Intro to Binary Exploitation/PWN

21 June 2025

by capang

$whoami

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- PwC Malaysia Cyber Threat Operations, Intern
- CTF player
  - Malaysia Representative for ACS Hacking Contest Vietnam 2024
  - 3rd Place (Malaysia) PwC Hack-A-Day 2024
- Malaysia Cybersecurity Camp 2024 Alumni
- PWN Challenge Creator
  - Girls in CTF 2024
  - BlackBerry CCoE CTF 2025
  - UM Cybersecurity Summit CTF 2025
- Passionate about computers and networking

Blog: https://brocapang.github.io/

LinkedIn: https://www.linkedin.com/in/gnapac/

Disclaimer

This session is intended for educational purposes only.

Please be aware that:

- All activities demonstrated during this session are conducted in a controlled environment with explicit permission.
- Unauthorized access to computer systems is illegal and unethical.
- Ensure that your actions comply with all applicable laws and regulations.
- The information shared should be used to improve your own security posture and not for malicious purposes.
- By participating in this session, you agree to abide by these principles and use the knowledge gained responsibly.

PS: I am a student learning about this also so… feel free to correct any mistakes I make!

What is PWN?

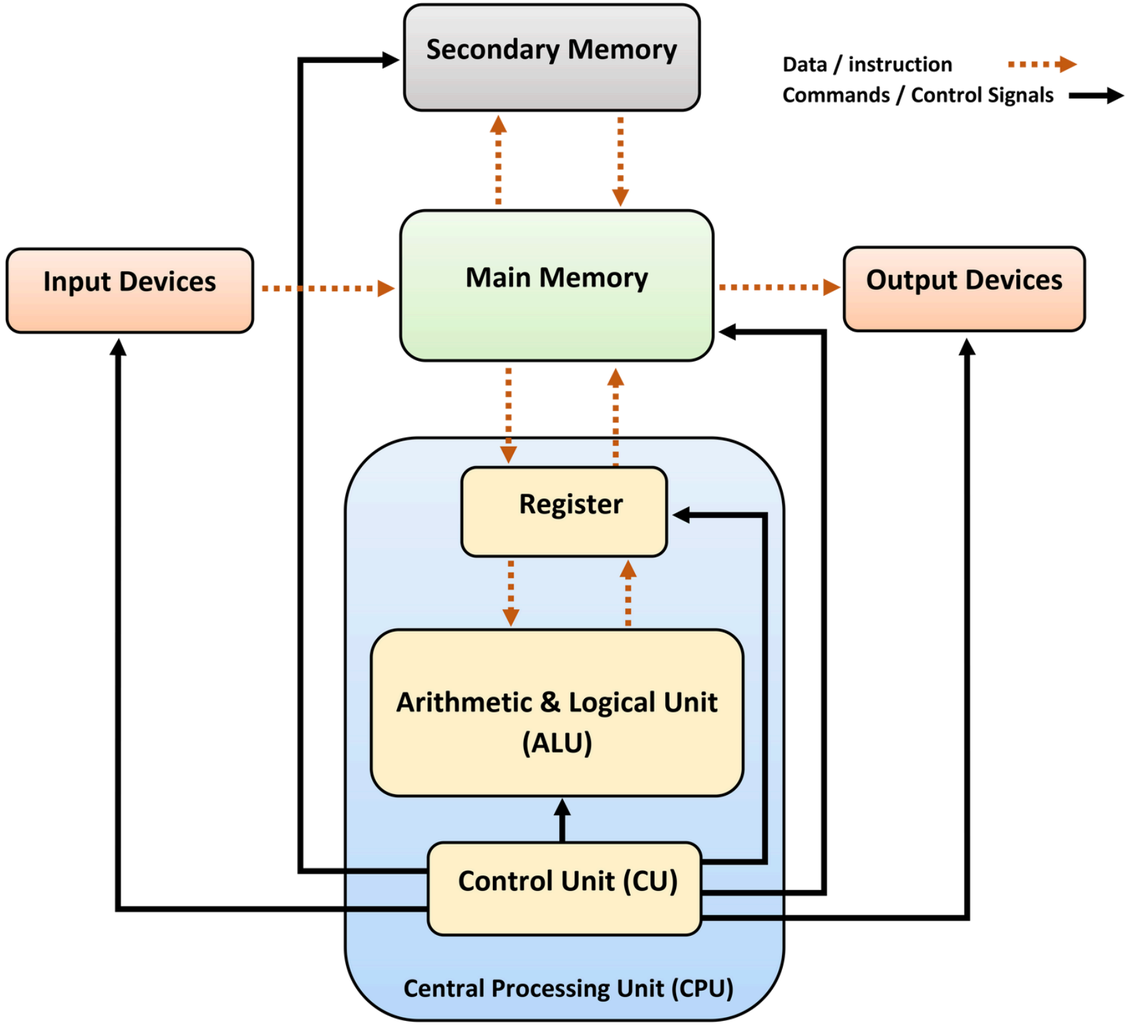
What is PWN?

- PWN = “own”
- Finding a vulnerability in a compiled program
- Using that vulnerability to control the program’s behavior

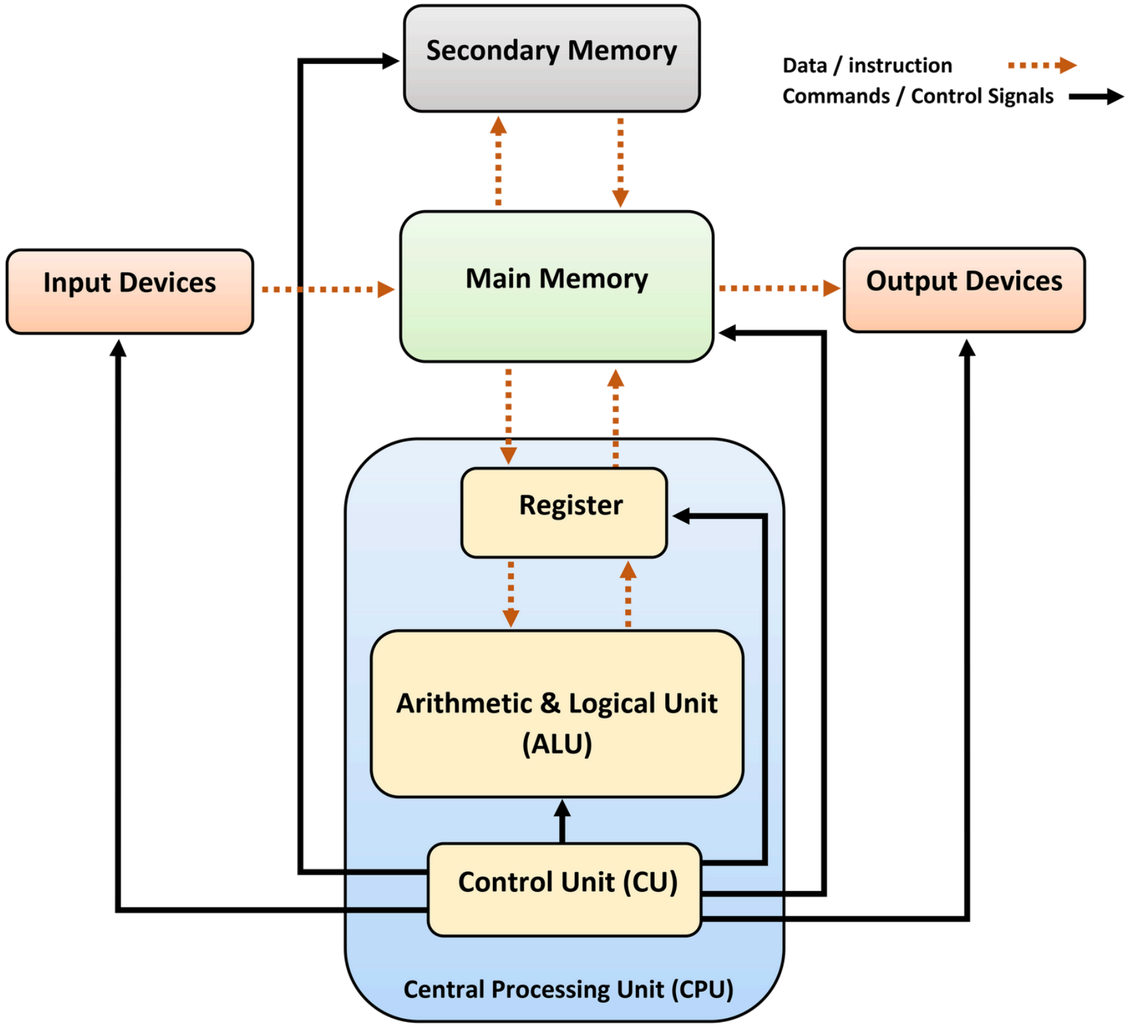
reading code → to crashing a program → run our own commands

Experience doing PWN

Overview of Computer Architecture for Binary Exploitation


Secondary Memory
Data / instruction
Commands / Control Signals
Input Devices
Main Memory
Output Devices
Register
Arithmetic & Logical Unit
(ALU)
Control Unit (CU)
Central Processing Unit (CPU)

Von Neumann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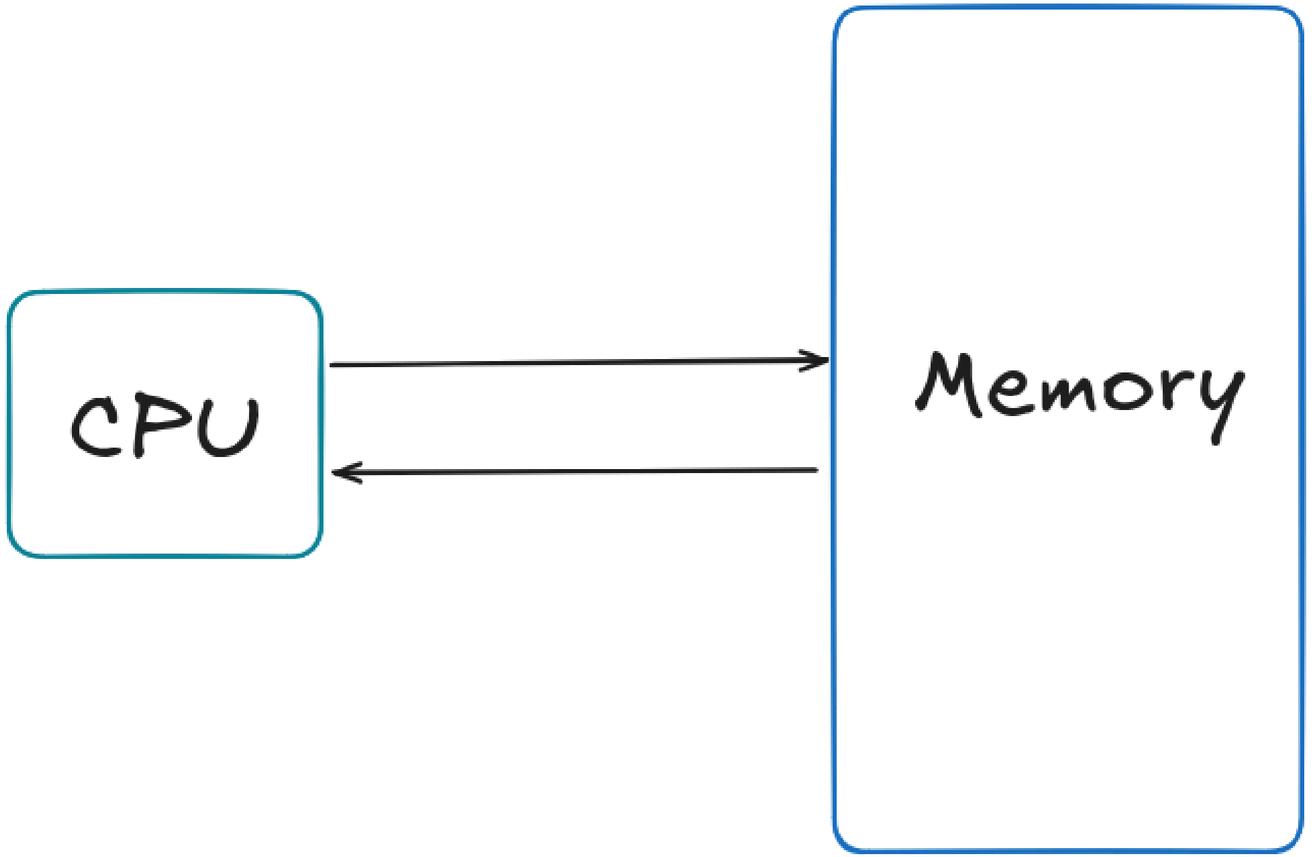
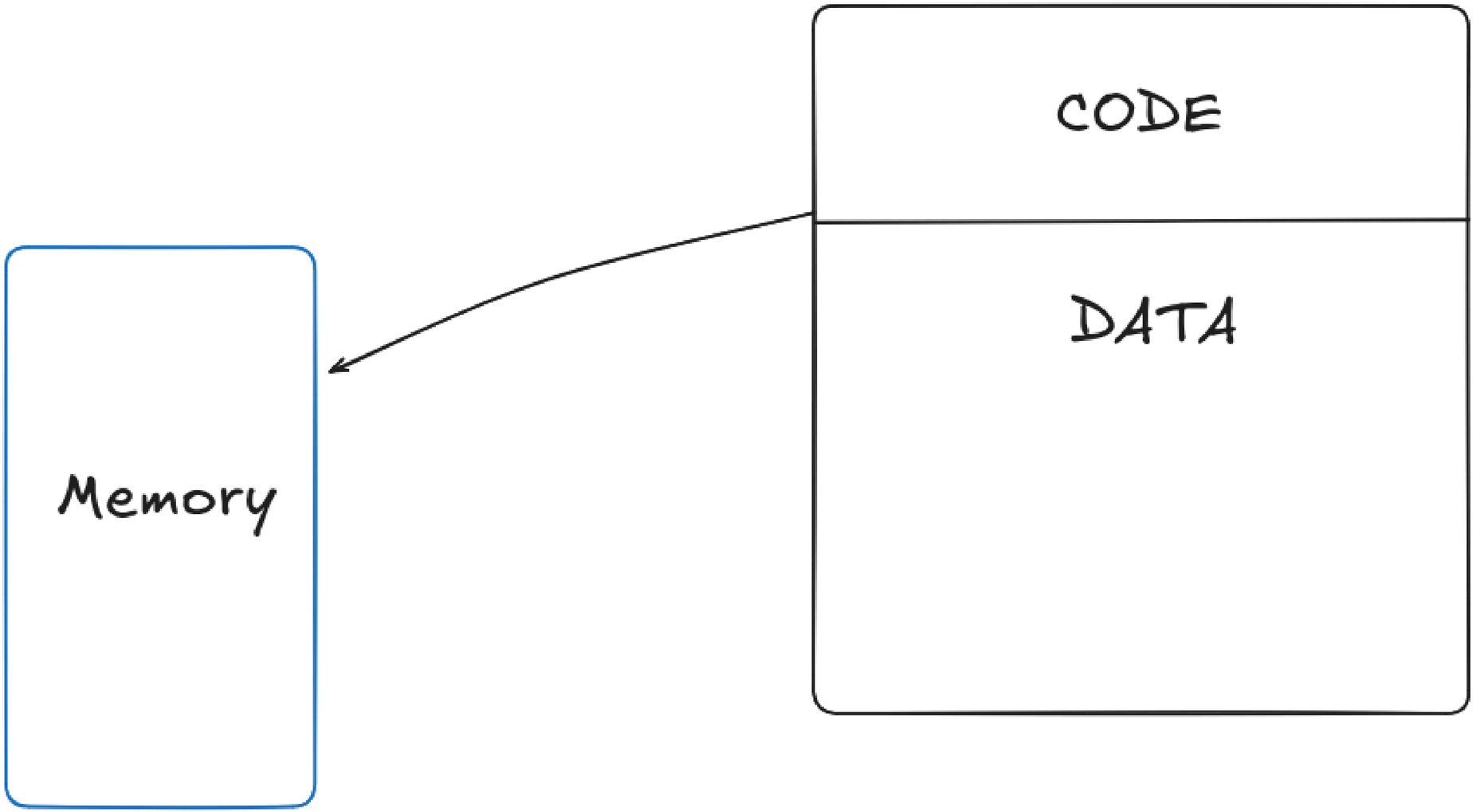
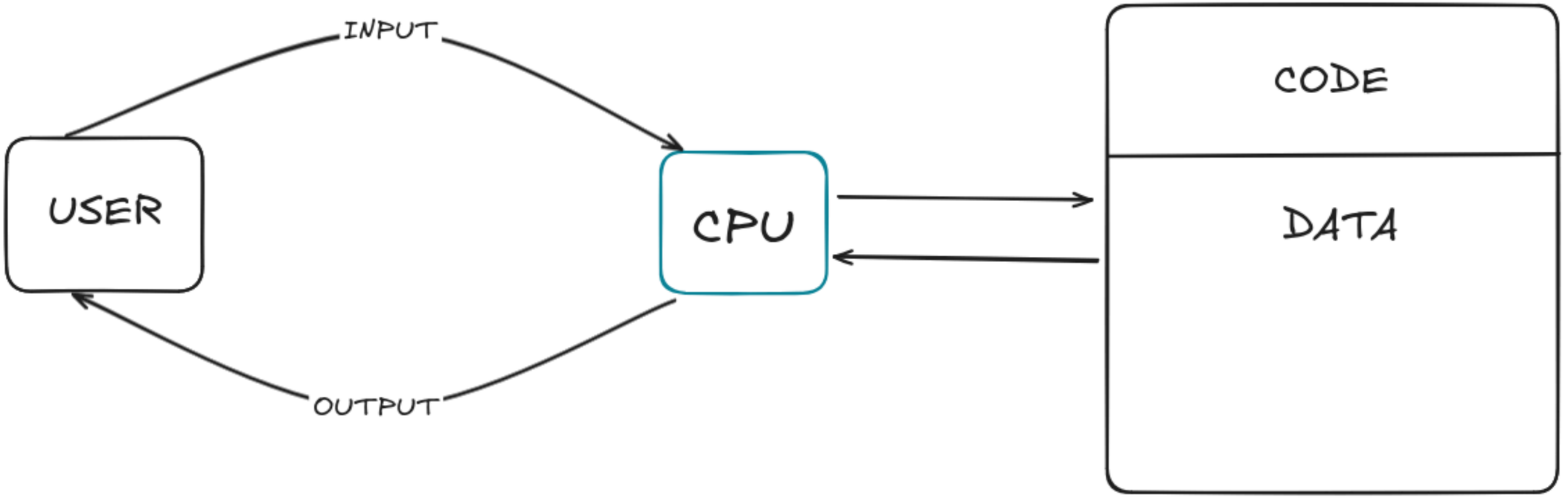

