Linux Binary Exploitation

Return-oriented Programing

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Outline

- ROP
- Using ROP bypass ASLR
- Stack migration

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- Stack migration

ROP

- 透過 ret 去執行其他包含 ret 的程式碼片段
- 這些片段又稱為 gadget

```
4027ba:    5b                      pop    rbx
4027bb:    5d                      pop    rbp
4027bc:    41 5c                   pop    r12
4027be:    41 5d                   pop    r13
4027c0:    41 5e                   pop    r14
4027c2:    41 5f                   pop    r15
4027c4:    c3                      ret
```

```
40274c:    48 81 c7 00 06 00 00    add    rdi,0x600
402753:    48 89 f8                mov    rax,rdi
402756:    c3                      ret
```

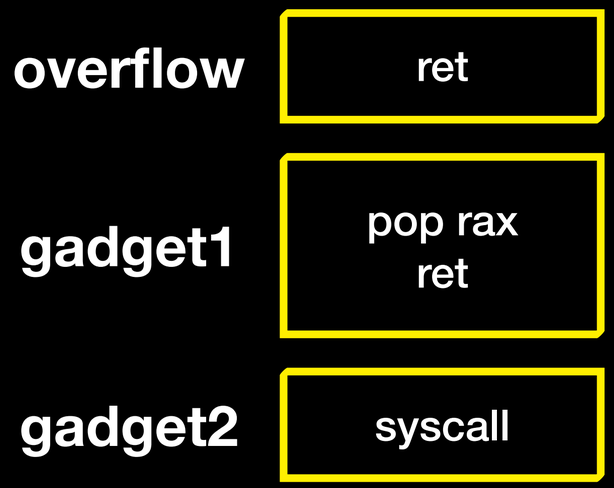
```
4026c5:    5a                      pop    rdx
4026c6:    58                      pop    rax
4026c7:    48 83 c4 08             add    rsp,0x8
4026cb:    5d                      pop    rbp
4026cc:    c3                      ret
```

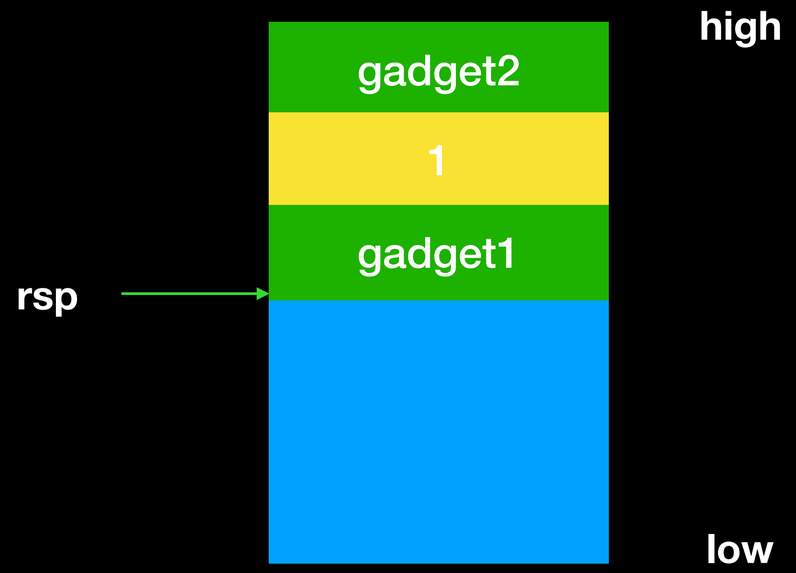
ROP

- Why do we need ROP ?
  - Bypass DEP
  - Static linking can do more thing

ROP

- ROP chain
  - 在夠長的 buffer overflow 後 stack 內容幾乎都由我們控制，我們可以藉由 ret = pop rip 指令，持續的控制 rip





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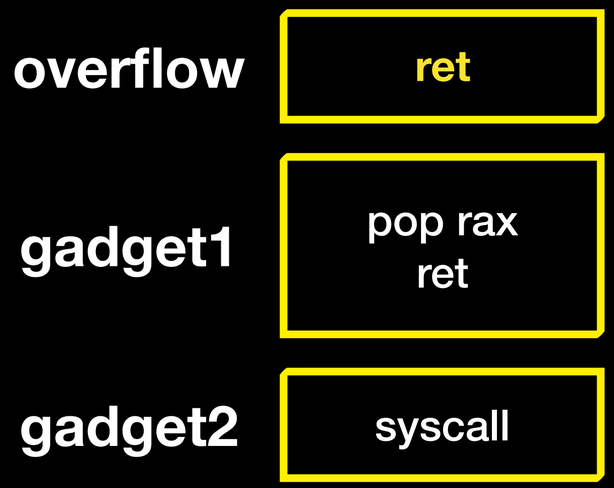

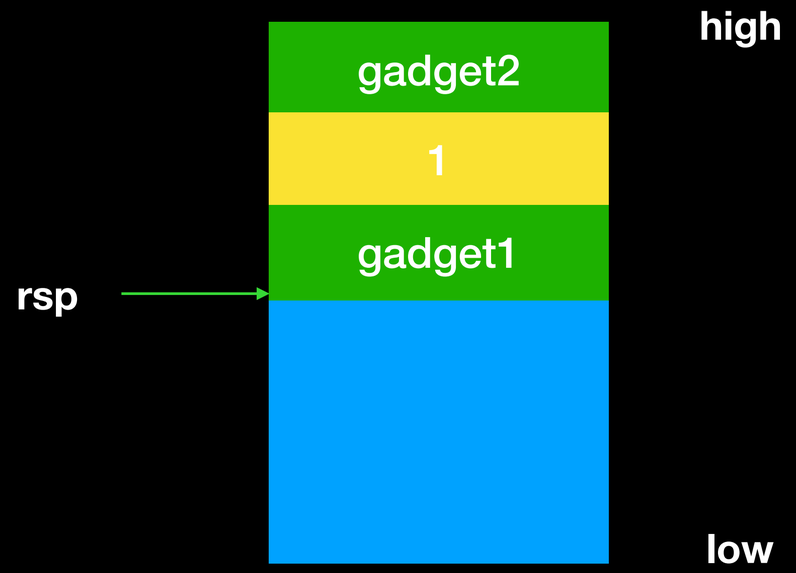

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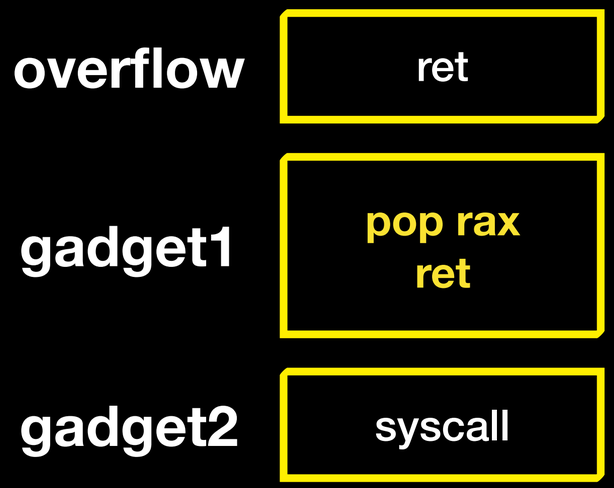

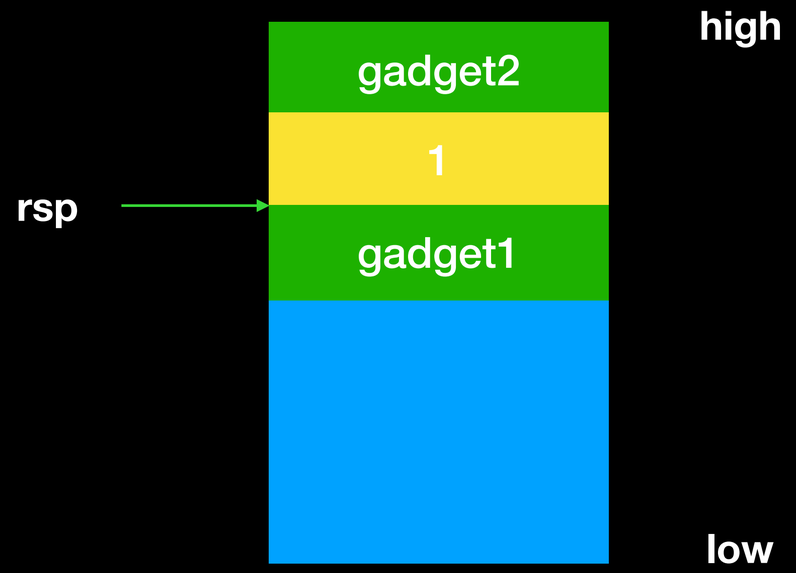

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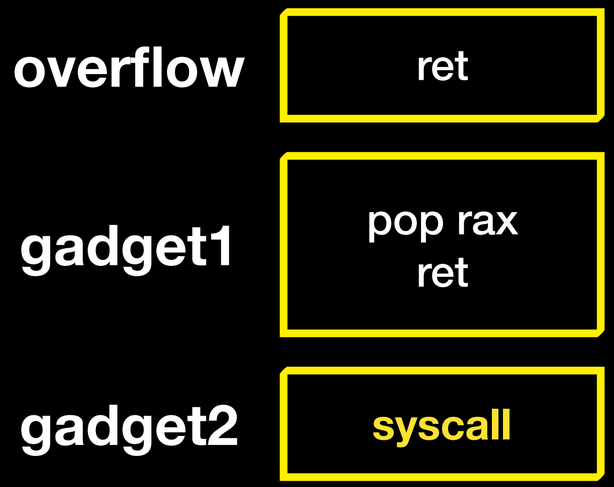

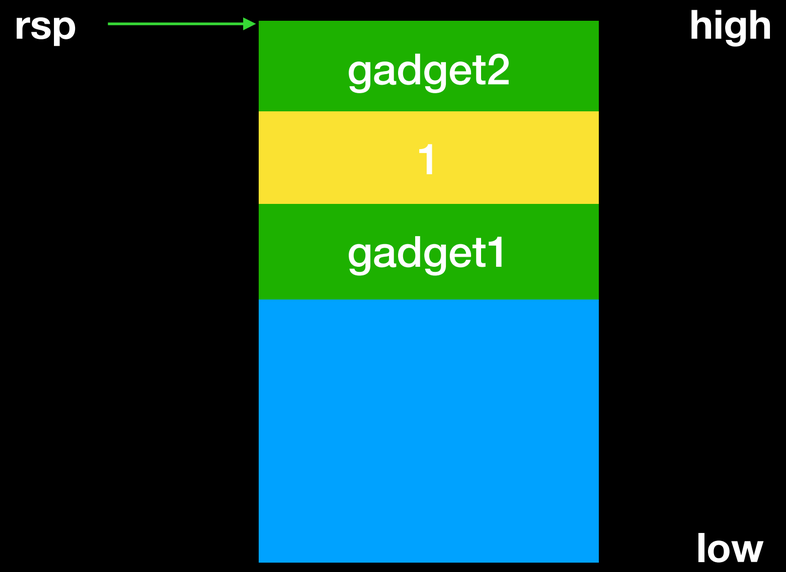

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ROP

- ROP chain
  - 由眾多的 ROP gadget 組成
  - 藉由不同的 register 及記憶體操作，呼叫 system call 達成任意代碼執行
  - 基本上就是利用 ROP gadget 來串出我們之前寫的 shellcode 的效果

ROP

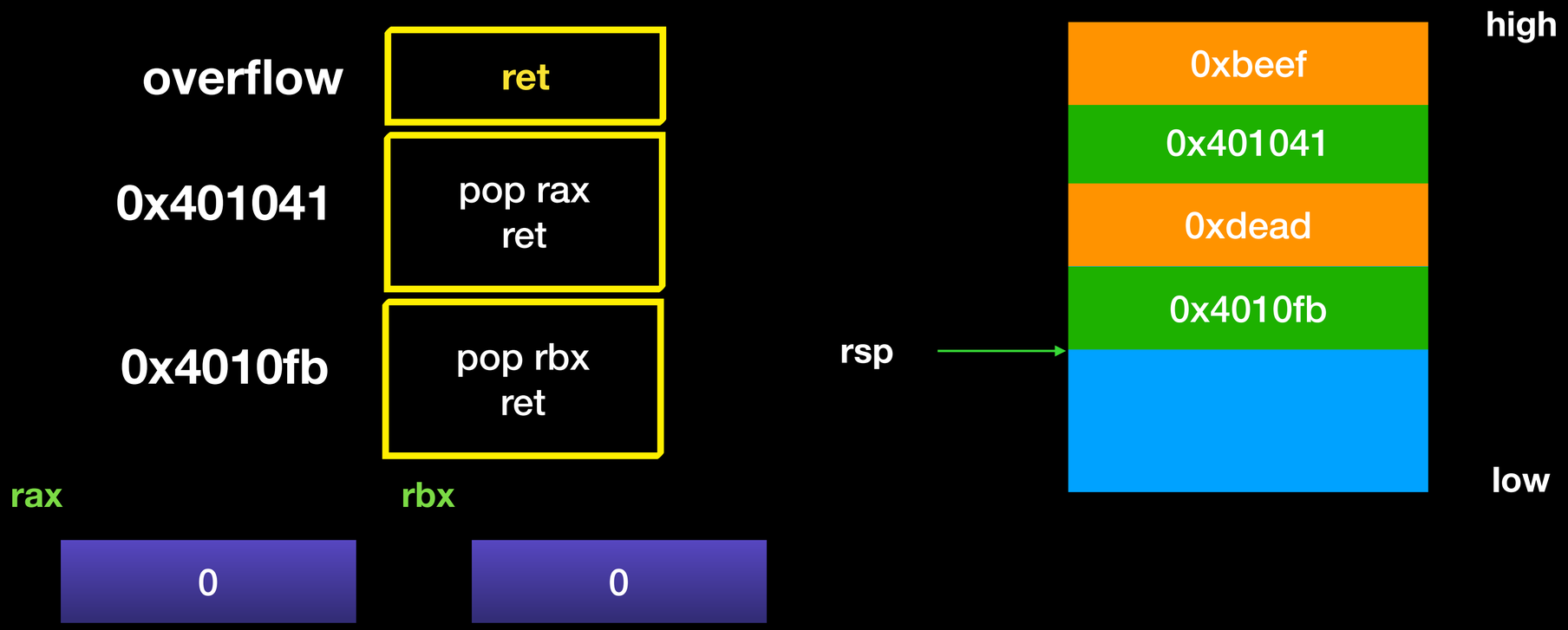
- Gadget
  - read/write register/memory
    - pop rax;pop rcx ; ret
    - mov [rax],rcx ; ret
  - system call
    - syscall
  - change rsp
    - pop rsp ; ret
    - leave ; ret

ROP

- Write to Register
  - pop reg ; ret
  - mov reg, reg ; ret
  - …

ROP

- Write to Register
  - let rax = 0xdead rbx = 0xbeef



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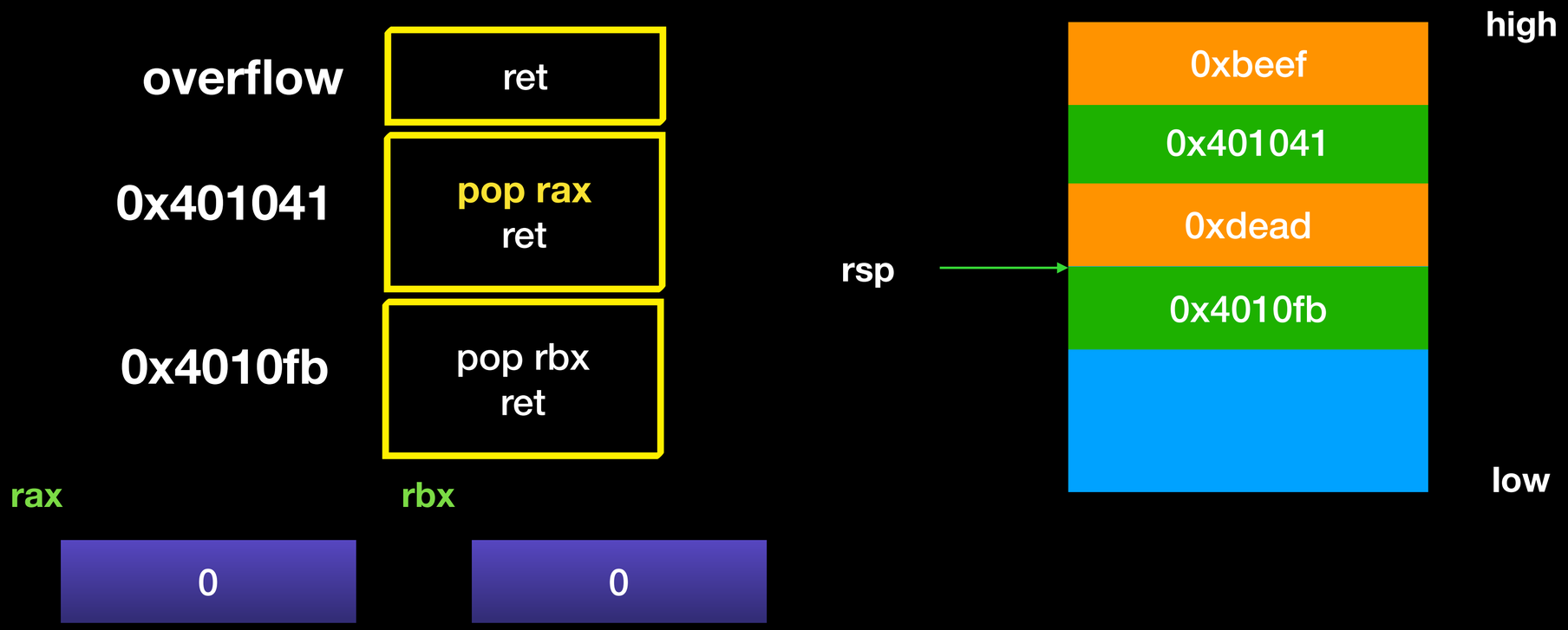

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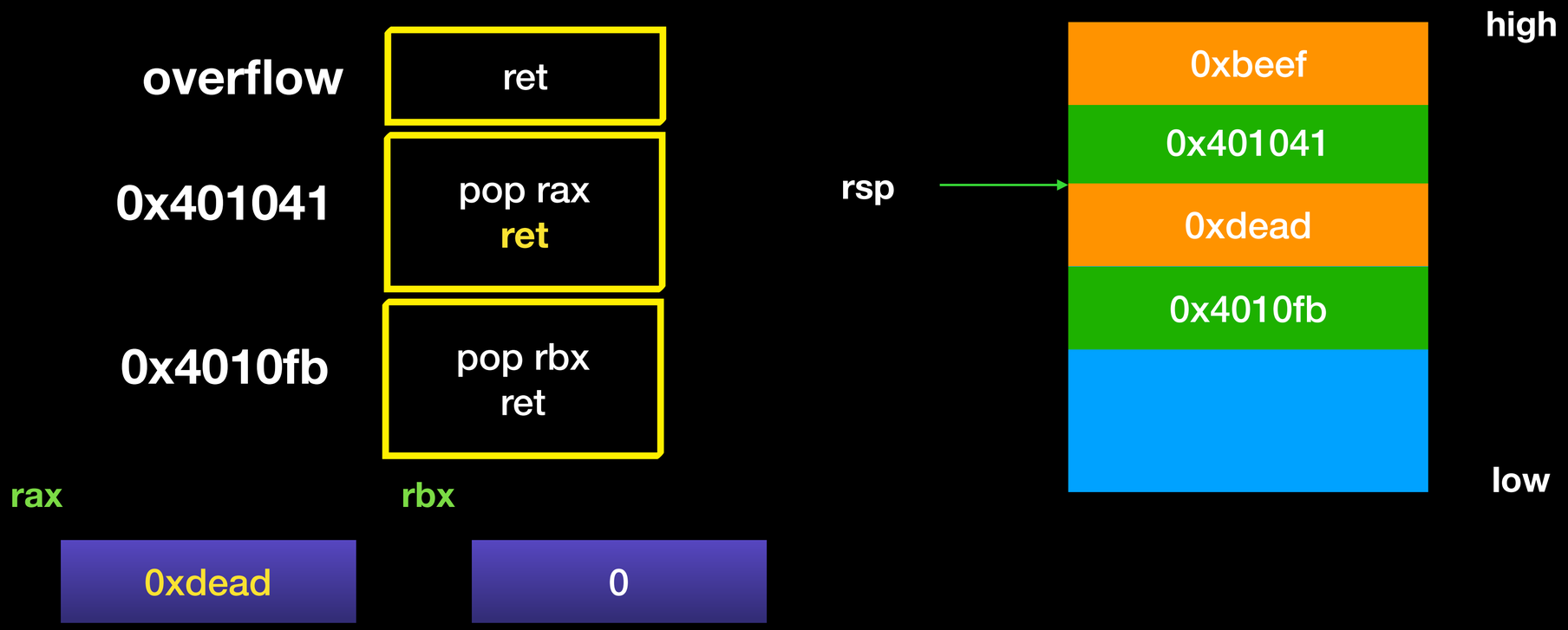

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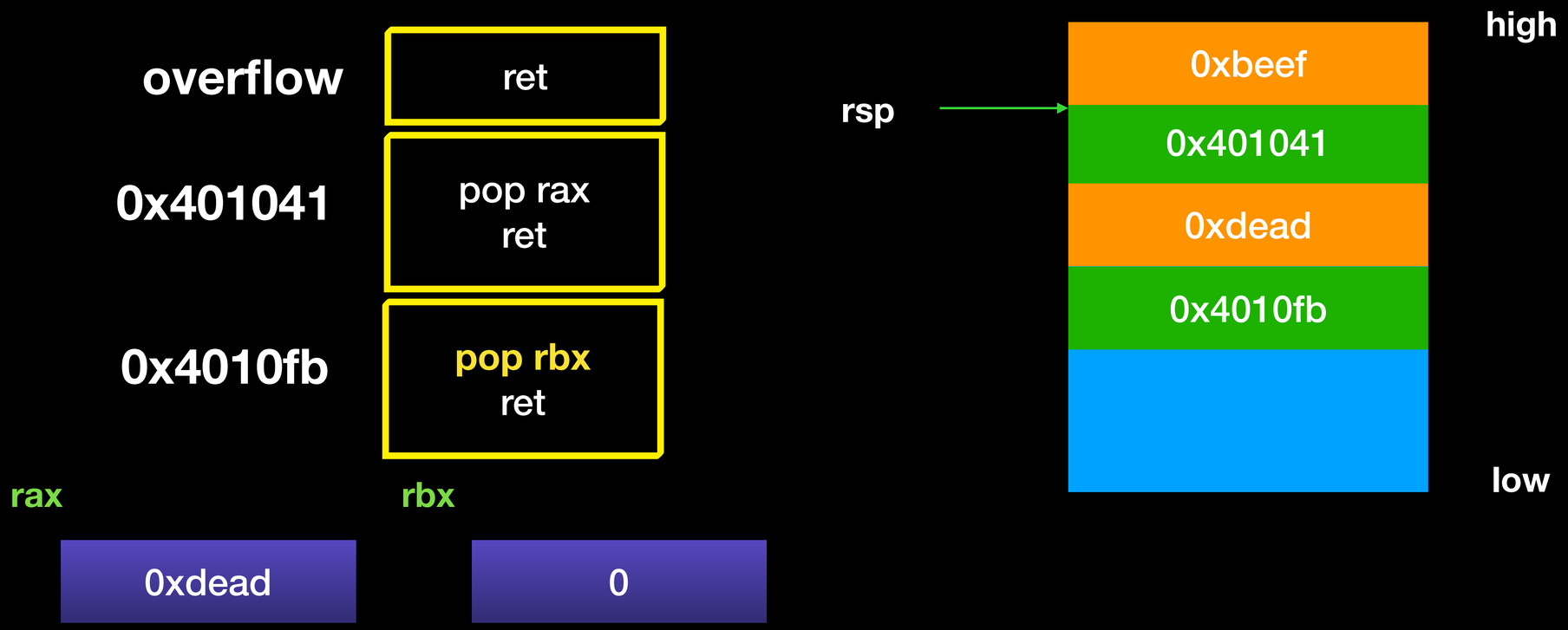

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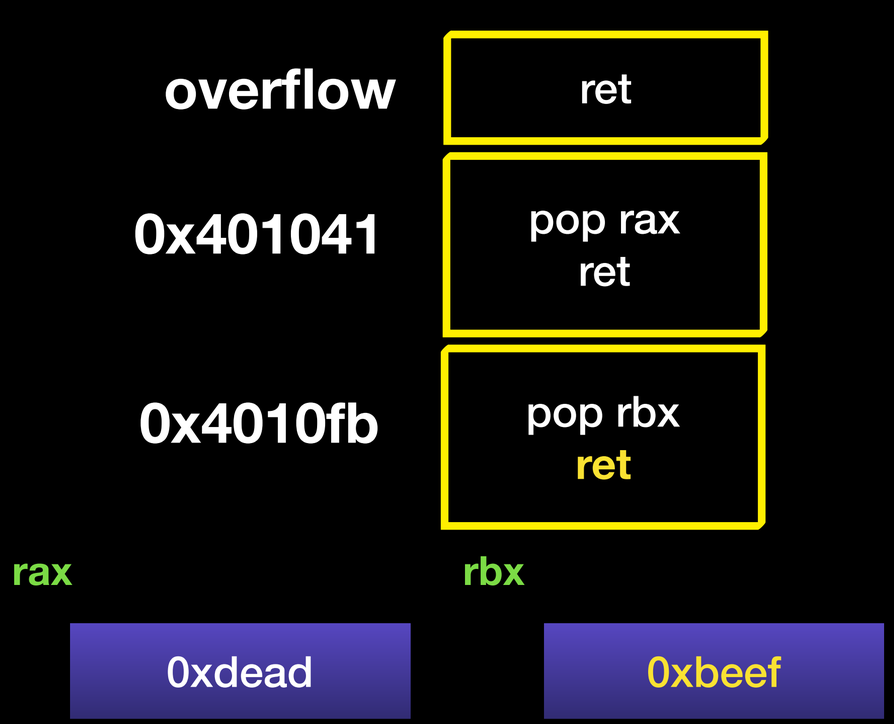
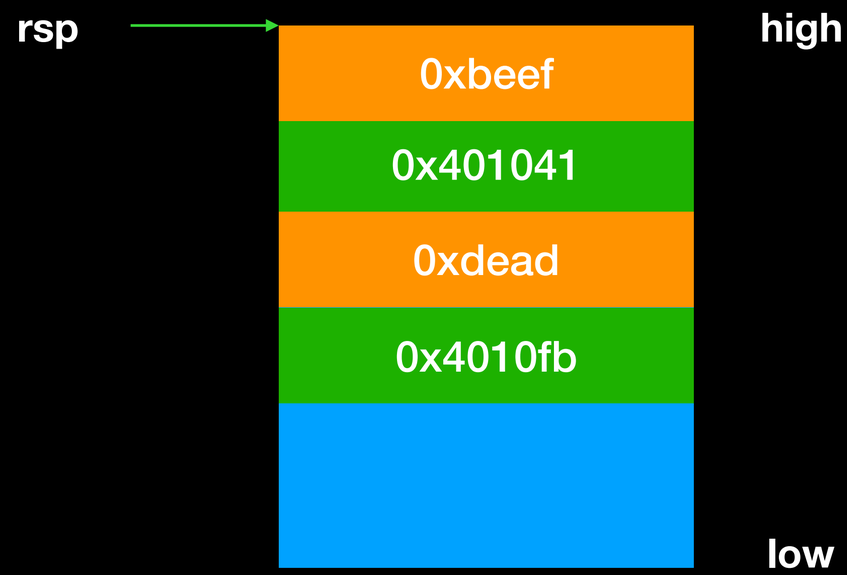


