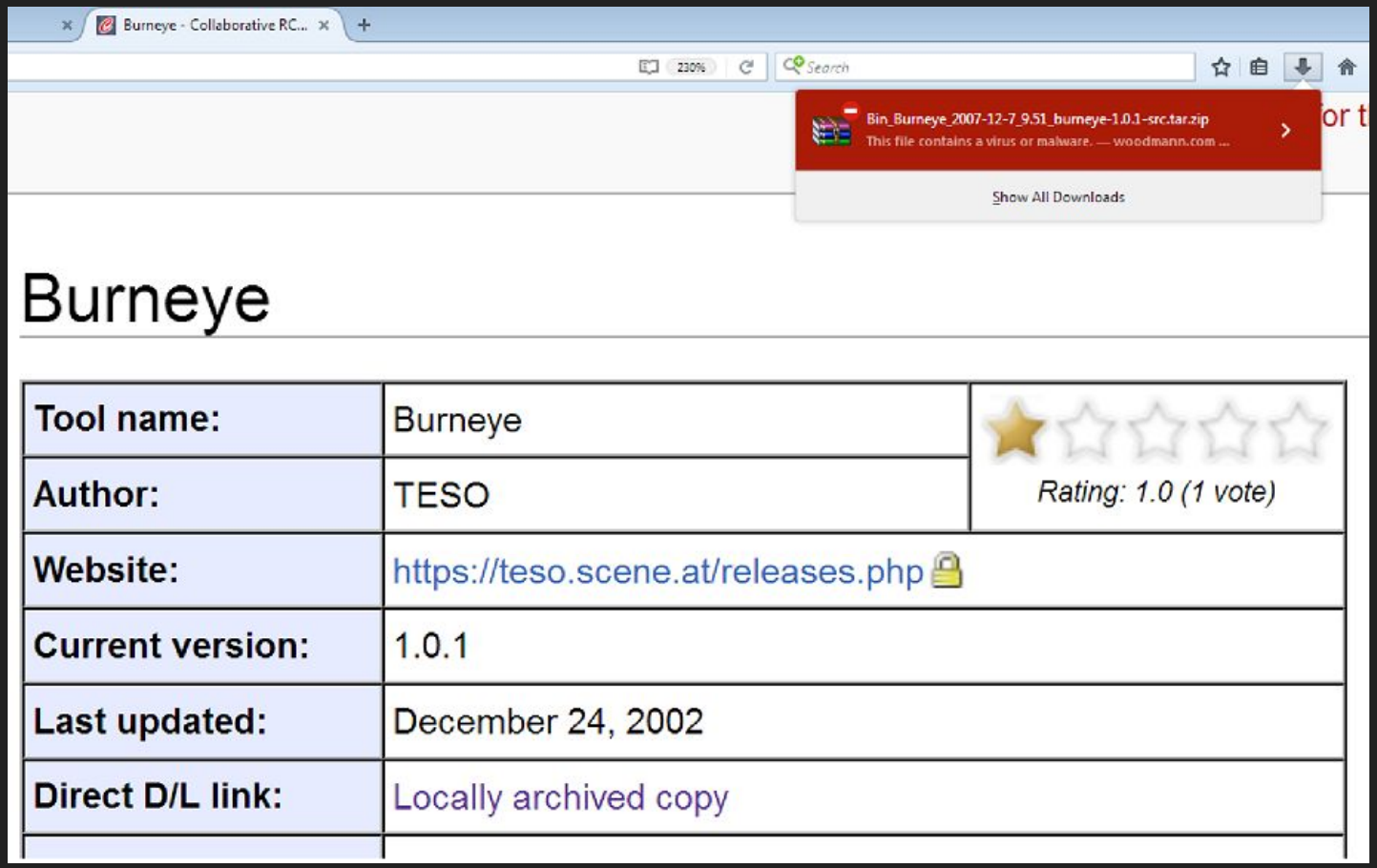
Other ELF packers I researched so far..

TABLE OF PACKER DATA	Origin	Features (Crypt etc)	Dificulty score	Dissection info	Arch	Reference
BurnEye	2002	Password protected (TESO Elf Encrypt Engine)	low	burndump.c - burneye unwrapper by [ByteRage]	x86	woodmann.com/collaborative/tools/index.php/Burneye
ElfCrypter/ ElfJunk	2004-2005	Encryption with crypt-7lib Obfuscation	low	Script & manual	x86	elf-encrypter.sourceforge.net
Shiva	Shiva-0.96 by Clowes & Mehta	Packed ELF crypted w/ AES/ 128 Passw=SHA1 hash	Hard, several anti reversing & adapt BurnEye	Manual	x86	secureareality.com.au/archives/shiva-0.95.tar.gz
VMProtect	last test: 2017/ Vmpsoft	VM protect Junk ASM Anti reverse	Very hard	Manual	x86_32 x86_64	VMProtect Demo for Linux 3.1.2.946

Other ELF packers I researched so far..

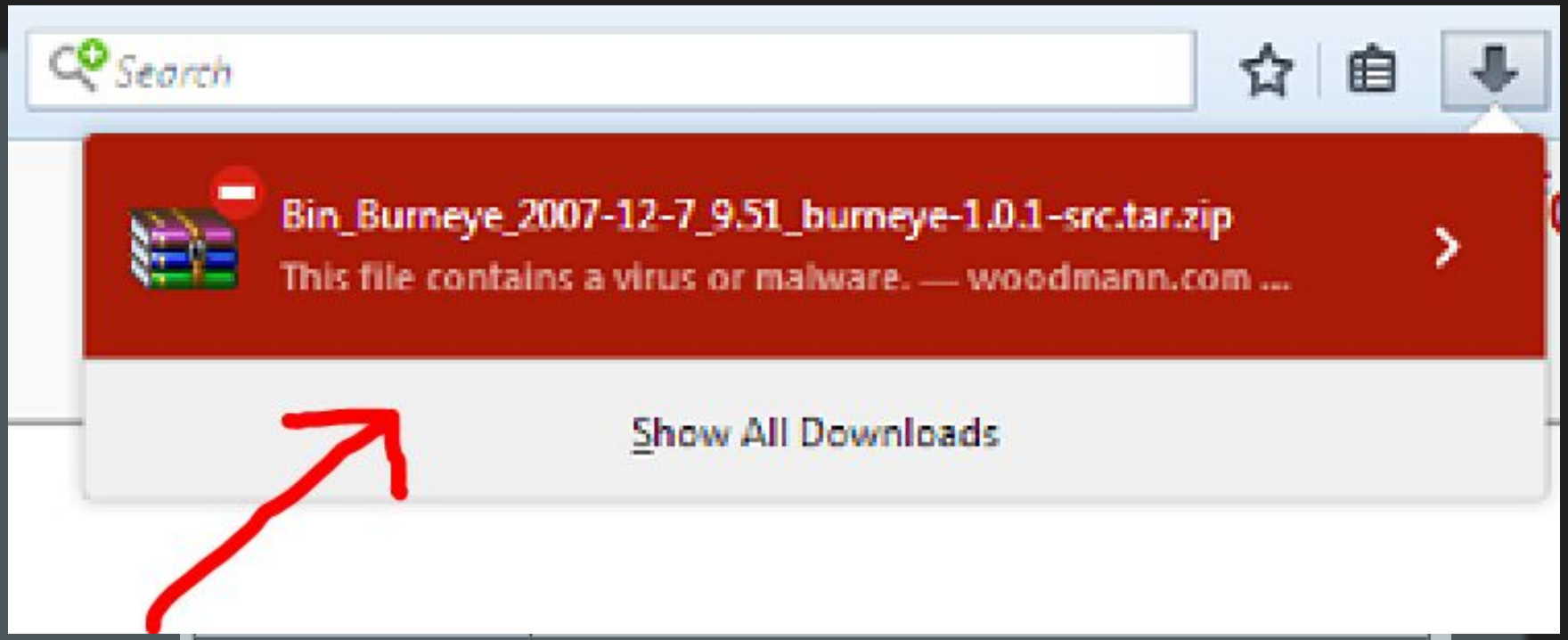
Be careful in downloading known ancient packer's source code, your network security sensors may raise alarm! Some sigs just can't differ..

PoC:



Other ELF packers I researched so far..

Be careful in downloading known packer's source code, your network security sensors may raise alarm!



Last updated:	December 24, 2002
Direct D/L link:	Locally archived copy

Other ELF packers I researched so far..

ELF-Encrypter home page

The ELF-Encrypter program suite is a collection of programs to encrypt ELF binaries using various algorithms, including the ones provided by *GPG*.
One can choose a lot of methods to obtain the encryption key, such as hashing a list of PCI peripheals, MAC addresses of ethernet cards, file inode numbers, passphrases and passwords.

Here is the complete list:

- 8-bit fixed mask (used only for testing)
- 32-bit user selectable mask (used only for testing)
- Password
- Cast5 (using GPG)
- GPG - Encrypt (using GPG)
- GPG - Sign (using GPG)
- Ethernet MAC
- Ethernet MAC and file inode
- File inode
- PCI binding

Executable files can be encrypted using the *crypt-7lib* program, then decrypted at runtime by a shared library (*libdecrypt*), directly linked to the binary or listed in LD_PRELOAD.
Users are strongly encouraged to use *gpg-agent*; however a special support for *quintuple-agent* is available at compilation time.

The suite also contains programs to manipulate and inject plain or encrypted code into ELF binaries.

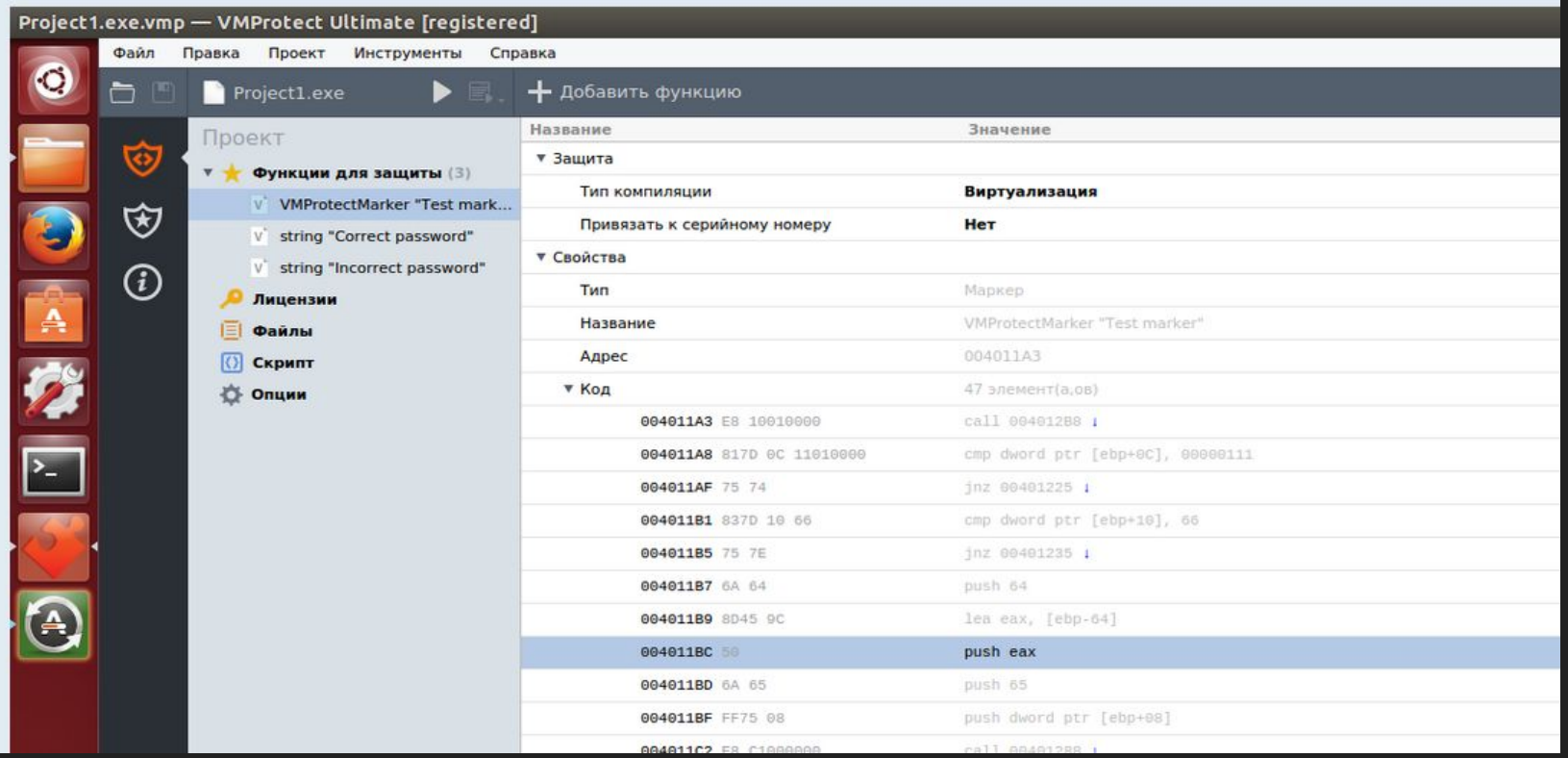
This project is written in C and assembly for the x86 platform.