CPU
Memory


CODE
DATA
Memory


INPUT
USER
CPU
CODE
DATA
OUTPUT

```c
#include <stdio.h>

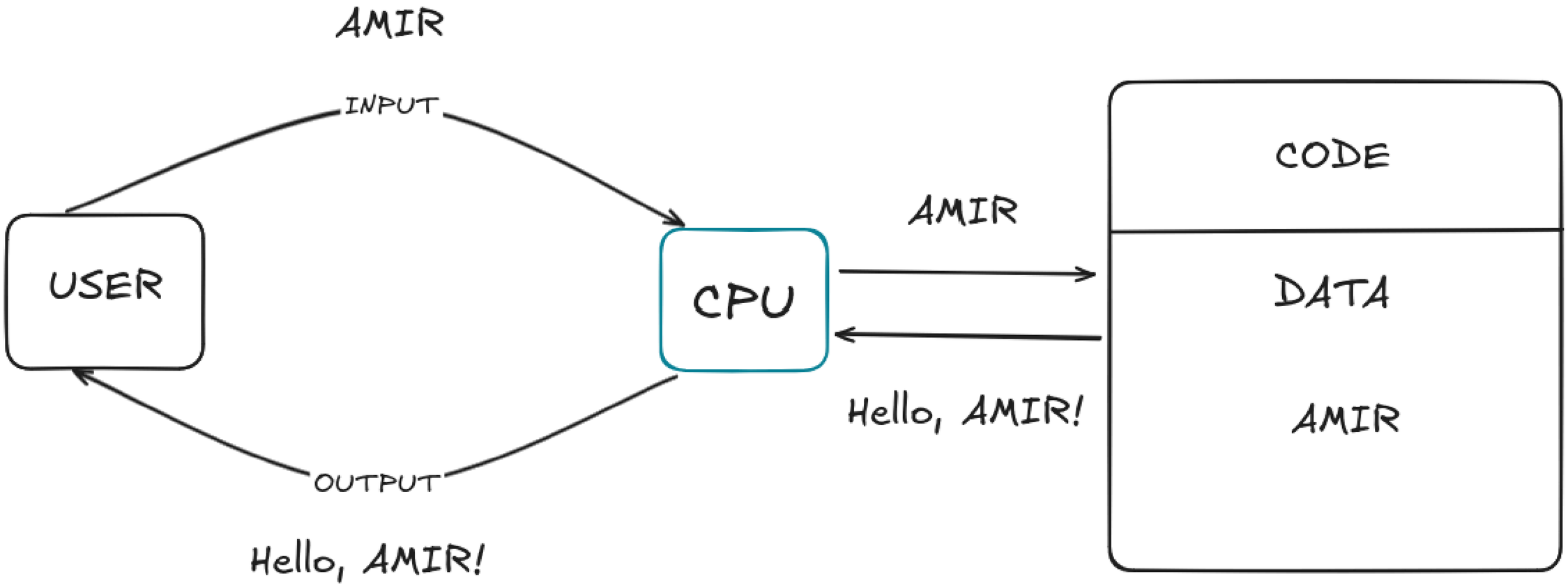
int main() {
    char name[100];

    printf("Enter your name: ");
    // Read name
    gets(name, sizeof(name), stdin);

    printf("Hello, %s!\n", name);

    return 0;
}

```

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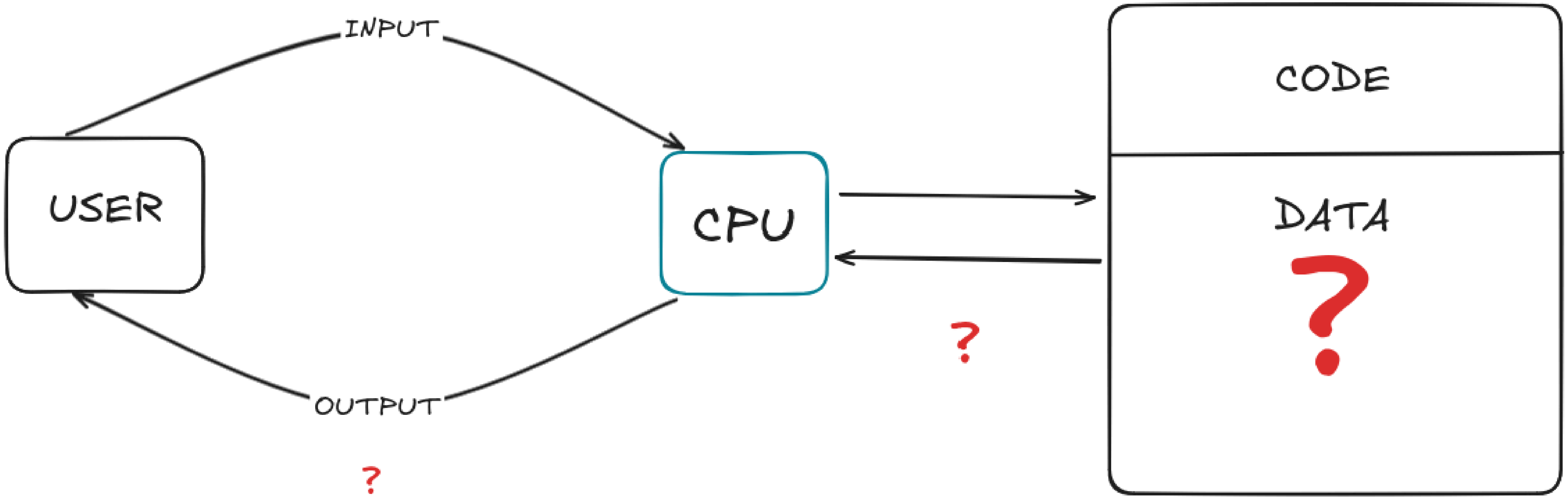


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The Goal of this Session

- Basics on Low Level Computer Knowledge
- Basics on PWN
  - Understand Buffer Overflow
  - Understand Return Oriented Programming

Pointers

What is Pointers?

- A pointer stores a memory address
- It "points to" a location in memory
- Not the data, just the address

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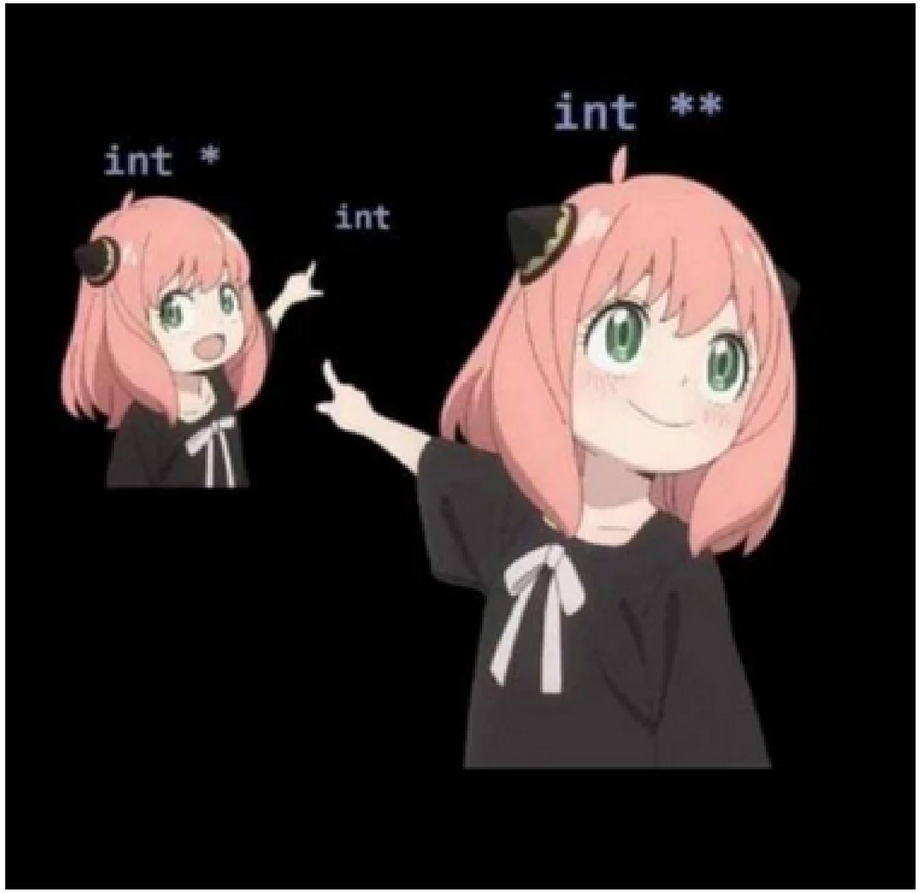

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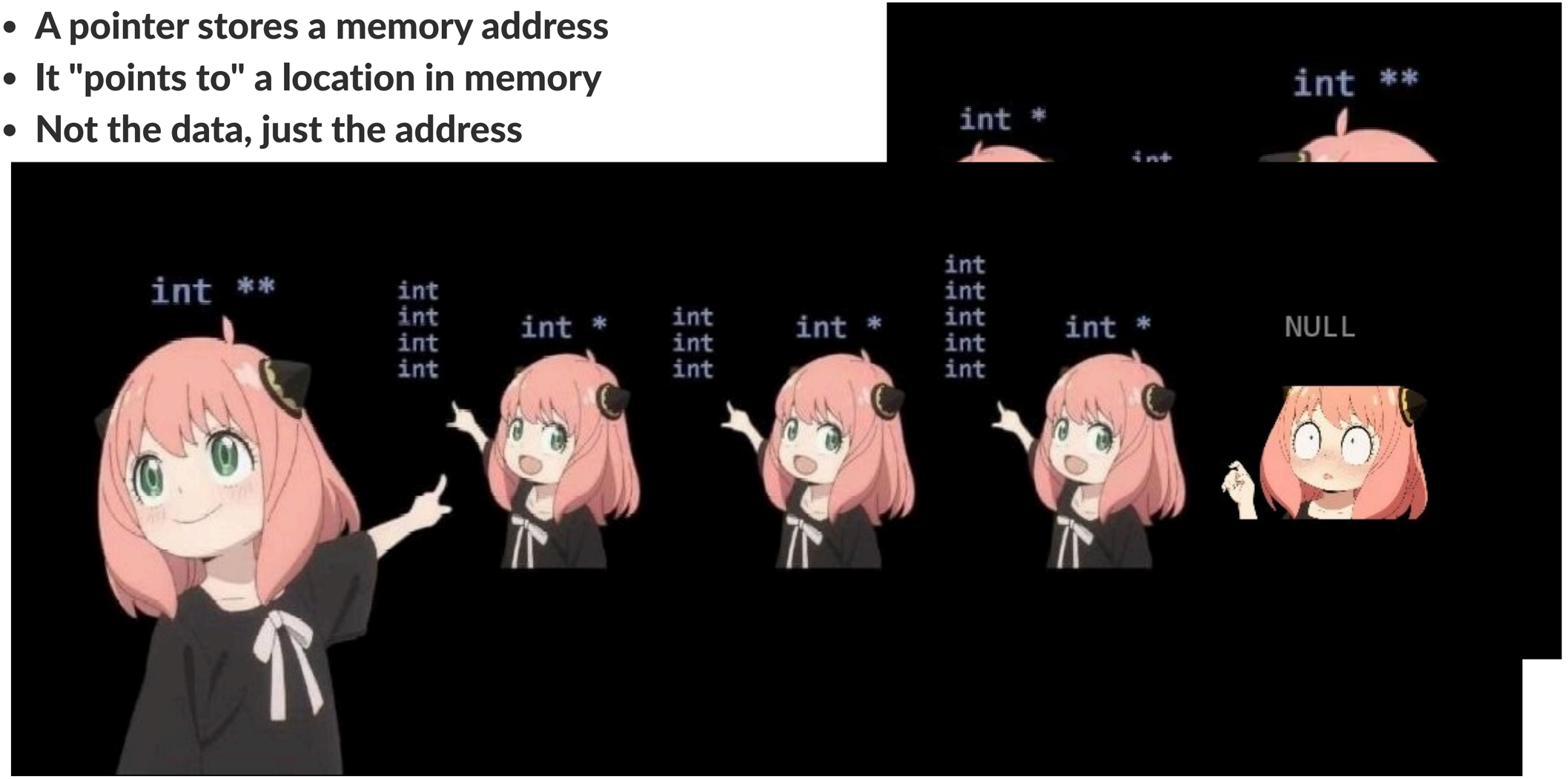

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int x = 20;

int *p = &x;
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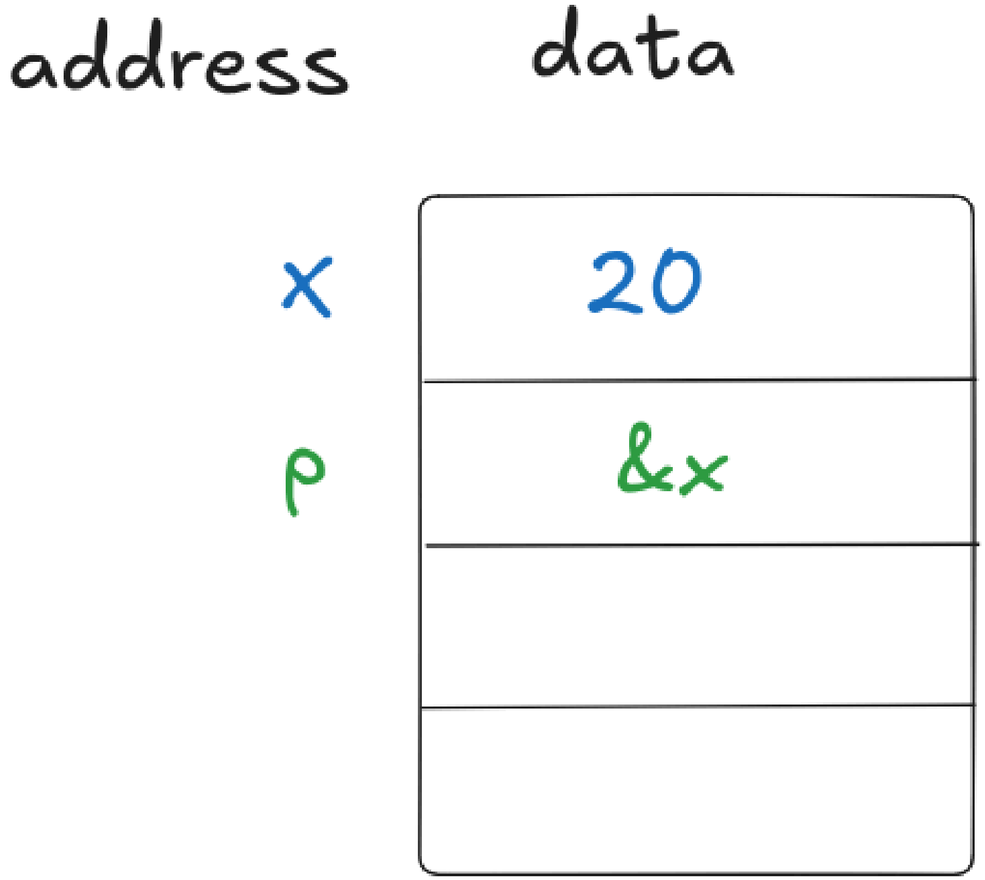

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        printf("x: %d\n",x);
        printf("&x: %p\n",&x);
        printf("p: %p\n",p);


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What is Pointers?