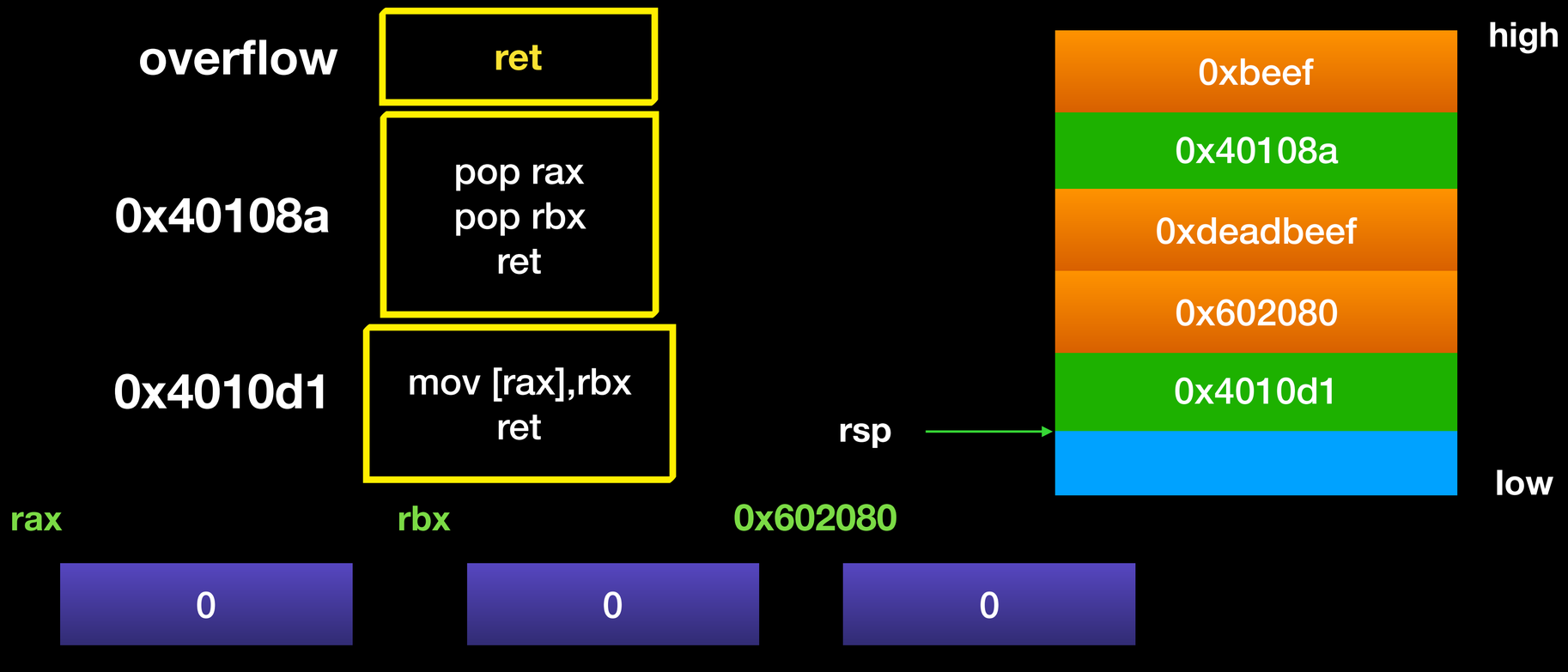


ROP

- Write to Memory
  - mov [reg],reg
  - mov [reg+xx], reg
  - …

ROP

- Write to Memory
  - let *0x602080 = 0xdeadbeef



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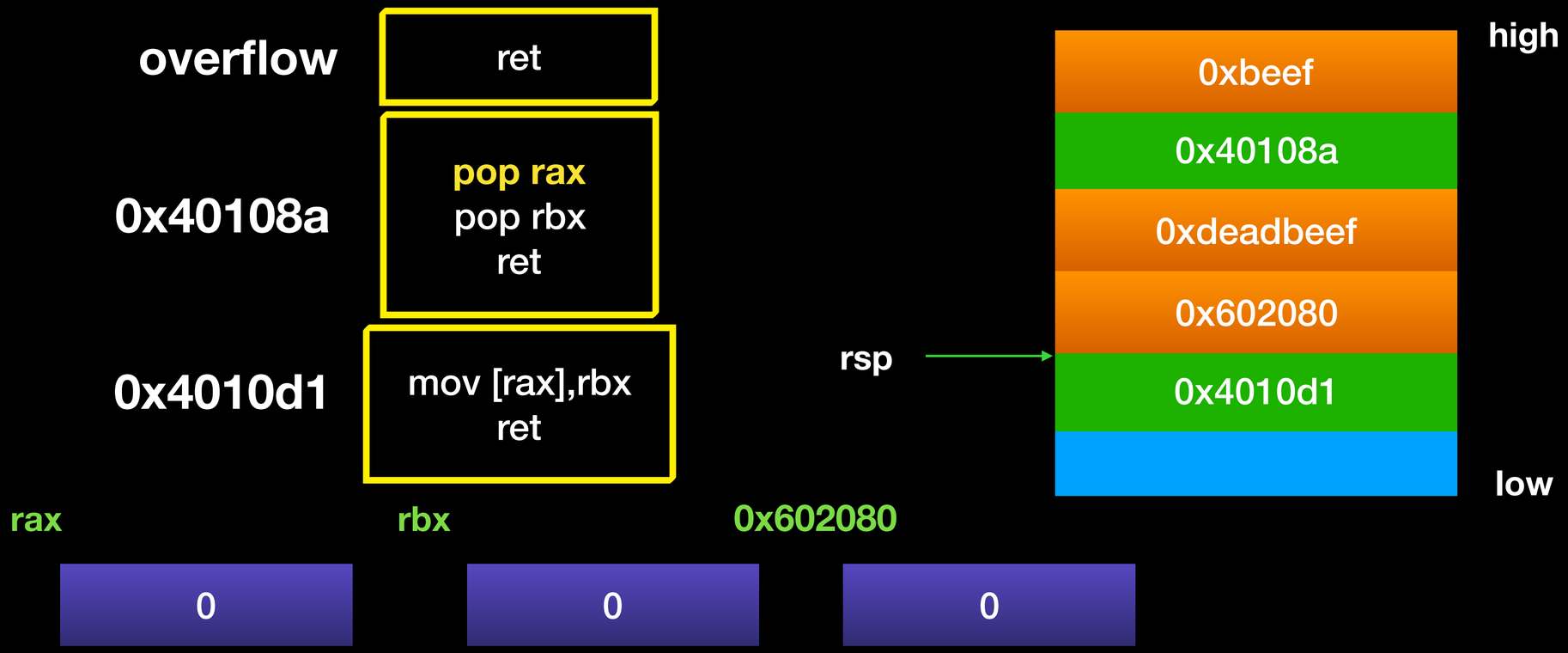

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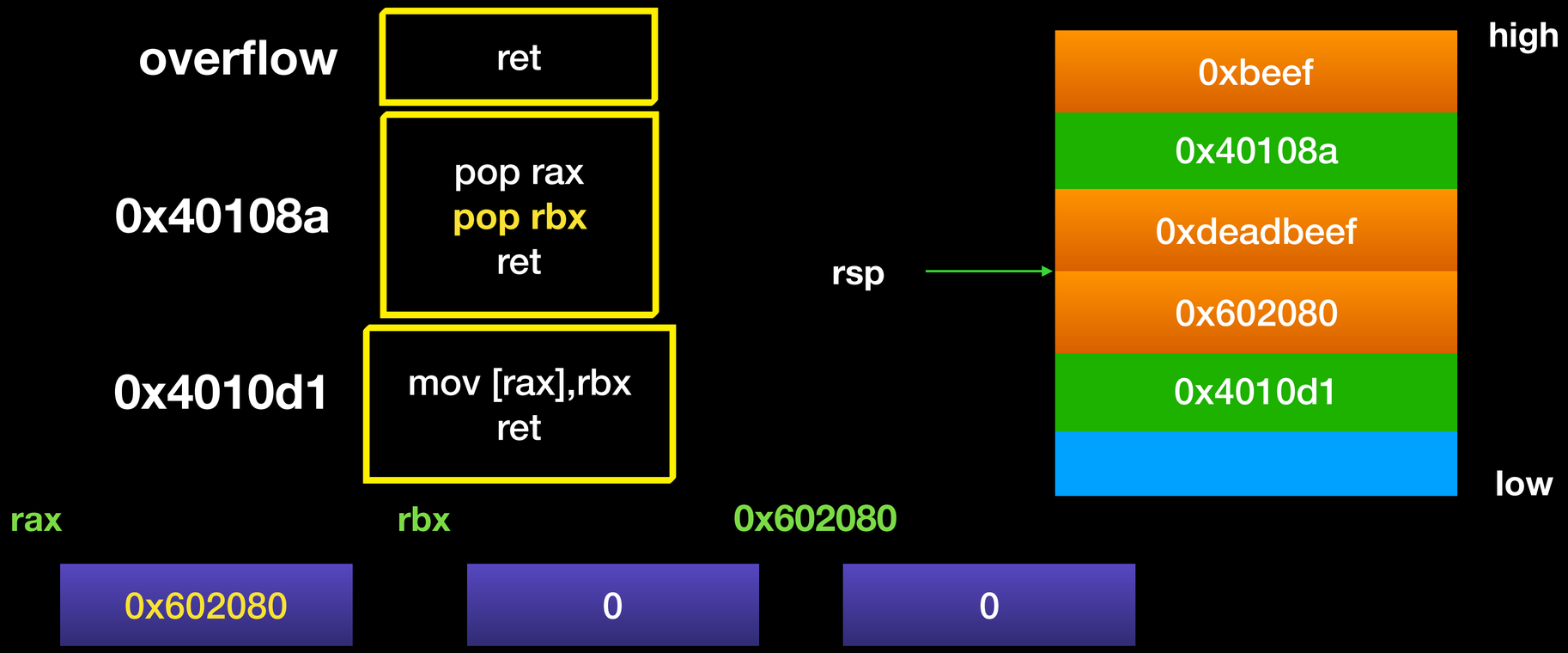

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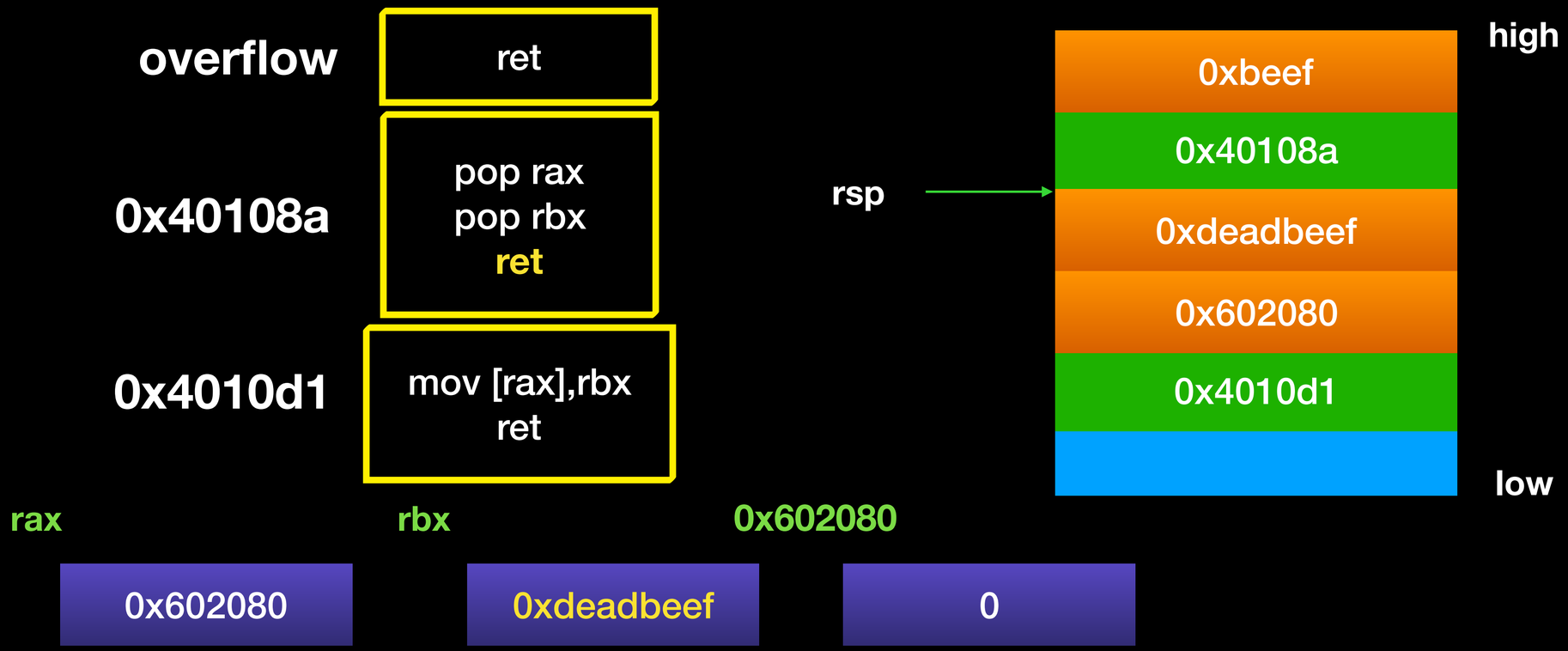

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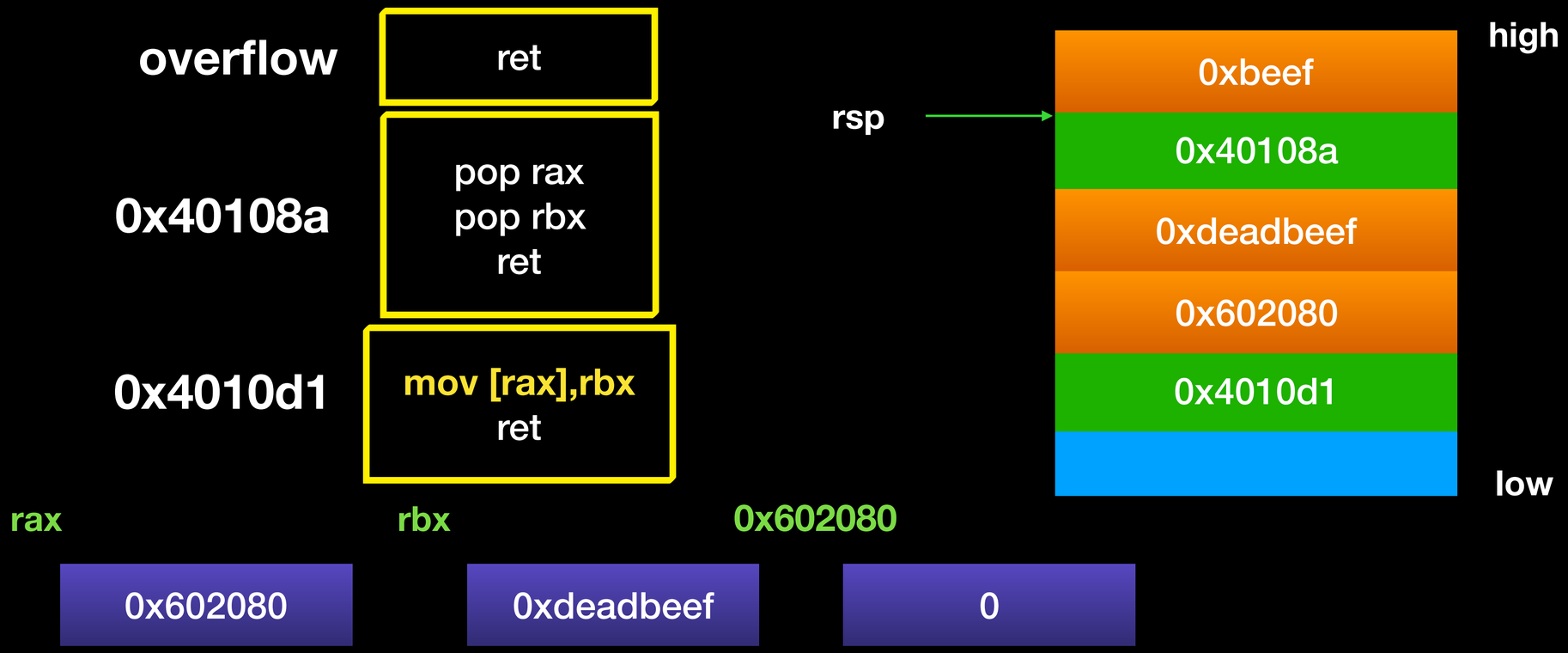

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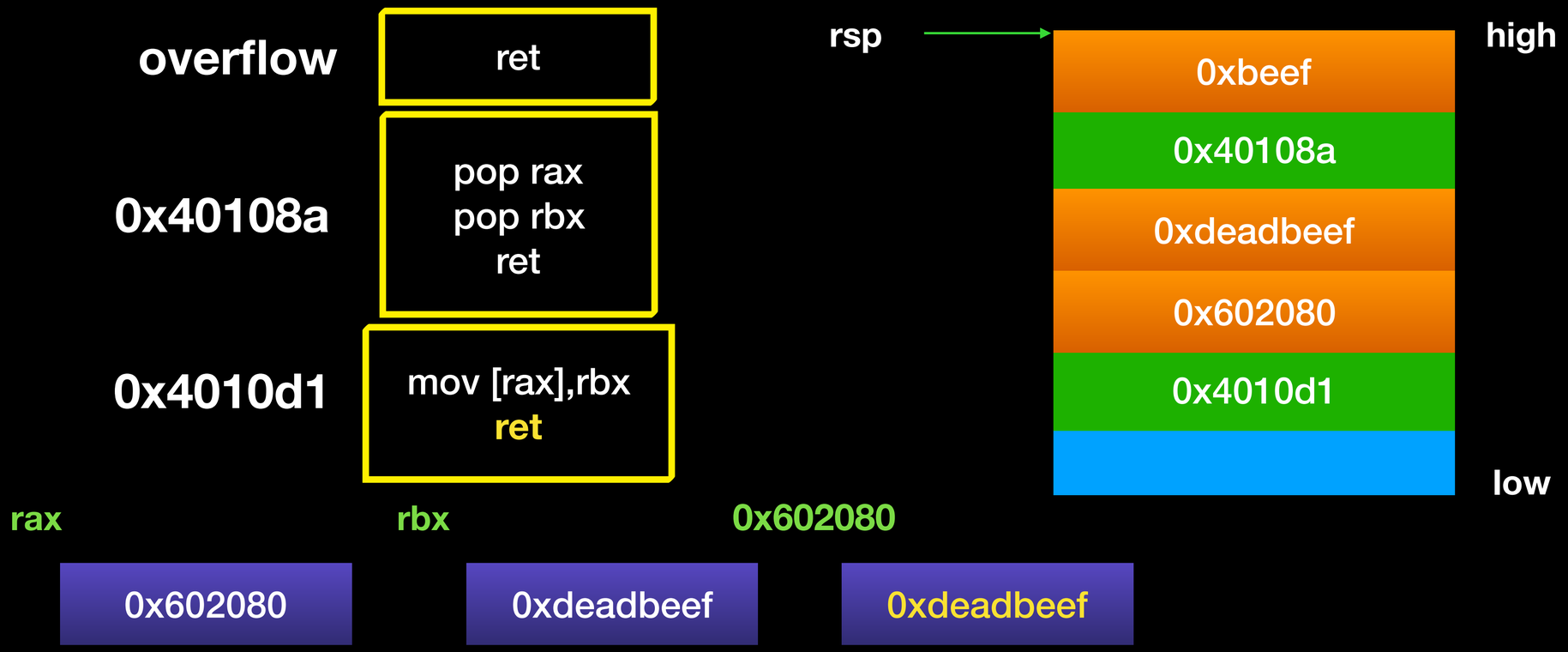


ROP

- execve(“/bin/sh”,NULL,NULL)
  - write to memory
    - 將 “/bin/sh” 寫入已知位置記憶體中
    - 可分多次將所需字串寫入記憶體中

ROP

- execve(“/bin/sh”,NULL,NULL)
  - write to register
    - rax = 0x3b , rdi = address of “/bin/sh”
    - rsi = 0 , rdx = 0
  - syscall

ROP

- find gadget
  - https://github.com/JonathanSalwan/ROPgadget

```
0x0000000000401947 : pop r12 ; pop r13 ; pop r14 ; pop r15 ; ret
0x00000000004016da : pop r12 ; pop r13 ; pop r14 ; ret
0x0000000000401ee0 : pop r12 ; pop r13 ; ret
0x0000000000401949 : pop r13 ; pop r14 ; pop r15 ; ret
0x00000000004016dc : pop r13 ; pop r14 ; ret
0x0000000000401ee2 : pop r13 ; ret
0x000000000040194b : pop r14 ; pop r15 ; ret
0x00000000004016de : pop r14 ; ret
0x000000000040194d : pop r15 ; ret
0x00000000004026c6 : pop rax ; add rsp, 8 ; pop rbp ; ret
0x000000000040260d : pop rax ; ret
0x0000000000400f92 : pop rbp ; mov byte ptr [rip + 0x20309e], 1 ; ret
0x0000000000400f1f : pop rbp ; mov edi, 0x604018 ; jmp rax
0x0000000000401946 : pop rbp ; pop r12 ; pop r13 ; pop r14 ; pop r15 ; ret
0x00000000004016d9 : pop rbp ; pop r12 ; pop r13 ; pop r14 ; ret
0x0000000000401edf : pop rbp ; pop r12 ; pop r13 ; ret
0x000000000040194a : pop rbp ; pop r14 ; pop r15 ; ret
0x00000000004016dd : pop rbp ; pop r14 ; ret
0x0000000000400f30 : pop rbp ; ret
0x0000000000401ede : pop rbx ; pop rbp ; pop r12 ; pop r13 ; ret
0x0000000000401540 : pop rbx ; pop rbp ; ret
0x000000000040228e : pop rbx ; ret
0x000000000040194e : pop rdi ; ret
```

ROP

- find gadget
  - ROPgadget - - binary binary
  - ROPgadget - - ropchain - - binary binary
    - 在 Static linking 通常可以組成功 execve 的 rop chain 但通常都很長，需要自己找更短的 gadget 來改短一點

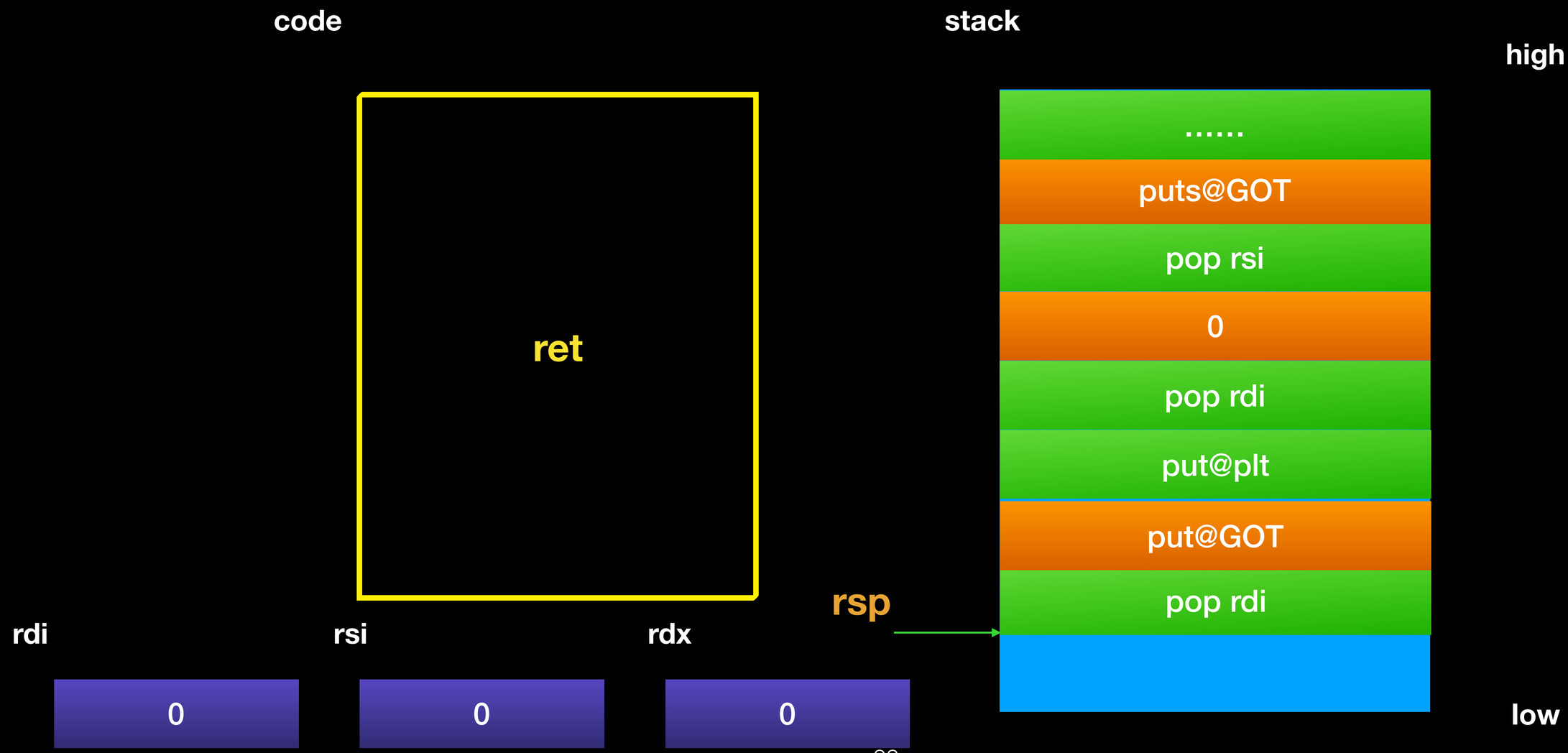
Outline

- ROP
- Using ROP bypass ASLR
- Stack migration

Using ROP bypass ASLR

- 假設 dynamic 編譯的程式中有 Buffer Overflow 的漏洞且在沒 PIE 情況下 (先不考慮 StackGuard 的情況)
- How to bypass ASLR and DEP ?
  - Use .plt section to leak some information
    - ret2plt
  - 通常一般的程式中都會有 put 、 send 、write 等 output function