Other ELF packers I researched so far..

VMProtect for Linux

by **Admin** » Tue Apr 18, 2017 6:28 pm

VMProtect Demo for Linux 3.1.2.946:
http://vmpsoft.com/files/VMProtectDemo_x64.tar.gz



Part two - some soup

“ Interesting ELF packers today
(A good take-away for you) “

Interesting “cool” ELF packers exist today

1. arisada/midgetpack (feature: Curve25519 - challenge-response)
   https://github.com/arisada/midgetpack
2. glen-mac/ELF-Packer (feature: Polymorphic python packer ELF)
   https://github.com/glen-mac/ELF-Packer
3. sebastiencs/Packer_ELF (simplistic, for learning or base of dev)
   https://github.com/sebastiencs/Packer_ELF
4. ps2dev/ps2-packer (designed for PS2, and modular design)
   https://github.com/ps2dev/ps2-packer
5. timhsutw/elfuck (using NRV2E decompressor, string burner polymorphic & adapting BurnEye locking feature)
   https://github.com/timhsutw/elfuck

...see its URL above for the further details, they are so self explanatory, I made review on each of them as per written above after my tests.

Motto of the day

ARE YOU STILL OKAY?

Now you now some cool packer’s too!
..but some of you may feel like:

“Okay! I know more packers than you!
Enough talking & gimme THAT main
course!! “

Part three - the main course

“ The story of :
a Non-Unpackable ELF Packer.. “

What I want to share today (about this N.U.P)

1. I don't know the source for this packer yet, I will call it with a dumb-pseudo-name: Non-Unpackable Packer (N.U.P) until we know exactly what the real name is...
2. Spotted in the public threat sector (+ "maybe" some targeted sectors)
3. It aims 3.1.) fileless forensics and 3.2) obviously hiding its packed binary to make sure even static analysis can not break it..

Why you called it “non-unpackable” ?

1. I found this hard to be dissected statically
2. It was designed to be anti-emulator (in our case is ESIL) with cascade chains of obfuscation
3. It’s actually a custom made from one of previous packers mentioned..

Here we go . .

Non Unpackable Packer

The sample is an ITW threat, and goes with this ELF headers:

```
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00400000  7f45 4c46 0201 0103 0000 0000 0000 0000  .ELF............
0x00400010  0200 3e00 0100 0000 48e1 5500 0000 0000  ..>.....H.U.....
0x00400020  4000 0000 0000 0000 0000 0000 0000 0000  @...............
0x00400030  0000 0000 4000 3800 0200 4000 0000 0000  ....@.8...@.....
0x00400040  0100 0000 0500 0000 0000 0000 0000 0000  ................
0x00400050  0000 4000 0000 0000 0000 4000 0000 0000  ..@.......@.....
0x00400060  1ef2 1500 0000 0000 1ef2 1500 0000 0000  ................
0x00400070  0000 2000 0000 0000 0100 0000 0600 0000  .. .............
0x00400080  c875 1b00 0000 0000 c875 9b00 0000 0000  .u.......u......
0x00400090  c875 9b00 0000 0000 0000 0000 0000 0000  .u..............
0x004000a0  0000 0000 0000 0000 0000 2000 0000 0000  .......... .....
0x004000b0  bf5a 40d4 0a00 0000 e010 0d16 0000 0000  .Z@.............
0x004000c0  10e1 3a00 10e1 3a00 9001 0000 7c00 0000  ..:...:.....|...
0x004000d0  0e00 0000 3c07 003f 9145 8460 1007 0060  ....<..?.E.`...`
0x004000e0  0ffe ab66 80b1 f1d6 6d3c 8016 4d31 d7e6  ...f....m<..M1..
0x004000f0  7d11 15a0 edd7 2188 e817 32e6 c7d8 05be  }.....!...2.....
0x00400100  67c4 77cd 56bc 9af4 3dee 2e85 10f4 44ee  g.w.V...=.....D.
0x00400110  2bab 45f6 a955 0456 5177 5211 269b 4ef5  +.E..U.VQwR.&.N.
0x00400120  5245 53f0 055e be85 7aa3 8d65 c966 6e09  RES..^..z..e.fn.
0x00400130  a098 2f3c e4ef 7fc7 5116 9083 c947 ad95  ../<....Q....G..
```

Non Unpackable Packer

The sample is an ITW threat, and goes with this ELF headers (ELFDump)

```
elf header:
    e_ident: ELFCLASS64 ELFDATA2LSB ELFOSABI_LINUX
    e_type: ET_EXEC
    e_machine: EM_X86_64
    e_version: EV_CURRENT
    e_entry: 0x55e148
    e_phoff: 64
    e_shoff: 0
    e_flags: 0
    e_ehsize: 64
    e_phentsize: 56
    e_phnum: 2
    e_shentsize: 64
    e_shnum: 0
    e_shstrndx: 0
```

```
entry: 0
    p_type: PT_LOAD
    p_offset: 0
    p_vaddr: 0x400000
    p_paddr: 0x400000
    p_filesz: 1438238
    p_memsz: 1438238
    p_flags: PF_X|PF_R
    p_align: 2097152
entry: 1
    p_type: PT_LOAD
    p_offset: 1799624
    p_vaddr: 0x9b75c8
    p_paddr: 0x9b75c8
    p_filesz: 0
    p_memsz: 0
    p_flags: PF_W|PF_R
    p_align: 2097152
```

Non Unpackable Packer

The sample is an ITW threat, and goes with this ELF headers (ReadELF):

```
ELF Header:
  Magic:   7f 45 4c 46 02 01 01 03 00 00 00 00 00 00 00 00
  Class:                             ELF64
  Data:                              2's complement, little endian
  Version:                           1 (current)
  OS/ABI:                            UNIX - GNU
  ABI Version:                       0
  Type:                              EXEC (Executable file)
  Machine:                           Advanced Micro Devices X86-64
  Version:                           0x1
  Entry point address:               0x55e148
  Start of program headers:          64 (bytes into file)
  Start of section headers:          0 (bytes into file)
  Flags:                             0x0
  Size of this header:               64 (bytes)
  Size of program headers:           56 (bytes)
  Number of program headers:         2
  Size of section headers:           64 (bytes)
  Number of section headers:         0
  Section header string table index: 0

There are no sections in this file.

There are no sections to group in this file.
```

Non Unpackable Packer

The sample is an ITW threat, and goes with this ELF headers (ObjDump)

```
There are no sections to group in this file.

Program Headers:
  Type           Offset             VirtAddr           PhysAddr
                 FileSiz            MemSiz              Flags  Align
  LOAD           0x0000000000000000 0x0000000000400000 0x0000000000400000
                 0x00000000015f21e  0x00000000015f21e  R E    200000
  LOAD           0x00000000001b75c8 0x00000000009b75c8 0x00000000009b75c8
                 0x0000000000000000 0x0000000000000000  RW     200000

There is no dynamic section in this file.

There are no relocations in this file.

There are no unwind sections in this file.

Dynamic symbol information is not available for displaying symbols.

No version information found in this file.
```

Non Unpackable Packer

No strings what-so-ever... (r2 ; px, you can check further with iz?? too)

```
0x00400140  3a92 7514 5b61 94ed 86b8 cf8b 9851 096c  :.u.[a.......Q.l
0x00400150  e266 3900 1da7 1500 0e00 0000 3c07 0002  .f9.........<...
0x00400160  0030 0210 8601 fdaa 087a 0182 1581 886f  .0.......z......o
0x00400170  dca2 6823 d362 f422 ddd6 e66f e359 60dc  ..h#.b."...o.Y`.
0x00400180  b474 dc77 c931 a0fb ba2a 58fb d55e db8d  .t.w.1...*X..^..
0x00400190  65c5 bead db85 2e54 ba4a 88bb 35f2 ede1  e......T.J..5...
0x004001a0  f958 70d7 b0cf 979c 9715 bc9f b092 535a  .Xp...........SZ
0x004001b0  3c45 222f 56f2 b246 b057 8d90 a0f8 d395  <E"/V..F.W......
0x004001c0  945d 23c3 7fc6 03e7 539f 1427 bd4c 0f90  .]#.....S..'.L..
0x004001d0  cee0 07bc 875f f1dc 2d32 8cfd b72b c90b  ....._..-2...+..
0x004001e0  a9ee 19d0 558d f354 7537 4b86 714c c9d4  ....U..Tu7K.qL..
0x004001f0  2a12 eed3 9279 ea14 84c8 accc 6436 f1e1  *....y......d6..
0x00400200  2a6a 0d1e 3ff5 678d e963 6196 36b1 ddb6  *j..?.g..ca.6...
0x00400210  62d3 93cd c782 c86a 9c98 5086 c076 123e  b......j..P..v.>
0x00400220  da28 27c9 e41a 23c3 b4fb fefb d7fc 7fbc  .('...#.........
0x00400230  6382 1e20 6ff2 2866 2974 0421 1305 fe47  c.. o.(f)t.!...G
0x00400240  782c 2b10 6e7f 2df8 6be5 a672 bc5a 9ccc  x,+.n.-.k..r.Z..
0x00400250  f070 3c48 1488 1934 0492 c56a 7ba3 4fd3  .p<H...4...j{.O.
0x00400260  6d31 3caf f836 d51f 03ea 387a f6a6 bfae  m1<..6....8z....
0x00400270  a06f 3882 d863 a05d 887f 9da4 a954 e815  .o8..c.].....T..
0x00400280  c9af c335 cd43 f211 8fc6 9cd7 22de 84f1  ...5.C......"...
0x00400290  5f65 96d7 06f2 43a8 3492 9eed 731a 7841  _e....C.4...s.xA
0x004002a0  e79e 34a8 8bc0 4d65 10e2 de3a e59b 6067  ..4...Me...:..`g
0x004002b0  026e 0adb 155c 37a1 c062 7a1b 14f1 cb82  .n...\7..bz.....
0x004002c0  96ea 2328 018a a25c cc8d cfd4 678c 84a3  ..#(...\....g...
0x004002d0  8ce2 465b a9f6 95d9 c996 1bb1 da29 4581  ..F[.........)E.
0x004002e0  4681 32eb 9fa1 15e4 d33c b70f ecfd fbbd  F.2......<......
0x004002f0  ad8c 5613 be02 98f1 fe25 a291 4721 ba2d  ..V......%..G!.-
0x00400300  ab55 9352 598d de2c 1b81 ba7e 02e1 e72e  .U.RY..,...~....
0x00400310  1286 67b1 40c2 0d38 54e5 5a98 765f c846  ..g.@..8T.Z.v_.F
0x00400320  8c1b 5384 f456 40e8 0947 d77c 1942 ad7b  ..S..V@..G.|.B.{
0x00400330  5ca2 2897 1dc5 2a5a ddcd 0a8f 9b47 7dc7  \.(...*Z.....G}.
0x00400340  994b 29c8 2e26 7c25 f01f d510 37cb edb1  .K)..&|%....7...
0x00400350  e1f3 b11a e183 5e91 23ae 829f 5fb3 9b41  ......^.#...._..A
0x00400360  77fe 00a1 e843 efd4 364f 313a e20f f5e6  w....C..601:....
0x00400370  a78d 3267 2cb3 5b15 664b bc16 bd9d b144  ..2g,.[.fK.....D
0x00400380  faed 6736 a06e 79f8 f0cd b843 0611 894b  ..g6.ny....C...K
0x00400390  d11d 3399 16ca 89de 409d f6de 9ad4 276d  ..3.....@.....'m
0x004003a0  8bd4 d1e7 9abc b98d fc06 63af 0a5a bdfc  ..........c..Z..
0x004003b0  48ca f537 04e8 376f fac9 a5db 7abd d435  H..7..7o....z..5
```

```
0x0055efd9  6bc7 62de a762 3b8e e36e 6c77 cbed dffc  k.b..b;..nlw....
0x0055efe9  545f 3fdc 1375 c07d b3af 7024 e783 d875  T_?..u.}..p$...u
0x0055eff9  8fe2 657a 469e 274f 3aa1 14ba 3f52 1c98  ..ezF.'O:...?R..
0x0055f009  15db 994c 7ae7 ff15 6e7d 5dd8 9f59 475c  ...Lz...n}]..YG\
0x0055f019  0442 21a2 32d6 6bff 894b c039 e66e d5d3  .B!.2.k..K.9.n..
0x0055f029  2c5d d78a 3c64 a5e9 ceb6 01a9 1950 82c7  ,]..<d.......P..
0x0055f039  5b6a 9769 1a2b 1802 62b8 37f0 4160 3890  [j.i.+..b.7.A`8.
0x0055f049  bb6d 73f8 b3df a690 b262 dcc3 6c10 21c0  .ms......b..l.!.
0x0055f059  2eff d3e8 c98d 0a28 2508 bfe4 1a9d cfed  .......(%.......
0x0055f069  dcf3 d0ba 3255 cfad 3548 244a ae20 29ff  ....2U..5H$J. ).
0x0055f079  e107 6046 5457 da28 b074 3541 21b3 bd6d  ..`FTW.(.t5A!..m
0x0055f089  cc74 ea19 b06c deda 38ca 1858 23c4 20cb  .t...l..8..X#. .
0x0055f099  ffa0 c838 f793 68cf b305 3a92 b5d0 5cb8  ...8..h...:...\.
0x0055f0a9  aa04 73eb 9281 52c4 0b60 c008 c4fc ba74  ..s...R..`.....t
0x0055f0b9  9604 a6e7 d791 32f2 57d9 9de9 c603 f0b3  ......2.W.......
0x0055f0c9  7562 182b 36f9 fdaa 5ac8 63f4 9b7b 82f1  ub.+6...Z.c..{..
0x0055f0d9  5d9e 7652 b14f 4559 610b b750 5dd8 8b73  ].vR.OEYa..P]..s
0x0055f0e9  fe49 b16d 8ed6 e53a 50ee ea20 91af f0d7  .I.m...:P.. ....
0x0055f0f9  307c 3d5a 9614 d1ff 4160 abb0 91f9 9aaf  0|=Z....A`......
0x0055f109  f4dd 502b 7783 f6e6 cd28 416a 6498 74c3  ..P+w....(Ajd.t.
0x0055f119  9ead 63c5 fc75 05ee fd1e e77e d77c 3d41  ..c..u.....~.|=A
0x0055f129  4c6d 3283 3d56 46ad 5088 8d13 a2ec bb85  Lm2.=VF.P.......
0x0055f139  9749 eb67 1aca 3014 9ce5 339e 8782 bce7  .I.g..0...3.....
0x0055f149  938b fc95 490b f7a3 f897 69f5 ab56 4716  ....I.....i..VG.
0x0055f159  62f9 78ea ca3d 4079 c408 ad9d bbff a71e  b.x..=@y.......
0x0055f169  7314 fb92 a95c 3c15 2678 f0ad 36e2 41e0  s....\<.&x..6.A.
0x0055f179  4cbd 0613 e25f 721d fc66 852e 1ea6 bd90  L...._r..f......
0x0055f189  3f43 3c87 4ac7 2e30 99fd 9dc5 d768 4d4e  ?C<.J..0.....hMN
0x0055f199  4bcd b259 4d5c 7e91 6840 b23b a133 2ed8  K..YM\~.h@.;.3..
0x0055f1a9  101a 8f72 e115 513d 0bdd b4fd d256 3f0c  ...r..Q=.....V?.
0x0055f1b9  2616 83ac c897 db86 0bf8 8d8f 097a 8bb4  &............z..
0x0055f1c9  7a07 e727 1766 db89 a114 37f4 68c6 f00f  z..'.f....7.h...
0x0055f1d9  4da1 4c56 442e 94f9 fe5b 8590 0f65 904a  M.LVD....[...e.J
0x0055f1e9  c1cb fca7 870f 546c 13d1 022c 68b9 fbb4  ......Tl...,h...
0x0055f1f9  a4ad 0d4f 76c6 2c8f cc56 fad6 af8d f2d6  ...Ov.,..V......
0x0055f209  423c 8f36 1782 692f 8da0 ec70 a108 1dee  B<.6..i/...p....
0x0055f219  11be 93be 20ff ffff ffff ffff ffff ffff  .... ............
0x0055f229  ffff ffff ffff ffff ffff ffff ffff ffff  ................
0x0055f239  ffff ffff ffff ffff ffff ffff ffff ffff  ................
0x0055f249  ffff ffff ffff ffff ffff ffff ffff ffff  ................
```