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int main() {

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        printf("x: %d\n",x);
        printf("&x: %p\n",&x);
        printf("p: %p\n",p);


        return;
}
```

```
x: 20
&x: 0x7fffbd64a0bc
p: 0x7fffbd64a0bc
```

Registers and the CPU

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- Used for temporary data, addresses, control
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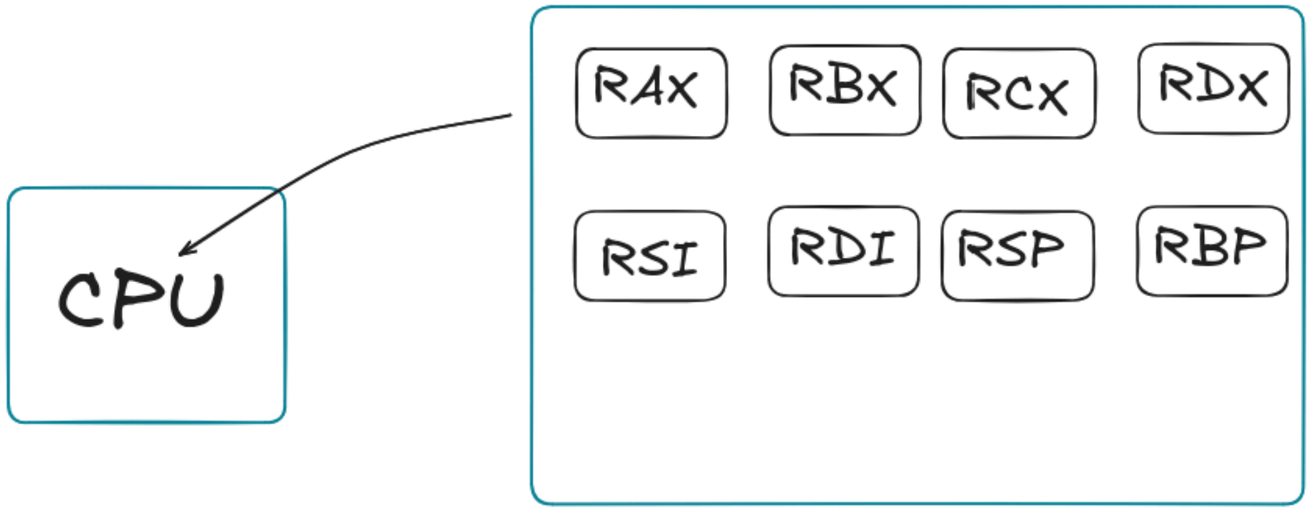

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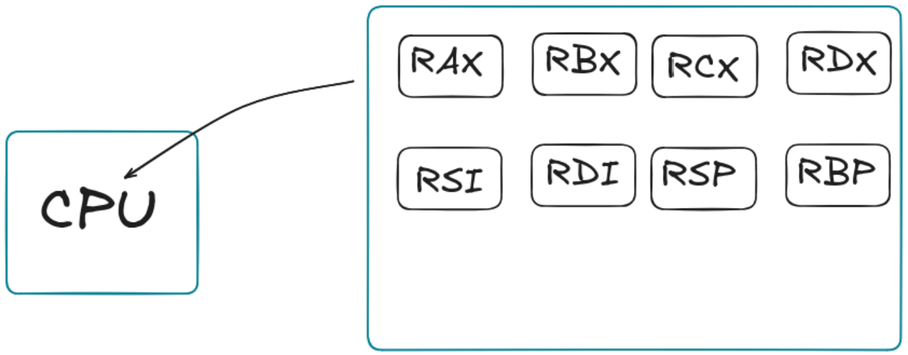
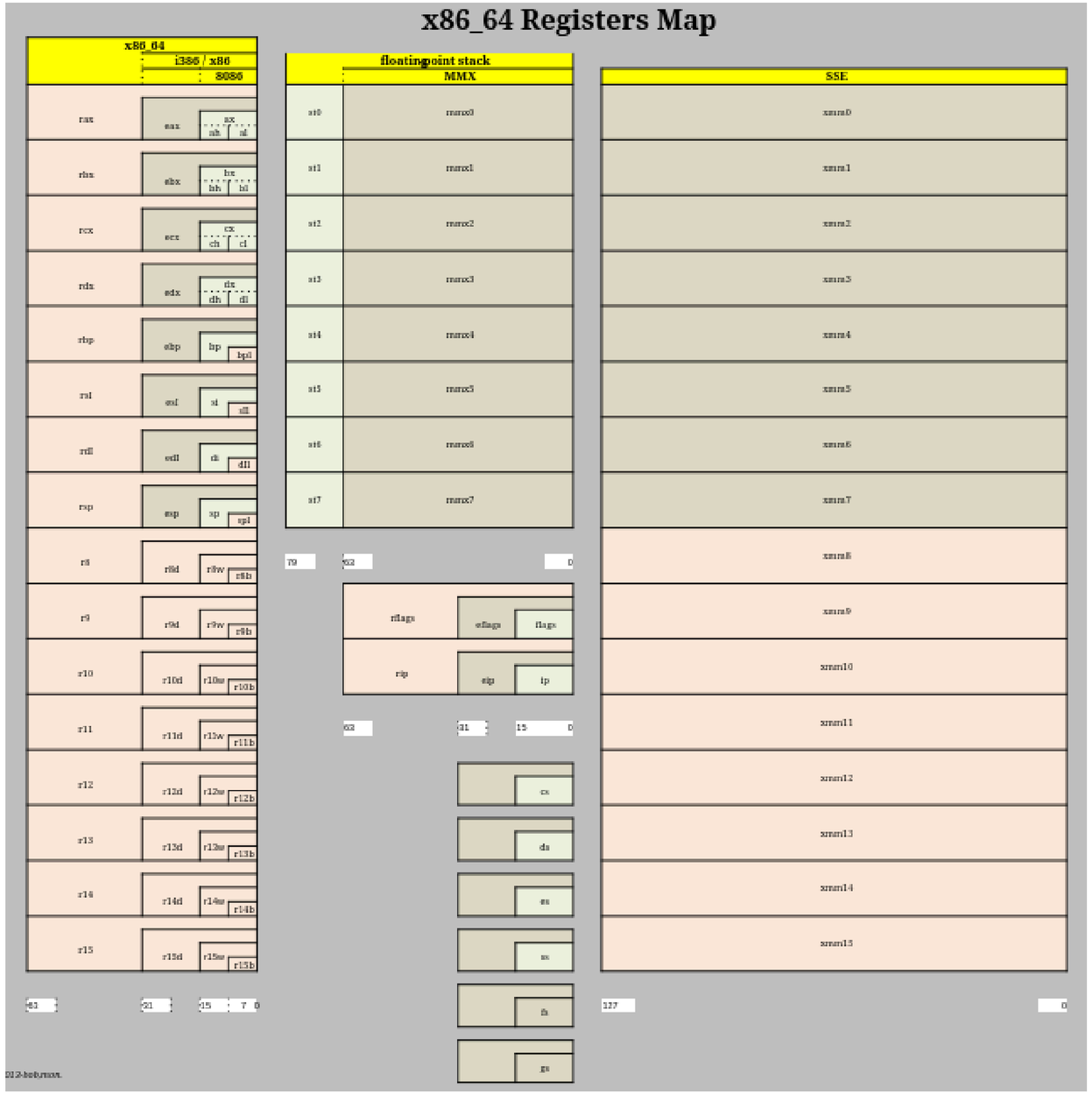


q (8 bytes)	l (4 bytes)	w (2 bytes)	b (1 byte)	
%rax	%eax		%ax	accumulate
%rbx	%ebx		%bx	base
%rcx	%ecx		%cx	counter
%rdx	%edx		%dx	data
%rsi	%esi		%si	source index
%rdi	%edi		%di	destination index
%rsp	%esp		%sp	stack pointer
%rbp	%ebp		%bp	base pointer



source: https://upload.wikimedia.org/wikipedia/commons/3/3e/X86_64-registers.svg

Key Registers to take note

- **RSP and RBP: Manages the STACK**
- **RIP: Keeps track of functions called/returned**
- **RDI, RSI, RDX: Function parameters**

The STACK and Function Calling

What is the Stack?

- One of the “region” of memory for function execution
- Used to store:
  - Function arguments
  - Return addresses
  - Local variables
- Grows downward in memory (from high to low addresses)

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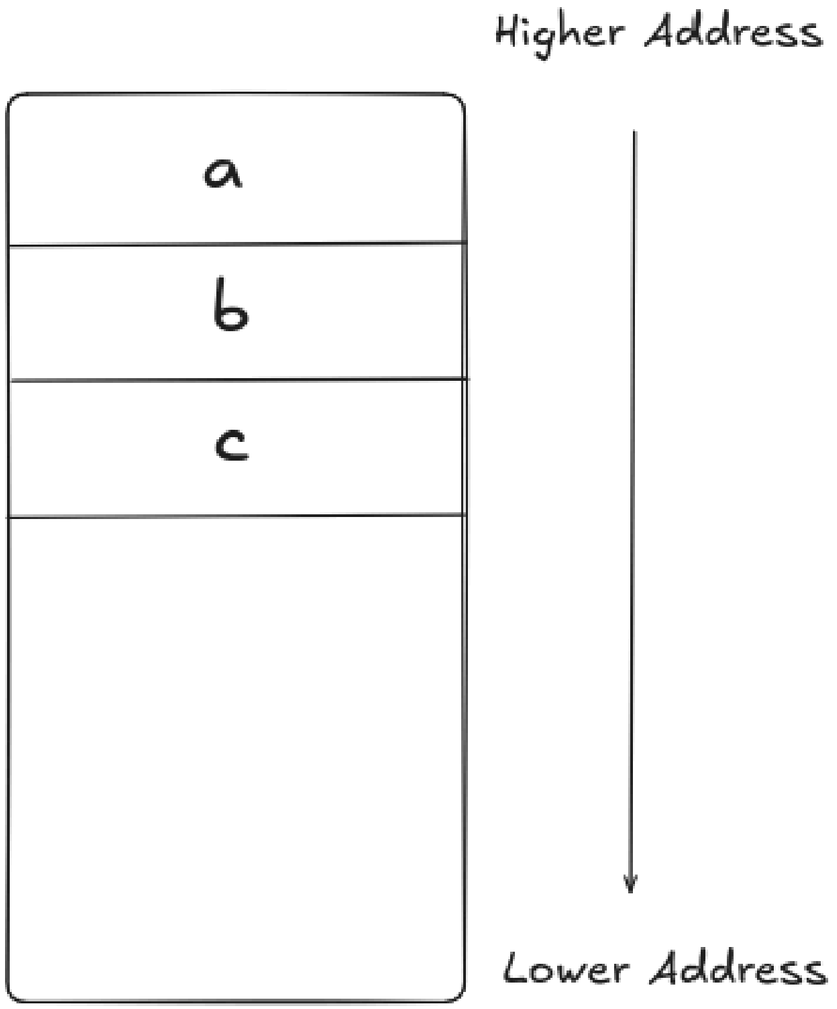

What is the Stack?

```
1   #include <stdio.h>
 1  void function2(){
 2          int d = 400;
 3          int e = 500;
 4          int f = 600;
 5
 6
 7          return;
 8  }
 9
10
11
12  void function1(){
13          int a = 10;
14          int b = 20;
15          int c = 30;
16
17          function2();
18          return;
19
20  }
```

What is the Stack?

```c
#include <stdio.h>
void function2(){
        int d = 400;
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        return;
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```

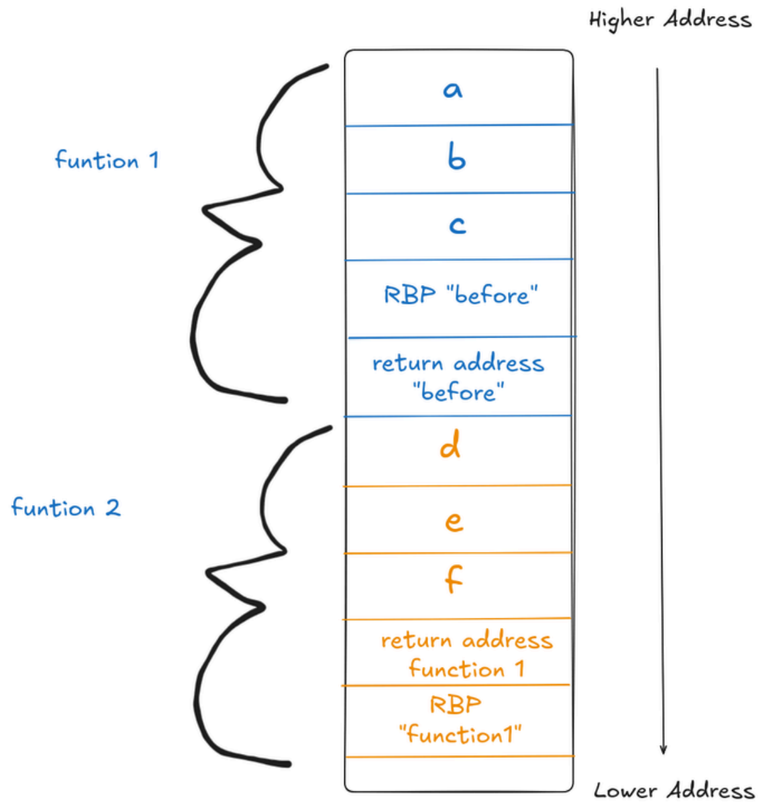

How does the program tracks the size?

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#include <stdio.h>
void function2(){
        int d = 400;
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        return;
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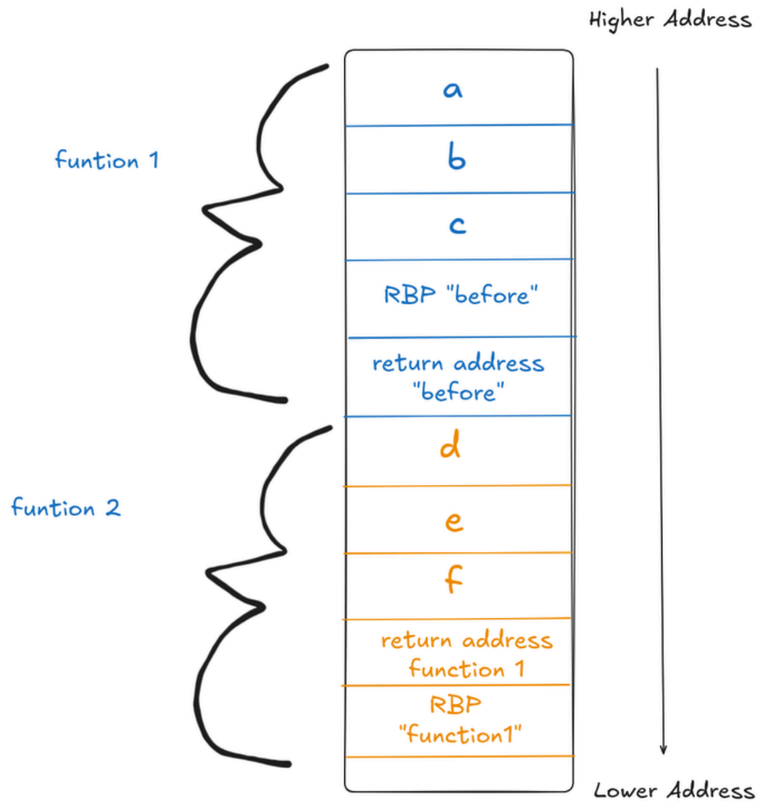

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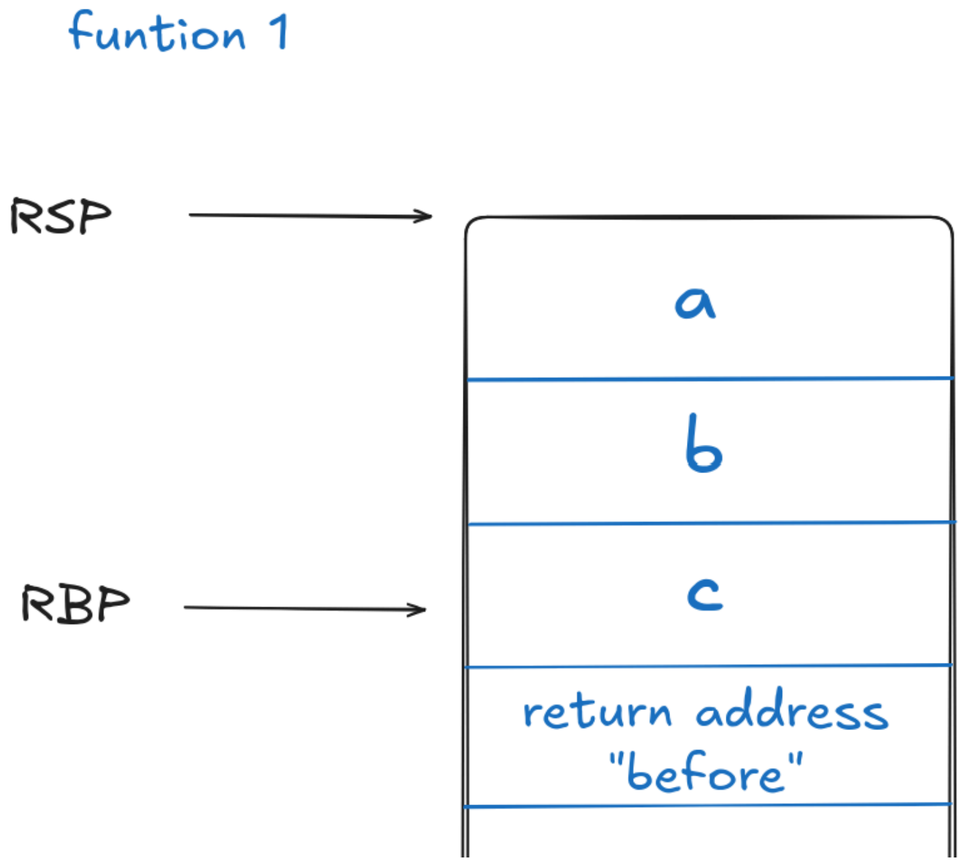