Using ROP bypass ASLR



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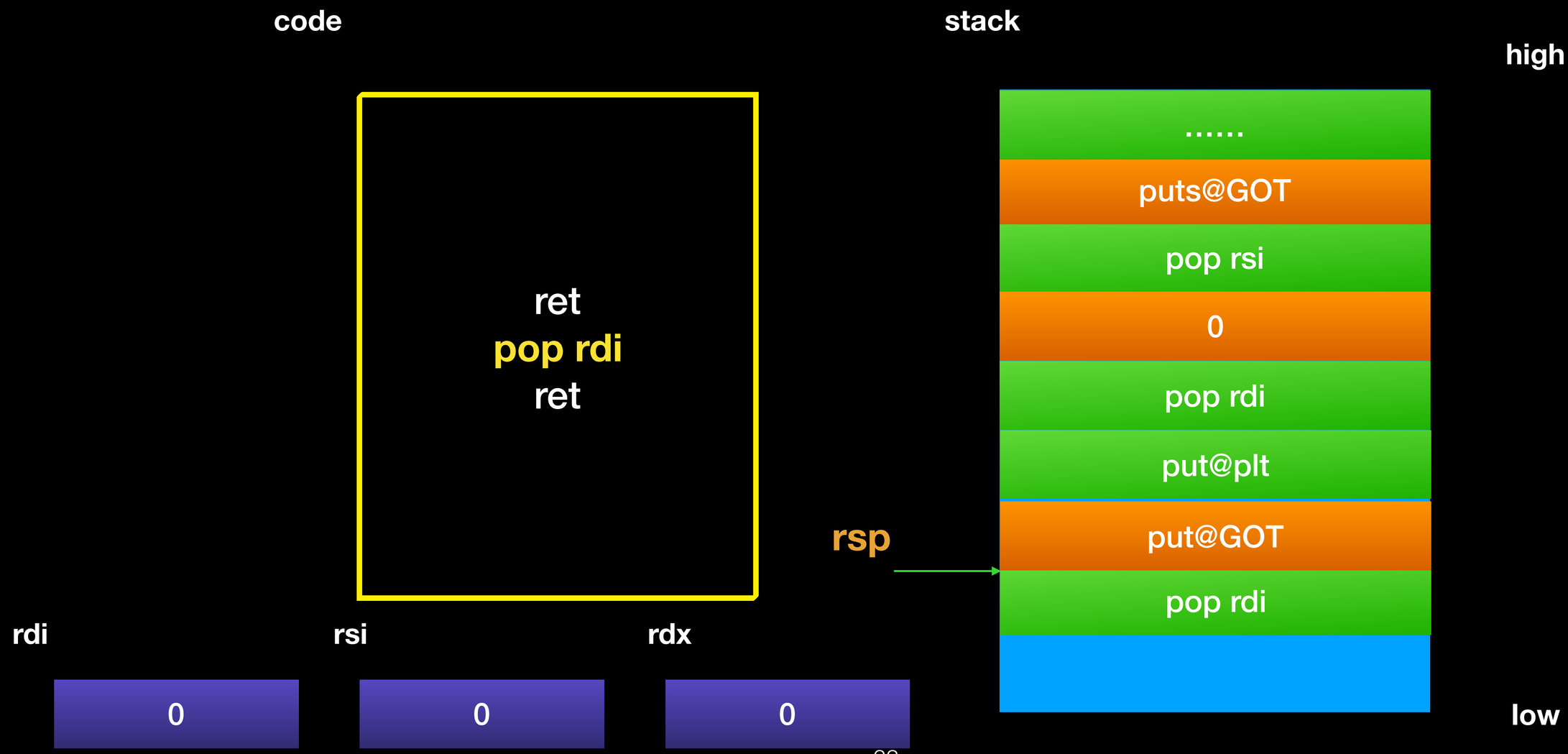

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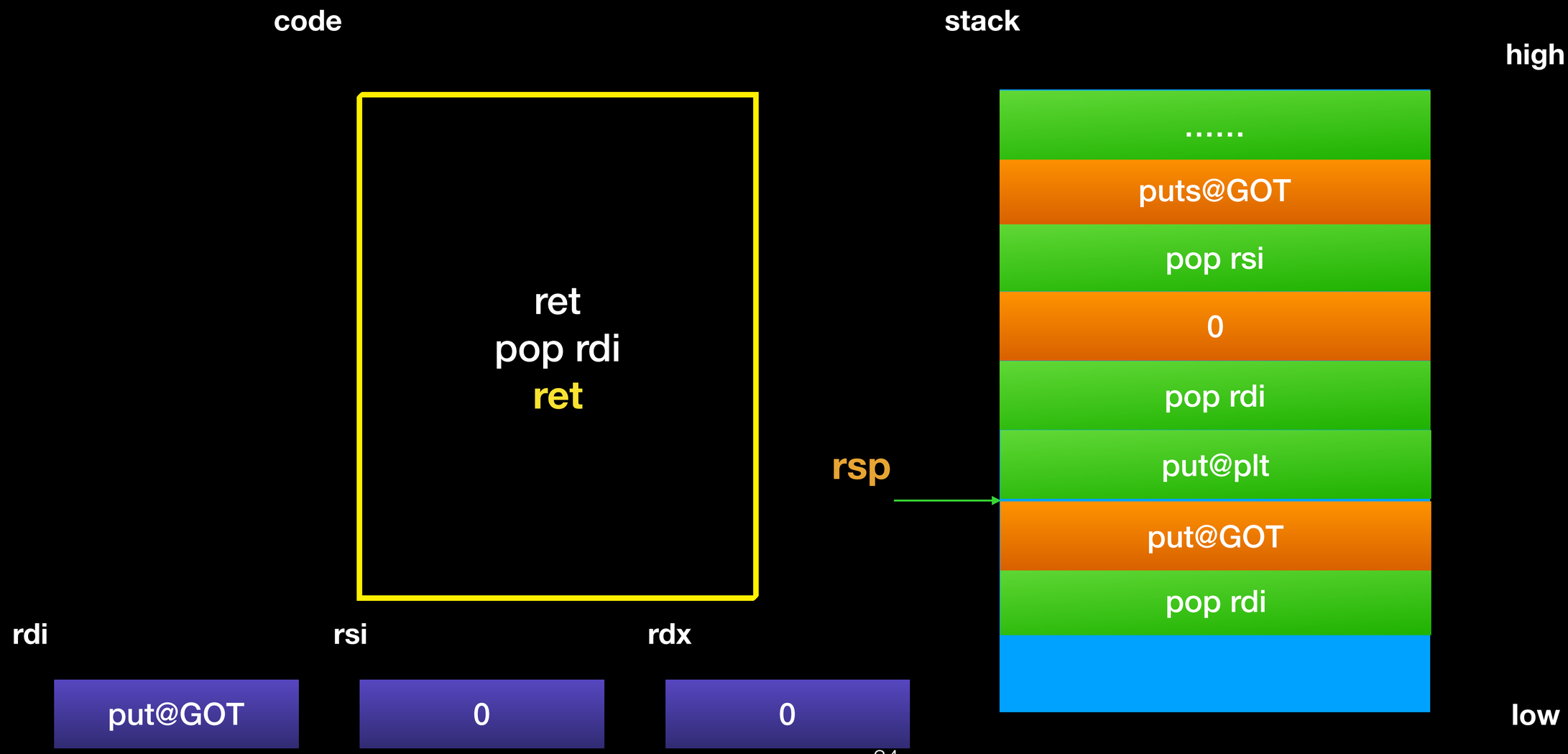

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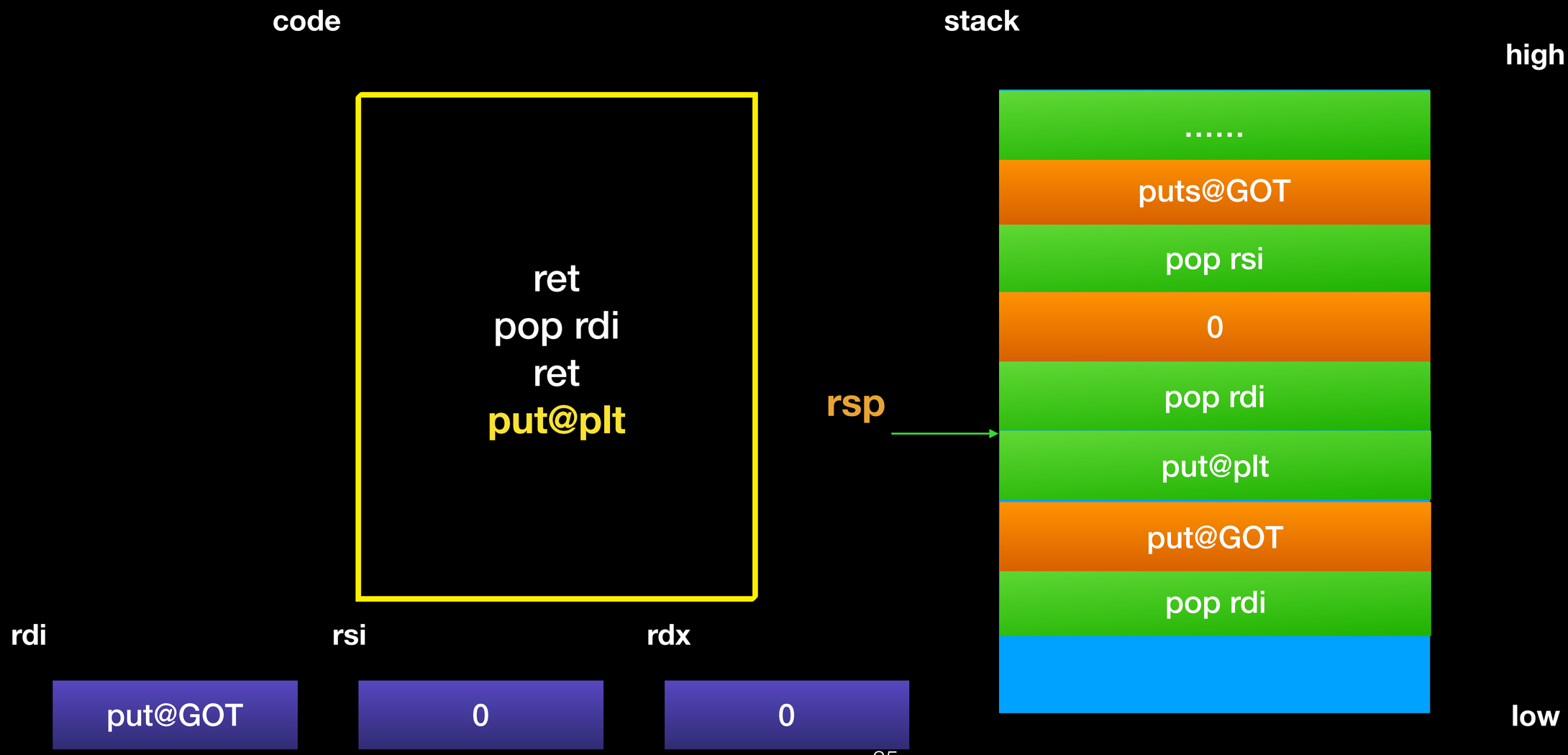

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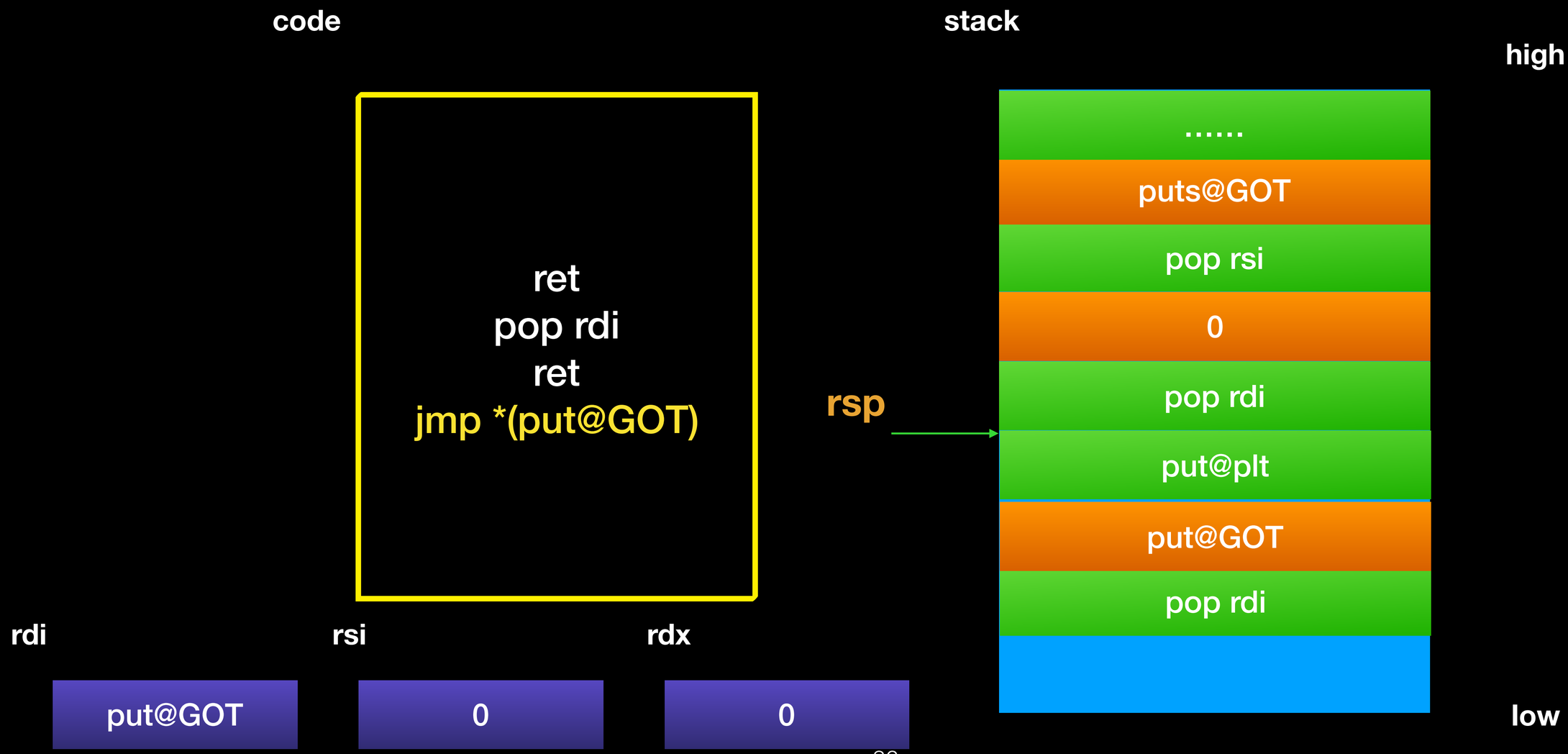

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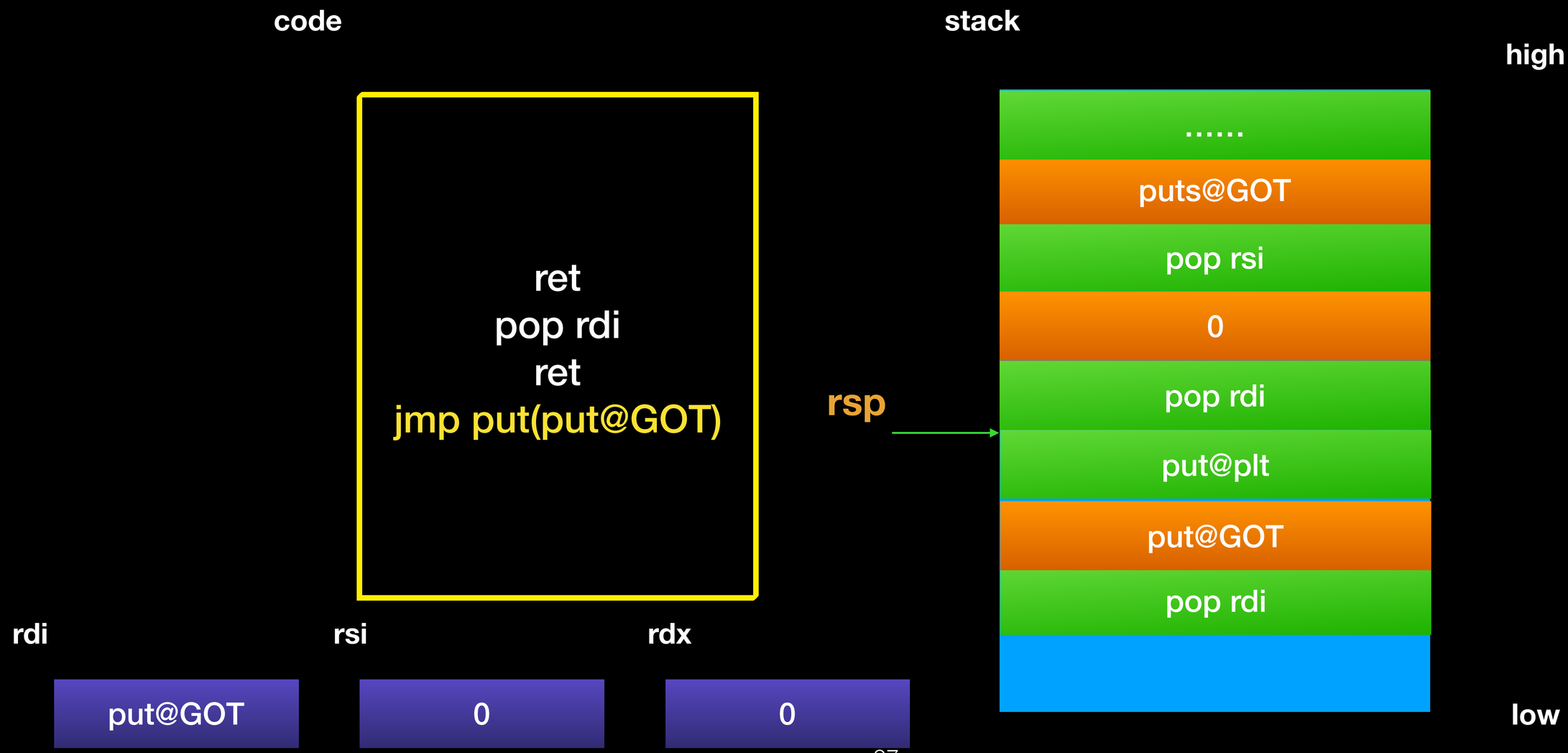

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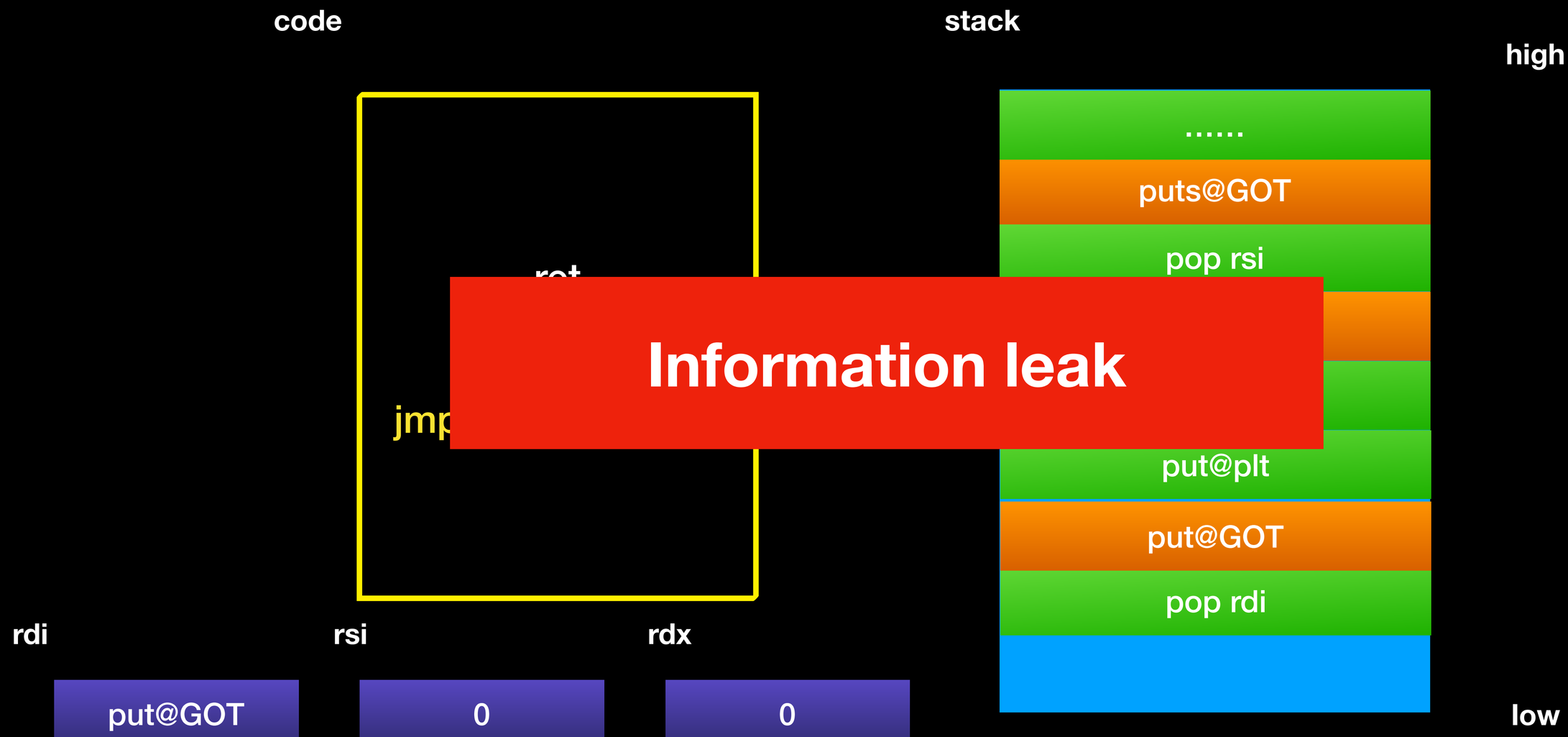

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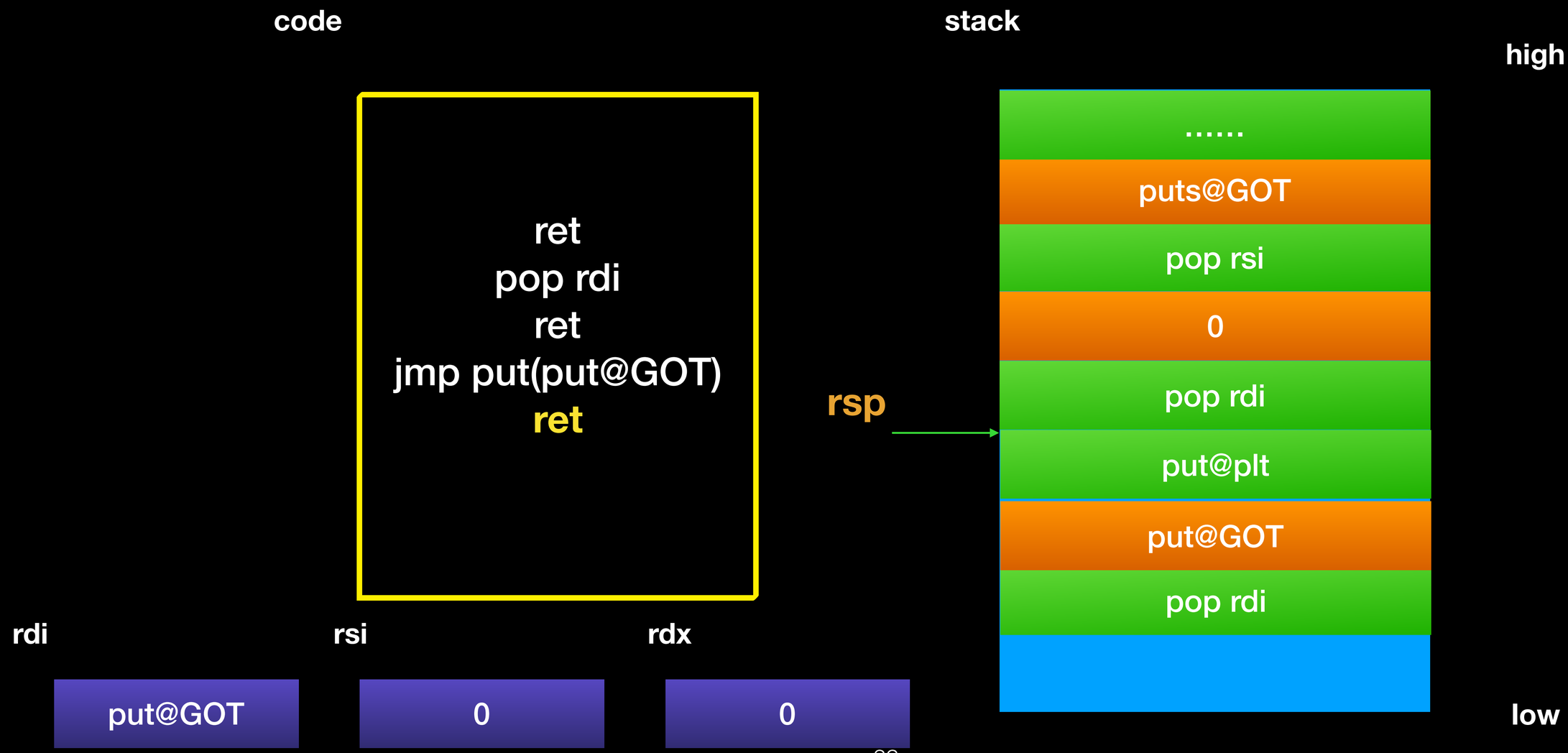