Non Unpackable Packer

This is how the entry point goes… see that first call

```
[0x0055e148]> af;pd 66
            ;-- rip:
 (fcn) entry0 2708
   entry0 (int arg_1h, int arg_10h);
            ; var int local_8h @ rbp-0x8
            ; arg int arg_1h @ rbp+0x1
            ; arg int arg_10h @ rbp+0x10
            ; var int local_38h @ rsp+0x38
            0x0055e148      e84b0b0000     call 0x55ec98 ; this is where the unpackingfunc is called
            0x0055e14d      55             push rbp
            0x0055e14e      53             push rbx
            0x0055e14f      51             push rcx
            0x0055e150      52             push rdx
            0x0055e151      4801fe         add rsi, rdi  ; '''
            0x0055e154      56             push rsi
```

Non Unpackable Packer

This what I call it as “unpacking’s loader” part, called by entry_0 1st call,
In here after the “loader program” is being executed, this unpacker program is used to decompress a packed of ELF data.

```
(fcn) fcn.0055ec98 57
  fcn.0055ec98 ();
          ; var int local_9h @ rbp-0x9
          ; CALL XREF from 0x0055e148 (entry0)
          0x0055ec98      5d              pop rbp
          0x0055ec99      488d45f7        lea rax, [local_9h]
          0x0055ec9d      448b38          mov r15d, dword [rax]
          0x0055eca0      bac8000000      mov edx, 0xc8                ; 200
          0x0055eca5      4c29f8          sub rax, r15
          0x0055eca8      4129d7          sub r15d, edx
          0x0055ecab      488d0c10        lea rcx, [rax + rdx]
          0x0055ecaf      e879ffffff      call fcn.0055ec2d            ;[1] ; the unpacker loader
      ┌─< 0x0055ecb4      7206            jb 0x55ecbc                  ;[2] ; the data of the loader program
      │   0x0055ecb6      0000            add byte [rax], al
      │   0x0055ecb8      5e              pop rsi
      │   0x0055ecb9      0500000e00      add eax, 0xe0000
      │   0x0055ecbe      0000            add byte [rax], al
      :   0x0055ecc0      3c07            cmp al, 7                    ; 7
      :   0x0055ecc2      007417bc        add byte [rdi + rdx - 0x44], dh
      :   0x0055ecc6      1a02            sbb al, byte [rdx]
      :   0x0055ecc8      f381c8de6317.   or eax, 0x9d1763de
      └─< 0x0055eccf      7227            jb 0x55ecf8                  ;[3]
```

Non Unpackable Packer

The loader logic load the packed data from the start of *0x40000c*, use reserved address *0x5bbf1a* as work-space & write + exec compress ELF result to base addr *0x400000*. (see the picture)

This loader has specific calls sequence: mmap, load.., exec, write, exit..

```
fcn.0055ec2d ();
:    ; var int local_8h @ rsp+0x8
:    ; var int local_18h @ rsp+0x18
:    ; CALL XREF from 0x0055ecaf (fcn.0055ec98)
:    0x0055ec2d      5b              pop rbx
:    0x0055ec2e      6a01            push 1                          ; 1
:    0x0055ec30      680c004000      push 0x40000c
:    0x0055ec35      50              push rax
:    0x0055ec36      681abf5b00      push 0x5bbf1a
:    0x0055ec3b      51              push rcx
:    0x0055ec3c      4157            push r15
:    0x0055ec3e      bf0000a000      mov edi, 0xa00000
:    0x0055ec43      6a07            push 7                          ; 7
:    0x0055ec45      5a              pop rdx
:    0x0055ec46      be1abf5b00      mov esi, 0x5bbf1a
:    0x0055ec4b      6a32            push 0x32                       ; '2' ; 50
:    0x0055ec4d      415a            pop r10
:    0x0055ec4f      4529c0          sub r8d, r8d
:    0x0055ec52      6a09            push 9                          ; 9
:    0x0055ec54      58              pop rax
:    0x0055ec55      0f05            syscall
:    0x0055ec57      39c7            cmp edi, eax
`=<  0x0055ec59      0f857dffffff    jne 0x55ebdc
     0x0055ec5f      be00004000      mov esi, 0x400000               ; section.ehdr
     0x0055ec64      89fa            mov edx, edi
     0x0055ec66      29f2            sub edx, esi
,=<  0x0055ec68      7415            je 0x55ec7f
|    0x0055ec6a      01d5            add ebp, edx
|    0x0055ec6c      01542408        add dword [local_8h], edx
|    0x0055ec70      01542418        add dword [local_18h], edx
|    0x0055ec74      89d9            mov ecx, ebx
|    0x0055ec76      29f1            sub ecx, esi
|    0x0055ec78      c1e903          shr ecx, 3
|    0x0055ec7b      fc              cld
|    0x0055ec7c      f348a5          rep movsq qword [rdi], qword ptr [rsi]
`->  0x0055ec7f      97              xchg eax, edi
     0x0055ec80      4889de          mov rsi, rbx
     0x0055ec83      50              push rax
```

Non Unpackable Packer

After successfully decompressed the packed data (on memory), the packed data is still in obfuscated form. The next process in entry point will be used to load the image & deobfuscate it (blue marked region)..

```
(fcn) entry0 2708
  entry0 (int arg_1h, int arg_10h);
          ; var int local_8h @ rbp-0x8
          ; arg int arg_1h @ rbp+0x1
          ; arg int arg_10h @ rbp+0x10
          ; var int local_38h @ rsp+0x38
          0x0055e148      e84b0b0000      call 0x55ec98
          0x0055e14d      55              push rbp
          0x0055e14e      53              push rbx
          0x0055e14f      51              push rcx
          0x0055e150      52              push rdx
          0x0055e151      4801fe          add rsi, rdi                ; '''
          0x0055e154      56              push rsi
          0x0055e155      4180f80e        cmp r8b, 0xe                ; 14
          0x0055e159      0f856c0a0000    jne 0x55ebcb
          0x0055e15f      55              push rbp
          0x0055e160      4889e5          mov rbp, rsp
          0x0055e163      448b09          mov r9d, dword [rcx]
          0x0055e166      4989d0          mov r8, rdx
          0x0055e169      4889f2          mov rdx, rsi
          0x0055e16c      488d7702        lea rsi, [rdi + 2]          ; 2
          0x0055e170      56              push rsi
          0x0055e171      8a07            mov al, byte [rdi]
          0x0055e173      ffca            dec edx
          0x0055e175      88c1            mov cl, al
          0x0055e177      2407            and al, 7
          0x0055e179      c0e903          shr cl, 3
          0x0055e17c      48c7c300fdff.   mov rbx, 0xffffffffffffd00
          0x0055e183      48d3e3          shl rbx, cl
```

done!