Function Calling

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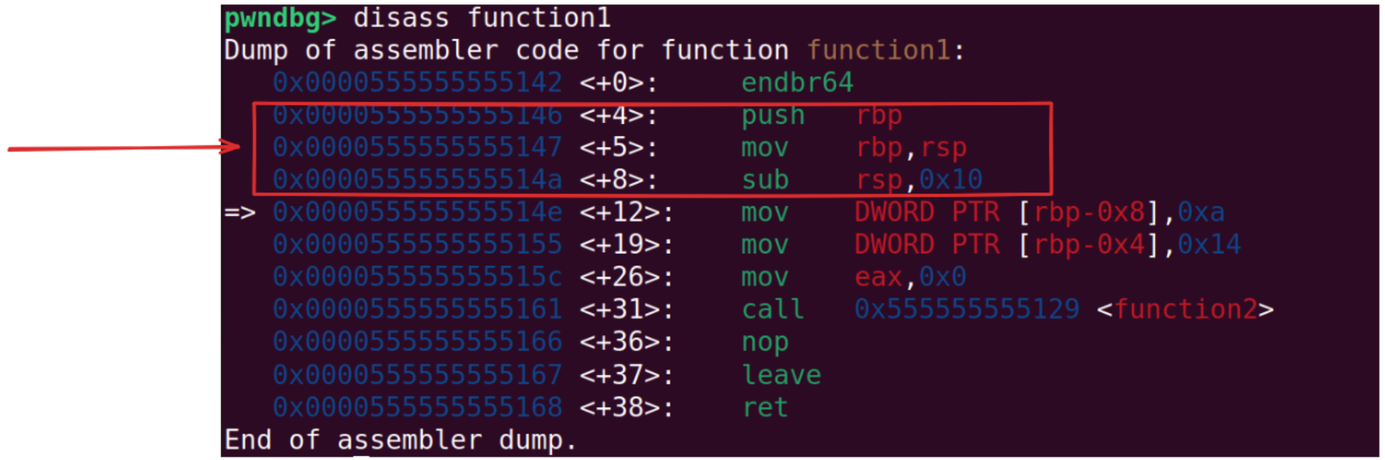
```

```
pwndbg> disass function1
Dump of assembler code for function function1:
   0x0000555555555142 <+0>:     endbr64
   0x0000555555555146 <+4>:     push   rbp
   0x0000555555555147 <+5>:     mov    rbp,rsp
   0x000055555555514a <+8>:     sub    rsp,0x10
=> 0x000055555555514e <+12>:    mov    DWORD PTR [rbp-0x8],0xa
   0x0000555555555155 <+19>:    mov    DWORD PTR [rbp-0x4],0x14
   0x000055555555515c <+26>:    mov    eax,0x0
   0x0000555555555161 <+31>:    call   0x555555555129 <function2>
   0x0000555555555166 <+36>:    nop
   0x0000555555555167 <+37>:    leave
   0x0000555555555168 <+38>:    ret
End of assembler dump.
```

Function Calling

STACK
Space
Allocation

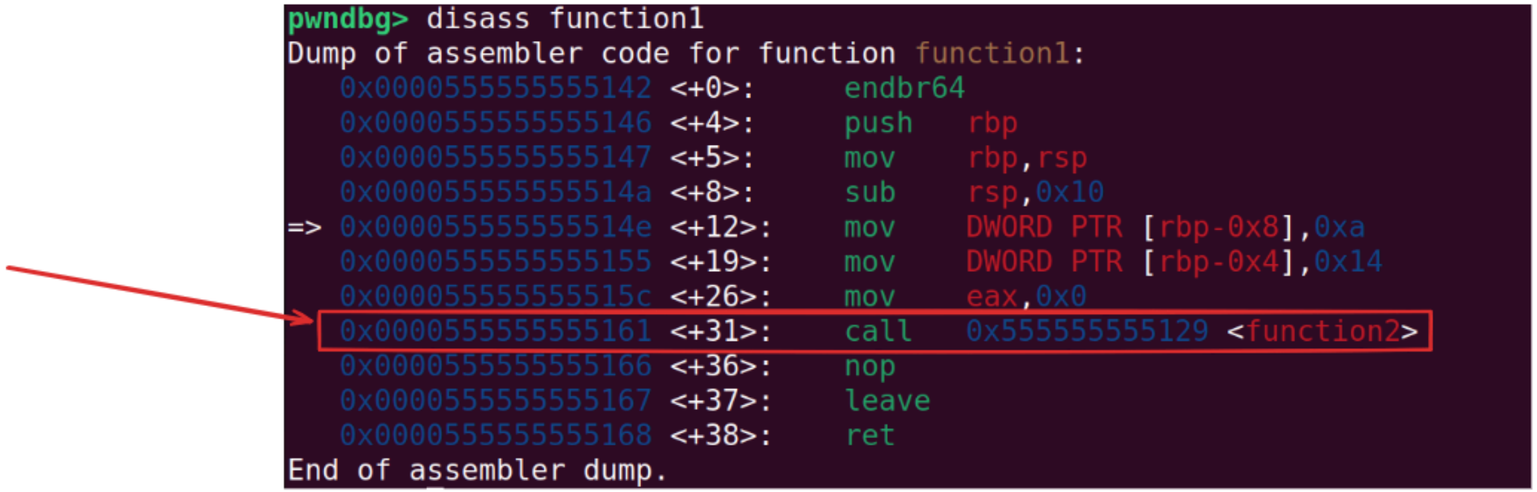


Function Calling

Local Variable

Function Calling

Calling function2



Function Exit?

Function Exit

exit function

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   0x0000555555555168 <+38>:    ret
End of assembler dump.
```

leave → mov rsp, rbp;
pop rbp;

QnA

No Question = Im a great teacher

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No Question = Understand Nothing

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Dont Worry, Just need a lot of homework

Buffer Overflow

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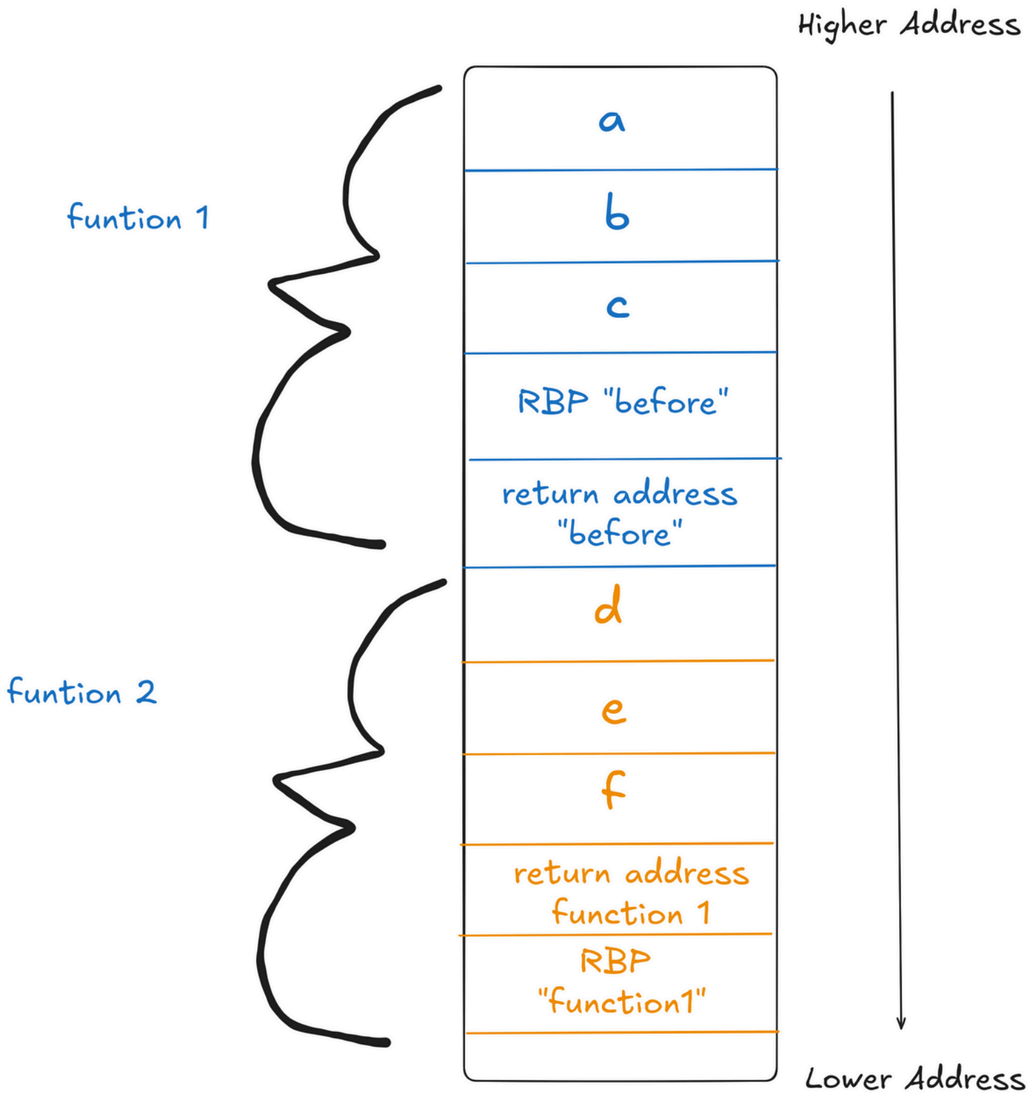

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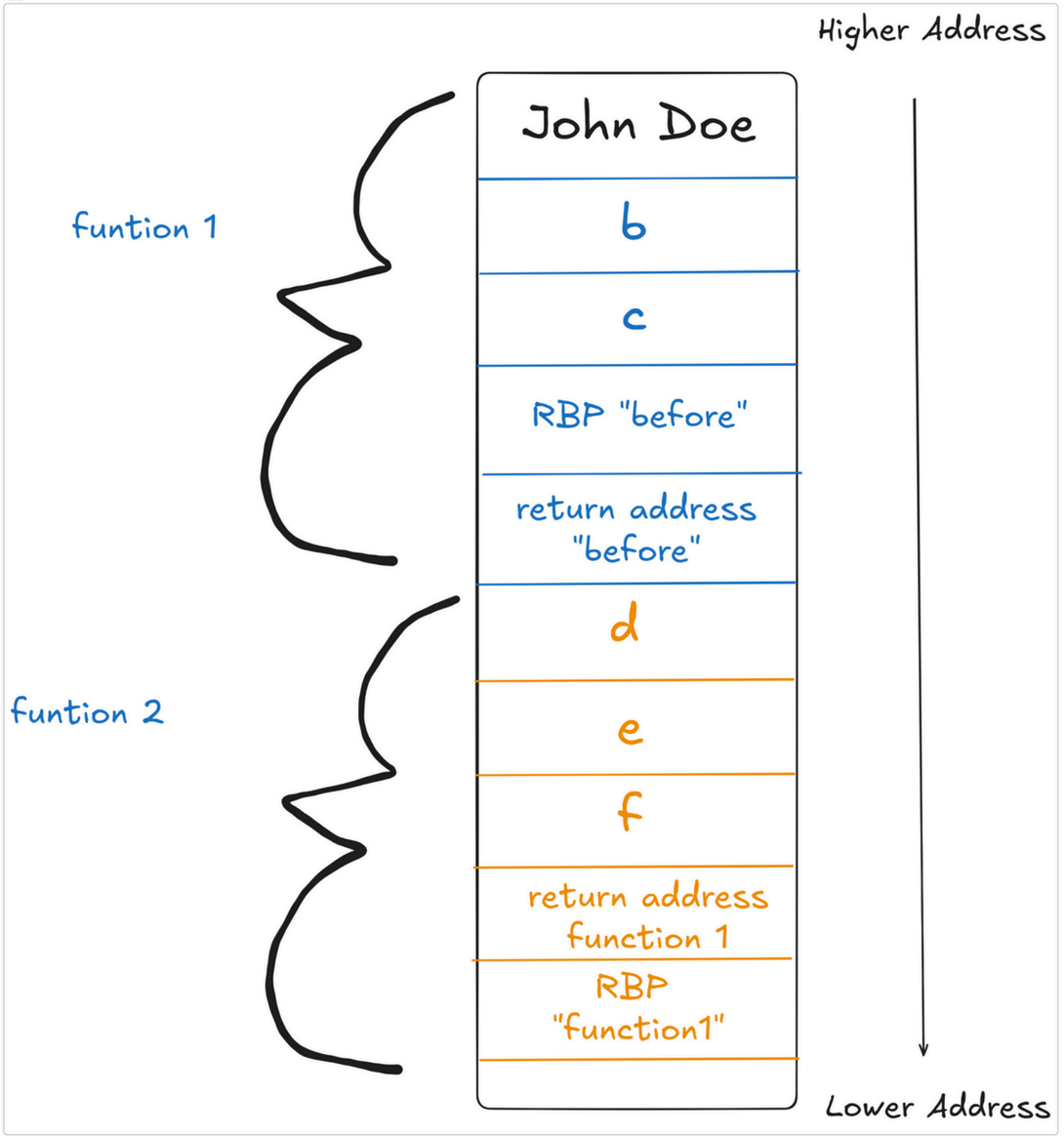

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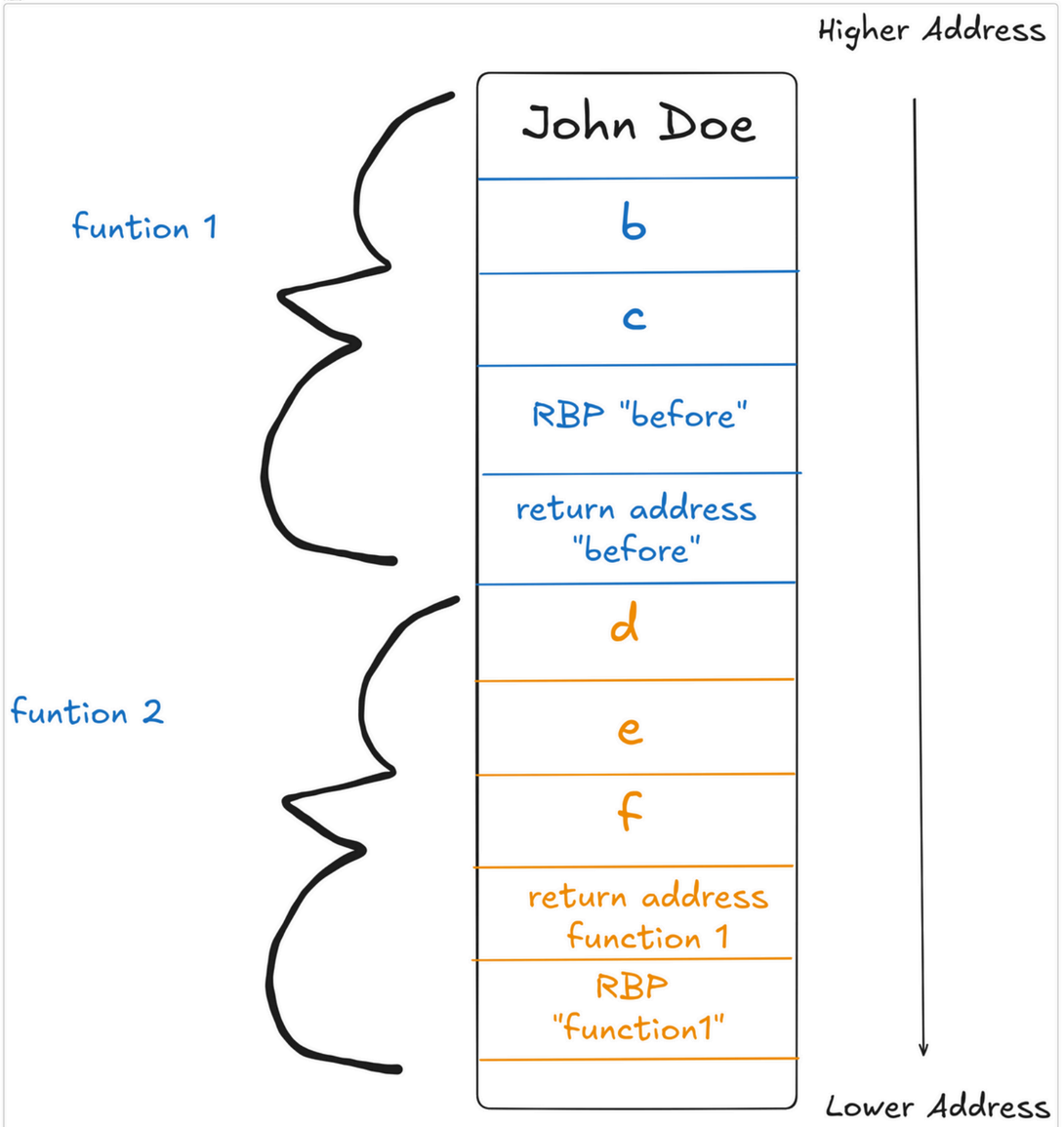