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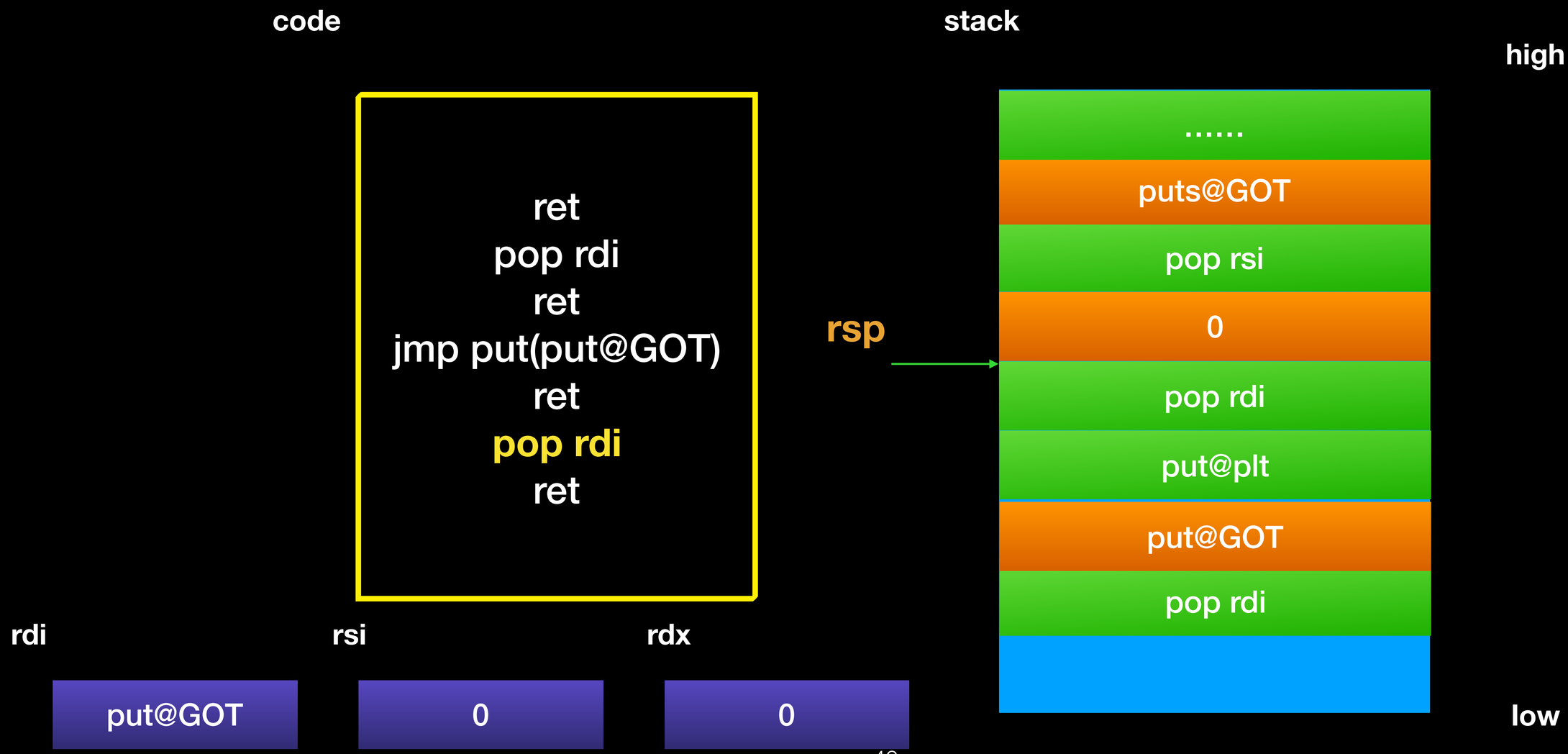

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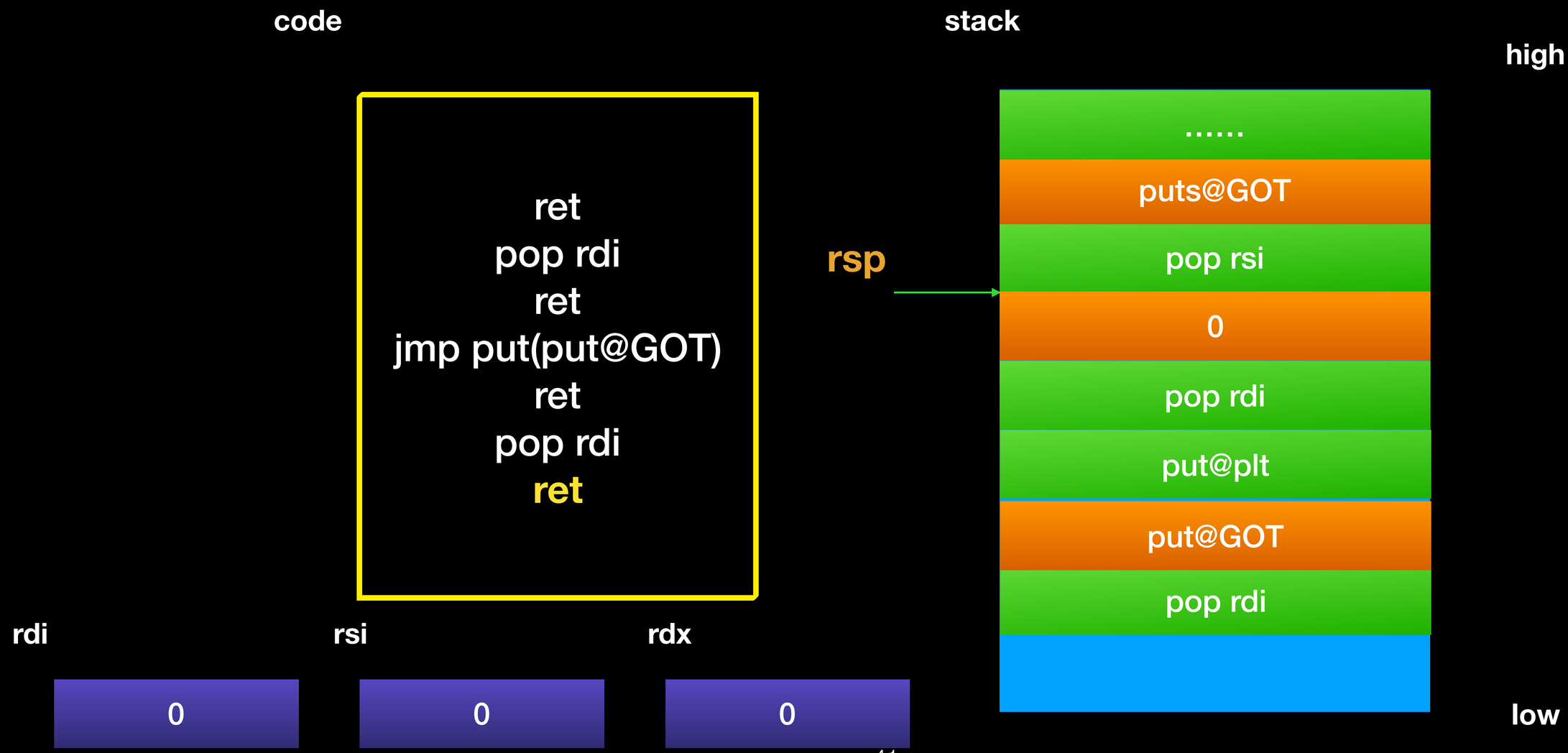

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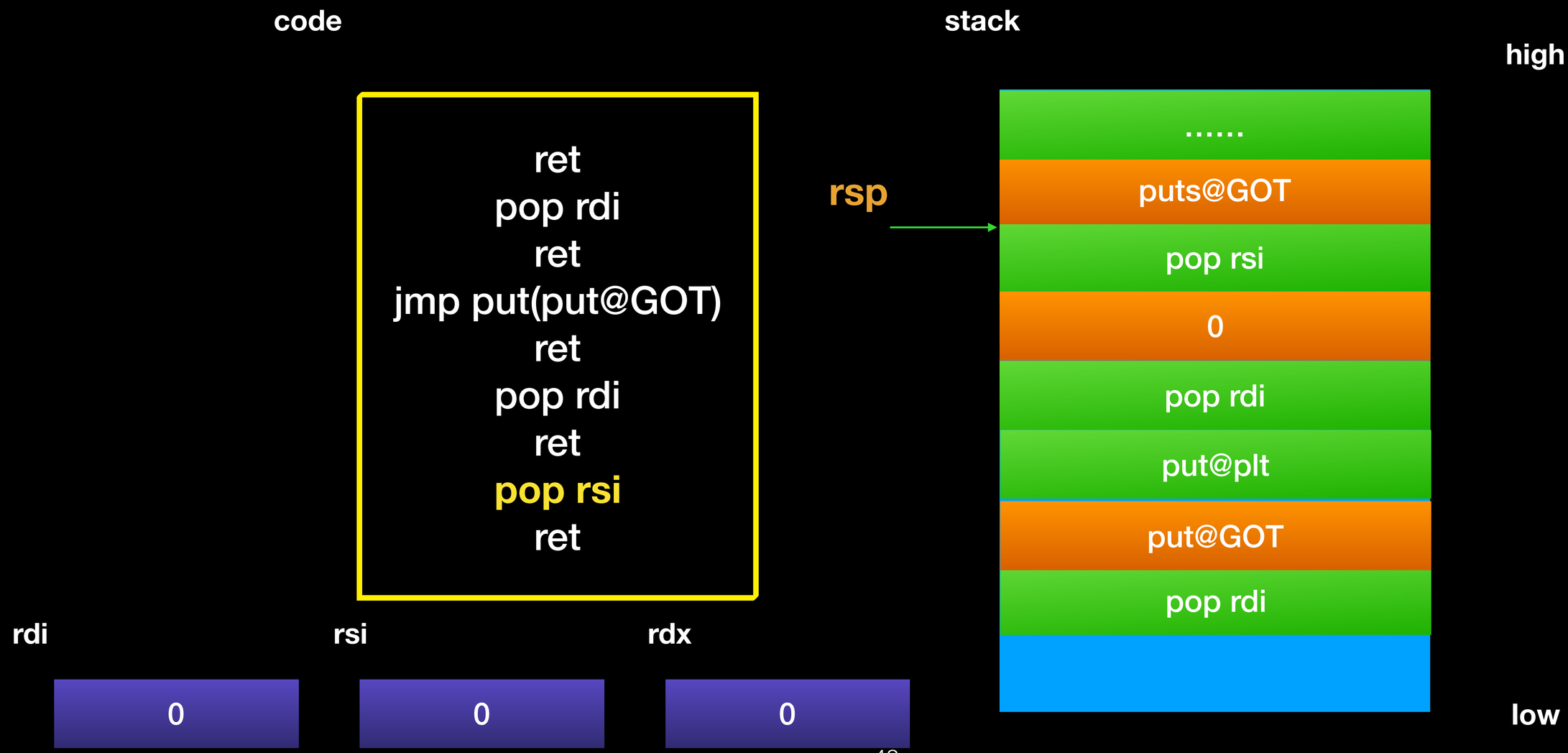

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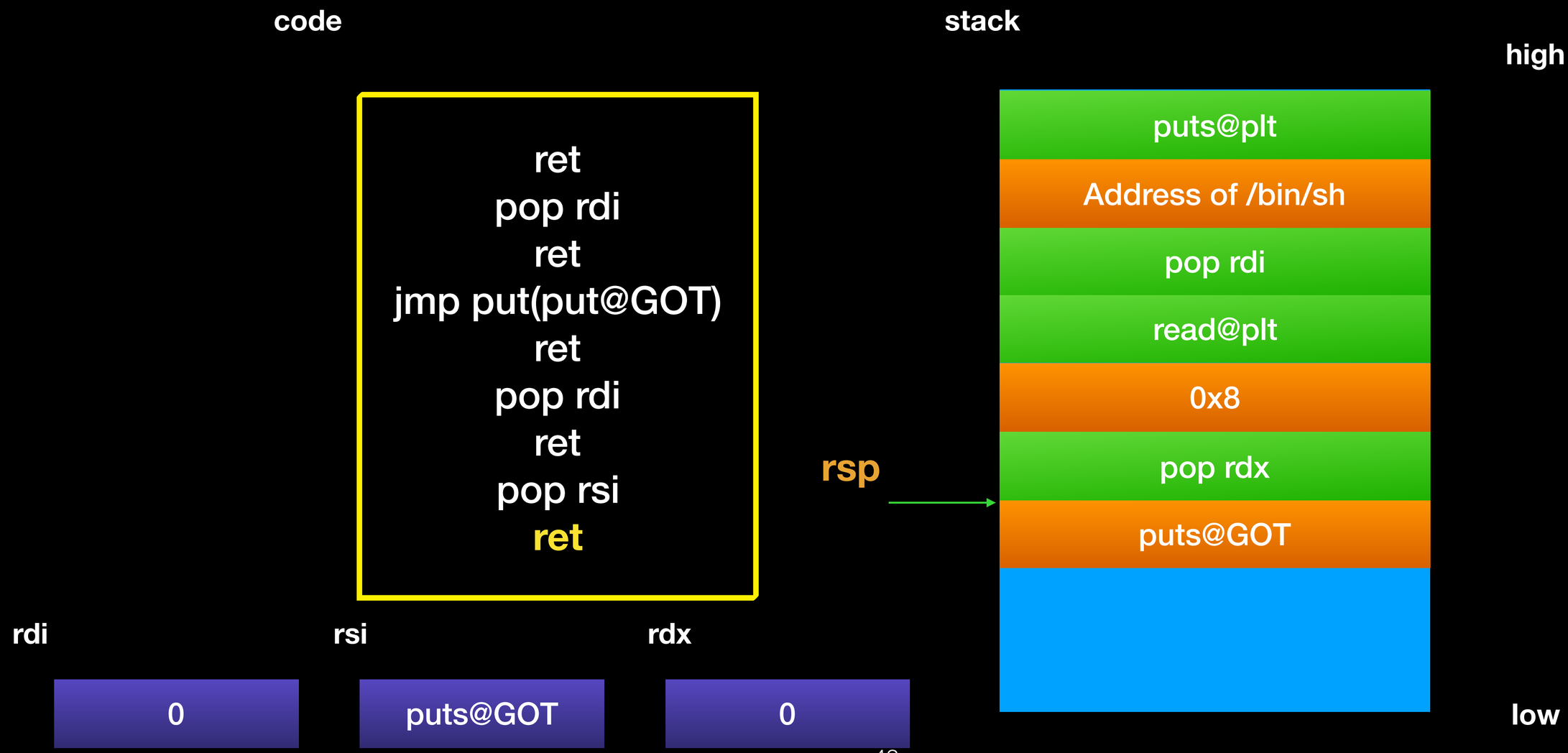

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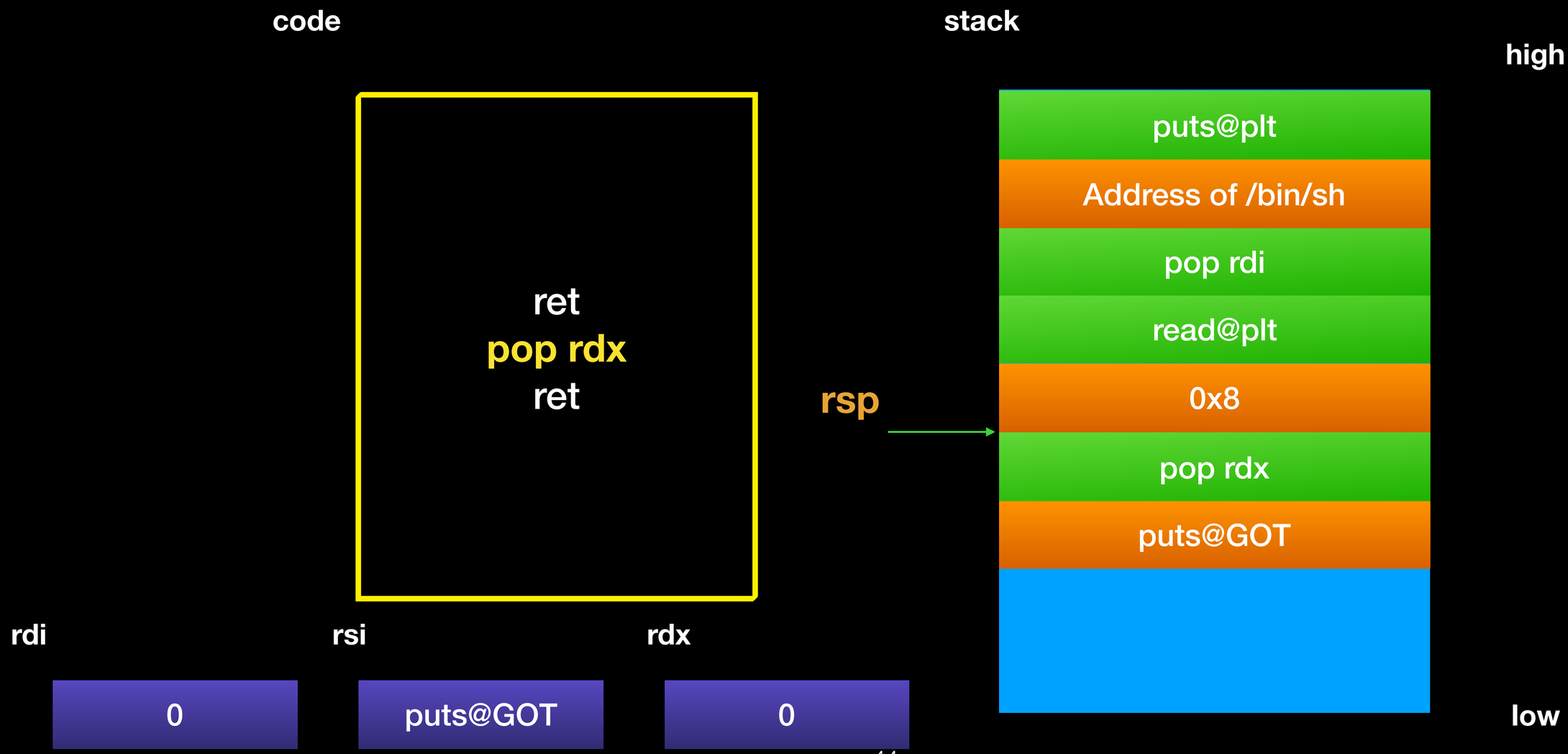

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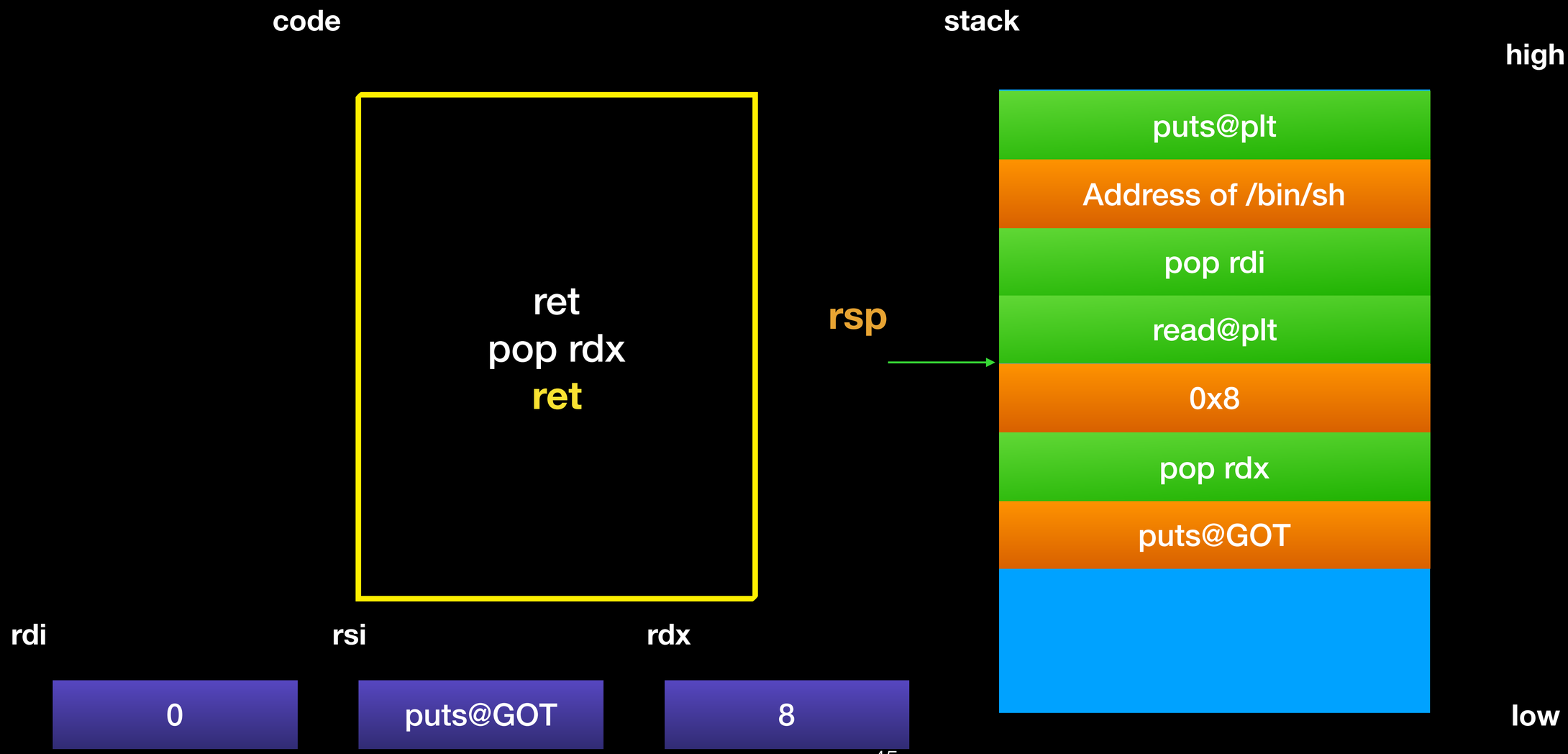

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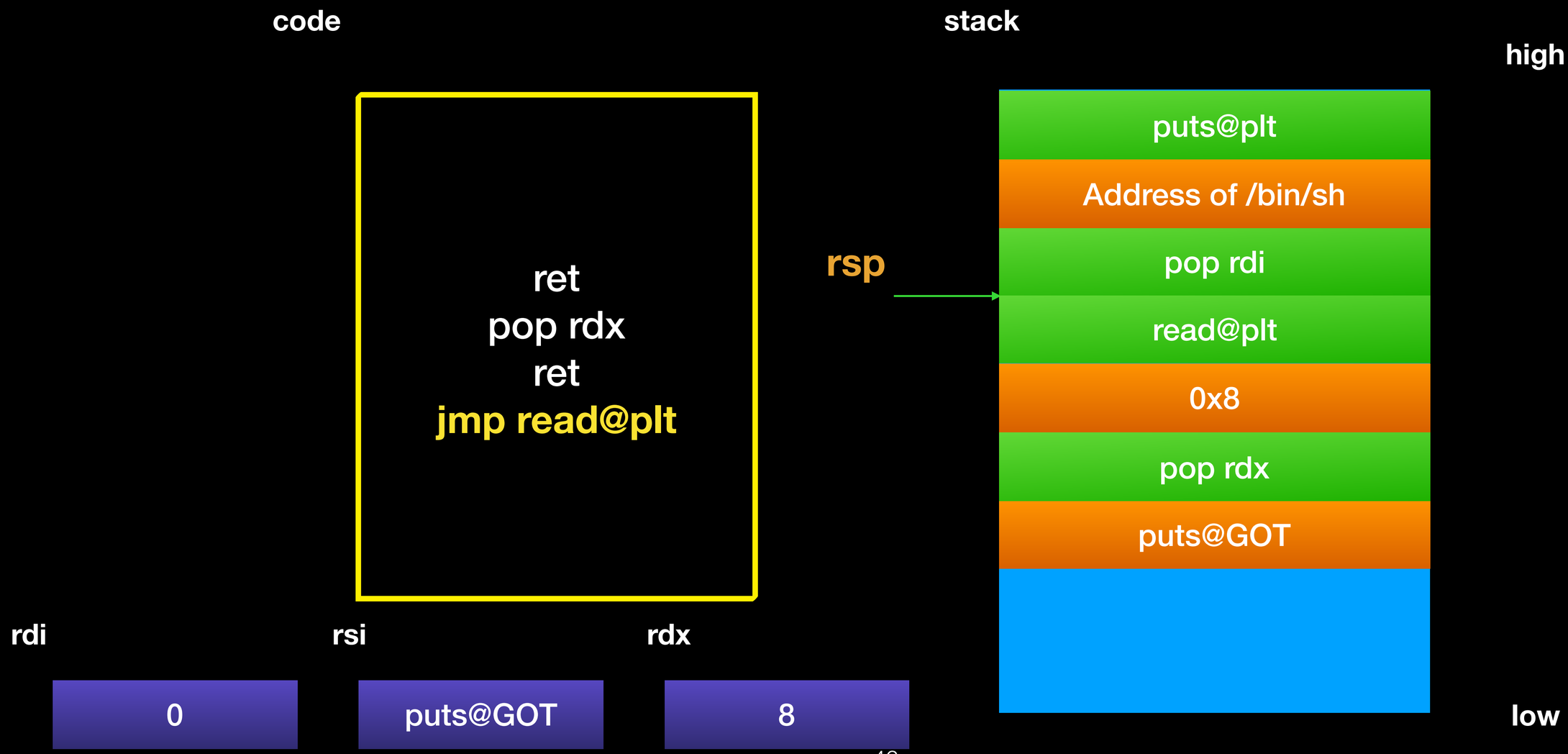