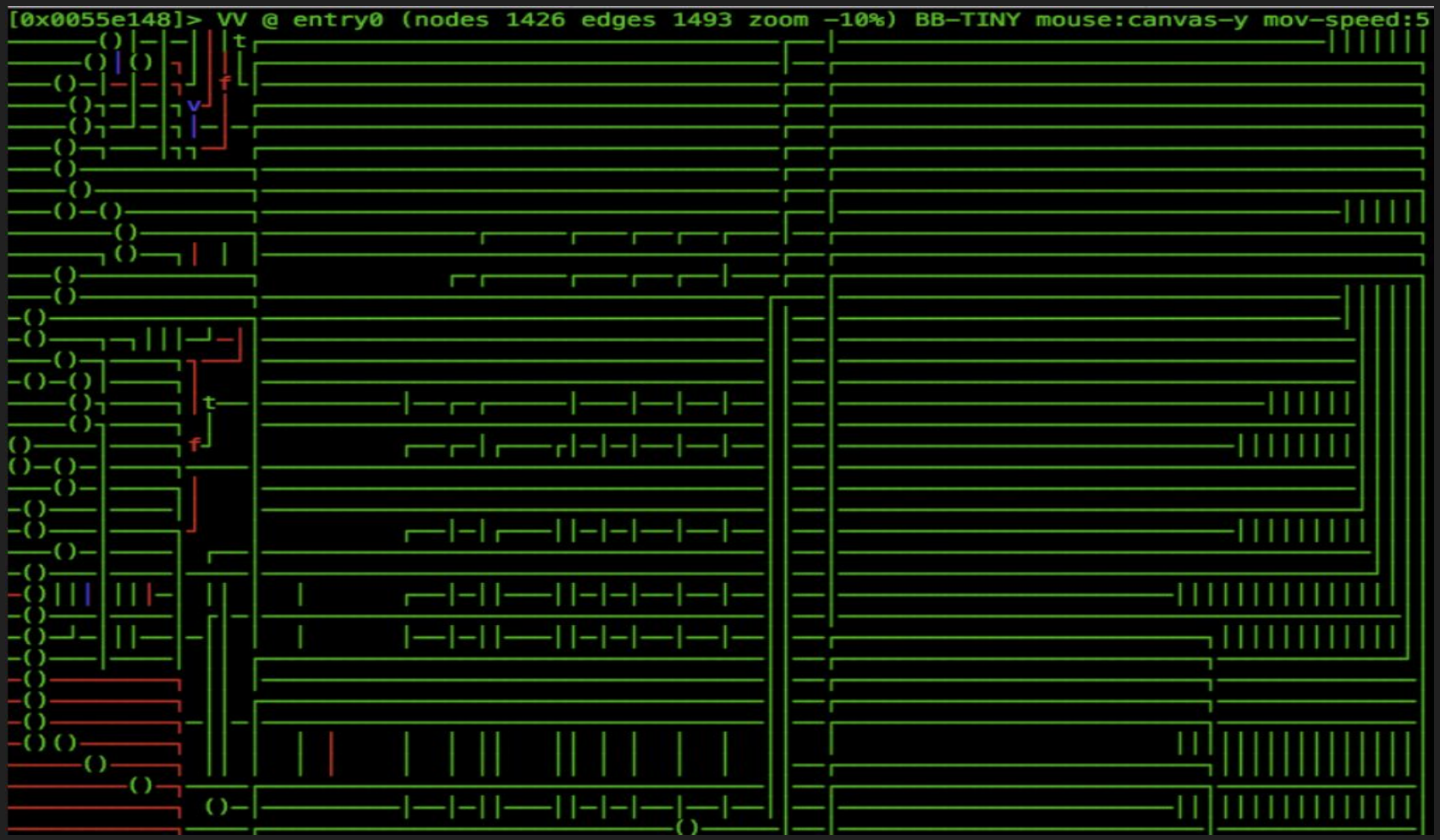
next step for obfuscation is from here!

Non Unpackable Packer

At the described on the blue section, the loaded packed data will be deobfuscated on several loop of subroutines looks like this in radare2:

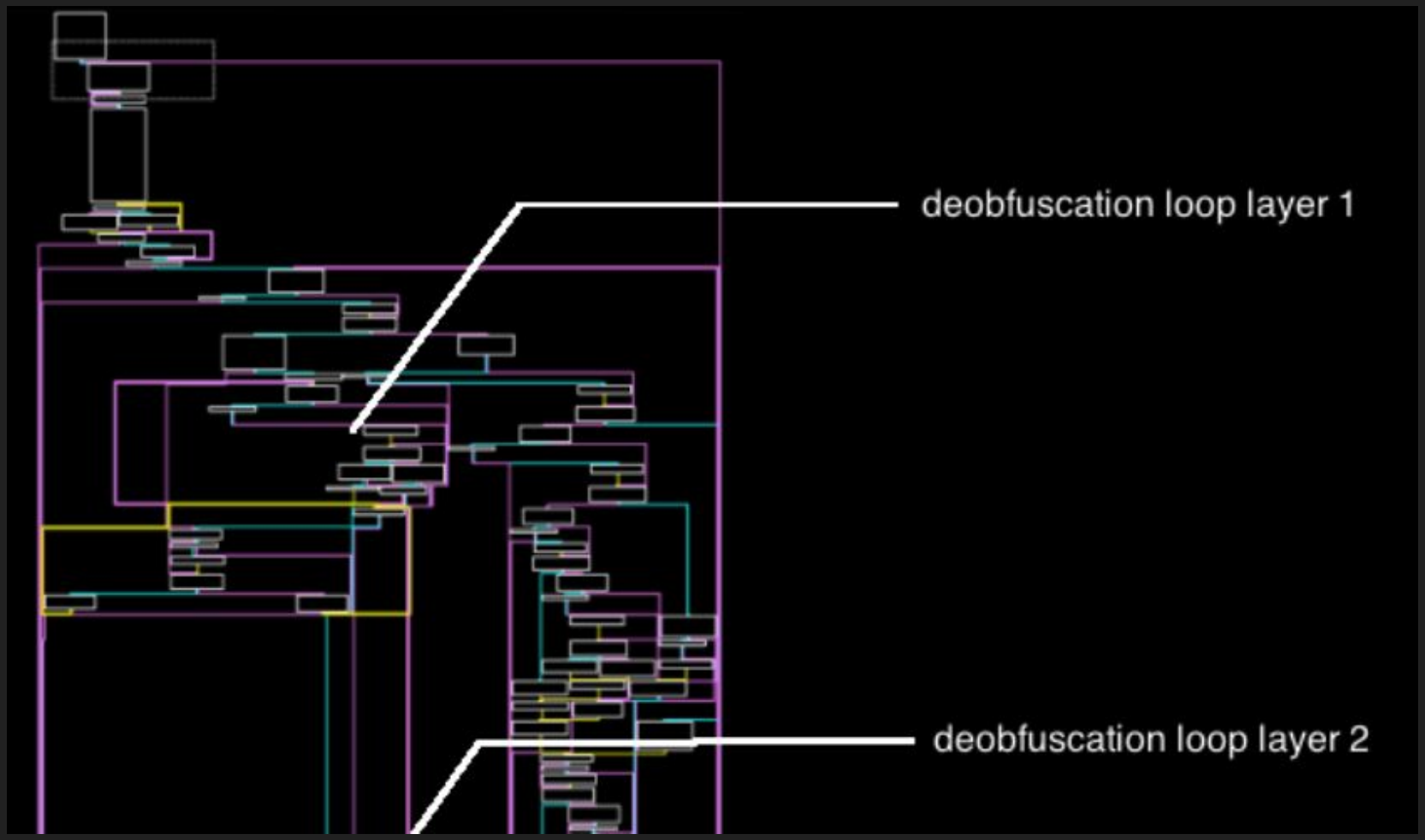
Non Unpackable Packer

I can not see much of it in the normal mode.. will need a super big screen..



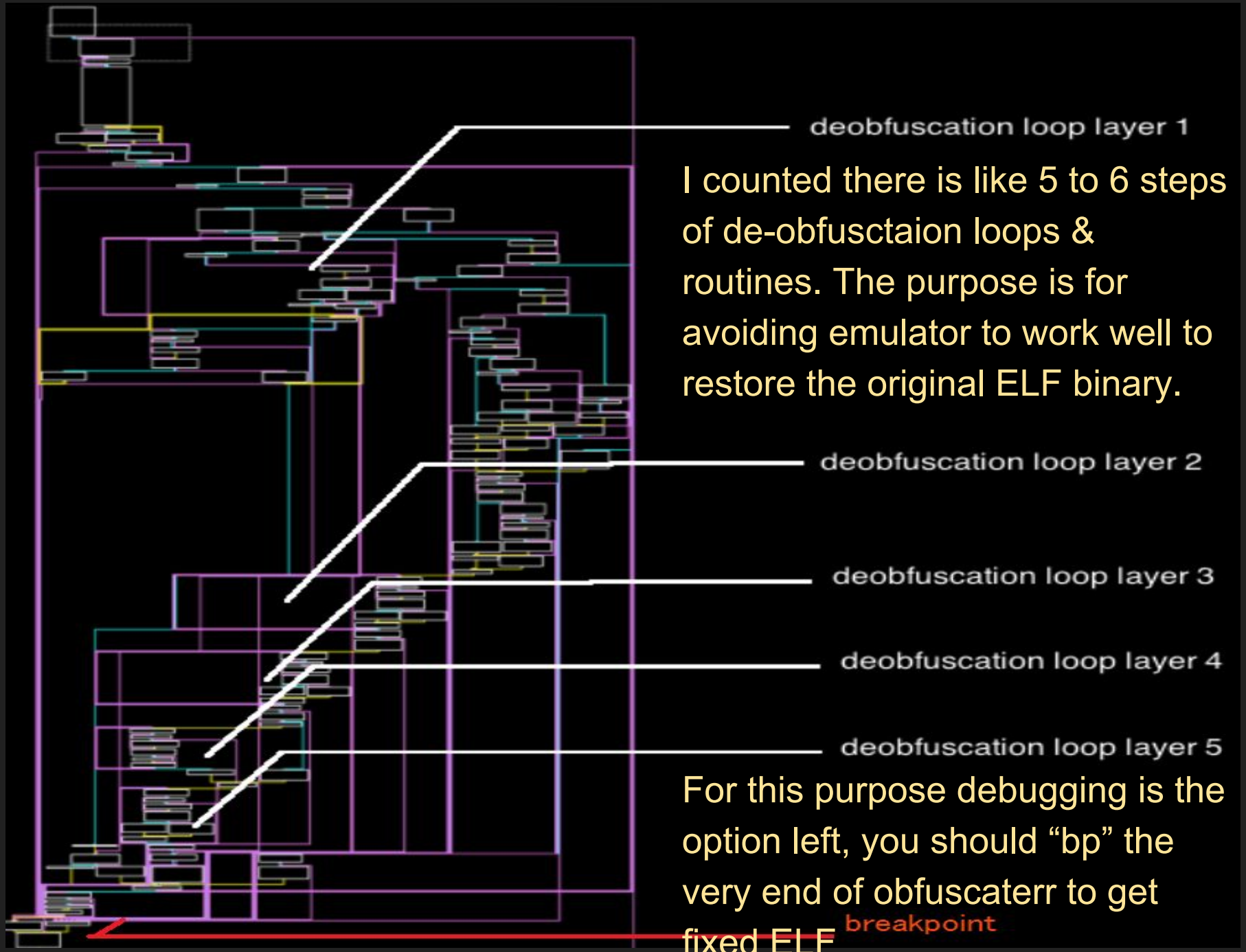
Non Unpackable Packer

Borrowing some blah blah tool graph, It actually looks like this….(part one)



Non Unpackable Packer

It actually looks like this….(part two)



I counted there is like 5 to 6 steps of de-obfusctaion loops & routines. The purpose is for avoiding emulator to work well to restore the original ELF binary.

For this purpose debugging is the option left, you should “bp” the very end of obfuscaterr to get fixed ELF

Non Unpackable Packer

Unpacked binary is written & exec at base address *0x400000* w/same image name. You can use ESIL to see the this process better, but don't use ESIL to extract the packed ELF since 1 byte mistake will ruin real ELF

```
fcn.0055ec2d ();
    :   ; var int local_8h @ rsp+0x8
    :   ; var int local_18h @ rsp+0x18
    :   ; CALL XREF from 0x0055ecaf (fcn.0055ec98)
    :   0x0055ec2d      5b              pop rbx                         ; (pstr 0x7ffc4256b94f) "./cung"
    :   0x0055ec2e      6a01            push 1                          ; 1 ; rsp
    :   0x0055ec30      680c004000      push 0x40000c                   ; (cstr 0x7ffc4256b94f) "./cung"
    :   0x0055ec35      50              push rax
    :   0x0055ec36      681abf5b00      push 0x5bbf1a
    :   0x0055ec3b      51              push rcx
    :   0x0055ec3c      4157            push r15
    :   0x0055ec3e      bf0000a000      mov edi, 0xa00000
    :   0x0055ec43      6a07            push 7                          ; 7
    :   0x0055ec45      5a              pop rdx
    :   0x0055ec46      be1abf5b00      mov esi, 0x5bbf1a
    :   0x0055ec4b      6a32            push 0x32                       ; '2' ; 50
    :   0x0055ec4d      415a            pop r10
    :   0x0055ec4f      4529c0          sub r8d, r8d
    :   0x0055ec52      6a09            push 9                          ; 9
    :   0x0055ec54      58              pop rax
    :   0x0055ec55      0f05            syscall                         ; 59 = execve ("..
    :   0x0055ec57      39c7            cmp edi, eax
    :   0x0055ec59      0f857dffffff    jne 0x55ebdc                    ; unlikely
        0x0055ec5f      be00004000      mov esi, map.home_mung_test_cung.r_x ; 0x400000
        0x0055ec64      89fa            mov edx, edi
        0x0055ec66      29f2            sub edx, esi
        0x0055ec68      7415            je 0x55ec7f                     ; unlikely
        0x0055ec6a      01d5            add ebp, edx
        0x0055ec6c      01542408        add dword [local_8h], edx
        0x0055ec70      01542418        add dword [local_18h], edx
        0x0055ec74      89d9            mov ecx, ebx
        0x0055ec76      29f1            sub ecx, esi
        0x0055ec78      c1e903          shr ecx, 3
        0x0055ec7b      fc              cld
        0x0055ec7c      f348a5          rep movsq qword [rdi], qword ptr [rsi]
        0x0055ec7f      97              xchg eax, edi
```

```
fcn.0055ec2d ();
    ; var int local_8h @ rsp+0x8
    ; var int local_18h @ rsp+0x18
    ; CALL XREF from 0x0055ecaf (fcn.0055ec98)
    0x0055ec2d    5b            pop rbx                          ; (pstr 0x7ffc4256b94f) "./cung"
    0x0055ec2e    6a01          push 1                           ; 1 ; rsp
    0x0055ec30    680c004000    push 0x40000c                    ; (cstr 0x7ffc4256b94f) "./cung"
    0x0055ec35    50            push rax
    0x0055ec36    681abf5b00    push 0x5bbf1a
    0x0055ec3b    51            push rcx
    0x0055ec3c    4157          push r15
    0x0055ec3e    bf0000a000    mov edi, 0xa00000
    0x0055ec43    6a07          push 7                           ; 7
    0x0055ec45    5a            pop rdx
    0x0055ec46    be1abf5b00    mov esi, 0x5bbf1a
    0x0055ec4b    6a32          push 0x32
    0x0055ec4d    415a          pop r10
    0x0055ec4f    4529c0        sub r8d, r8d
    0x0055ec52    6a09          push 9                           ; 9
    0x0055ec54    58            pop rax
    0x0055ec55    0f05          syscall                          ; 59 = execve ("...
    0x0055ec57    39c7          cmp edi, eax
    0x0055ec59    0f857dffffff  jne 0x55ebdc                     ; unlikely
    0x0055ec5f    be00004000    mov esi, map.home_mung_test_cung.r_x ; 0x400000
    0x0055ec64    89fa          mov edx, edi
    0x0055ec66    29f2          sub edx, esi
    0x0055ec68    7415          je 0x55ec7f                      ; unlikely
    0x0055ec6a    01d5          add ebp, edx
    0x0055ec6c    01542408      add dword [local_8h], edx
    0x0055ec70    01542418      add dword [local_18h], edx
    0x0055ec74    89d9          mov ecx, ebx
    0x0055ec76    29f1          sub ecx, esi
    0x0055ec78    c1e903        shr ecx, 3
    0x0055ec7b    fc            cld
    0x0055ec7c    f348a5        rep movsq qword [rdi], qword ptr [rsi]
    0x0055ec7f    97            xchg eax, edi
```