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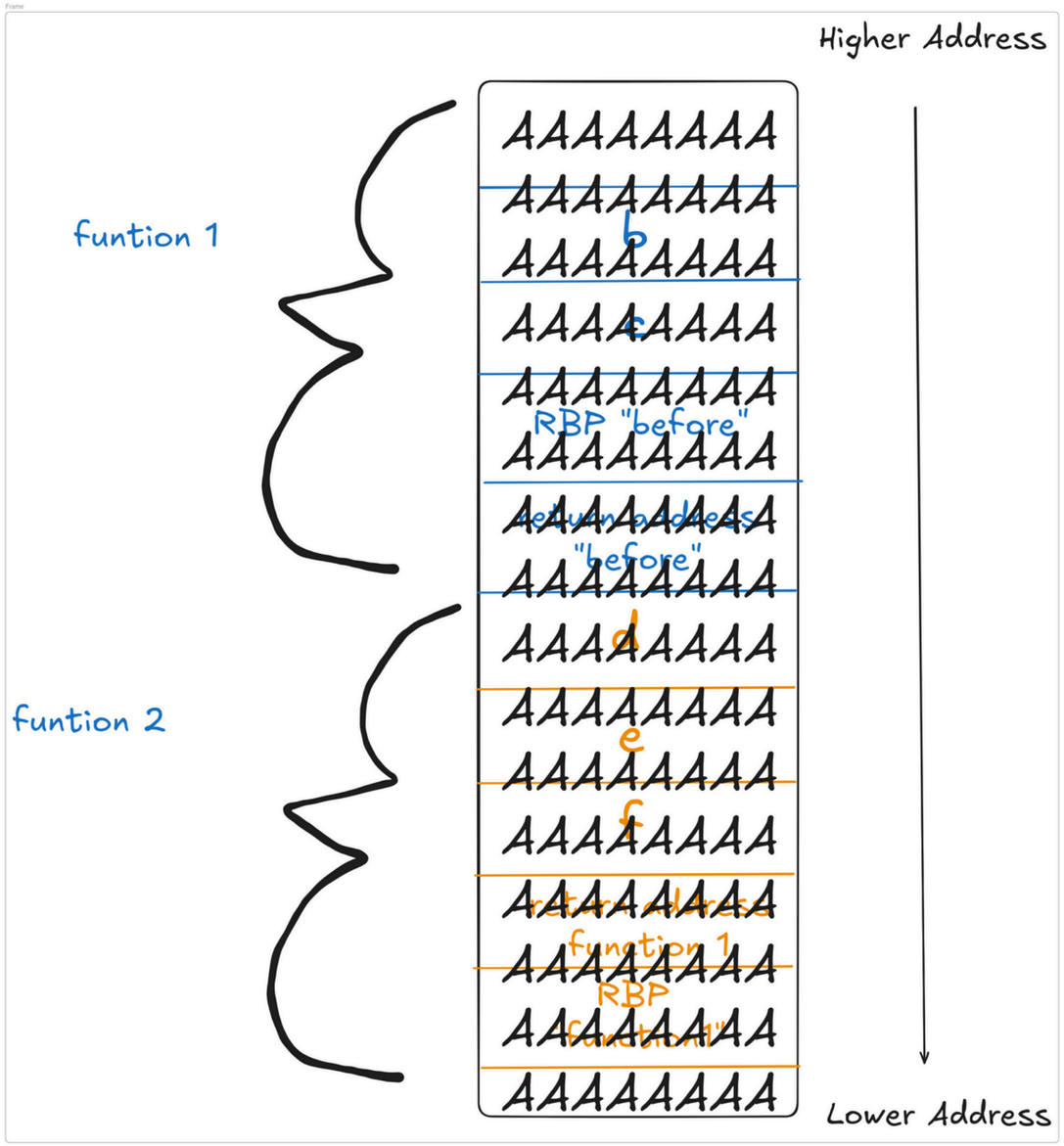

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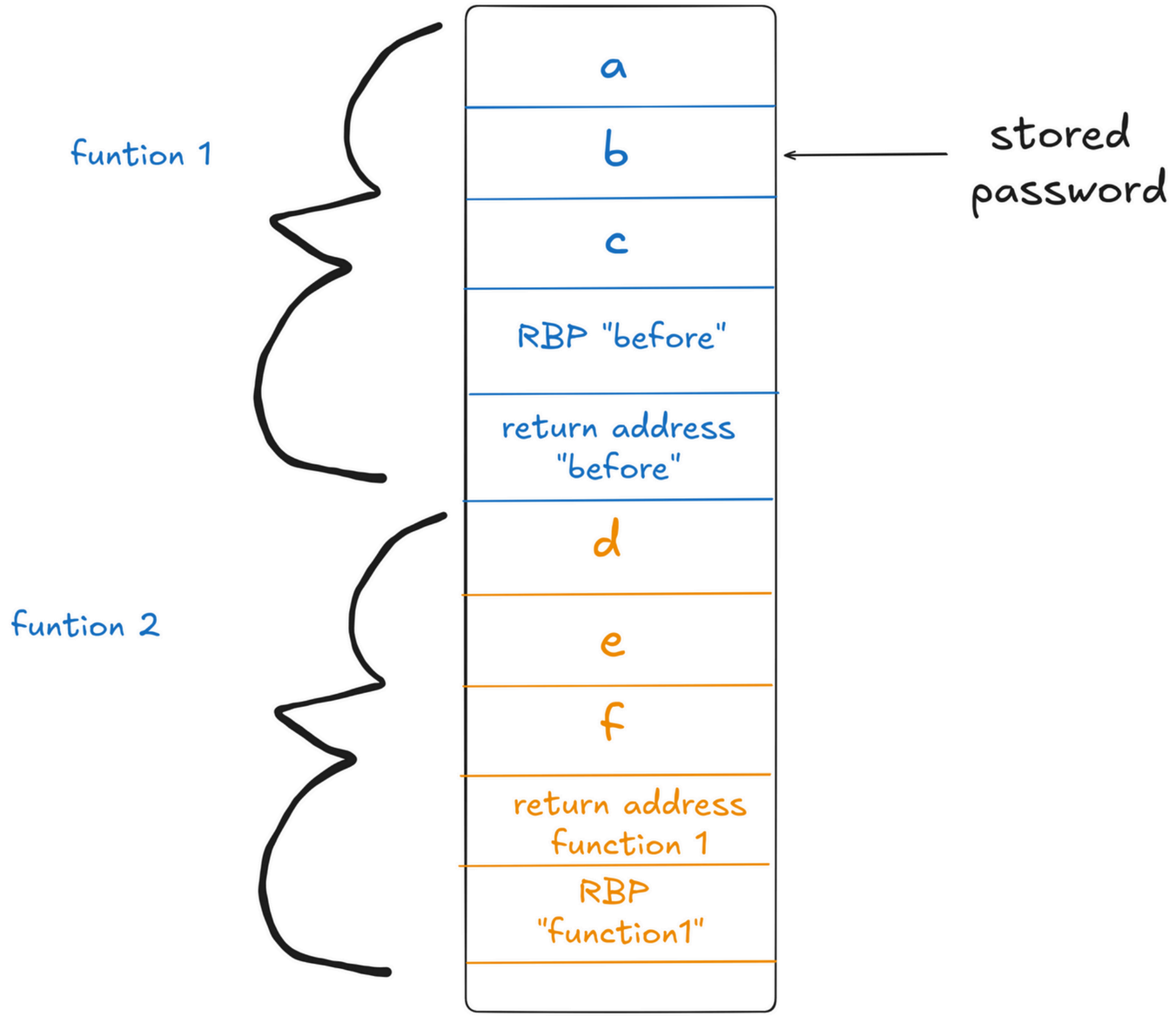

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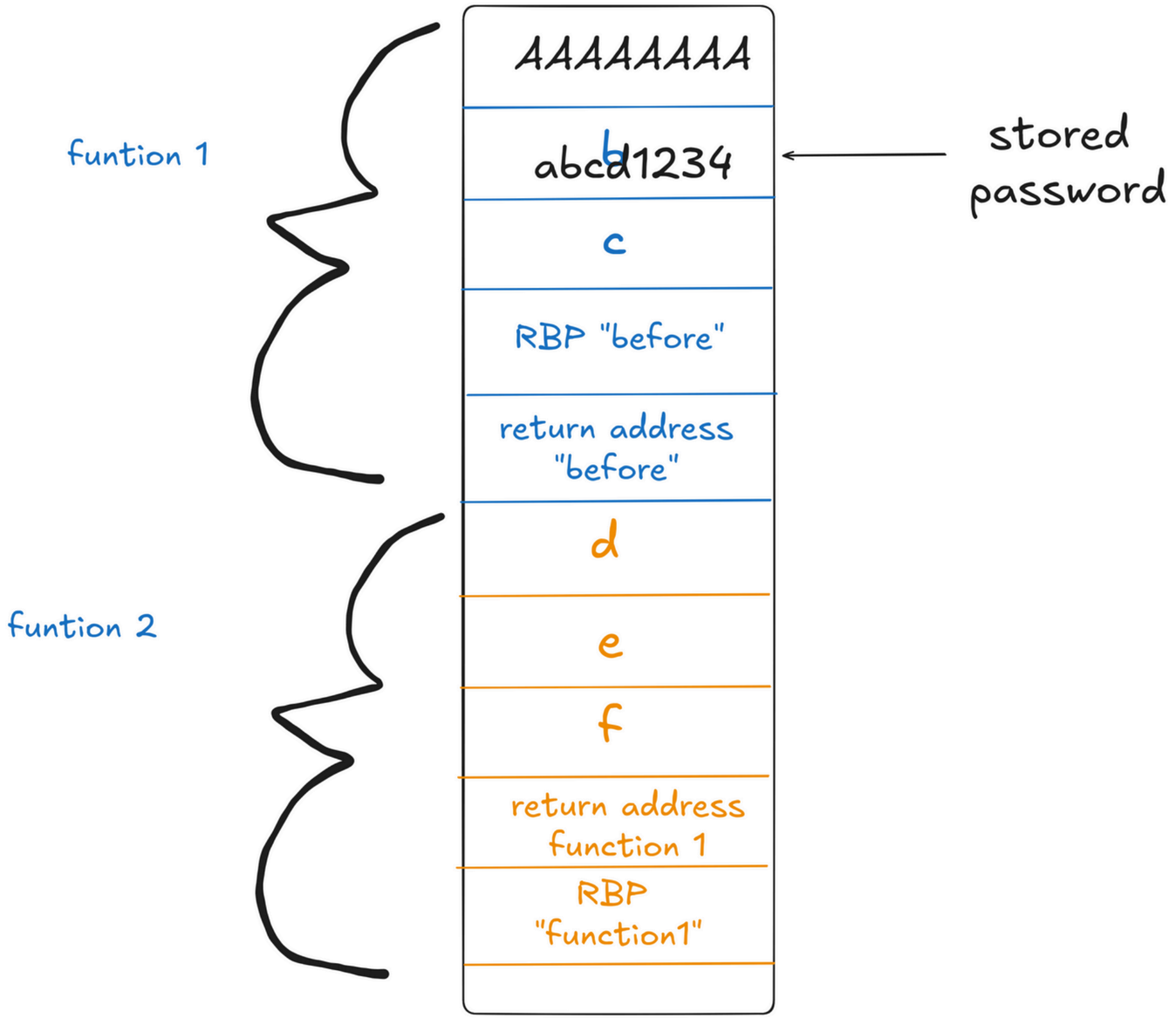

Return Oriented Programming

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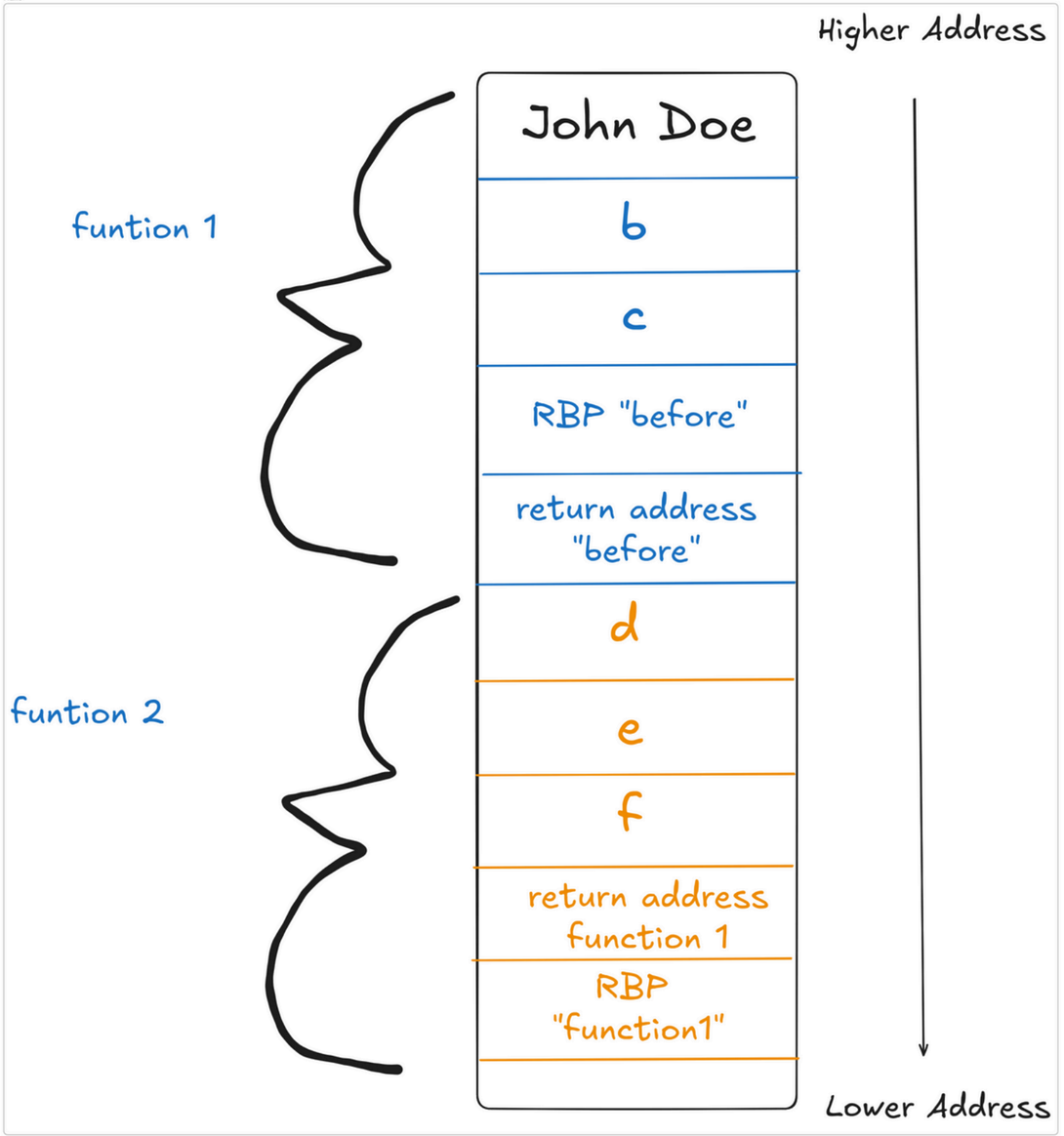

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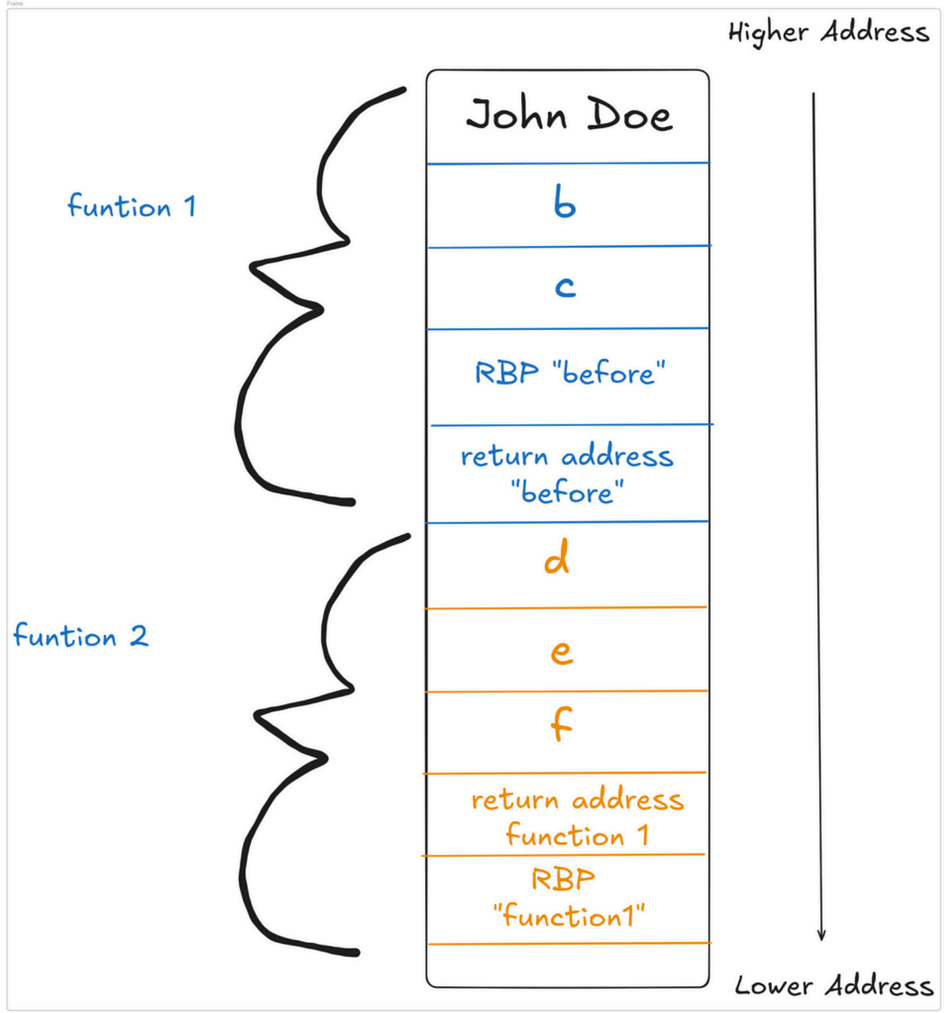