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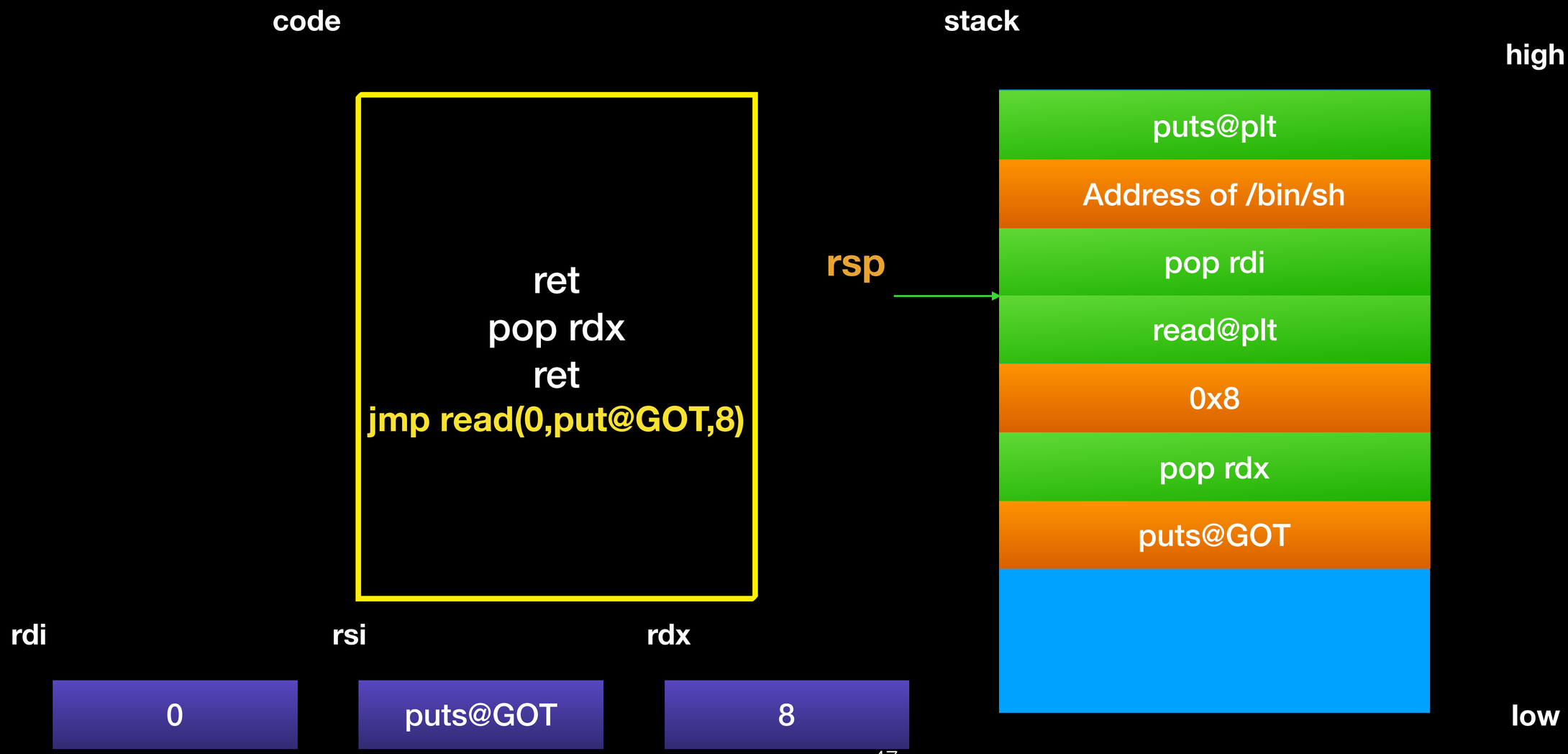

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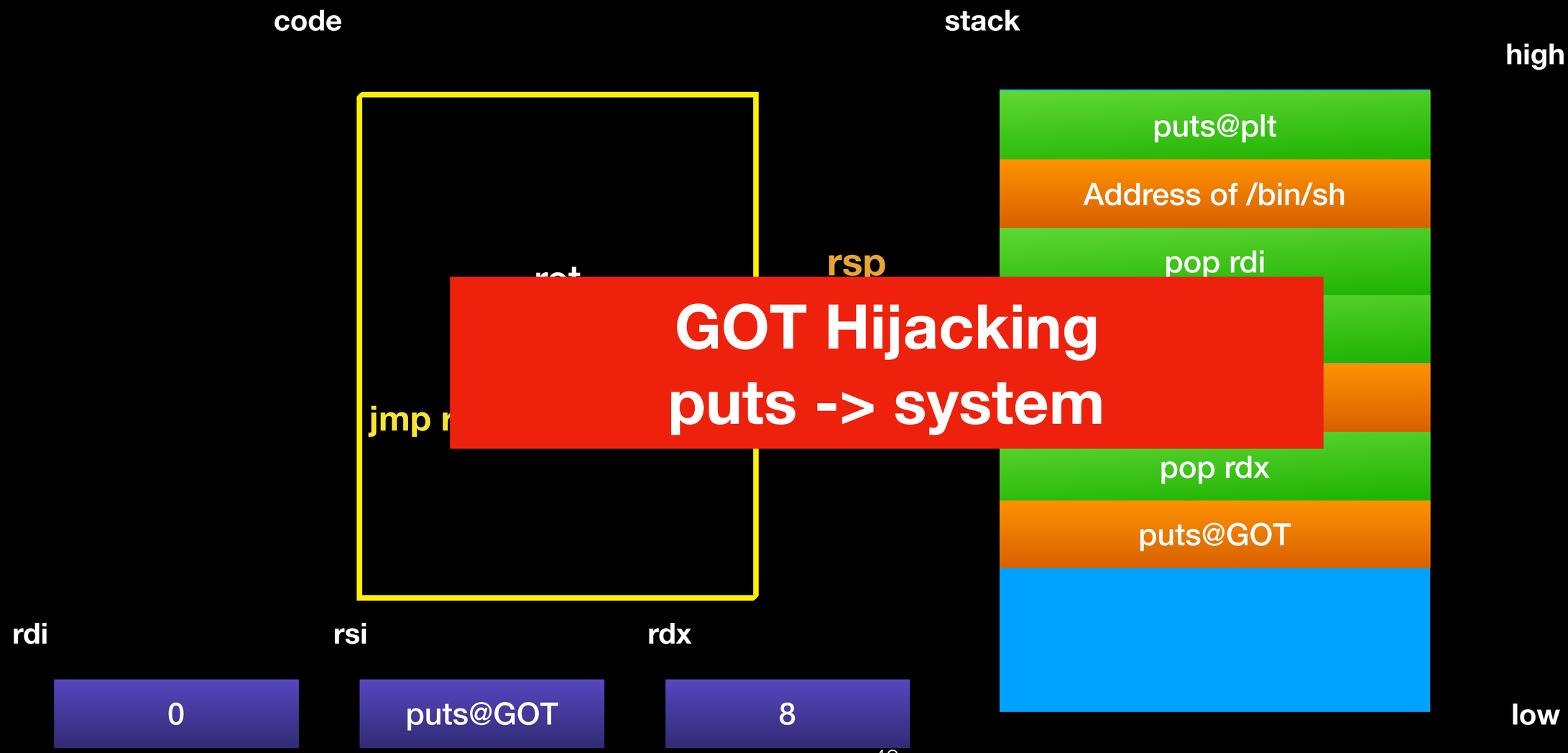

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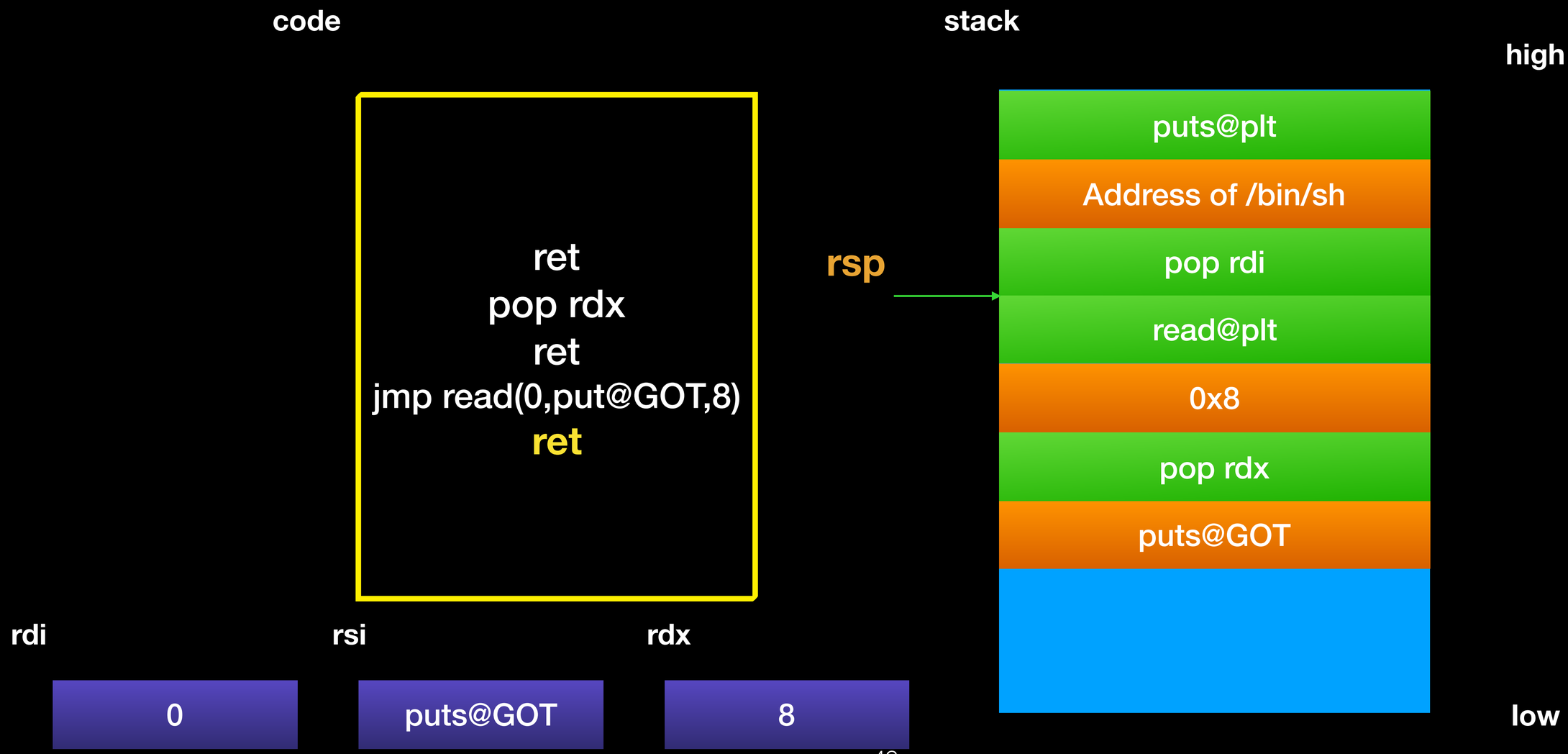

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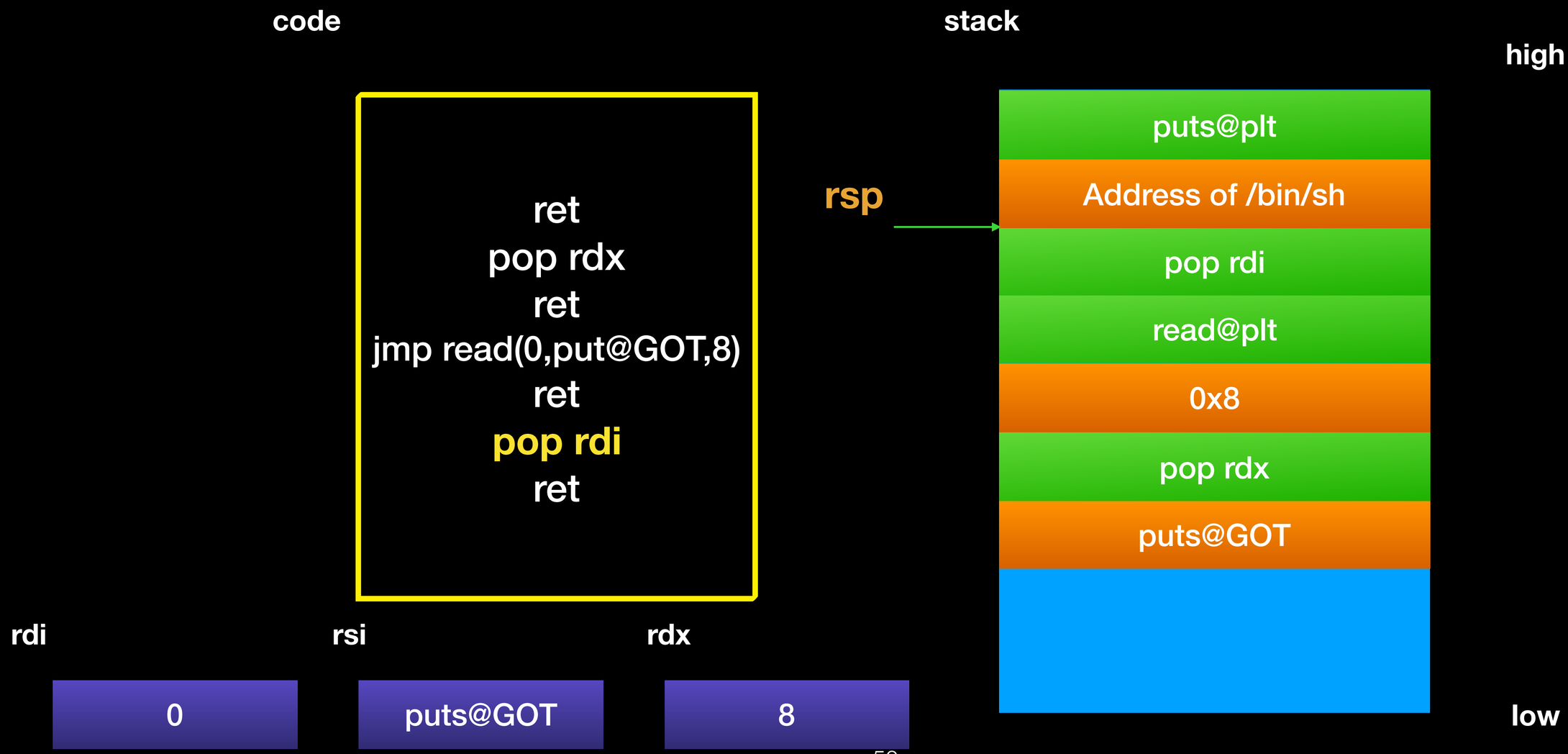

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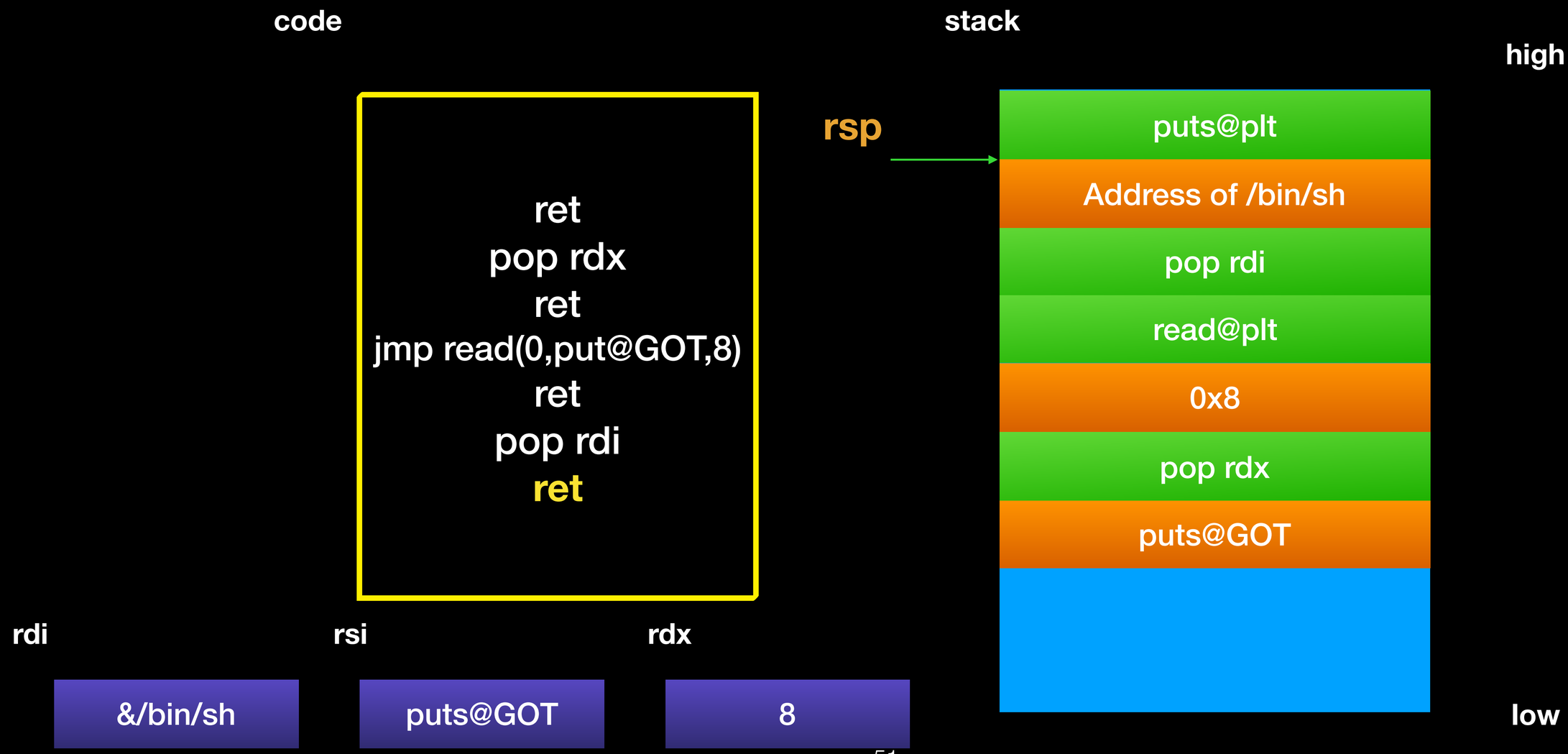

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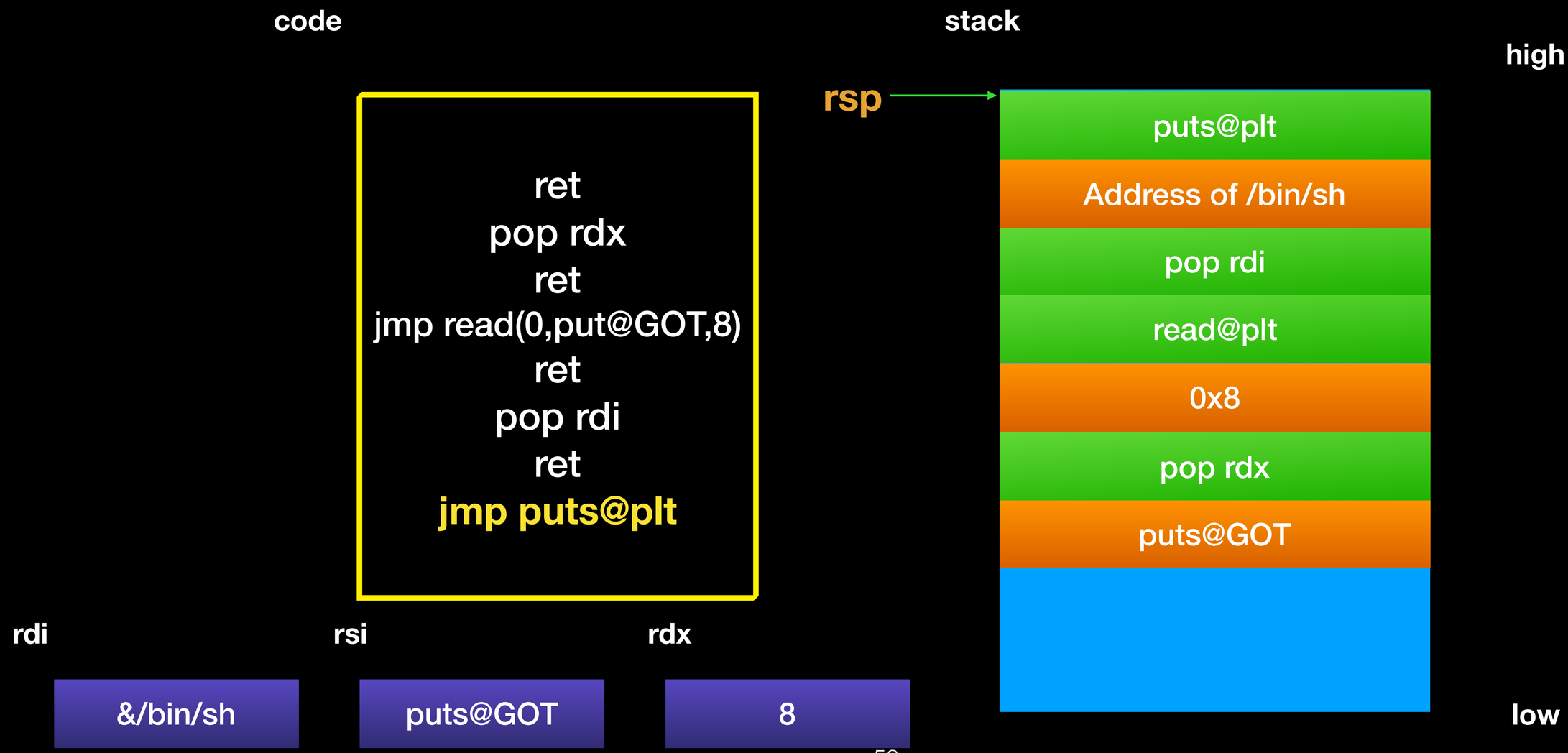