This is the execution's trail..of the unpacked ELF in a base address mentioned

Non Unpackable Packer

Other tip is, same method of analysis can be done by command pdda using r2dec (great work! > r2dec @wagio).

```
0x0055ec16  and byte [rax], ah                      |        *(rax) &= ah;
0x0055ec18  and byte [rdx], cl                      |        *(rdx) &= cl;
0x0055ec1a  add byte [rax + 0x5f026a5e], dl         |        *(rax + 0x5f026a5e) += dl;
0x0055ec20  push 1                                  |
0x0055ec22  pop rax                                 |        rax = 1;
0x0055ec23  syscall                                 |        __asm (syscall);
0x0055ec25  push 0x7f                               |
0x0055ec27  pop rdi                                 |        rdi = 0x7f;
0x0055ec28  push 0x3c                               |
0x0055ec2a  pop rax                                 |        rax = 0x3c;
0x0055ec2b  syscall                                 |        __asm (syscall);
0x0055ec2d  pop rbx                                 |
0x0055ec2e  push 1                                  |
0x0055ec30  push 0x40000c                           |
0x0055ec35  push rax                                |
0x0055ec36  push 0x5bbf1a                           |
0x0055ec3b  push rcx                                |
0x0055ec3c  push r15                                |
0x0055ec3e  mov edi, 0xa00000                       |        edi = 0xa00000;
0x0055ec43  push 7                                  |
0x0055ec45  pop rdx                                 |        rdx = 7;
0x0055ec46  mov esi, 0x5bbf1a                       |        esi = 0x5bbf1a;
0x0055ec4b  push 0x32                               |
0x0055ec4d  pop r10                                 |        r10 = 0x32;
0x0055ec4f  sub r8d, r8d                            |        r8d -= r8d;
0x0055ec52  push 9                                  |
0x0055ec54  pop rax                                 |        rax = 9;
0x0055ec55  syscall                                 |        __asm (syscall);
0x0055ec57  cmp edi, eax                            |
0x0055ec59  invalid                                 |
0x0055ec5a  invalid                                 |
                                                    |        if (edi < eax) {
0x0055ec5b  jge 0x55ec5c                            |
                                                    |        }
0x0055ec5d  invalid                                 |
0x0055ec5e  invalid                                 |
0x0055ec5f  mov esi, 0x400000                       |        esi = map.home_mung_test_cung.r_x;
                                                    |    }
```

```
0x0055ec16  and byte [rax], ah                  |        *(rax) &= ah;
0x0055ec18  and byte [rdx], cl                  |        *(rdx) &= cl;
0x0055ec1a  add byte [rax + 0x5f026a5e], dl     |        *(rax + 0x5f026a5e) += dl;
0x0055ec20  push 1                              |
0x0055ec22  pop rax                             |        rax = 1;
0x0055ec23  syscall                             |        __asm (syscall);
0x0055ec25  push 0x7f                           |
0x0055ec27  pop rdi                             |        rdi = 0x7f;
0x0055ec28  push 0x3c                           |
0x0055ec2a  pop rax                             |        rax = 0x3c;
0x0055ec2b  syscall                             |        __asm (syscall);
0x0055ec2d  pop rbx                             |
0x0055ec2e  push 1                              |
0x0055ec30  push 0x40000c                       |
0x0055ec35  push rax                            |
0x0055ec36  push 0x5bbf1a                       |
0x0055ec3b  push rcx                            |
0x0055ec3c  push r15                            |
0x0055ec3e  mov edi, 0xa00000                   |        edi = 0xa00000;
0x0055ec43  push 7                              |
0x0055ec45  pop rdx                             |        rdx = 7;
0x0055ec46  mov esi, 0x5bbf1a                   |        esi = 0x5bbf1a;
0x0055ec4b  push 0x32                           |
0x0055ec4d  pop r10                             |        r10 = 0x32;
0x0055ec4f  sub r8d, r8d                        |        r8d -= r8d;
0x0055ec52  push 9                              |
0x0055ec54  pop rax                             |        rax = 9;
0x0055ec55  syscall                             |        __asm (syscall);
0x0055ec57  cmp edi, eax                        |
0x0055ec59  invalid                             |
0x0055ec5a  invalid                             |
                                                |        if (edi < eax) {
0x0055ec5b  jge 0x55ec5c                        |
                                                |        }
0x0055ec5d  invalid                             |
0x0055ec5e  invalid                             |
0x0055ec5f  mov esi, 0x400000                   |        esi = map.home_mung_test_cung.r_x;
                                                |    }
```

Way to go Giovanni!

R2dec nailed it good!

Non Unpackable Packer

The successfully unpacked binary is being rewritten at *0x400000* like this.

```
[[0x00400000]> !date
Mon May 28 07:58:05 UTC 2018
[[0x00400000]> s 0x400000
[[0x00400000]> px 1111
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x00400000  7f45 4c46 0201 0103 0000 0000 0f05 c390  .ELF............
0x00400010  0200 3e00 0100 0000 1019 4000 0000 0000  ..>.......@.....
0x00400020  4000 0000 0000 0000 10d9 3a00 0000 0000  @.........:.....
0x00400030  0000 0000 4000 3800 0600 4000 2000 1f00  ....@.8...@. ...
0x00400040  0100 0000 0500 0000 0000 0000 0000 0000  ................
0x00400050  0000 4000 0000 0000 0000 4000 0000 0000  ..@.......@.....
0x00400060  7268 3900 0000 0000 7268 3900 0000 0000  rh9.....rh9.....
0x00400070  0000 2000 0000 0000 0100 0000 0600 0000  .. ..............
0x00400080  006a 3900 0000 0000 006a 9900 0000 0000  .j9......j......
0x00400090  006a 9900 0000 0000 a856 0100 0000 0000  .j.......V......
0x004000a0  c80b 0200 0000 0000 0000 2000 0000 0000  .......... .....
0x004000b0  0400 0000 0400 0000 9001 0000 0000 0000  ................
0x004000c0  9001 4000 0000 0000 9001 4000 0000 0000  ..@.......@.....
0x004000d0  4400 0000 0000 0000 4400 0000 0000 0000  D.......D.......
0x004000e0  0400 0000 0000 0000 0700 0000 0400 0000  ................
0x004000f0  006a 3900 0000 0000 006a 9900 0000 0000  .j9......j......
0x00400100  006a 9900 0000 0000 2800 0000 0000 0000  .j......(.......
0x00400110  6000 0000 0000 0000 0800 0000 0000 0000  `...............
0x00400120  51e5 7464 0600 0000 0000 0000 0000 0000  Q.td............
0x00400130  0000 0000 0000 0000 0000 0000 0000 0000  ................
0x00400140  0000 0000 0000 0000 0000 0000 0000 0000  ................
0x00400150  1000 0000 0000 0000 52e5 7464 0400 0000  ........R.td....
0x00400160  006a 3900 0000 0000 006a 9900 0000 0000  .j9......j......
0x00400170  006a 9900 0000 0000 0016 0000 0000 0000  .j..............
0x00400180  0016 0000 0000 0000 0100 0000 0000 0000  ................
0x00400190  0400 0000 1000 0000 0100 0000 474e 5500  ............GNU.
0x004001a0  0000 0000 0200 0000 0600 0000 2000 0000  ............ ...
0x004001b0  0400 0000 1400 0000 0300 0000 474e 5500  ............GNU.
```

Non Unpackable Packer

After the unpacked ELF formed, we can dump it (I use “wtf”) and check:

```
33594 0x002a0aac 0x006a0aac   8   9 (LOAD0) ascii CRAM-MD5
33595 0x002a0ab5 0x006a0ab5   4   5 (LOAD0) ascii AQ==
33596 0x002a0aba 0x006a0aba   6   7 (LOAD0) ascii GSSAPI
33597 0x002a0ac8 0x006a0ac8  41  42 (LOAD0) ascii Unsupported SASL authentication mechanism
33598 0x002a0b38 0x006a0b38   4   5 (LOAD0) ascii /../
33599 0x002a0b3d 0x006a0b3d  20  21 (LOAD0) ascii Invalid input packet
33600 0x002a0b52 0x006a0b52   4   5 (LOAD0) ascii SMBS
33601 0x002a0b7c 0x006a0b7c  10  11 (LOAD0) ascii NT LM 0.12
33602 0x002a0b88 0x006a0b88  67  68 (LOAD0) ascii %s %02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x%02x
33603 0x002a0bcc 0x006a0bcc   7   8 (LOAD0) ascii nonce="
33604 0x002a0bd4 0x006a0bd4   7   8 (LOAD0) ascii realm="
33605 0x002a0bdc 0x006a0bdc  10  11 (LOAD0) ascii algorithm=
33606 0x002a0be7 0x006a0be7   5   6 (LOAD0) ascii qop="
33607 0x002a0bed 0x006a0bed   8   9 (LOAD0) ascii md5-sess
33608 0x002a0bf6 0x006a0bf6   8   9 (LOAD0) ascii auth-int
33609 0x002a0bff 0x006a0bff   9  10 (LOAD0) ascii auth-conf
33610 0x002a0c09 0x006a0c09  16  17 (LOAD0) ascii %08x%08x%08x%08x
33611 0x002a0c1a 0x006a0c1a  19  20 (LOAD0) ascii %s:%s:%08x:%s:%s:%s
33612 0x002a0c2e 0x006a0c2e  15  16 (LOAD0) ascii %s, opaque="%s"
33613 0x002a0c3e 0x006a0c3e  18  19 (LOAD0) ascii %s, algorithm="%s"
33614 0x002a0c51 0x006a0c51   5   6 (LOAD0) ascii stale
33615 0x002a0c57 0x006a0c57   5   6 (LOAD0) ascii realm
33616 0x002a0c5d 0x006a0c5d   6   7 (LOAD0) ascii opaque
33617 0x002a0c68 0x006a0c68   8   9 (LOAD0) ascii MD5-sess
33618 0x002a0c78 0x006a0c78  90  91 (LOAD0) ascii username="%s",realm="%s",nonce="%s",cnonce="%s",nc="%s",digest-uri="%s",response=%s
33619 0x002a0cd8 0x006a0cd8  32  33 (LOAD0) ascii d41d8cd98f00b204e9800998ecf8427e
33620 0x002a0d00 0x006a0d00  92  93 (LOAD0) ascii username="%s", realm="%s", nonce="%s", uri="%s", cnonce="%s", nc=%08x, qop=%s, resp
33621 0x002a0d60 0x006a0d60  62  63 (LOAD0) ascii username="%s", realm="%s", nonce="%s", uri="%s", response="%s"
33622 0x002a0da0 0x006a0da0  46  47 (LOAD0) ascii NTLM handshake failure (empty type-2 message)\n
33623 0x002a0dd0 0x006a0dd0  44  45 (LOAD0) ascii NTLM handshake failure (bad type-2 message)\n
33624 0x002a0e00 0x006a0e00  97  98 (LOAD0) ascii NTLM handshake failure (bad type-2 message). Target Info Offset Len is set incorrec
33625 0x002a0e68 0x006a0e68   9  10 (LOAD0) ascii NTLMSSP%c
33626 0x002a0e72 0x006a0e72  50  51 (LOAD0) ascii %c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%s%s
33627 0x002a0ea8 0x006a0ea8  42  43 (LOAD0) ascii gethostname() failed, continuing without!\n
33628 0x002a0ed8 0x006a0ed8   9  10 (LOAD0) ascii NTLMSSP%c
33629 0x002a0ee2 0x006a0ee2 110 111 (LOAD0) ascii %c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%c%
```