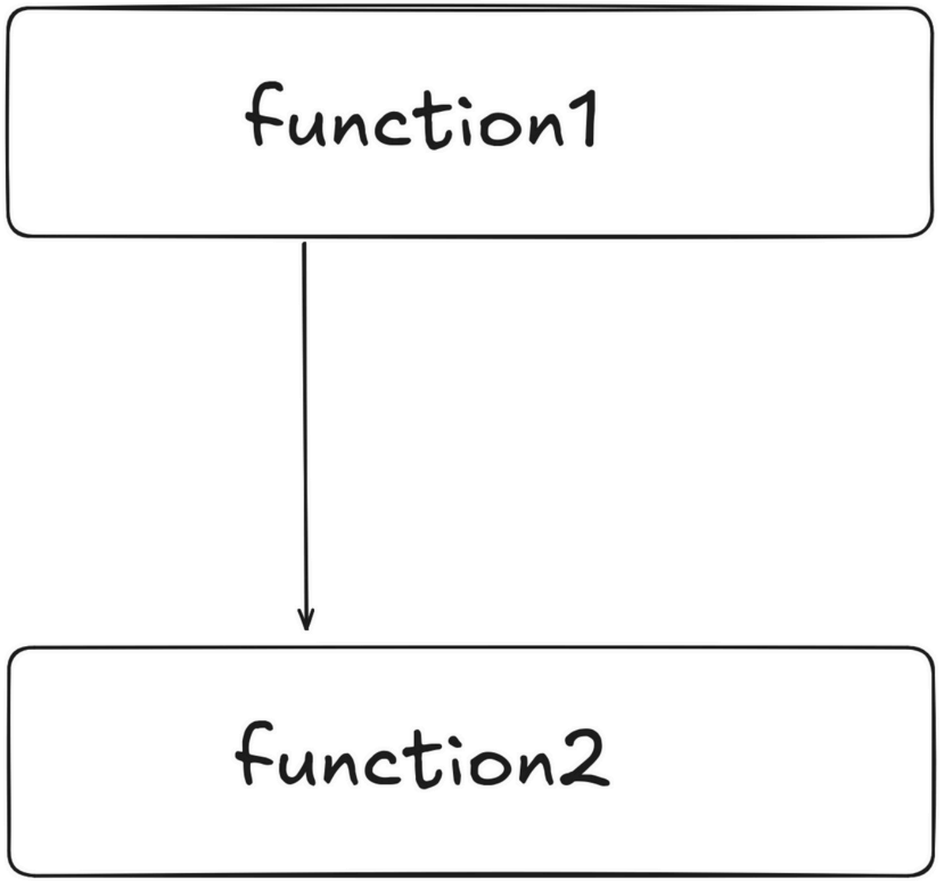

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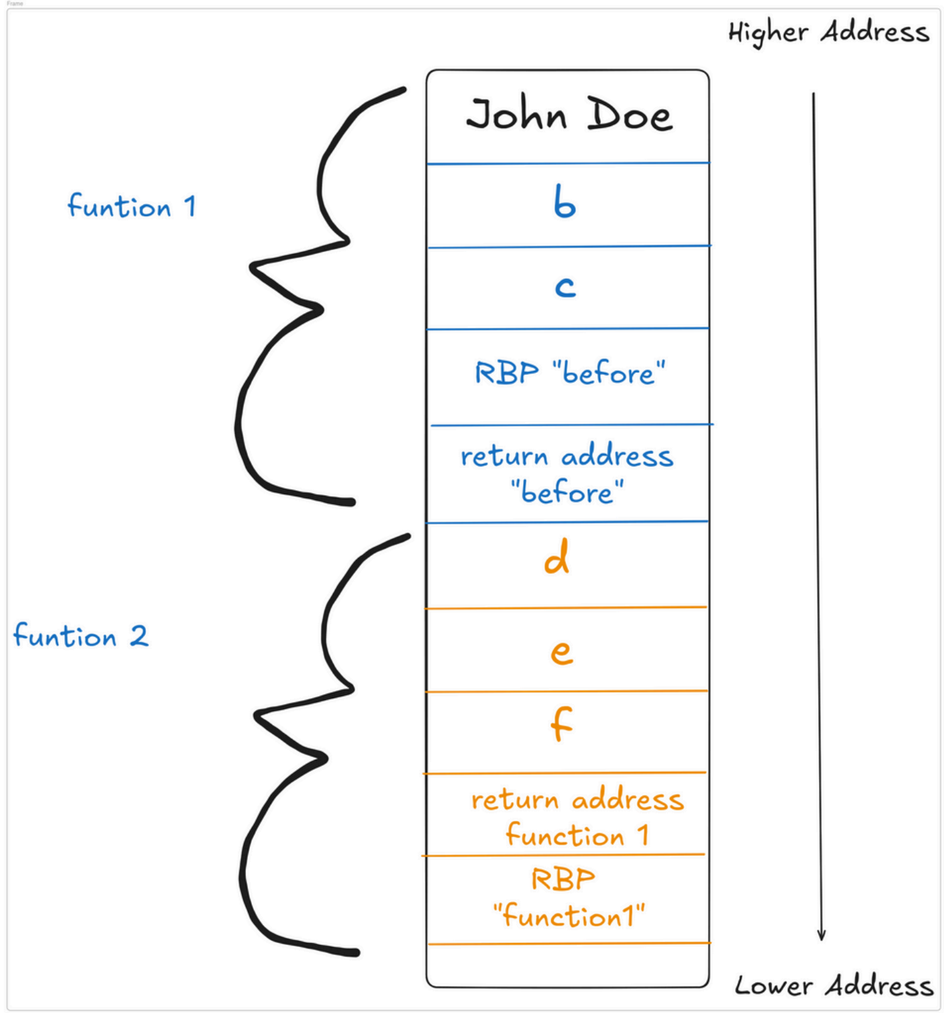

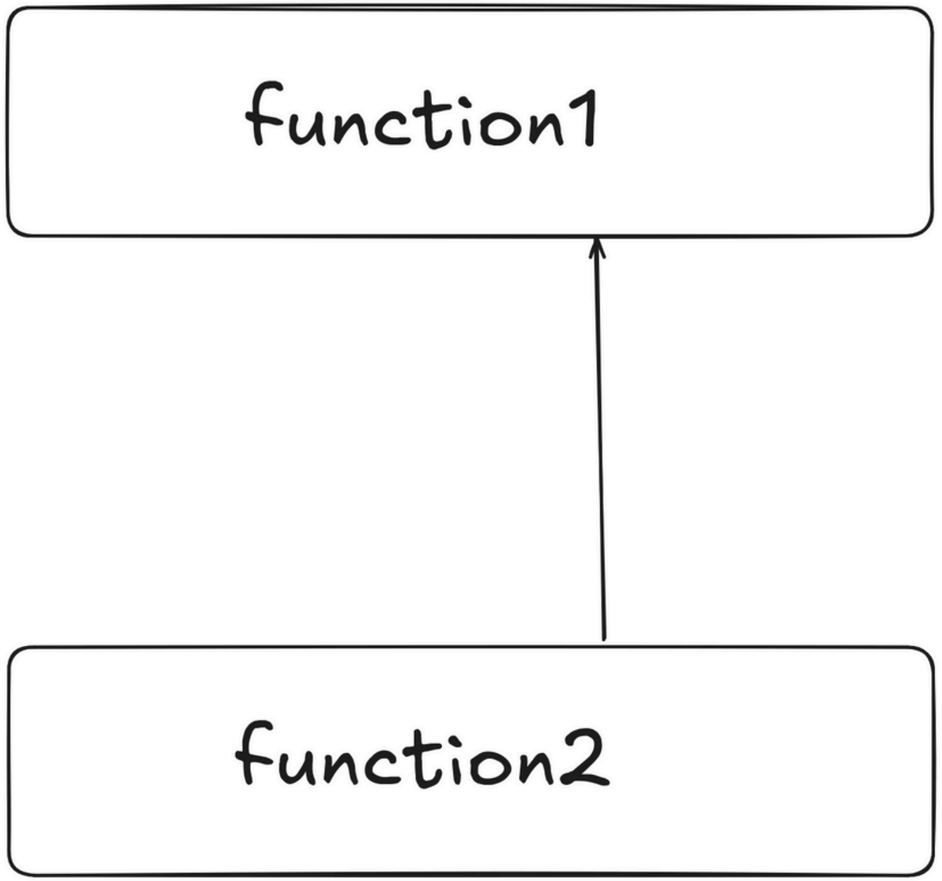

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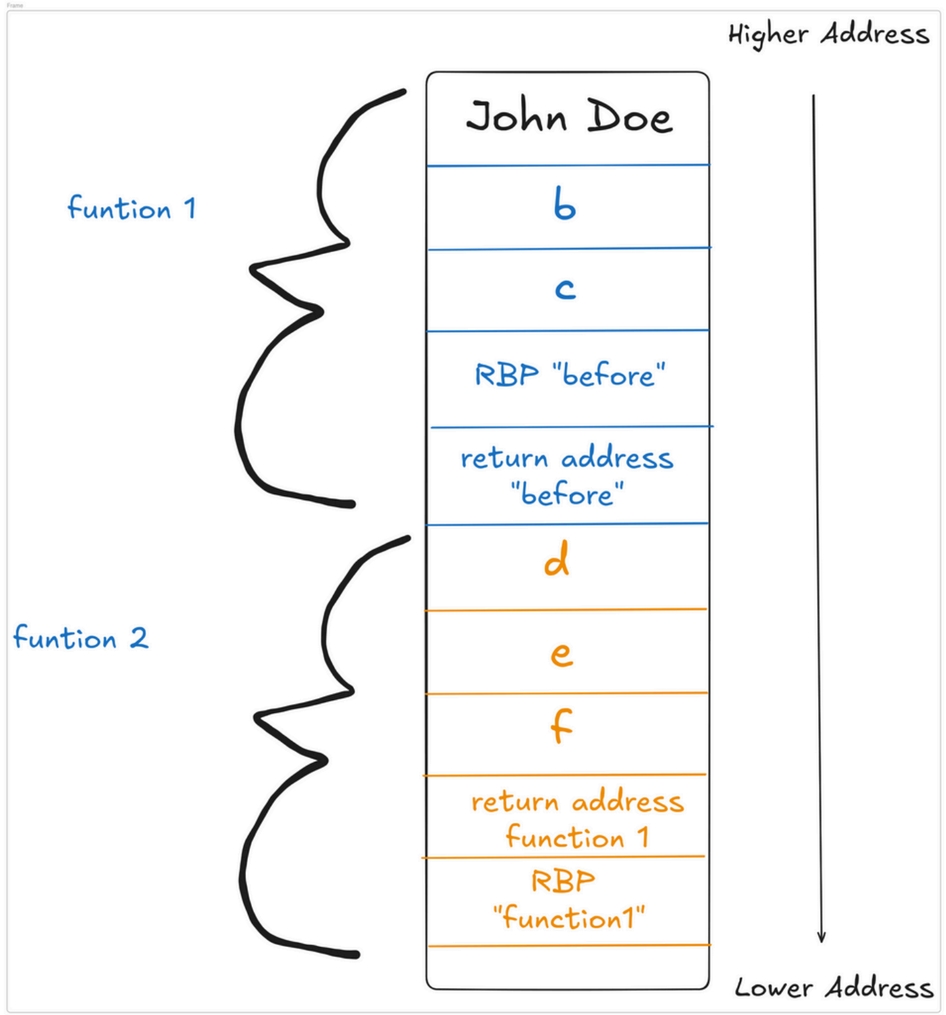