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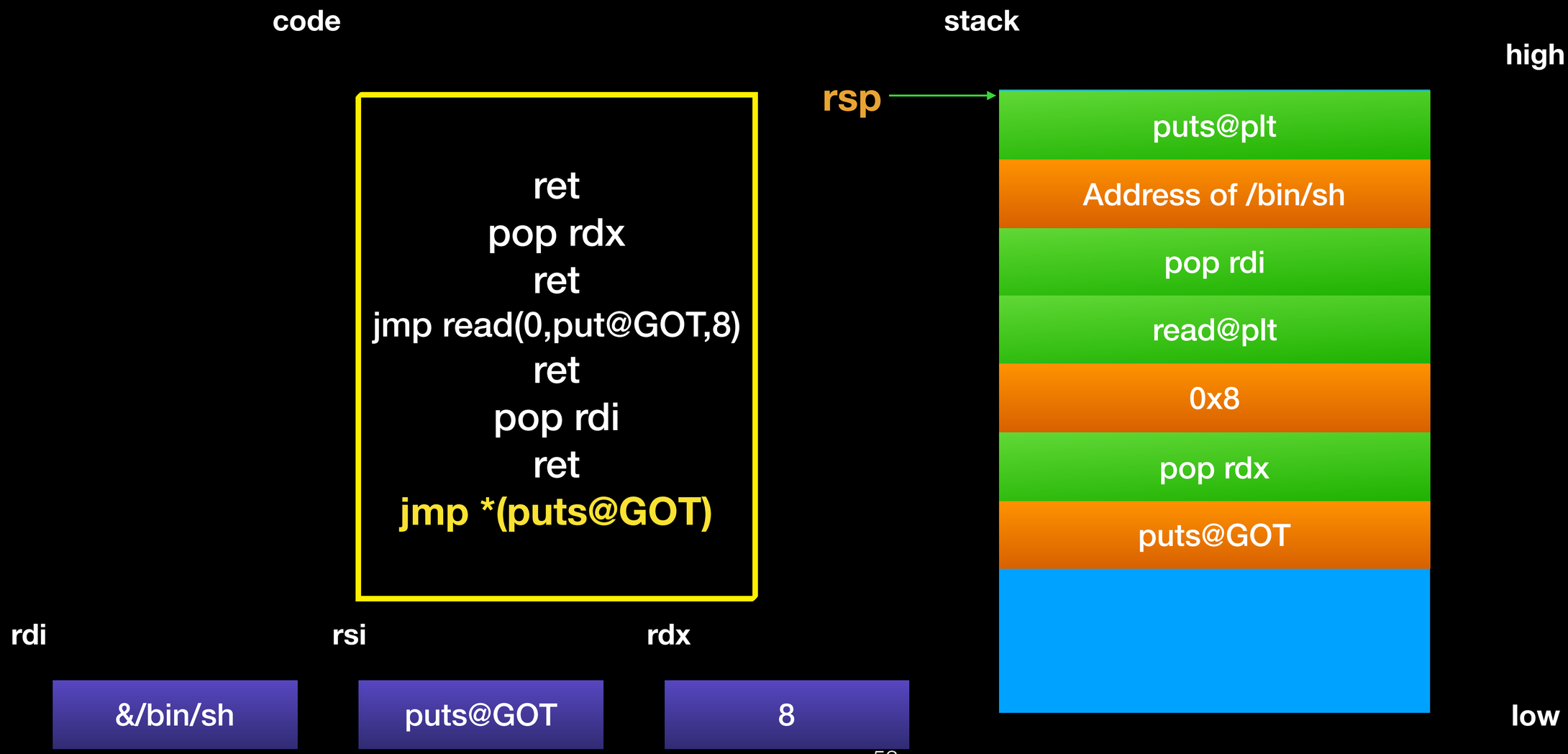
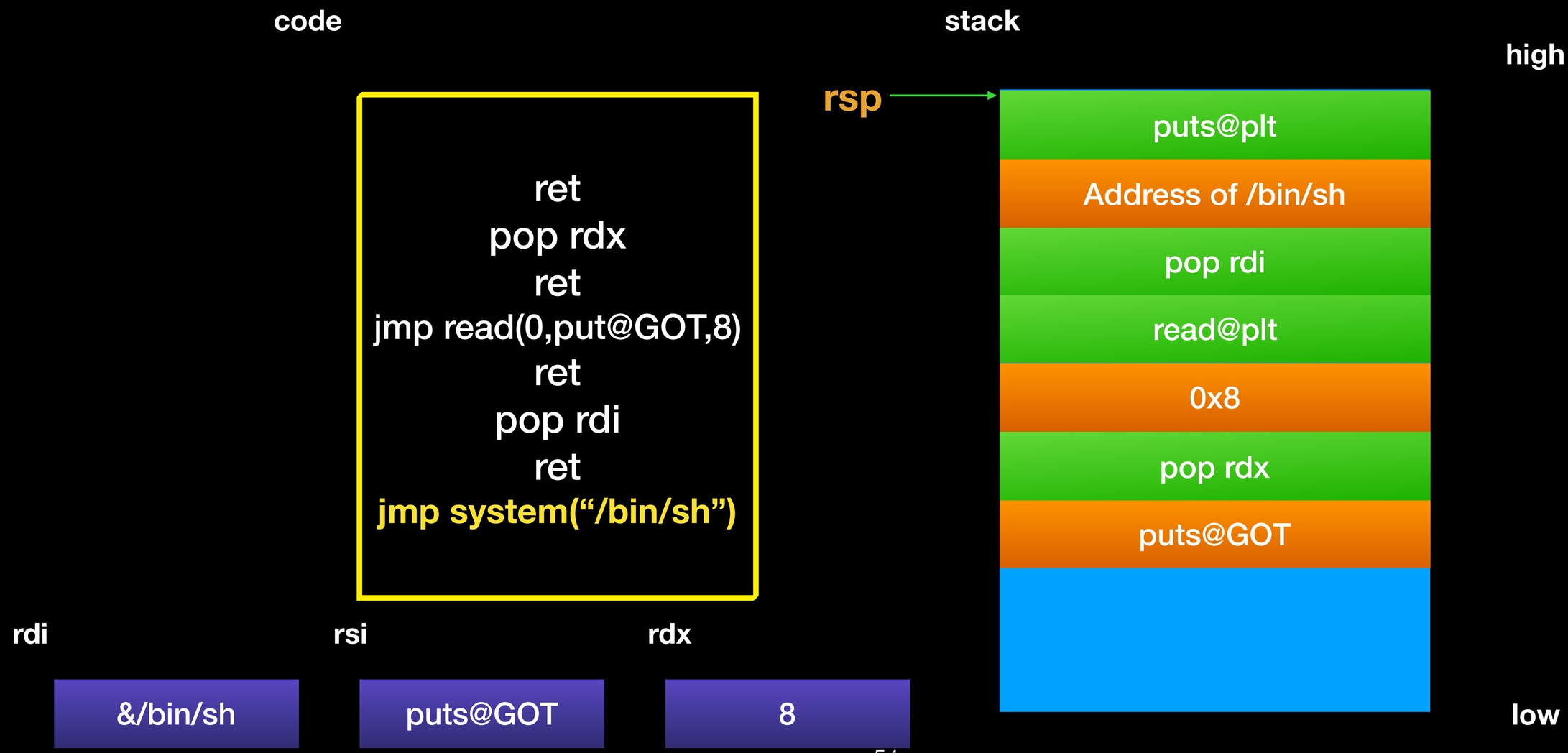
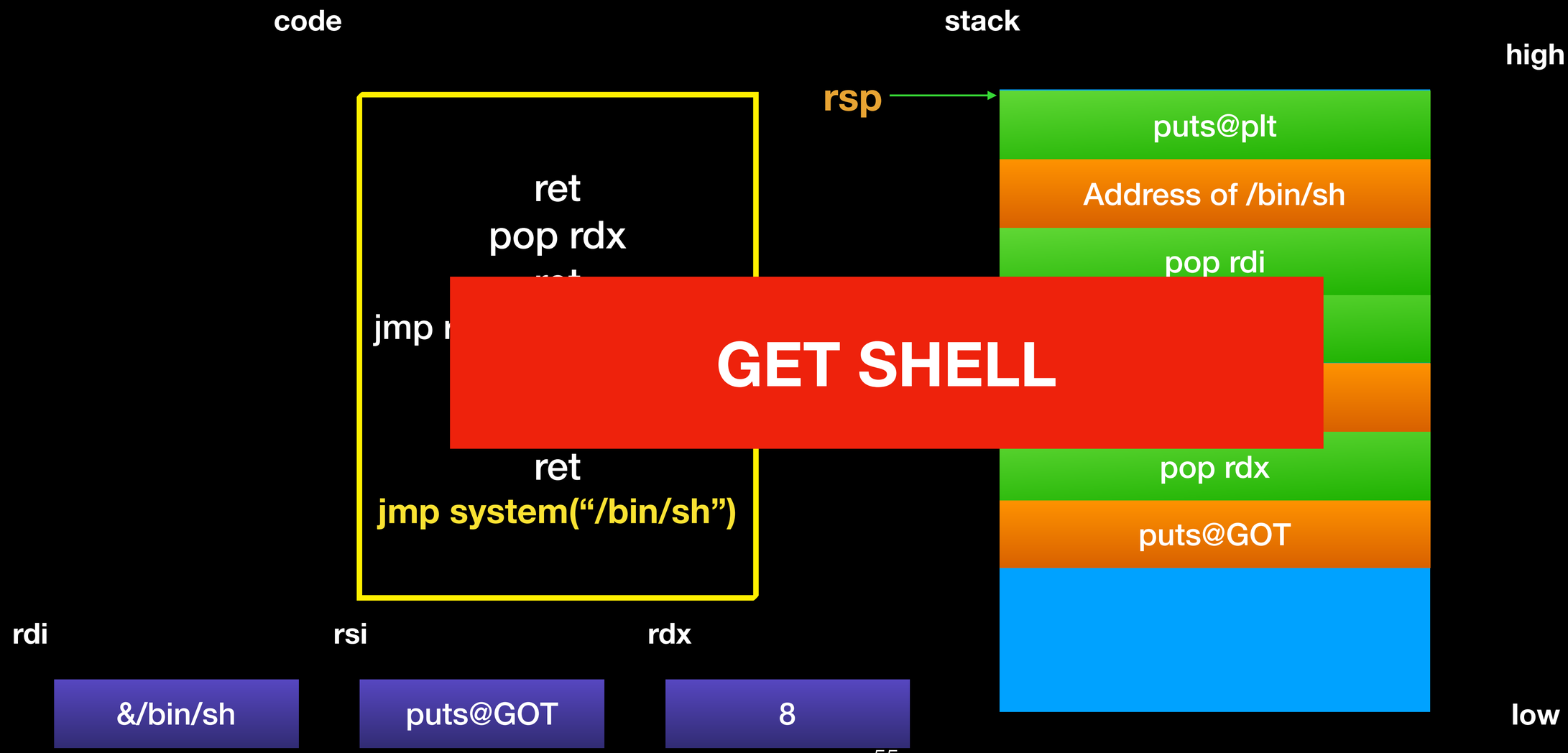


Using ROP bypass ASLR



Using ROP bypass ASLR



Using ROP bypass ASLR

- Bypass PIE
  - 必須比平常多 leak 一個 code 段的位置，藉由這個值算出 code base 進而推出所有 GOT 等資訊
  - 有了 code base 之後其他就跟沒有 PIE 的情況下一樣

Using ROP bypass ASLR

- Bypass StackGuard
  - canary 只有在 function return 時做檢查
  - 只檢查 canary 值時否一樣
  - 所以可以先想辦法 leak 出 canary 的值，塞一模一樣的內容就可 bypass，或是想辦法不要改到 canary 也可以

Using ROP bypass ASLR

- Weakness in fork
  - canary and memory mappings are same as parent.

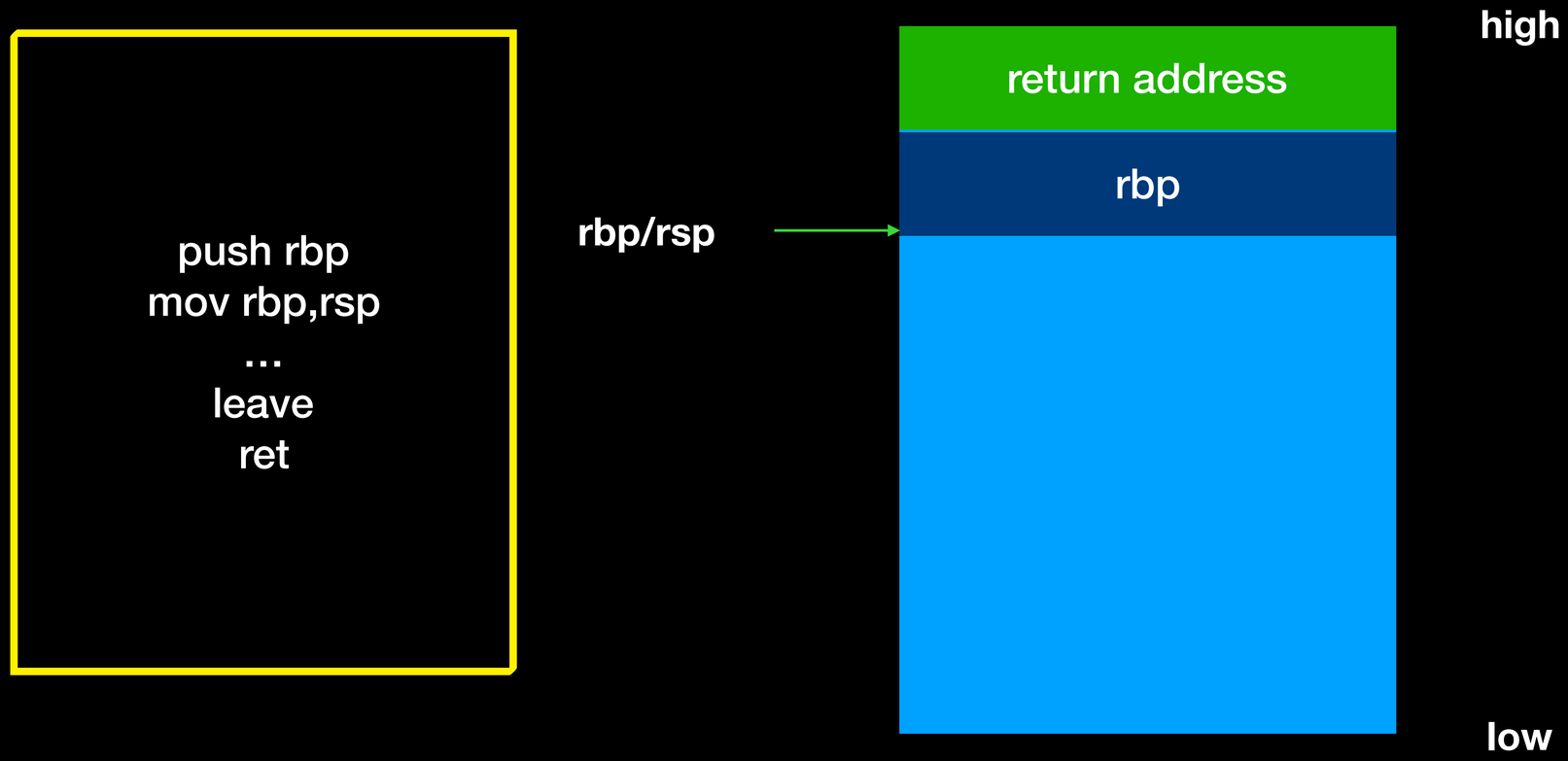
Outline

- ROP
- Using ROP bypass ASLR
- Stack migration

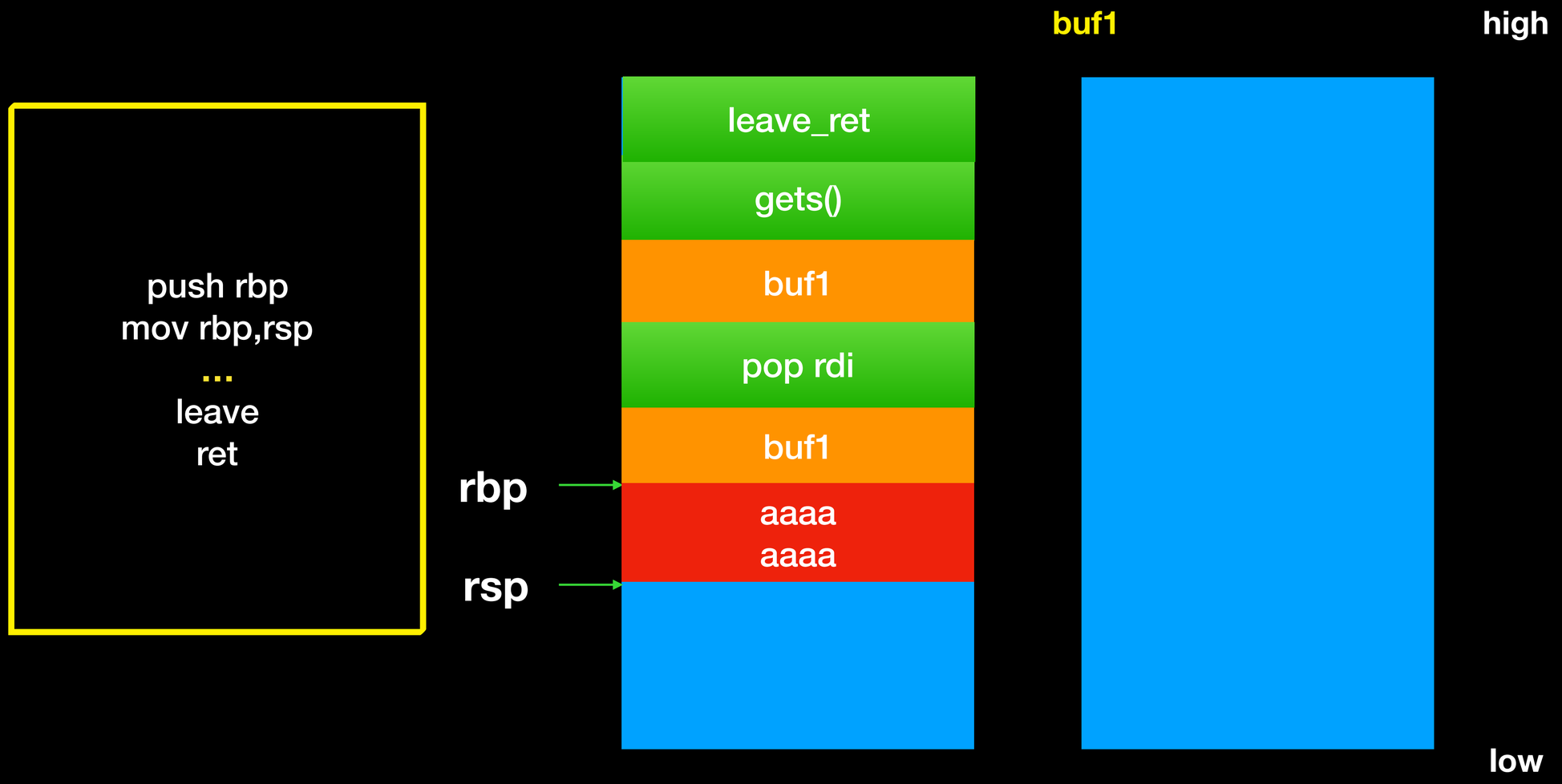
Stack Migration

- 將 ROP Chain 寫在已知固定位置上
- 再利用 leave 搬移 Stack 位置到已知位置
- 可無限接 ROP Chain
- 必須注意到 Migration 之後 stack 要留大一點，有些 function 可能會需要很大的 stack frame ，太小可能會存取到唯獨區域，導致 Segmentation Fault

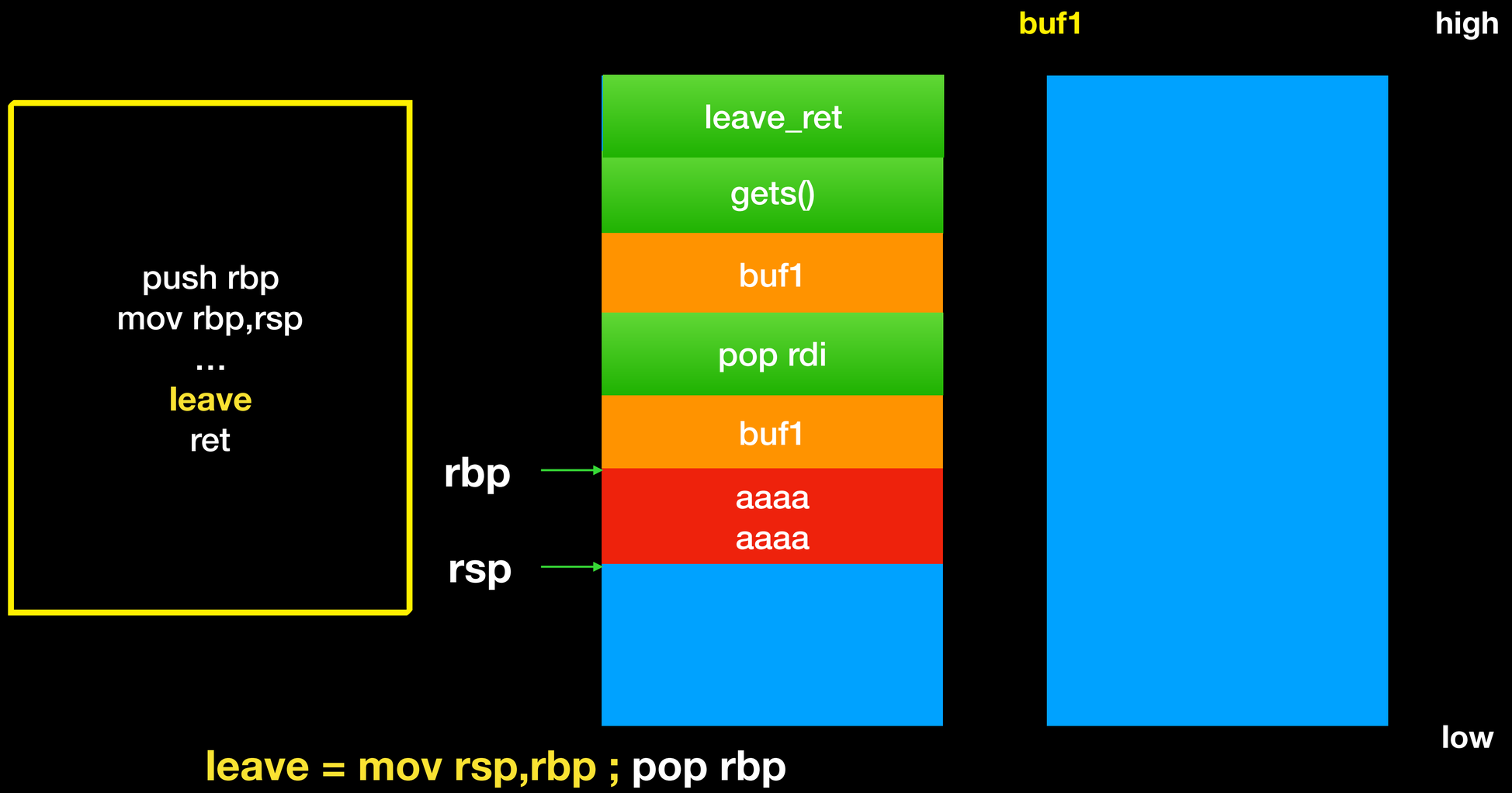
Stack Migration



Stack Migration

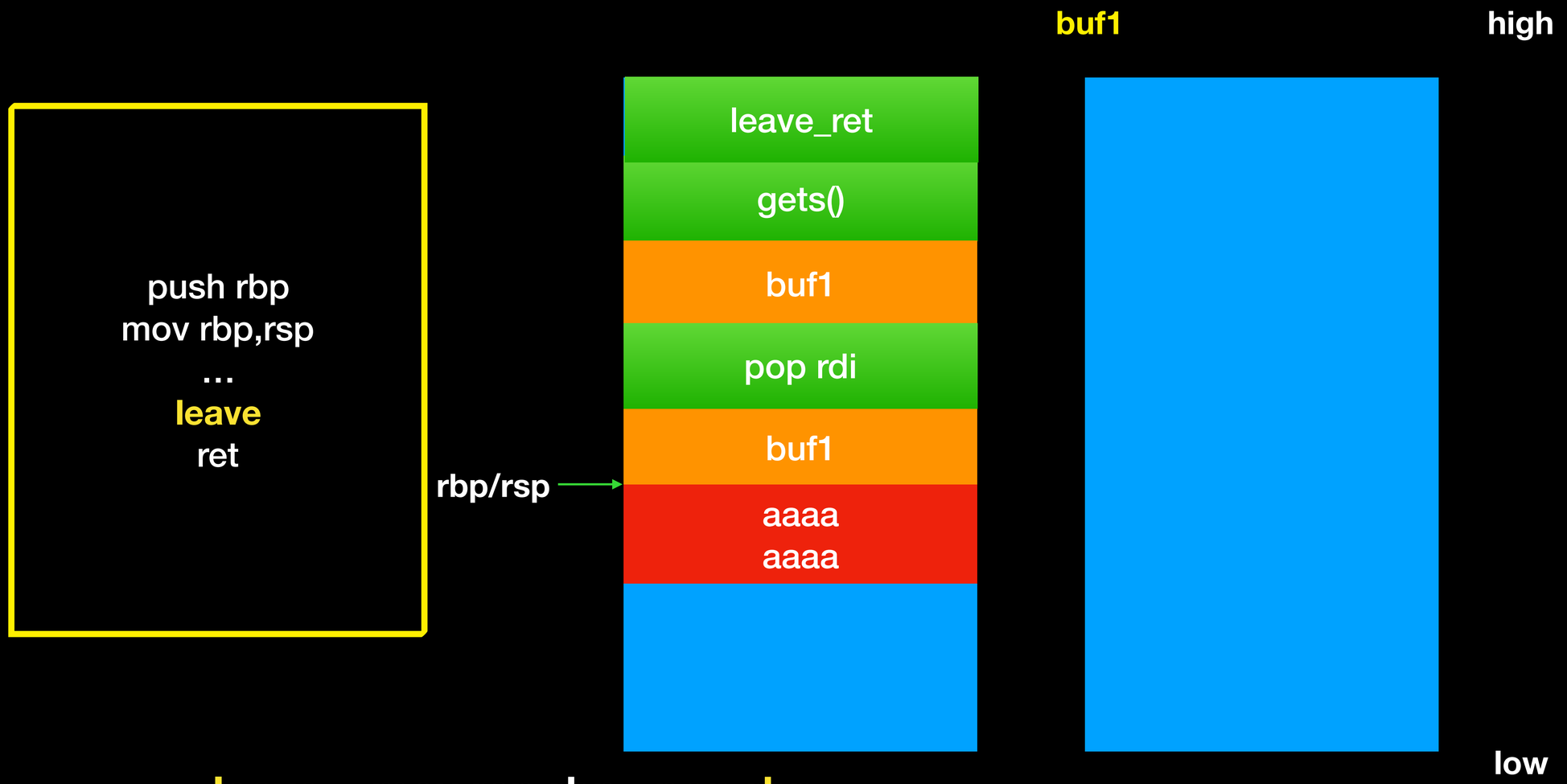


Stack Migration



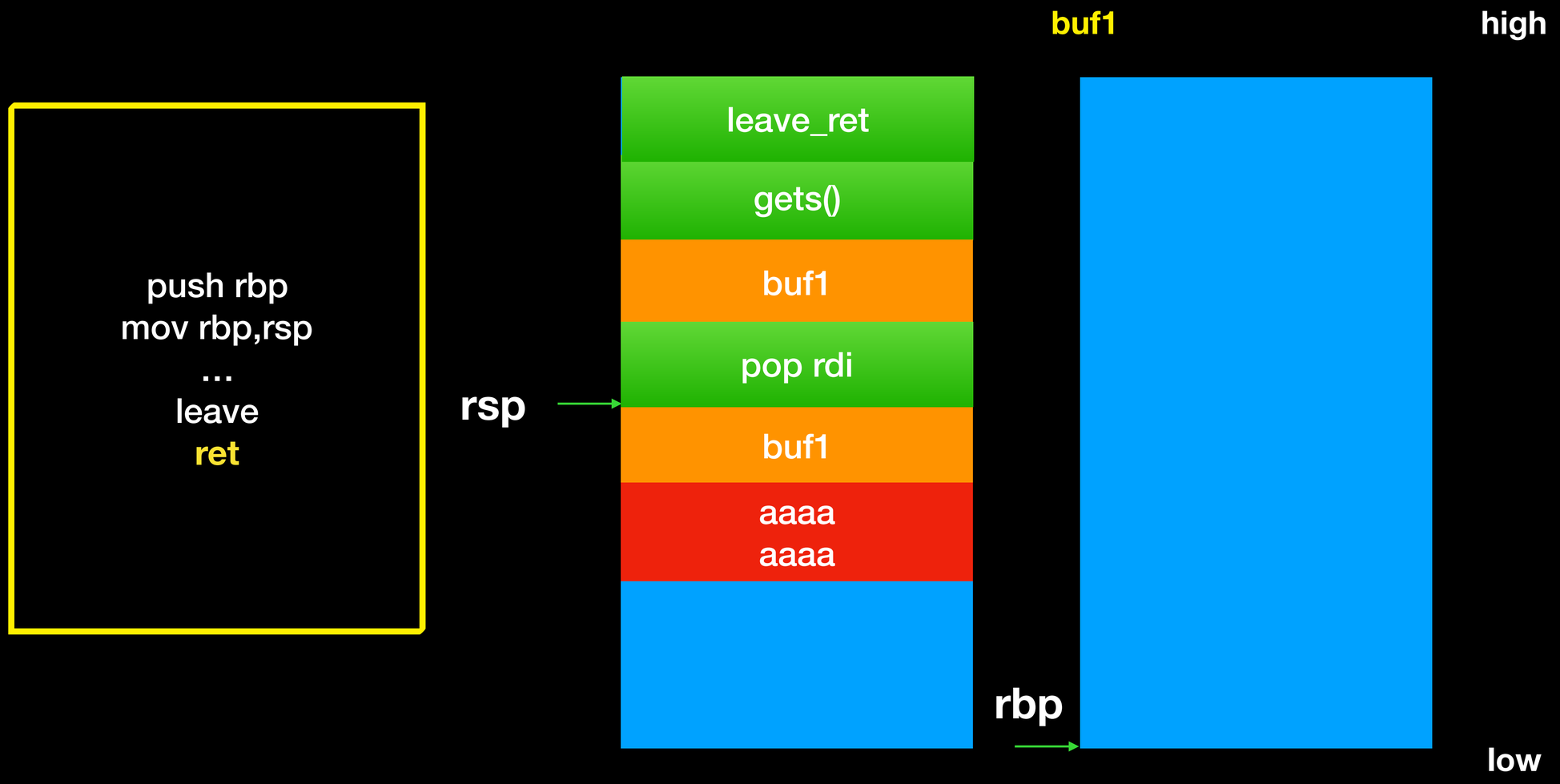
leave = mov rsp,rbp ; pop rbp

Stack Migration



leave = mov rsp,rbp ; pop rbp

Stack Migration



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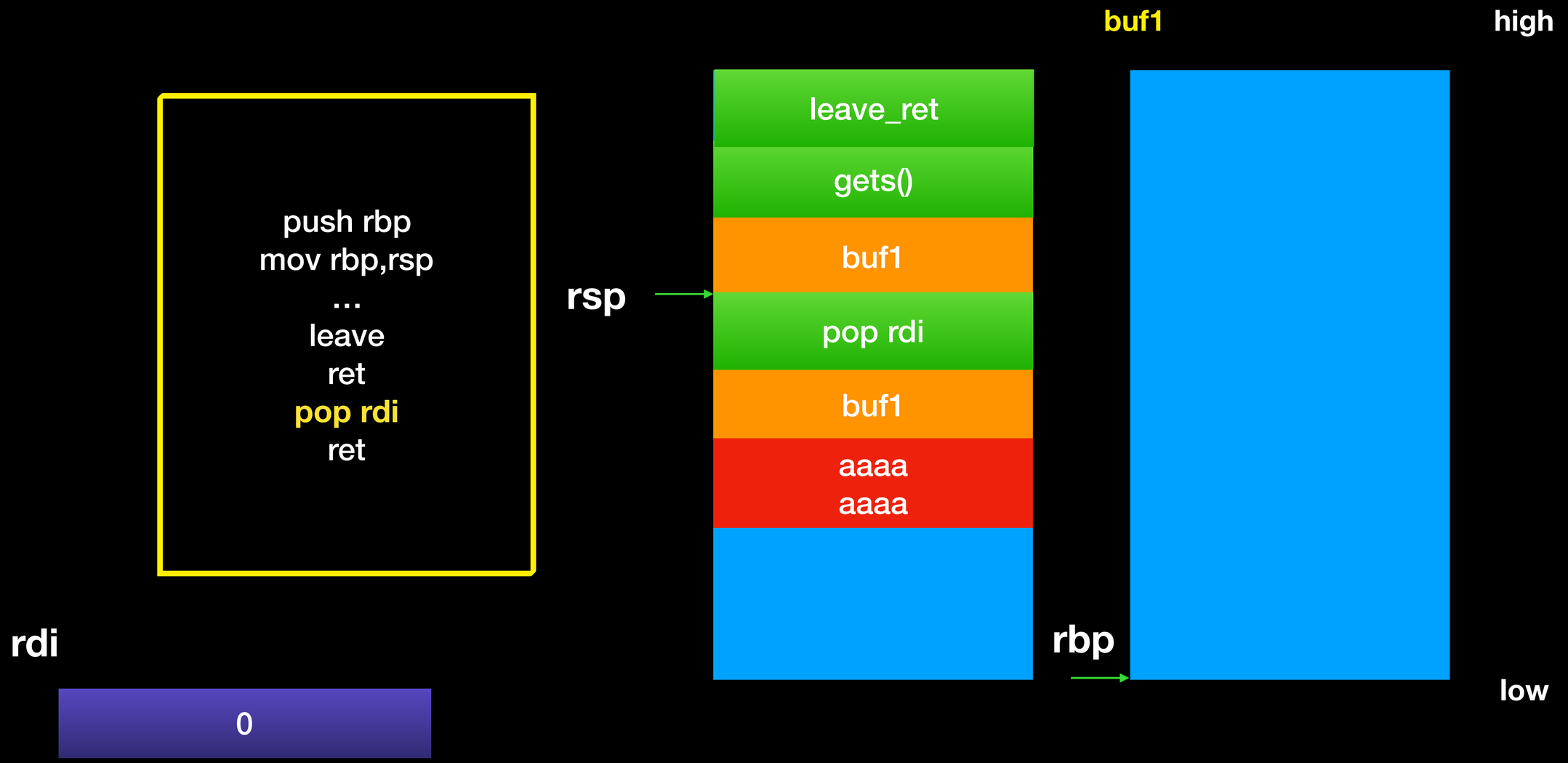