Non Unpackable Packer

Fix the address correctly with base 0x400000 and you can analyze the ELF as usual static ways to ID it, in example, like this, boom! Busted!

```
[0x00400000]> / var
Searching 3 bytes in [0x400000-0x797000]
hits: 15
0x00402b93 hit1_0 .fH/var/run$ H$.
0x00402bb3 hit1_1 .$ .H/var/lockH$ .
0x00402bf3 hit1_2 .$ H/var/tmp$ H$.
0x0064cfa9 hit1_3 .AIF*H/var/runH`f`.
0x00696127 hit1_4 . out/dev/shm//var/tmp//var/lock/.
0x00696131 hit1_5 .shm//var/tmp//var/lock//var/run/.
0x0069613c hit1_6 .mp//var/lock//var/run/%s/%s.xmr.
0x006a78c0 hit1_7 .Godavari X4.
0x00708750 hit1_8 .own module namevariable has no val.
0x0070886f hit1_9 . or environment variableconf_mod.c.
0x00711834 hit1_10 . many temporary variablesBNRANDBN.
0x00716d8a hit1_11 .d_funcDSO_bind_varDSO_convert_fil.
0x00717b30 hit1_12 .EAY_RAND_BYTES/var/run/egd-pool/d.
0x00730419 hit1_13 .e8e/var/tmp/var/profil.
0x00730422 hit1_14 .e/var/tmp/var/profilee.
[0x00400000]> / xmr
Searching 3 bytes in [0x400000-0x797000]
hits: 3
0x0069614c hit2_0 .var/run/%s/%s.xmrt[+] Already ru.
0x006966c8 hit2_1 .optimizations.xmrt 0.1 built on .
0x00699523 hit2_2 .1;32m * [01;37mxmrt 0.1    [01;36m.
[0x00400000]> / Tiny
Searching 4 bytes in [0x400000-0x797000]
hits: 1
0x006963e2 hit3_0 .ation.+ Tiny XMR mooner.++.
```

Non Unpackable Packer

PS: This ELF is also having own self decryption function (encrypted), but it can be handled by usual analysis.. You can hack this statically but as I said I am a debugger, so..I debug stuff faster.

```
[0x00401910]> i~file
file     dump-bin-elf
type     EXEC (Executable file)
[0x00401910]> i~mac
machine  AMD x86-64 architecture
[0x00401910]>
[0x00401910]>
[0x00401910]> af:pdf
[0x00401910]> af;pdf
            ;-- entry0:
 (fcn) fcn.rip 42
   fcn.rip ();
            0x00401910      31ed           xor ebp, ebp
            0x00401912      4989d1         mov r9, rdx
            0x00401915      5e             pop rsi
            0x00401916      4889e2         mov rdx, rsp
            0x00401919      4883e4f0       and rsp, 0xfffffffffffffff0
            0x0040191d      50             push rax
            0x0040191e      54             push rsp
            0x0040191f      49c7c0801a5e.  mov r8, 0x5e1a80  ; this is the decrypter 1
            0x00401926      48c7c1f0195e.  mov rcx, 0x5e19f0 ; this is the decrypter 2, to then exec the main
            0x0040192d      48c7c7a01340.  mov rdi, 0x4013a0 ; main ; "AVAU1\xc0ATUH\x89\xf5S\x89\xfb\xe8\x9c\x16
            0x00401934      e857f81d00     call fcn.005e1190
            0x00401939      f4             hlt
[0x00401910]>
```

Non Unpackable Packer

..you can analyze the packed ELF process too in memory, to check stuff:

```
- offset -   0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF
0x006962d6  ..JSON decode failed(%d): %s.hex2bin str truncated.hex2bin failed on '%s'.cryptonight.stratum+tc
0x00696336  p://.stratum+tcp://%s.%s --help...nicehash.com:. %d.%d.%d.. features: x86_64 AES-NI..%s..2.9.lib
0x00696396  jansson/%s..background.help.......Try --help for more information.........+ Tiny XMR mooner..+.+
0x006963f6    ./mooner -o poolurl.net:3333 -u username -p password.+.+  threads, affinity, and everything el
0x00696456  se is on automatically precalculated for you..+.+  -o        stratum pool url.+            strat
0x006964b6  um+tcp://poolurl.net:3333 or simply poolurl.net:3333.+  -u        username or monero wallet addr
0x00696516  ess.+  -p        password or email/difficulty (on some pools).+  -F        bring process to fore
0x00696576  ground, (background by default).+  -h        halp plz. :^).+.+  this is a rip-off of a miner. se
0x006965d6  nds some hashes to the dev. if you dont want that, choose another one..+  more hashes for you th
0x00696636  o. Especially optimized for Xeons and Core since Nehalem..Cryptonight hash self-test failed. Thi
0x00696696  s might be caused by bad compiler optimizations...xmrt 0.1. built on May 25 2017 with GCC.......
0x006966f6  ............@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@...
0x00696756  ....@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@...
0x006967b6  ....@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@...
0x00696816  ....@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@...
0x00696876  ....@......ci......................F........ci......................h........p...................
0x006968d6  ..p........p......................o........i......................u.............................
0x00696936  ..........a:c:khFp:Px:r:R:s:t:T:o:u:O:v:Vb:.job_id.JSON invalid job id.JSON invalid blob.JSON in
0x00696996  valid blob length.target.JSON key '%s' not found.JSON key '%s' is not a string.stratum_recv_line
0x006969f6   timed out.stratum_recv_line failed.job.Unknown method: "%s".error: "%s".KEEPALIVED.Keepalived r
0x00696a56  eceveid.0.1.Stratum authentication failed.JSON invalid result.JSON invalid id.JSON invalid statu
0x00696ab6  s.JSON returned status "%s".CURL initialization failed.http%s/....stratum_recv_line failed to pa
0x00696b16  rse a newline-terminated string...{"method":"keepalived","params":{"id":"%s"},"id":1}.....{"meth
0x00696b76  od":"login","params":{"login":"%s","pass":"%s","agent":"%s/%s"},"id":1}...Stratum authentication
0x00696bd6   failed: "%s".....Stratum connection failed: code: %d, text: %s.Pool set diff to %g.......accept
0x00696c36  ed: %lu/%lu (%.2f%%), %.2f H/s at diff %g........A......Y@.......>.............................
0x00696c96  ................................................................................................
```

Non Unpackable Packer

To make it short, this is what was encrypted.. (gained by debug mode)

```
- offset -   0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF
0x006962d6  ..JSON decode failed(%d): %s.hex2bin str truncated.hex2bin failed on '%s'.cryptonight.stratum+tc
0x00696336  p://.stratum+tcp://%s.%s --help...nicehash.com:. %d.%d.%d.. features: x86_64 AES-NI..%s..2.9.lib
0x00696396  jansson/%s..background.help.......Try --help for more information.........+ Tiny XMR mooner..+.+
0x006963f6    ./mooner -                                                                ty, and everything el
0x00696456  se is on aut                                                                rl.+            strat
0x006964b6  um+tcp://poo                                                                or monero wallet addr
0x00696516  ess.+  -p                                                                   bring process to fore
0x00696576  ground, (bac                                                                ip-off of a miner. se
0x006965d6  nds some has                                                                ore hashes for you th
0x00696636  o. Especiall                                                                self-test failed. Thi
0x00696696  s might be c                                                                2017 with GCC.......
0x006966f6  ............                                                                .@.......@.......@...
0x00696756  ....@.......                                                                .@.......@.......@...
0x006967b6  ....@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@...
0x00696816  ....@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@.......@...
0x00696876  ....@......ci......................F........ci......................h........p...................
0x006968d6  ..p........p......................o........i......................u.............................
0x00696936  ..........a:c:khFp:Px:r:R:s:t:T:o:u:O:v:Vb:.job_id.JSON invalid job id.JSON invalid blob.JSON in
0x00696996  valid blob length.target.JSON key '%s' not found.JSON key '%s' is not a string.stratum_recv_line
0x006969f6   timed out.stratum_recv_line failed.job.Unknown method: "%s".error: "%s".KEEPALIVED.Keepalived r
0x00696a56  eceveid.0.1.Stratum authentication failed.JSON invalid result.JSON invalid id.JSON invalid statu
0x00696ab6  s.JSON returned status "%s".CURL initialization failed.http%s/....stratum_recv_line failed to pa
0x00696b16  rse a newline-terminated string...{"method":"keepalived","params":{"id":"%s"},"id":1}.....{"meth
0x00696b76  od":"login","params":{"login":"%s","pass":"%s","agent":"%s/%s"},"id":1}...Stratum authentication
0x00696bd6   failed: "%s".....Stratum connection failed: code: %d, text: %s.Pool set diff to %g.......accept
0x00696c36  ed: %lu/%lu (%.2f%%), %.2f H/s at diff %g........A......Y@.......>.............................
0x00696c96  ................................................................................................
```

The mining ID and pool server address is what was encrypted, PS: in some cases are plain seen too..

Non Unpackable Packer

This ELF is actually letting user mining with its own pre-set configuration like pool server, user id/password set into "Donation pool" mode function if the mining config data is not provided… (of course that config wasn't even executed in command line or config JSON file...) Hmm.. weird..

```
0x00401e6e    4183f201       xor r10d, 1
0x00401e72    80fb01         cmp bl, 1                    ; 1
0x00401e75    4c0f440dd3a2.  cmove r9, qword [0x009ac150]
0x00401e7d    44881596a25a.  mov byte [0x009ac11a], r10b ; [0x9ac11a:1]=0
0x00401e84    4531e4         xor r12d, r12d
0x00401e87    4d890b         mov qword [r11], r9
0x00401e8a    e871572300     call fcn.00637600
0x00401e8f    beaf606900     mov esi, 0x6960af            ; "Switching to donation pool"
0x00401e94    bf01000000     mov edi, 1
0x00401e99    31c0           xor eax, eax
0x00401e9b    e8c0c80100     call fcn.0041e760
```

Non Unpackable Packer

Binaries just don’t lie..

```
[0x00401c20]> pd 22 @0x0401D72
            ; CODE XREF from 0x00401cf6 (fcn.00401c20)
            ; CODE XREF from 0x00401dcd (fcn.00401c20)
        ┌─> 0x00401d72      48c707010000.  mov qword [rdi], 1
        ¦   0x00401d79      48c787800000.  mov qword [rdi + 0x80], 1
        ¦   0x00401d84      4881c7000400.  add rdi, 0x400
        ¦   0x00401d8b      48c78700fdff.  mov qword [rdi - 0x300], 1
        ¦   0x00401d96      48c78780fdff.  mov qword [rdi - 0x280], 1
        ¦   0x00401da1      48c78700feff.  mov qword [rdi - 0x200], 1
        ¦   0x00401dac      48c78780feff.  mov qword [rdi - 0x180], 1
        ¦   0x00401db7      48c78700ffff.  mov qword [rdi - 0x100], 1
        ¦   0x00401dc2      48c747800100.  mov qword [rdi - 0x80], 1
        ¦   0x00401dca      4839ef         cmp rdi, rbp
        └─< 0x00401dcd      75a3           jne 0x401d72
            ; CODE XREF from 0x00401cb4 (fcn.00401c20)
            ; CODE XREF from 0x00401ced (fcn.00401c20)
            ; CODE XREF from 0x00401d70 (fcn.00401c20)
            0x00401dcf      803d43a35a00.  cmp byte [0x009ac119], 0
        ┌─< 0x00401dd6      0f84c4010000   je 0x401fa0
        │   0x00401ddc      803d35a35a00.  cmp byte [0x009ac118], 0
        │   0x00401de3      488b3d36a35a.  mov rdi, qword [0x009ac120] ; [0x9ac120:8]=0
        ┌─< 0x00401dea      0f85e8010000   jne 0x401fd8
        │   0x00401df0      48c707686069.  mov qword [rdi], 0x696068   ; [0x696068:8]=0x2b6d757461727473 ; "stratum+tcp://privpool.mone.ro.lt:8080"
        │   0x00401df7      c6051aa35a00.  mov byte [0x009ac118], 1    ; [0x9ac118:1]=0
        │   0x00401dfe      be68606900     mov esi, 0x696068           ; "stratum+tcp://privpool.mone.ro.lt:8080"
        │   ; CODE XREF from 0x00401fd0 (fcn.00401c20)
        │   ; CODE XREF from 0x00401fdb (fcn.00401c20)
        │   0x00401e03      e8589d0000     call fcn.0040bb60           ; fcn.0040b580+0x5e0
        │   0x00401e08      84c0           test al, al
        └─< 0x00401e0a      741e           je 0x401e2a
```