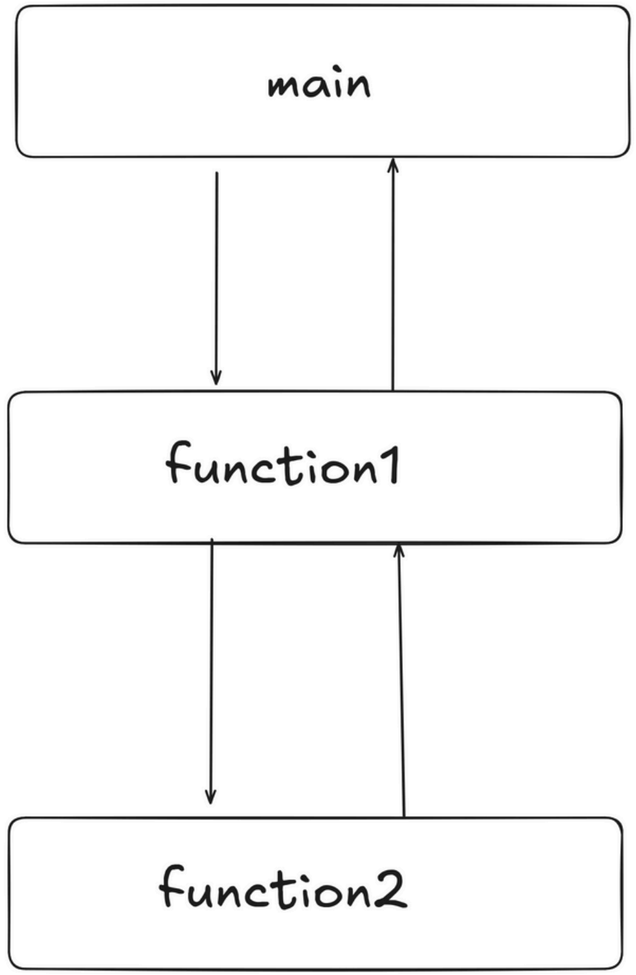

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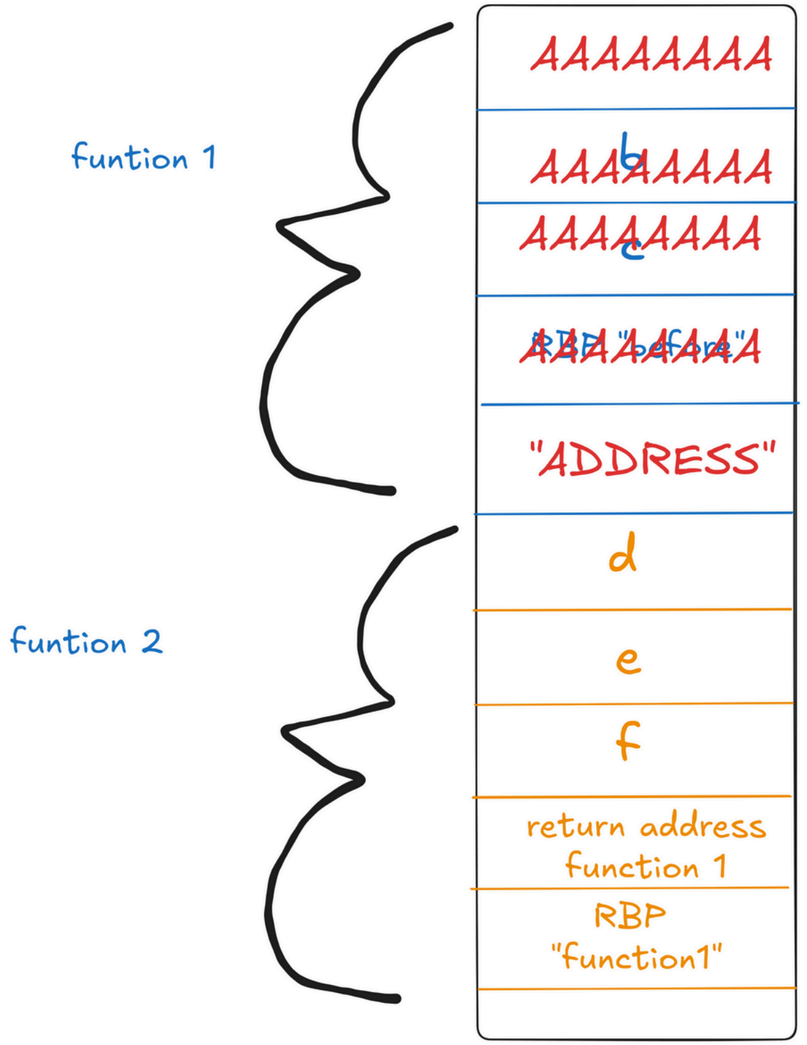
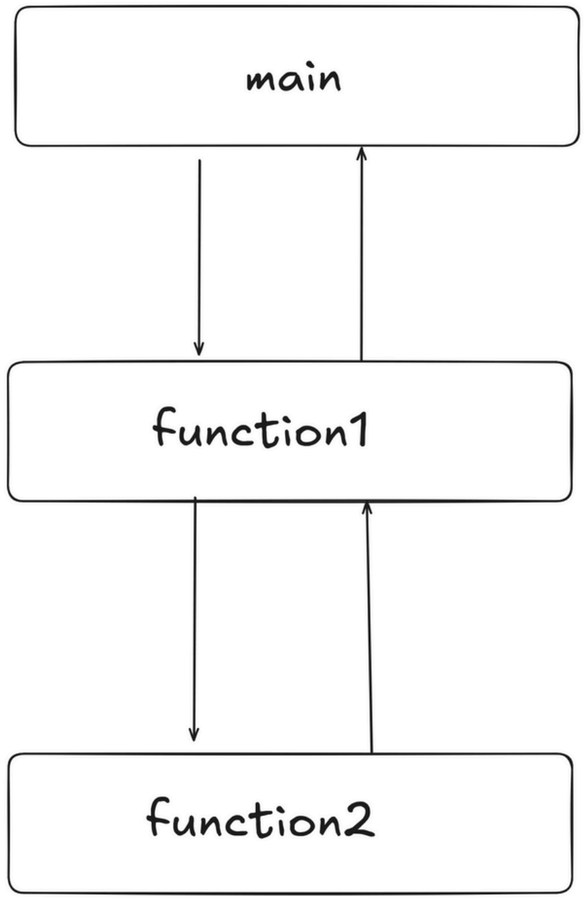
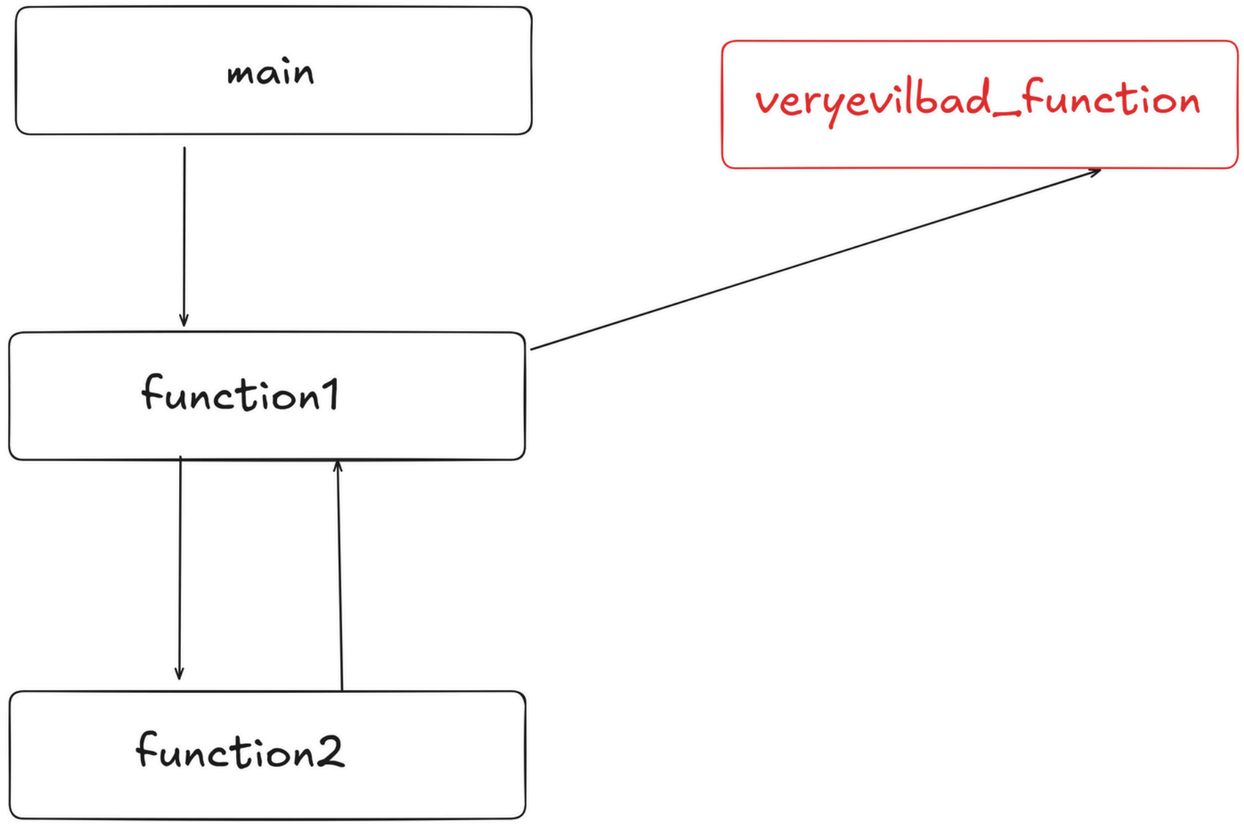
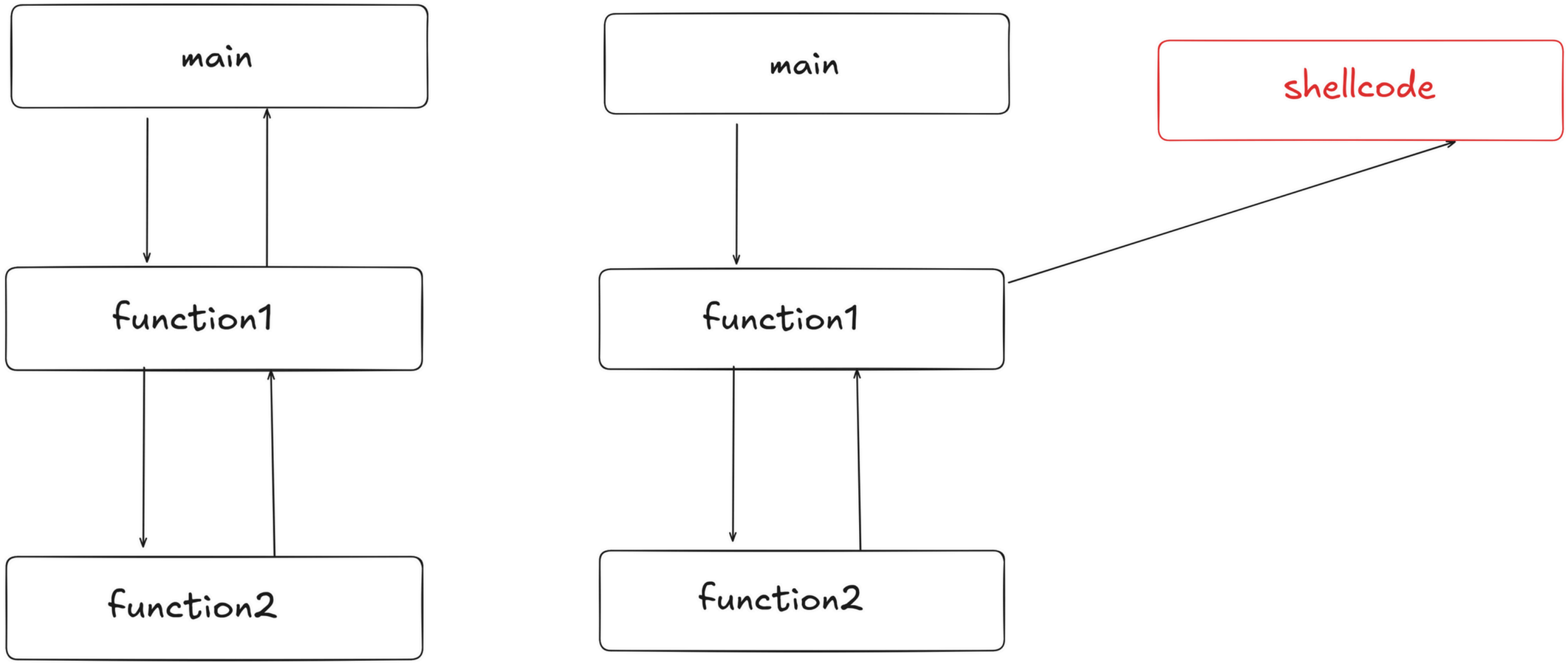


Return Oriented Programming





Return Oriented Programming



ROP Terminology

“gadgets”

A **gadget** is a **small sequence** of **machine instructions/asm code** that already exists somewhere in the binary, usually ending with a **“ret”**.

In exploitation, we weaponize these gadgets together to perform actions we want.

Can use **ROPgadget/objdump** to find these gadgets

```
0x00000000004011fd : pop rbp ; ret
0x0000000000401353 : pop rdi ; ret
0x0000000000401357 : pop rdx ; ret
0x0000000000401355 : pop rsi ; ret
0x0000000000401188 : push -0xffbfc0 ; loopne 0x4011f5 ; nop ; ret
0x000000000040134f : push rbp ; mov rbp, rsp ; pop rdi ; ret
0x000000000040101a : ret
0x0000000000401011 : sal byte ptr [rdx + rax - 1], 0xd0 ; add rsp, 8 ; ret
0x000000000040105b : sar edi, 0xff ; call qword ptr [rax - 0x5e1f00d]
0x0000000000401361 : sub esp, 8 ; add rsp, 8 ; ret
0x0000000000401360 : sub rsp, 8 ; add rsp, 8 ; ret
0x0000000000401010 : test eax, eax ; je 0x401016 ; call rax
0x0000000000401183 : test eax, eax ; je 0x401190 ; mov edi, 0x404068 ; jmp rax
0x00000000004011c5 : test eax, eax ; je 0x4011d0 ; mov edi, 0x404068 ; jmp rax
0x000000000040100f : test rax, rax ; je 0x401016 ; call rax
```

ROP Terminology

“gadgets”

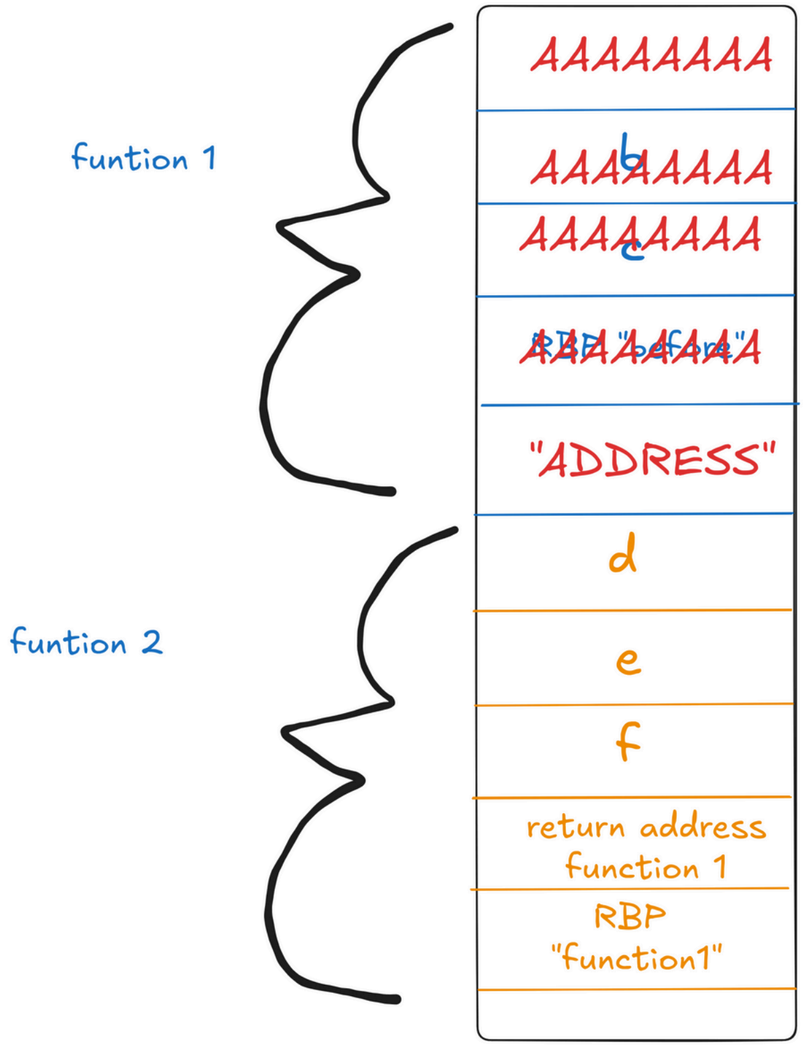
A **gadget** is a **small sequen** lready exists somewhere in the binary, usually ending

In exploitation, we weap s we want.

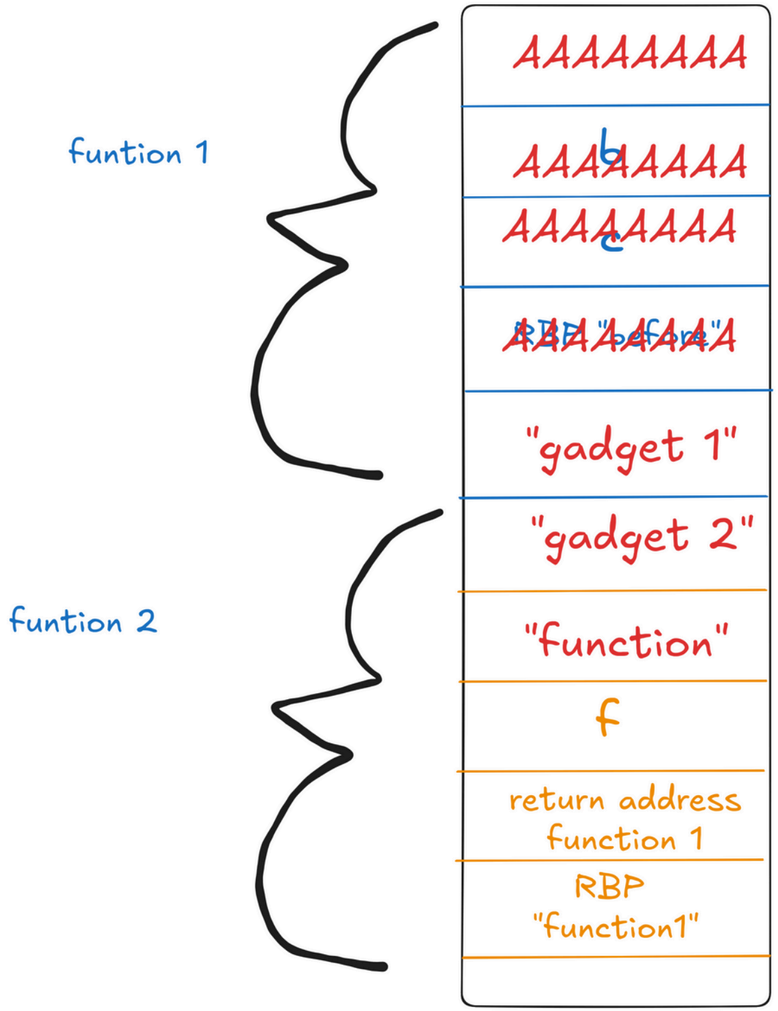
Can use **ROPgadget/objdump** to find these gadgets

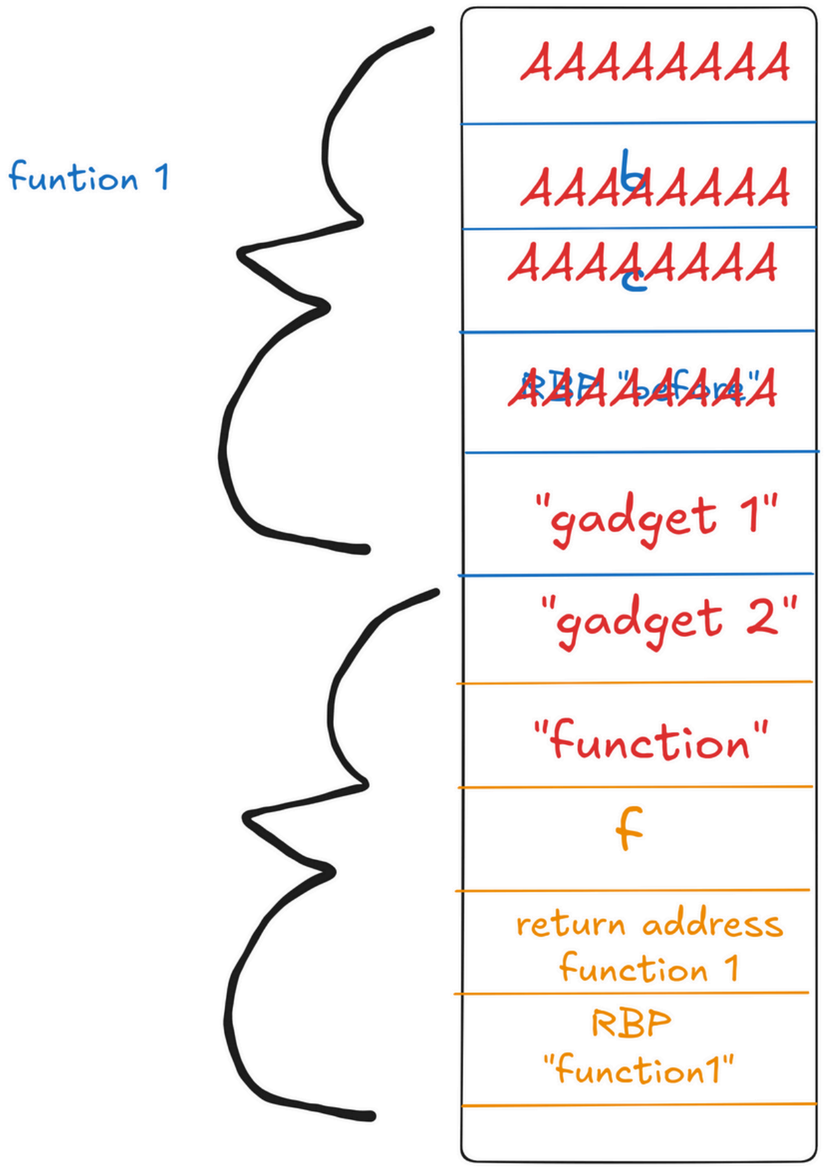
```
                                                    loopne 0x4011f5 ; nop ; ret
                                                    rbp, rsp ; pop rdi ; ret

                                                    [rdx + rax - 1], 0xd0 ; add rsp, 8 ; ret
                                                    0xff ; call qword ptr [rax - 0x5e1f00d]
                                                    p, 8 ; add rsp, 8 ; ret
                                                    b rsp, 8 ; add rsp, 8 ; ret
                    0000401010 : test eax, eax ; je 0x401016 ; call rax
                    0000401183 : test eax, eax ; je 0x401190 ; mov edi, 0x404068 ; jmp rax
0x00000000004011c5 : test eax, eax ; je 0x4011d0 ; mov edi, 0x404068 ; jmp rax
0x000000000040100f : test rax, rax ; je 0x401016 ; call rax
```