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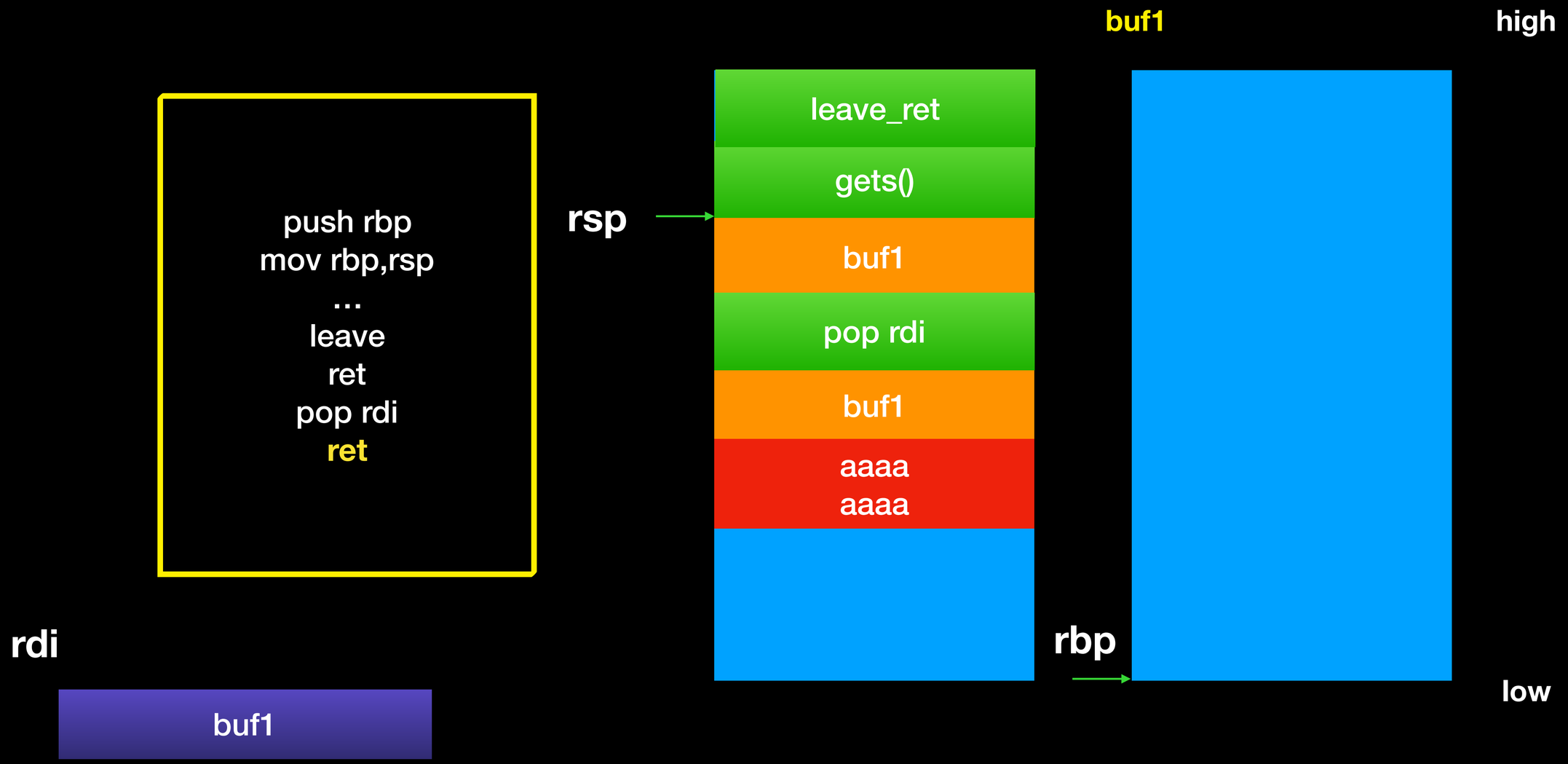

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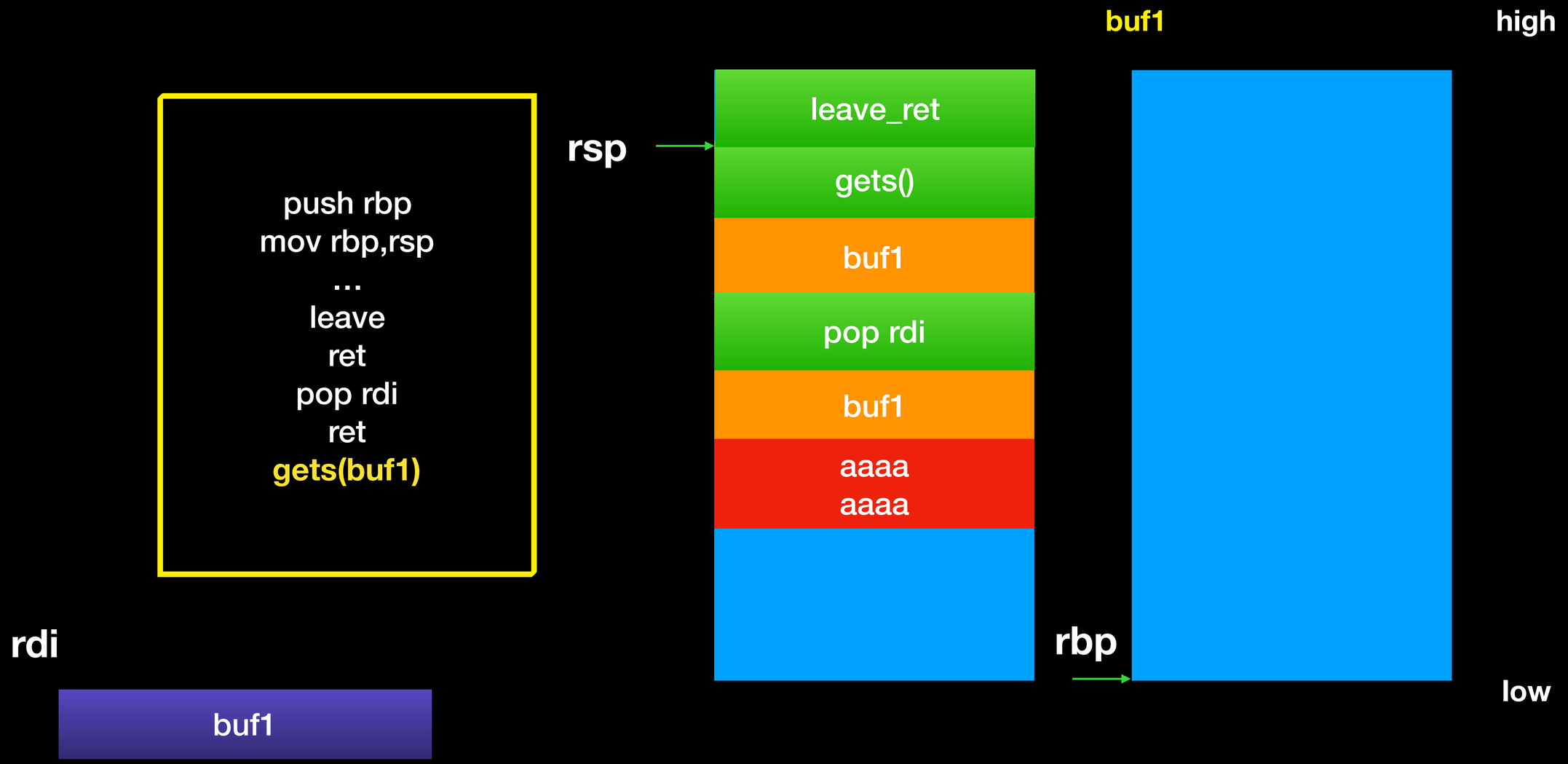

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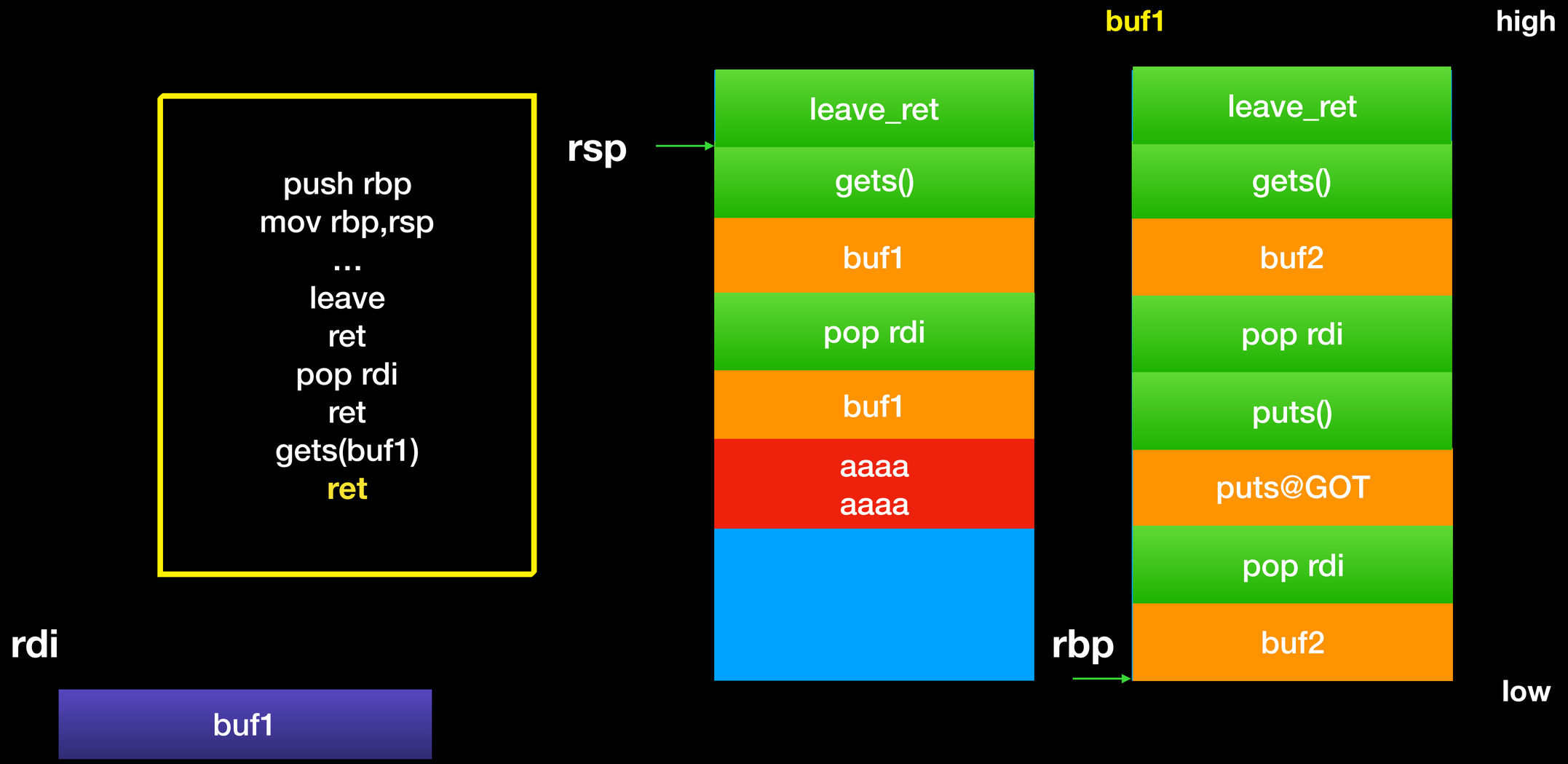

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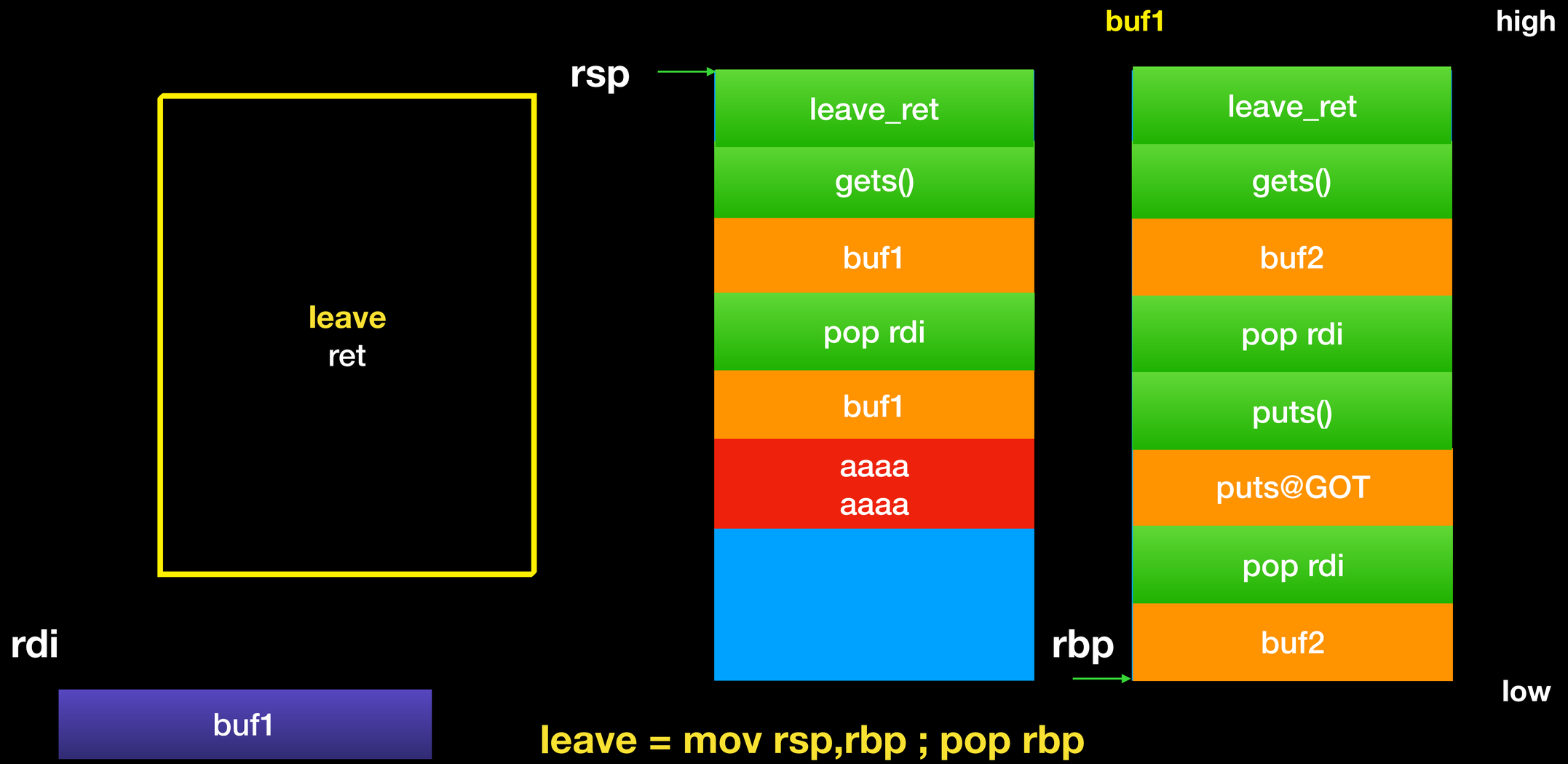

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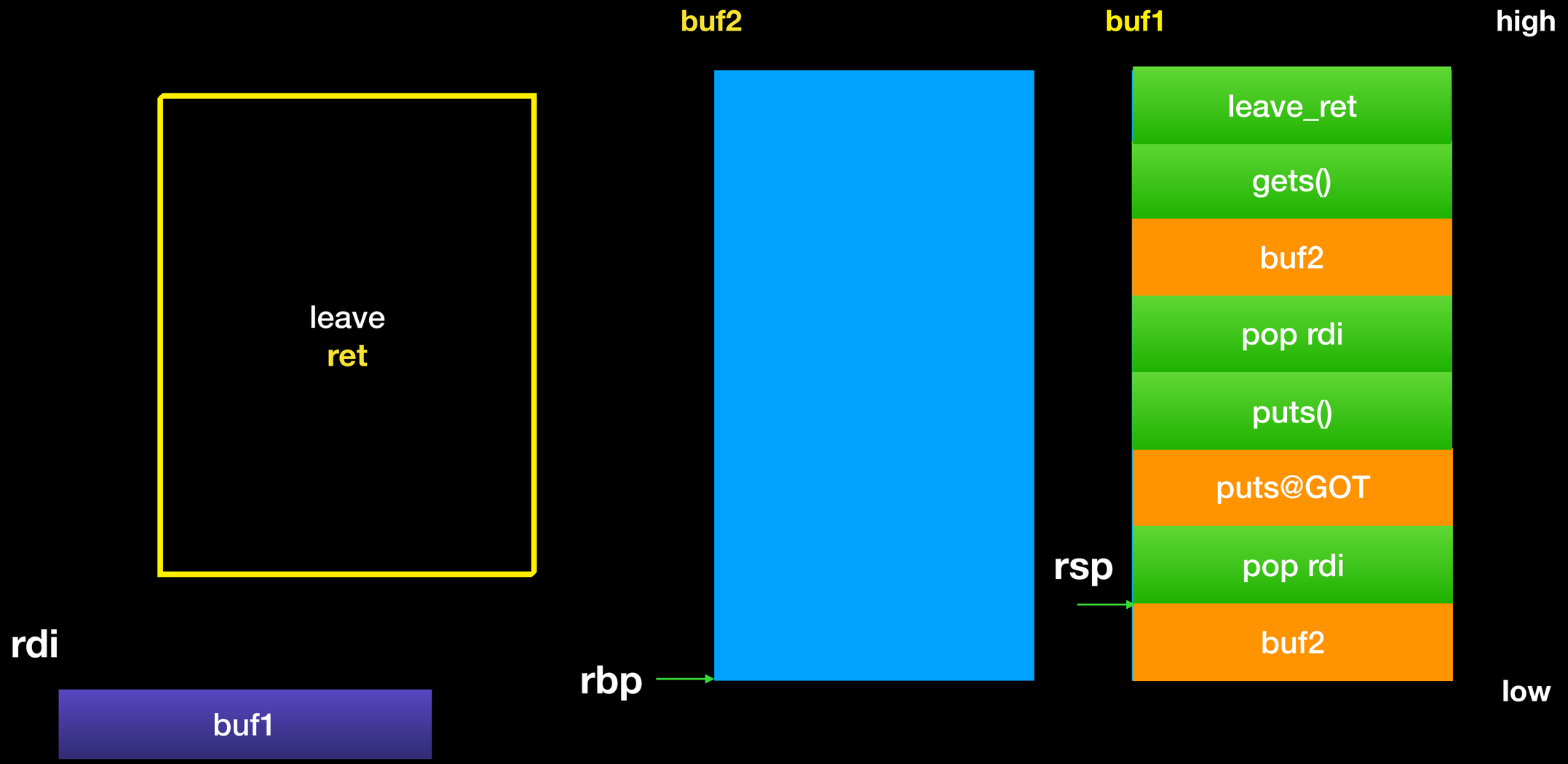

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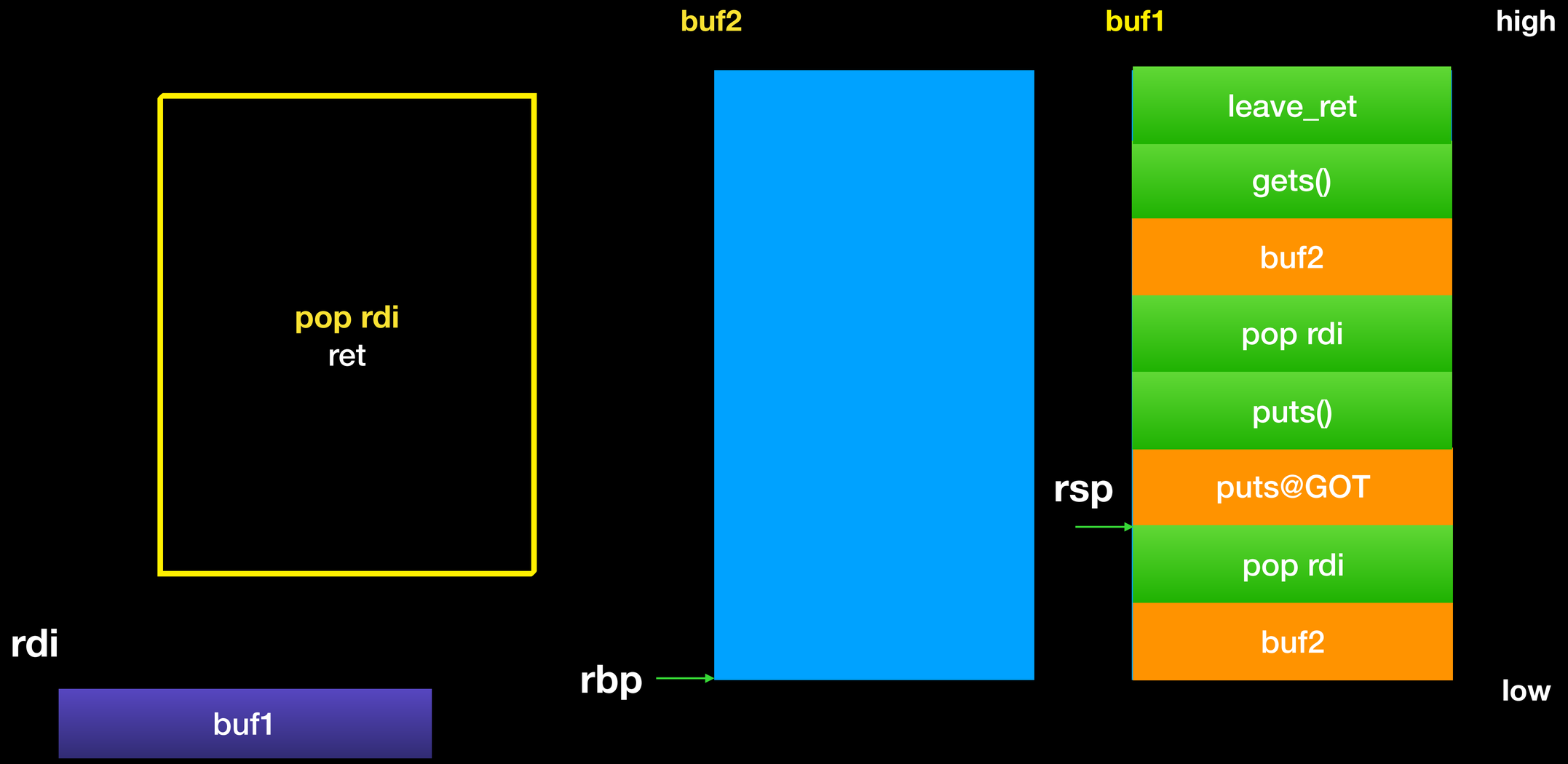