Non Unpackable Packer

Boom! Your carefully hidden miner servers has just been pwned..

```
cmp byte [0x009ac119], 0
je 0x401fa0
cmp byte [0x009ac118], 0
mov rdi, qword [0x009ac120] ; [0x9ac120:8]=0
jne 0x401fd8
mov qword [rdi], 0x696068   ; [0x696068:8]=0x2b6d757461727473 ; "stratum+tcp://privpool.mone.ro.lt:8080"
mov byte [0x009ac118], 1    ; [0x9ac118:1]=0
mov esi, 0x696068           ; "stratum+tcp://privpool.mone.ro.lt:8080"
```

Non Unpackable Packer

Infection/installation artifacts to check:
==========
(not so much since the process are mostly on memory)

Checks for:

- /dev/shm/
- /var/tmp/
- /var/lock/
- /var/run/
- /sys/devices/system/cpu/online"

(others are not that significant, like libs, config or resolv or host or gai.conf, I don't mention here)

Writes:

- /var/lock/.xmrt (lock file)
- /var/run/.xmrt.pid (pid file)
- /tmp/.xmrt (temporary work file)

Networking calls:
---
1. socket(PF_NETLINK, SOCK_RAW, 0) and bind(4, {sa_family=AF_NETLINK, pid=0, groups=00000000}, 12) for IP lookup, NOTED: literally, "pid=0", "groups=0"
2. socket(PF_INET, SOCK_DGRAM, IPPROTO_IP) and connect(4, {sa_family=AF_INET, sin_port=htons(8080), sin_addr=inet_addr("xxx")}, 16) to then endto() and recvform() to the pool server(s) with cryptonite JSON.

Non Unpackable Packer

Q: How many packed binaries using such packers?

A: A lot, and various customization, for example, this one (see the first call)

```
MILEMINE.FIL: ELF 64-bit LSB executable, x86-64,
version 1 (GNU/Linux), statically linked, stripped
```

```
        ;-- entry0:
(fcn) fcn.rip 50
  fcn.rip ();
        0x0045adf0    e8df010000    call fcn.0045afd4          ;[1] ; firstly loading the loader to unpack
        0x0045adf5    55            push rbp
        0x0045adf6    53            push rbx
        0x0045adf7    51            push rcx
        0x0045adf8    52            push rdx
        0x0045adf9    4801fe        add rsi, rdi               ; '''
        0x0045adfc    56            push rsi
        0x0045adfd    4889fe        mov rsi, rdi
        0x0045ae00    4889d7        mov rdi, rdx
        0x0045ae03    31db          xor ebx, ebx
        0x0045ae05    31c9          xor ecx, ecx
        0x0045ae07    4883cdff      or rbp, 0xffffffffffffffff
        0x0045ae0b    e850000000    call fcn.0045ae60          ;[2]
        0x0045ae10    01db          add ebx, ebx
        0x0045ae12    7402          je 0x45ae16                ;[3]
        0x0045ae14    f3c3          ret
        0x0045ae16    8b1e          mov ebx, dword [rsi]
```

Non Unpackable Packer

The loader part always call to loader part contains loads a program & data..

```
(fcn) fcn.0045afd4 40
  fcn.0045afd4 ();
        ; var int local_9h @ rbp-0x9
        ; CALL XREF from 0x0045adf0 (fcn.rip)
        0x0045afd4      5d            pop rbp
        0x0045afd5      488d45f7      lea rax, [local_9h]
        0x0045afd9      448b38        mov r15d, dword [rax]
        0x0045afdc      bac8000000    mov edx, 0xc8            ; 200
        0x0045afe1      4c29f8        sub rax, r15
        0x0045afe4      4129d7        sub r15d, edx
        0x0045afe7      488d0c10      lea rcx, [rax + rdx]
        0x0045afeb      e879ffffff    call fcn.0045af69        ;[1] ; mmap then write and exec
    ┌<  0x0045aff0      7206          jb 0x45aff8              ;[2] ; load binary data of the loader.
    │   0x0045aff2      0000          add byte [rax], al
    │   0x0045aff4      6c            insb byte [rdi], dx
    │   0x0045aff5      0500000849    add eax, 0x49080000
    │   0x0045affa      1100          adc dword [rax], eax
```

Non Unpackable Packer

Loader program itself, same steps: *mmap, load.., exec, write, exit*..

```
fcn.0045af63 (nodes 10 edges 12 zoom 100%) BB-OFF mouse:canvas-y mov-speed:5
0x0045af67 0f05          syscall
;-- fcn.0045af69:
; CALL XREF from 0x0045afeb (fcn.0045afd4)
0x0045af69 5b            pop rbx
; 1
0x0045af6a 6a01          push 1
0x0045af6c 680c004000    push 0x40000c
0x0045af71 50            push rax
0x0045af72 68d2ff2d00    push 0x2dffd2
0x0045af77 51            push rcx
0x0045af78 4157          push r15
0x0045af7a bf00008000    mov edi, 0x800000
; 7
0x0045af7f 6a07          push 7
0x0045af81 5a            pop rdx
0x0045af82 bed2ff2d00    mov esi, 0x2dffd2
; '2'
; 50
0x0045af87 6a32          push 0x32
0x0045af89 415a          pop r10
0x0045af8b 4529c0        sub r8d, r8d
; 9
0x0045af8e 6a09          push 9
0x0045af90 58            pop rax

0x45af91 ;[gb]
0x0045af91 0f05          syscall
0x0045af93 39c7          cmp edi, eax
0x0045af95 0f8590ffffff  jne 0x45af2b;[gc]

0x45af9b ;[gg]
; section.ehdr
0x0045af9b be00004000    mov esi, 0x400000
0x0045afa0 89fa          mov edx, edi
```

mmap()

```
[0x0045af63]> VV @ fcn.0045af63 (nodes 10 edges 12 zoom 100%) BB-OFF mouse:canvas-y mov-speed:5
0x0045af3d 45437c50      jl 0x45af91;[gb]

[0x45af41] ;[gd]
0x0045af41 52            push rdx
0x0045af42 4f54          push r12
0x0045af44 5f            pop rdi
0x0045af45 57            push rdi
0x0045af46 52            push rdx
0x0045af47 4954          push r12
0x0045af49 45206661      and byte [r14 + 0x61], r12b
0x0045af4d 696c65642e0a. imul ebp, dword [rbp + 0x64], 0xa2e
0x0045af55 90            nop
0x0045af56 90            nop
0x0045af57 90            nop
; CALL XREF from 0x0045af31 (fcn.0045ae60 + 209)
0x0045af58 5e            pop rsi
; 2
0x0045af59 6a02          push 2
0x0045af5b 5f            pop rdi
; 1
0x0045af5c 6a01          push 1
0x0045af5e 58            pop rax
0x0045af5f 0f05          syscall
; 127
0x0045af61 6a7f          push 0x7f

0x45af63 ;[ge]
(fcn) fcn.0045af63 169
  fcn.0045af63 (int arg_64h);
; arg int arg_64h @ rbp+0x64
; var int local_8h @ rsp+0x8
; var int local_18h @ rsp+0x18
0x0045af63 5f            pop rdi
; '<'
; 60
0x0045af64 6a3c          push 0x3c
0x0045af66 58            pop rax
0x0045af67 0f05          syscall
```

write()

exit()

Non Unpackable Packer

The packed ELF data is in the same address, of *0x40000c*

```
[[0x0045af69]> #the packed data is always in 0x40000c
[[0x0045af69]>
[[0x0045af69]> x @0x40000c!2000
- offset -   0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x0040000c  0000 0000 0200 3e00 0100 0000 f0ad 4500  ......>.......E.
0x0040001c  0000 0000 4000 0000 0000 0000 0000 0000  ....@...........
0x0040002c  0000 0000 0000 0000 4000 3800 0200 4000  ........@.8...@.
0x0040003c  0000 0000 0100 0000 0500 0000 0000 0000  ................
0x0040004c  0000 0000 0000 4000 0000 0000 0000 4000  ......@.......@.
0x0040005c  0000 0000 68b5 0500 0000 0000 68b5 0500  ....h.......h...
0x0040006c  0000 0000 0000 2000 0000 0000 0100 0000  ...... .........
0x0040007c  0600 0000 f09f 0d00 0000 0000 f09f 6d00  ..............m.
0x0040008c  0000 0000 f09f 6d00 0000 0000 0000 0000  ......m.........
0x0040009c  0000 0000 0000 0000 0000 0000 0000 2000  ............... .
0x004000ac  0000 0000 aa7e 1390 efbe adde 8007 0d16  .....~..........
0x004000bc  0000 0000 3404 0d00 3404 0d00 2001 0000  ....4...4... ...
```

Non Unpackable Packer

Sometimes you can see the packed's ELF header, BUT it's NOT UPX!!

```
0x004000cc  6600 0000 0800 0000 bbfb 20ff 7f45 4c46  f......... ..ELF
0x004000dc  0201 0100 0200 3e00 1ba7 0440 1f6e bba5  ......>....@.n..
0x004000ec  f640 0001 2638 0004 3357 200f 6cb1 053b  .@..&8..3W .l..;
0x004000fc  0f9e bb0c deba 636d 0020 6f06 11c0 2fc0  ......cm. o.../.
0x0040010c  6c0e f6ec c10f 3444 1df0 df00 6f07 6db0  l.....4D....o.m.
0x0040011c  2bf6 0604 6f08 5b1f 6c53 b03f 51e5 7464  +...o.[.lS.?Q.td
0x0040012c  0600 0110 0f24 4992 2400 0000 a8ff 7eba  .....$I.$.....~.
0x0040013c  0c00 5498 0500 0849 1100 606f b7ff 4883  ..T....I..`o..H.
0x0040014c  ec08 e811 0004 7a08 09e0 dd1a c408 c300  ......z.........
0x0040015c  01f6 7dff 7b53 89fb 4410 8974 240c 488d  ..}.{S..D..t$.H.
0x0040016c  08ba 0428 89df 5adb edef ed08 403f 30f8  ...(..Z.....@?0.
0x0040017c  ff75 1114 44dc 8b00 1604 74dd 0820 ebb7  .u..D.....t.. ..
0x0040018c  db7f bb04 2c14 19b9 2044 4a00 ba0d 015a  ....,... DJ....Z
0x0040019c  be9d 4212 bfe7 3cfe f7df 6708 5443 08c6  ..B...<...g.TC..
0x004001ac  105b c30f 1f84 bf48 8b3d 4905 2dff f36e  .[.....H.=I.-..n
0x004001bc  dfcc 4885 ff74 053e 055d 6422 5748 81ff  ..H..t.>.]d"WH..
0x004001cc  1007 6d00 d09d 75ed 741a 6654 444f 1f3b  ..m...u.t.fTDO.;
0x004001dc  81fb 2d48 7ffb 7f5f 0475 ec5b bf40 14e9  ..-H..._.u.[.@..
0x004001ec  1102 2f3c 8b05 b30b 6685 c074 7653 bfc0  ../<....f..tvS..
```

Non Unpackable Packer

If you fo the debugging.. you can see it is executed in base address

```
        :   0x00450f7b      4189c4          mov r12d, eax
      ,==< 0x00450f7e      751d            jne 0x450f9d                ;[1]
      |:   0x00450f80      e87b360300      call 0x484600               ;[2]
      |:   0x00450f85      833826          cmp dword [rax], 0x26       ; [0x26:4]=-1 ; '&' ; 38
     ,===< 0x00450f88      0f8596020000    jne 0x451224                ;[3]
     ||:   0x00450f8e      c70548fd2700.   mov dword [0x006d0ce0], 1    ; [0x6d0ce0:4]=0
    ,====< 0x00450f98      e987020000      jmp 0x451224                ;[3]
    ||`--> 0x00450f9d      4d85ed          test r13, r13
    ||,==< 0x00450fa0      7422            je 0x450fc4                 ;[4]
    |||:   0x00450fa2      833d3bfd2700.   cmp dword [0x006d0ce4], 0
   ,=====< 0x00450fa9      7419            je 0x450fc4                 ;[4]
   ||||:   0x00450fab      488d742428      lea rsi, [rsp + 0x28]       ; '(' ; 40
   ||||:   0x00450fb0      31d2            xor edx, edx
   ||||:   0x00450fb2      bf01000000      mov edi, 1
   ||||:   0x00450fb7      e894330400      call 0x494350               ;[5]
   ||||:   0x00450fbc      85c0            test eax, eax
   ||||`=< 0x00450fbe      0f8582feffff    jne 0x450e46                ;[6]
   `--`--> 0x00450fc4      e837360300      call 0x484600               ;[2]
    ||     0x00450fc9      bf01000000      mov edi, 1
Press <enter> to return to Visual mode.    mov r14, rax
:> e asm.arch;e asm.bits
x86
64
:> i
blksz    0x0
block    0xb4
fd       3
file     dbg://2908
format   any
iorw     true
mode     rwx
referer  dbg://2908
```