Return Oriented Programming



Return Oriented Programming





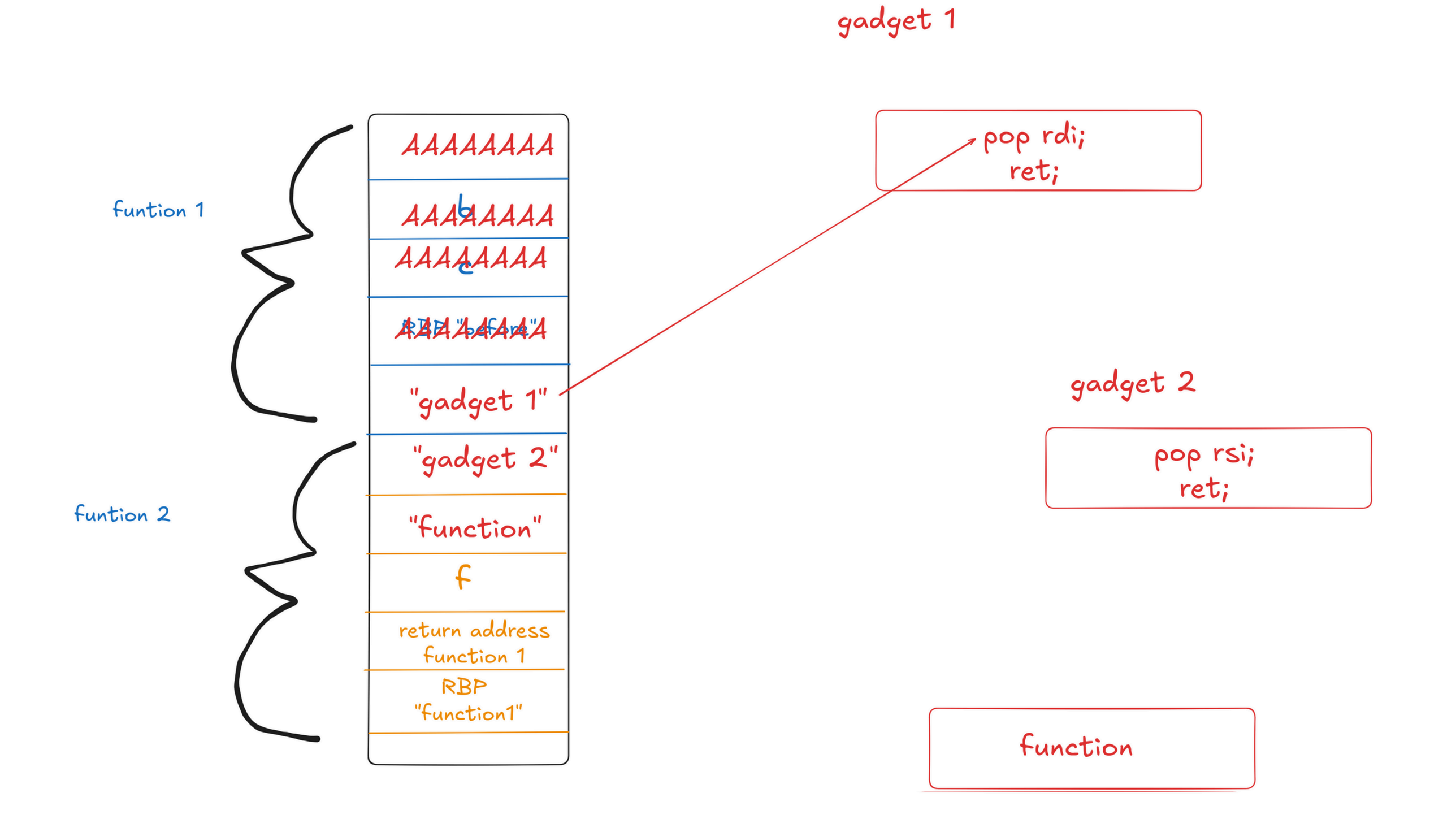
gadget 1

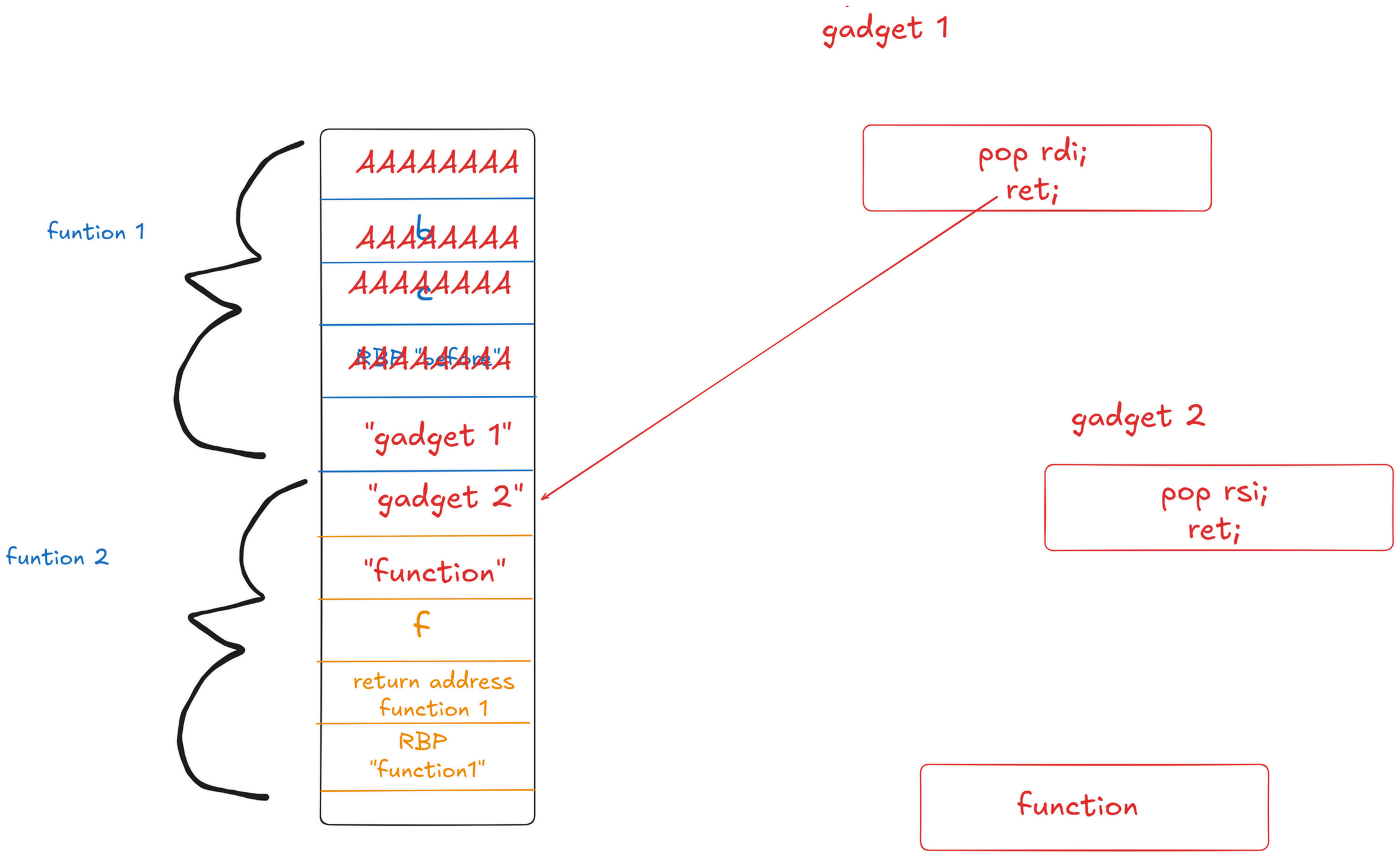
pop rdi;
ret;

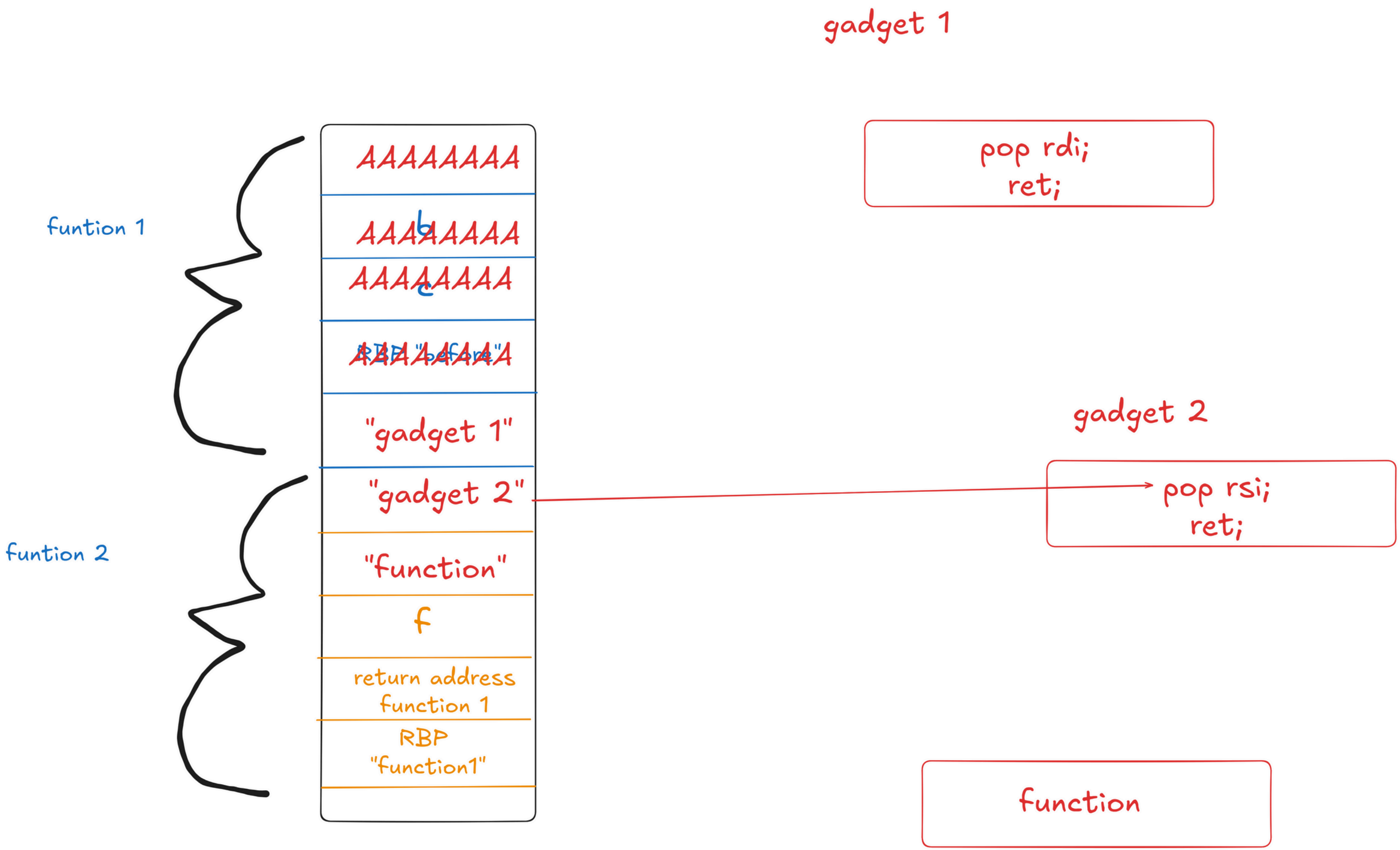
gadget 2

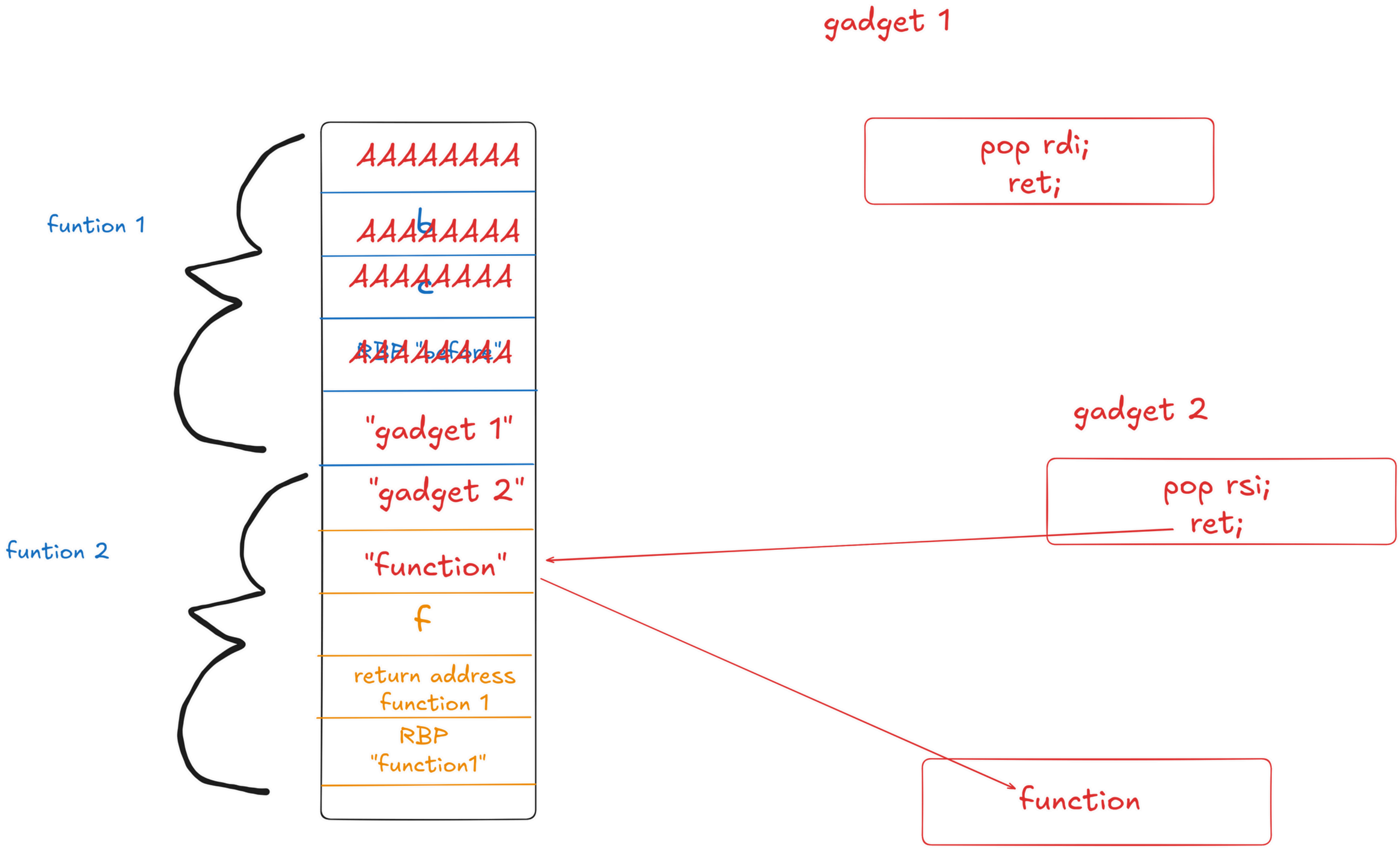
pop rsi;
ret;

function


gadget 1
funtion 1
AAAAAAAA
AAAAAAAA
AAAAAAAA
AAAAAAAA
"gadget 1"
"gadget 2"
"function"
f
return address
function 1
RBP
"function1"
pop rdi;
ret;
gadget 2
pop rsi;
ret;
funtion 2
function


gadget 1
funtion 1
AAAAAAAA
AAAAAAAA
AAAAAAAA
AAAAAAAA
"gadget 1"
"gadget 2"
"function"
f
return address
function 1
RBP
"function1"
pop rdi;
ret;
gadget 2
pop rsi;
ret;
funtion 2
function


gadget 1
pop rdi;
ret;
funtion 1
AAAAAAAA
AAAAAAAA
AAAAAAAA
AAAAAAAA
"gadget 1"
"gadget 2"
gadget 2
pop rsi;
ret;
funtion 2
"function"
f
return address
function 1
RBP
"function1"
function


gadget 1
pop rdi;
ret;
funtion 1
AAAAAAAA
AAAAAAAA
AAAAAAAA
AAAAAAAA
"gadget 1"
"gadget 2"
gadget 2
pop rsi;
ret;
funtion 2
"function"
f
return address
function 1
RBP
"function1"
function

Hands On

QnA

Challenge !!!!

Challenge Walkthrough

THANK YOU

Acknowledgement:

RE:HACK, cyber673, Yappare, Jia Yang ... etc