Non Unpackable Packer

Anyway, if you dump it, (command: wtf) this one is the XMRig...Unpacked

```
- offset -   0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF
0x0001d440  ..J.....................O........I.......................V.......
0x0001d480  ................................a:c:khBp:Px:r:R:s:t:T:o:u:O:v:VI
0x0001d4c0  :S..............................[01;32m * .[01;37mVERSIONS:
0x0001d500   .[01;36mXMRig/%s.[01;37m libuv/%s%s.... * VERSIONS:     XMRig/%
0x0001d540  s libuv/%s%s.....[01;32m * .[01;37mTHREADS:      .[01;36m%d.[01;
0x0001d580  37m, %s, av=%d, %sdonate=%d%%%s. * THREADS:      %d, %s, av=%d,
0x0001d5c0  %sdonate=%d%%%s..[01;32m * .[01;37mPOOL #%d:      .[01;36m%s:%d.
0x0001d600  .[01;32m * .[01;37mHUGE PAGES:   %s, %s..[01;32m * .[01;37mCPU:
0x0001d640          %s (%d) %sx64 %sAES-NI. * CPU:          %s (%d) %sx64 %
0x0001d680  sAES-NI..[01;32m * .[01;37mCOMMANDS:     .[01;35mh.[01;37mashrat
0x0001d6c0  e, .[01;35mp.[01;37mause, .[01;35mr.[01;37mesume........ * COMMA
0x0001d700  NDS:     'h' hashrate, 'p' pause, 'r' resume..[01;32menabled..[0
0x0001d740  1;31mdisabled..[01;32mavailable..[01;31munavailable..[01;32m..[0
0x0001d780  1;31m-..[01;31m. * POOL #%d:      %s:%d. gcc/%d.%d.%d. * HUGE PA
0x0001d7c0  GES:   %s, %s., affinity=0x%lX...................|B.....P}B.....
0x0001d800  ..B.......B.......B.............................n/a.%03.1f......
0x0001d840  .[01;37mspeed.[0m 2.5s/60s/15m .[01;36m%s .[22;36m%s %s .[01;36m
0x0001d880  H/s.[0m max: .[01;36m%s H/s.....speed 2.5s/60s/15m %s %s %s H/s
0x0001d8c0  max: %s H/s...................@.@...................B.......B.....
0x0001d900  ..B.......B.......B.........................................B.....
0x0001d940  ..B.....E^E.....setsid() failed (errno = %d).chdir() failed (err
0x0001d980  no = %d).XMRig.%s/%s (Linux .x86_64) libuv/%s...................
0x0001d9c0  ................................................................
```

Non Unpackable Packer

It will run like this without revealing forensics of the real sample is:

```
* VERSIONS:     XMRig/2.5.2 libuv/1.11.0 gcc/6.3.0
* HUGE PAGES:   available, disabled
* CPU:          [redacted]
* THREADS:      1, cryptonight, av=3, donate=20%
* POOL #1:      proxy.monoguide.ml:80
* COMMANDS:     hashrate, pause, resume
2018-06-14 00:55:50] use pool proxy.monoguide.ml:80 5.133.179.36
2018-06-14 00:55:50] new job from proxy.monoguide.ml:80 diff 2500
2018-06-14 00:56:12] dev donate started
2018-06-14 00:56:12] new job from proxy.poolnero.club:80 diff 2500
2018-06-14 00:56:46] speed 2.5s/60s/15m n/a n/a n/a H/s max: n/a H/s
```


```
{"id":1,"jsonrpc":"2.0","method":"login","params":{"login":"","pass":"x","agent":"XMRig/2.5.2
(Linux x86_64) libuv/1.11.0 gcc/6.3.0"}}
{"id":1,"jsonrpc":"2.0","error":null,"result":
{"id":"de302a7a-38ba-4895-8734-9dcba51a389e","job":
{"blob":"07078ffa86d9059328e4ef718f66e6f7e655b8804487c2013ee2a4e7d8ed9a45f654f137838b4f000000
00c23632ca53b467c42c7c24dc49bbbb5c94586e6ad728d8b6b6abd35685b44dc603","job_id":"mJVPaj3aWbB5i
vtt2MYIHG3PKCYV","target":"e2361a00","id":"de302a7a-38ba-4895-8734-9dcba51a389e"},"status":"O
K"}}
```

Non Unpackable Packer

It doesn't use much of anti-debugging, so you can enjoy this luxury:

```
write(12, "{¥"id¥":1,¥↓
          "jsonrpc¥":¥"2.0¥",¥↓
          "method¥":¥"login¥",¥↓
          "params¥":↓
              {¥"login¥":¥"¥",↓
               ¥"pass¥":¥"x¥",↓
               ¥"agent¥":¥"XMRig/2.5.2 (Linux x86_64) libuv/1.11.0 gcc/6.3.0¥"}}¥n",

read(12, "{¥↓
         "id¥":1,¥↓
         "jsonrpc¥":¥"2.0¥",¥↓
         "error¥":null,¥↓
         "result¥":{¥↓
         "id¥":¥"de302a7a-38ba-4895-8734-9dcba51a389e¥",¥↓
         "job¥":{¥↓
                "blob¥":¥"07078ffa86d9059328e4ef718f66e6f7e655b8804487c2013ee2a4e7d8ed
                 4dc49bbbb5c94586e6ad728d8b6b6abd35685b44dc603¥",¥↓
                "job_id¥":¥"mJVPaj3aWbB5ivtt2MYIHG3PKCYV¥",¥↓
         "target¥":¥"e2361a00¥",¥"↓
          id¥":¥"de302a7a-38ba-4895-8734-9dcba51a389e¥"}↓
          ,¥"status¥":¥"OK¥"}}¥n"↓
[EOF]
```

sent data to the bogus server.....

will reply to the exact mining ID....

Why they abuse these miners?

As per stated in the source code of this packed XMRig, looks like the same as Tiny XMR mooner they abused the donation functionality.. and this seems the one of aspects that bad actor(s) would like to hide.

```
 * If you plan on changing this setting to 0 please consider making a one off donation to my wallet:
 * XMR: 48edfHu7V9Z84YzzMa6fUueoELZ9ZRXq9VetWzYGzKt52XU5xvqgzYnDK9URnRoJMk1j8nLwEVsaSWJ4fhdUyZijBGUicoD
 * BTC: 1P7ujsXeX7GxQwHNnJsRMgAdNkFZmNVqJT
 */
constexpr const int kDefaultDonateLevel = 5;
constexpr const int kMinimumDonateLevel = 1;


#endif /* __DONATE_H__ */
```

Why they abused these miners?

No matter what, it will mine with actor's pre-set ID anyway..

Donation function is abused as a pre-set hardcoded. Tested! (below)


```
{"method":"login","params":{"login":"[redacted]","pass":"[redacted]","agent":"xmrt/0.1"},"id":1}
{"id":1,"jsonrpc":"2.0","error":null,"result":{"id":"0b369b54-4a34-4426-b0e7-a0492e59c455","job":
{"blob":"0707bf9cf7d50592d7a99607b66e36166170e5f1c0e6f5e03983962cc18728861b63cfd16435180000000466cb95b208354c0032b3
ebb997070048ce9c530a984e3c33498e01","job_id":"y9vqHqcaWnuZXOHh6wwQScuGRp4G","target":"cccccc0c","id":"0b369b54-4a34-
a0492e59c455"},"status":"OK"}}
{"method":"submit","params":{"id":"0b369b54-4a34-4426-b0e7-
a0492e59c455","job_id":"y9vqHqcaWnuZXOHh6wwQScuGRp4G","nonce":"08000000","result":"60ec8ffe003537932f230b6a5354faeca
4d13da79868428d8cf08"},"id":1}
{"id":1,"jsonrpc":"2.0","error":null,"result":{"status":"OK"}}
{"jsonrpc":"2.0","method":"job","params":
{"blob":"0707bf9cf7d50592d7a99607b66e36166170e5f1c0e6f5e03983962cc18728861b63cfd16435180000000796807abc082c79ebb00c
0d5a8f4e31e92b492144b7c2e3c3c12b01","job_id":"dH7t/tnAK2m/2ErdJeXbkFPd1fpX","target":"cccccc0c","id":"0b369b54-4a34-
a0492e59c455"}}
{"jsonrpc":"2.0","method":"job","params":
{"blob":"07079f9df7d5053e2d53baca9678cb0bc66f8d069a66ac0add2c69af3c74af3d77023f5407e07400000000bdf7f79413e1ef4d978ae
6eca4a695d843b219fe1bbbe9c5adc2001","job_id":"hNmHvWGXsmVcuarzZzGuTNm9UStl","target":"cccccc0c","id":"0b369b54-4a34-
a0492e59c455"}}
{"method":"submit","params":{"id":"0b369b54-4a34-4426-b0e7-
a0492e59c455","job_id":"hNmHvWGXsmVcuarzZzGuTNm9UStl","nonce":"04000000","result":"f21b64858d7c70a3b8e28a03054606e39
284a31eceb2ac03cbd03"},"id":1}
{"id":1,"jsonrpc":"2.0","error":null,"result":{"status":"OK"}}
{"jsonrpc":"2.0","method":"job","params":
{"blob":"07079f9df7d5053e2d53baca9678cb0bc66f8d069a66ac0add2c69af3c74af3d77023f5407e07400000000240f43322870596acb21f
922be68642dc2a8c5487c16545e9166001","job_id":"+oqJHUOVpgT8IiJuzmGYPLAoC7b/","target":"99999919","id":"0b369b54-4a34-
a0492e59c455"}}
```

NUP sample for you

4f1fdacaee8e3c612c9ffbbe162042b2

Conclusion

1. Let’s learn together on how ELF packers evolves
2. ...with don’t forget the BASIC of executable in ELF itself
3. Packers will always be there to protect binaries,
   so...let's ENJOY REVERSING THEM!
4. Using radare2 is always fun. Remember this great motto always:

JUST FIRE R2 AND EVERYTHING IS GOING TO BE OKAY! :)

My recommended reference

1. https://github.com/torvalds/linux/blob/v4.11/fs/binfmt_elf.c
2. http://www.sco.com/developers/gabi/2003-12-17/contents.html
3. http://phrack.org/issues/58/5.htm
4. http://www.skyfree.org/linux/references/ELF_Format.pdf

Others reading maybe can help you in practical level:
http://www.cirosantilli.com/elf-hello-world/
https://medium.com/@MrJamesFisher/understanding-the-elf-4bd60daac571

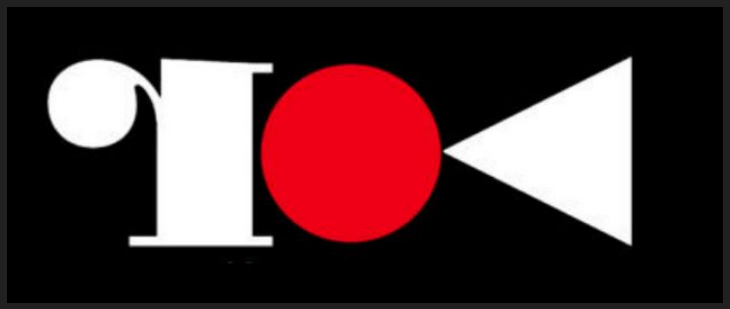
Good Tools:

1. ElfDump
   https://github.com/spurious/elftoolchain-mirror/blob/master/elfdump/elfdump.c
2. ElfToolChain https://sourceforge.net/projects/elftoolchain
3. PyElfTools https://github.com/eliben/pyelftools

Fin

Let's thank to pancake, radare2 dev, r2con2018 folks, you guys rock!

For the audience, if you find this useful, please:

0x0 - Blog your own found/made packer or share on how-to dissect them
0x1 - Tweet about it
0x2 - Don’t forget to mention: @radareorg and hashtags #radare2 + #r2con2018!
0x3 - <u>Present it in the r2con2019!</u>

Question(s)?