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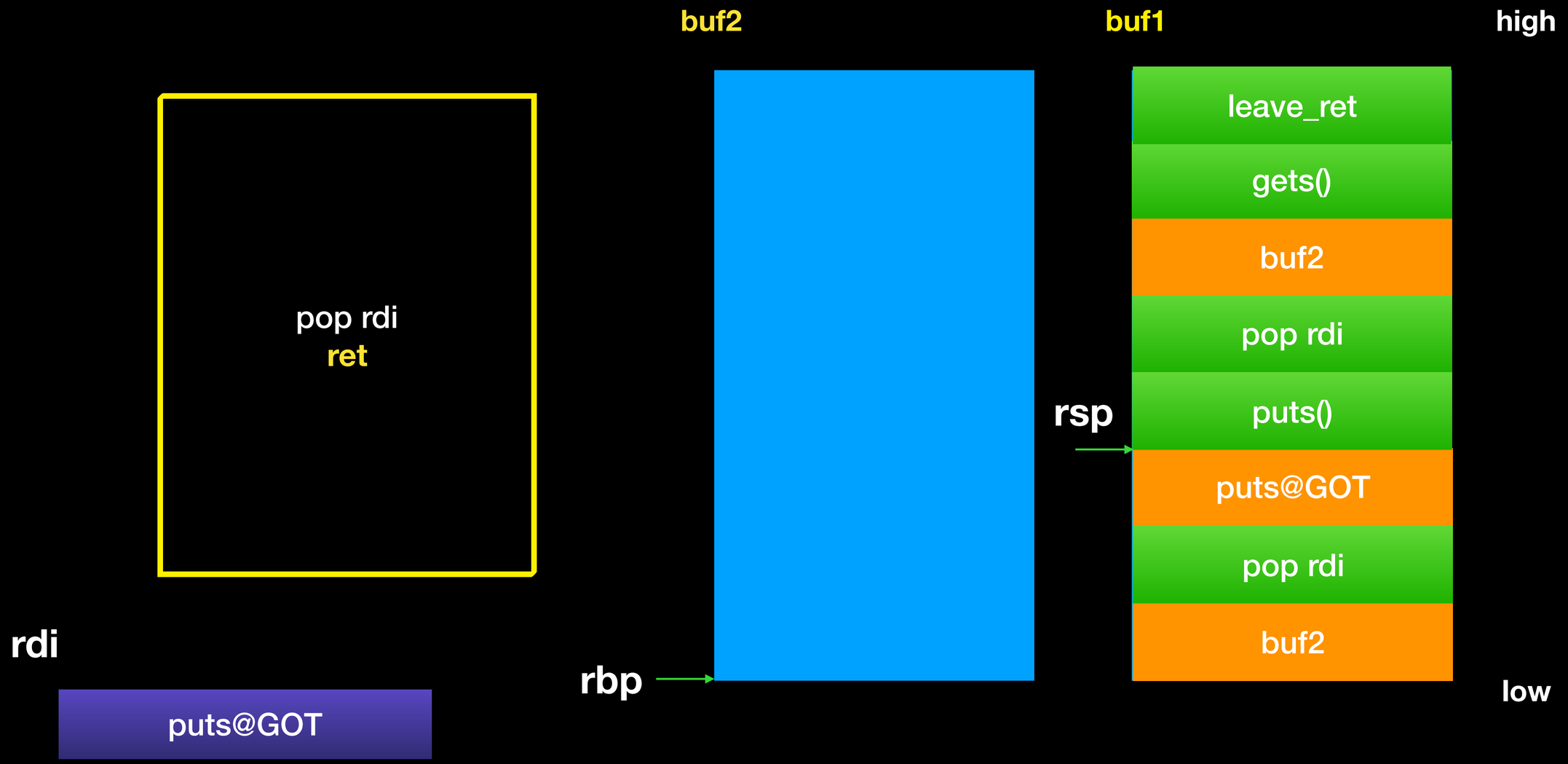

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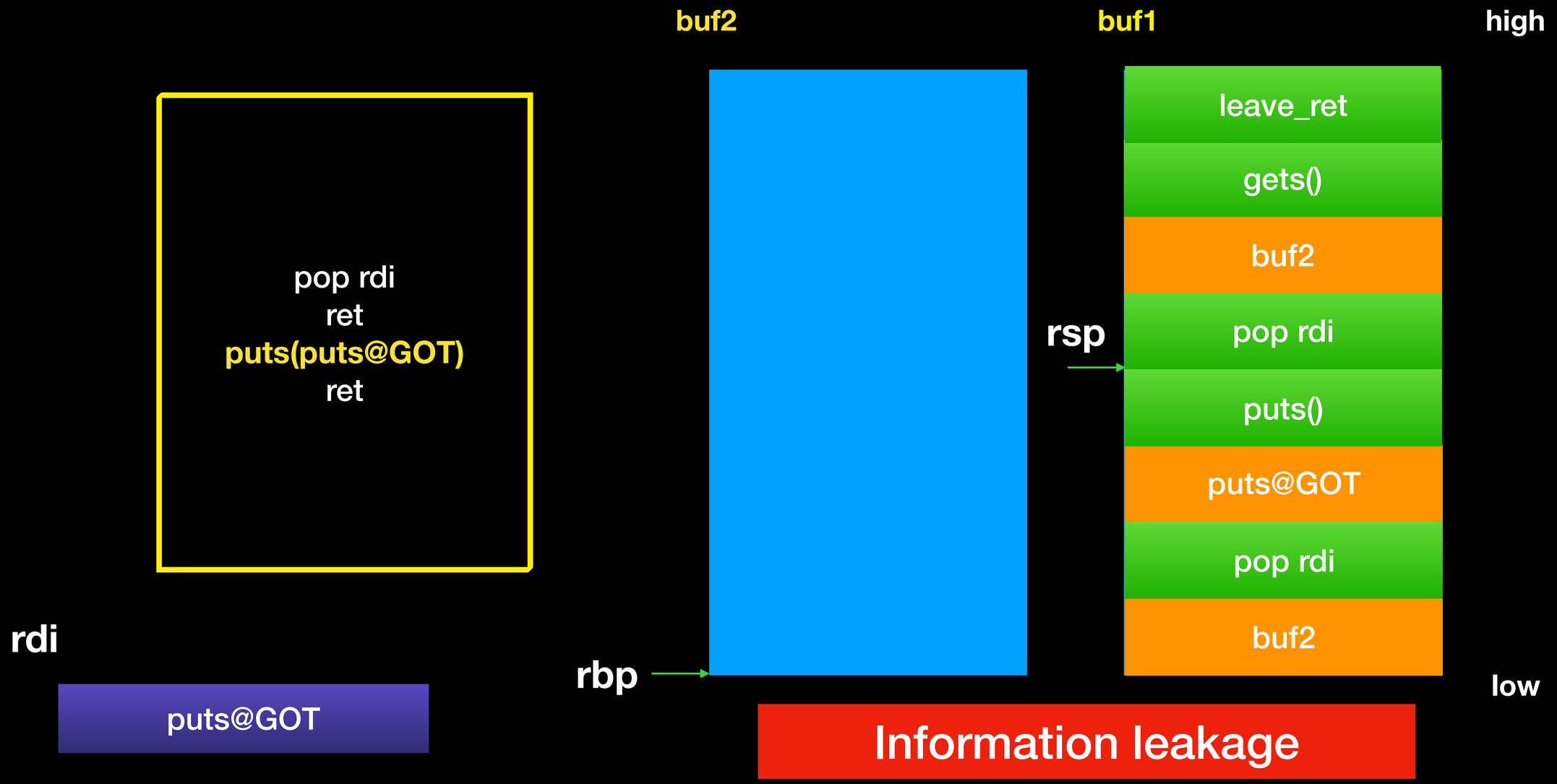

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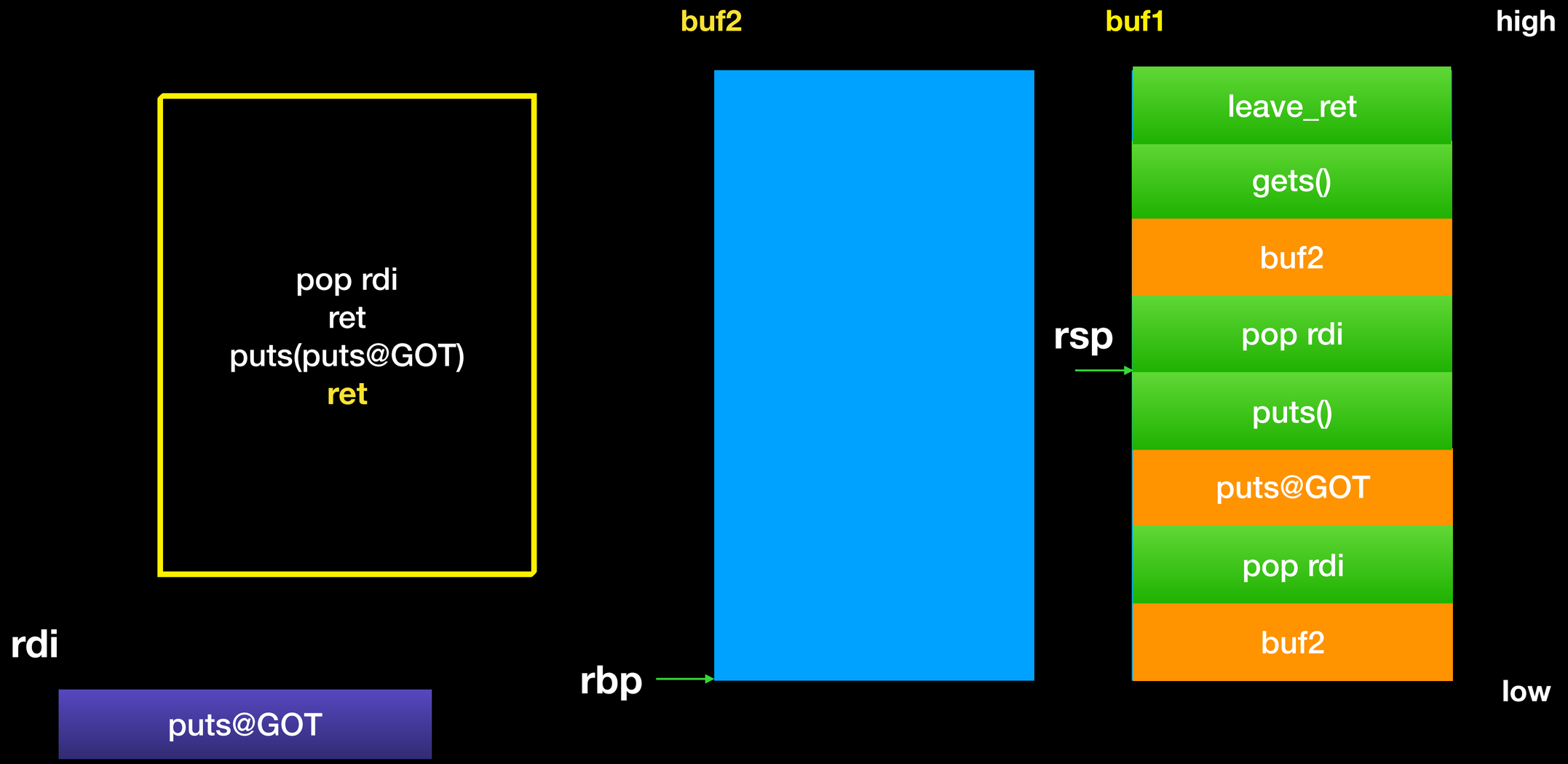

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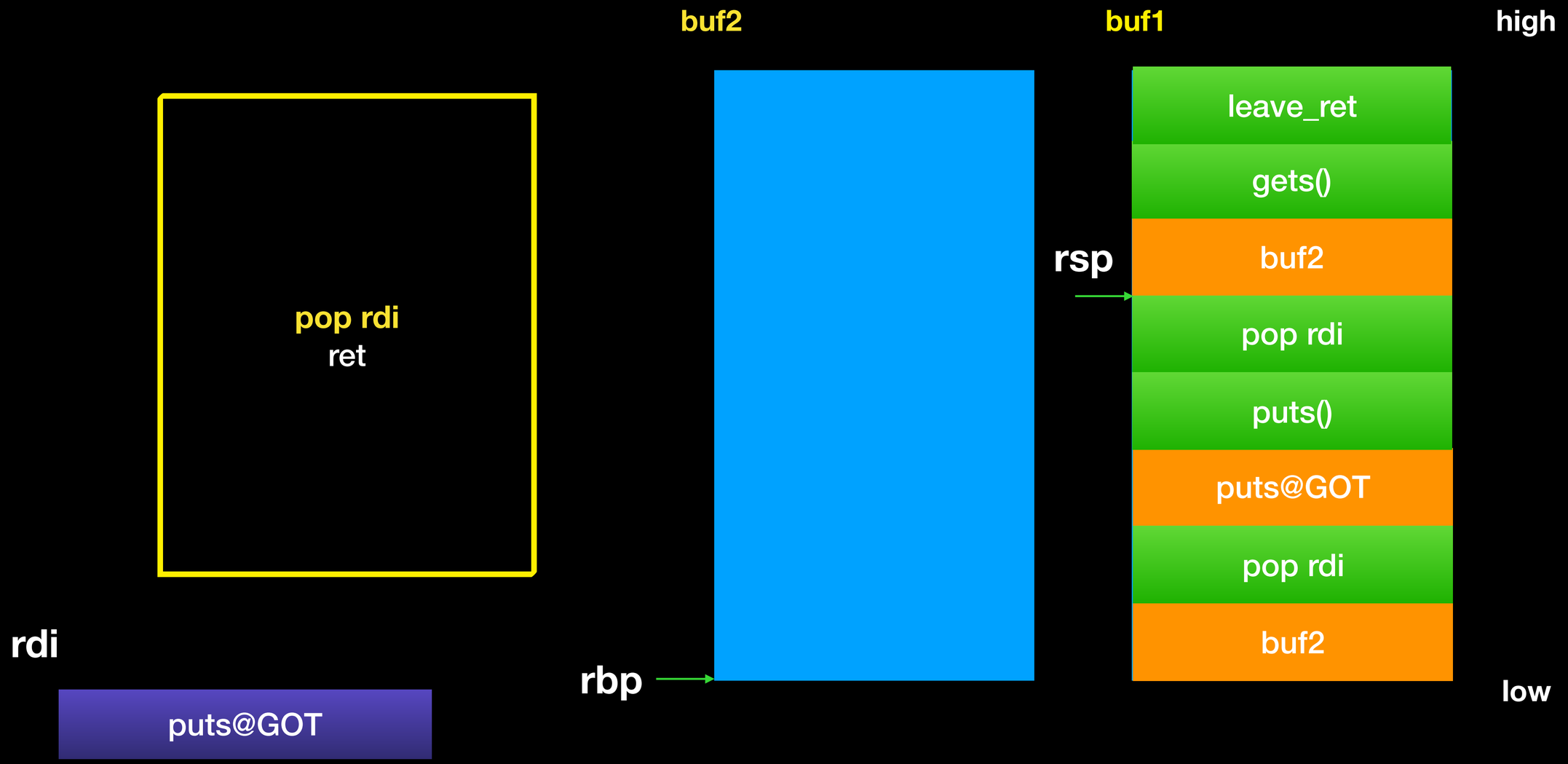

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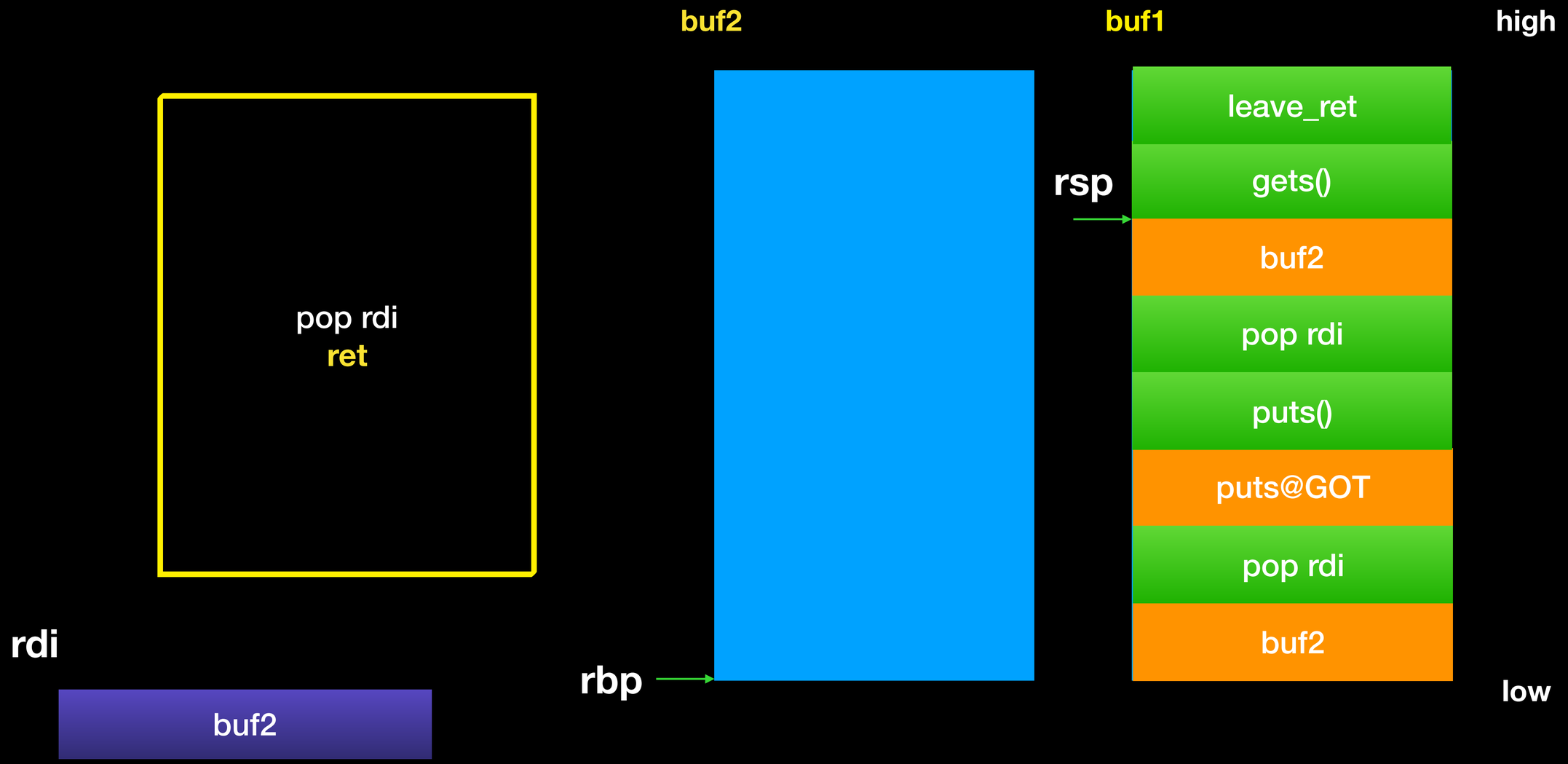

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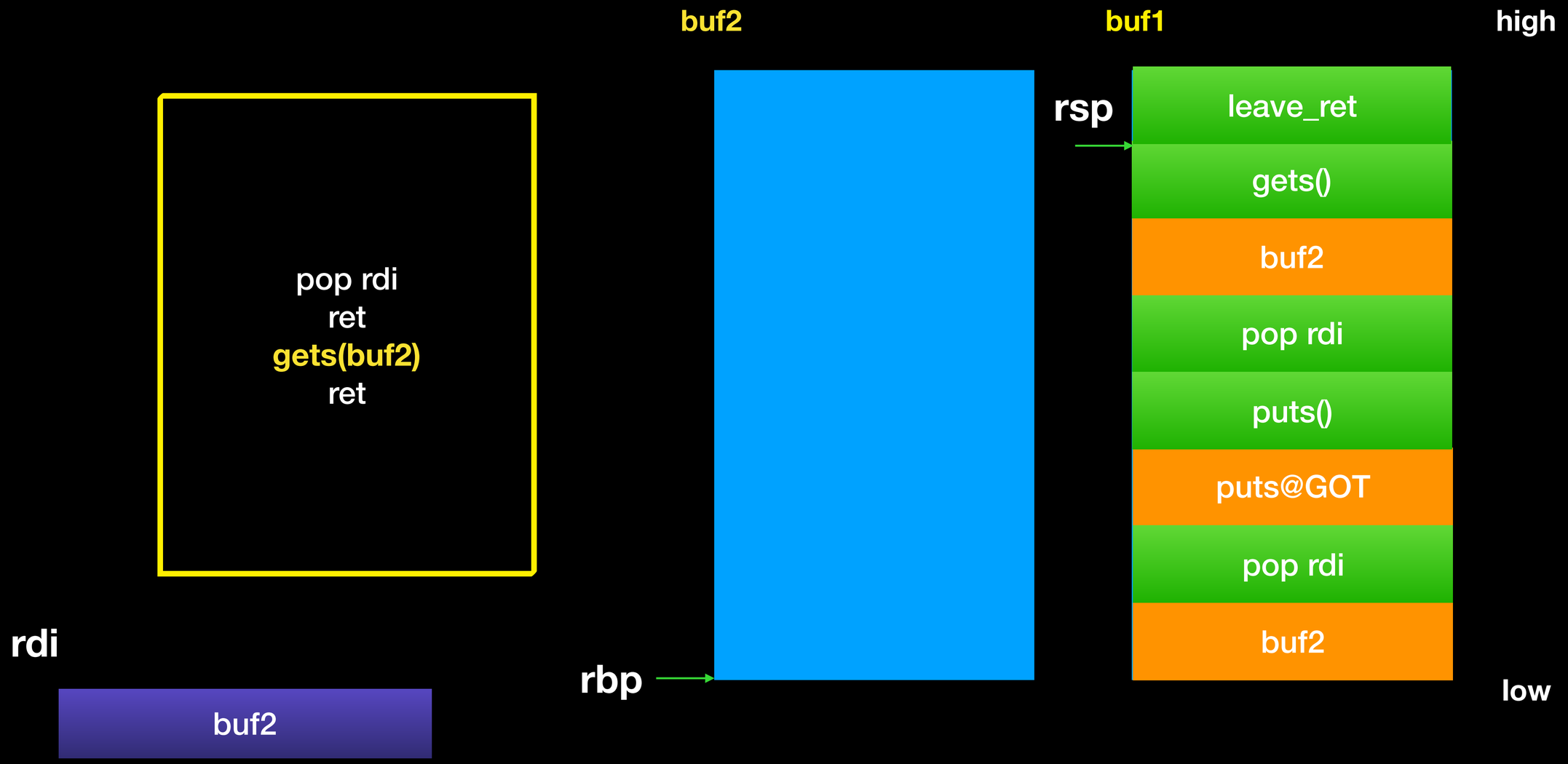

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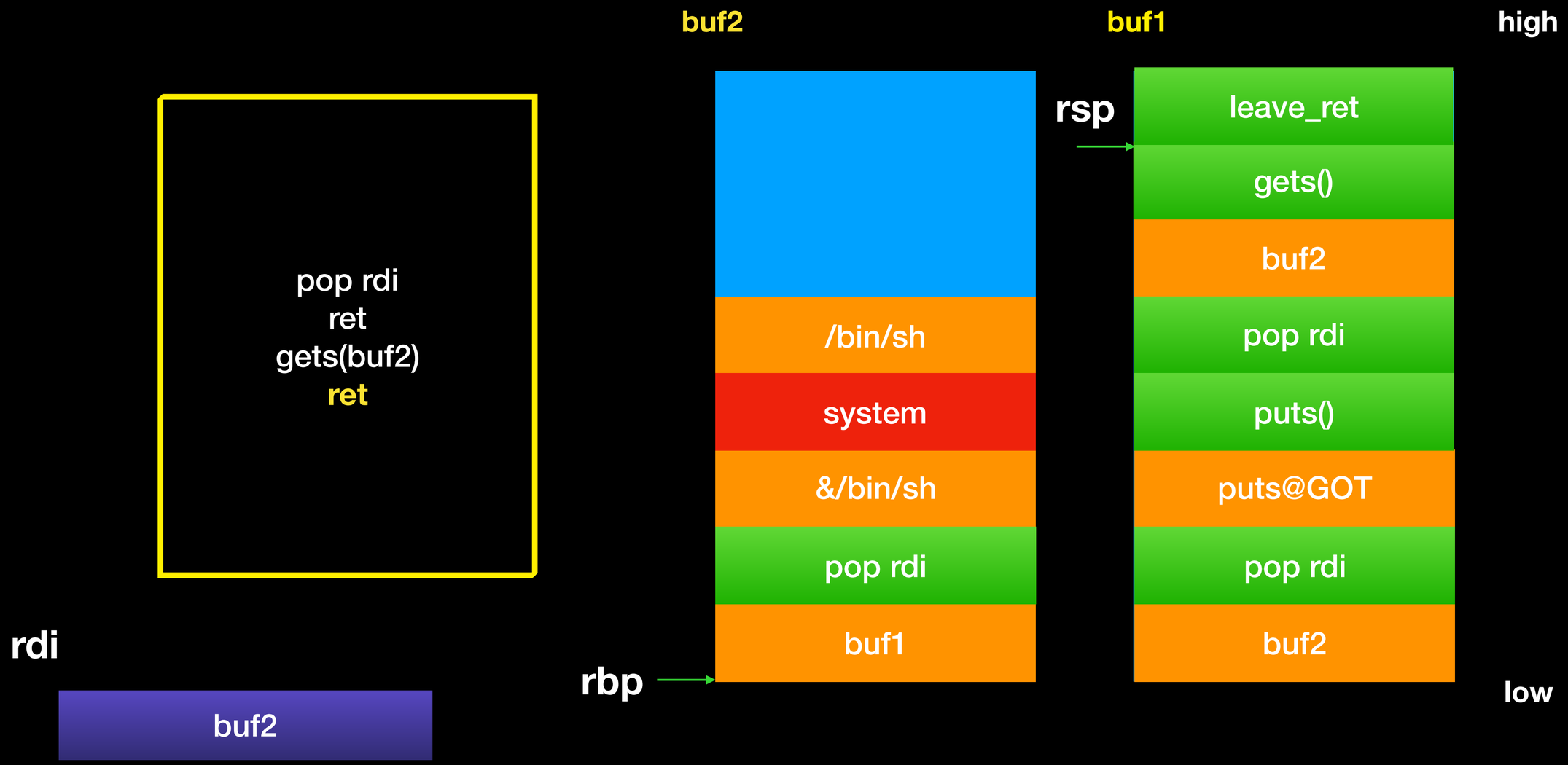

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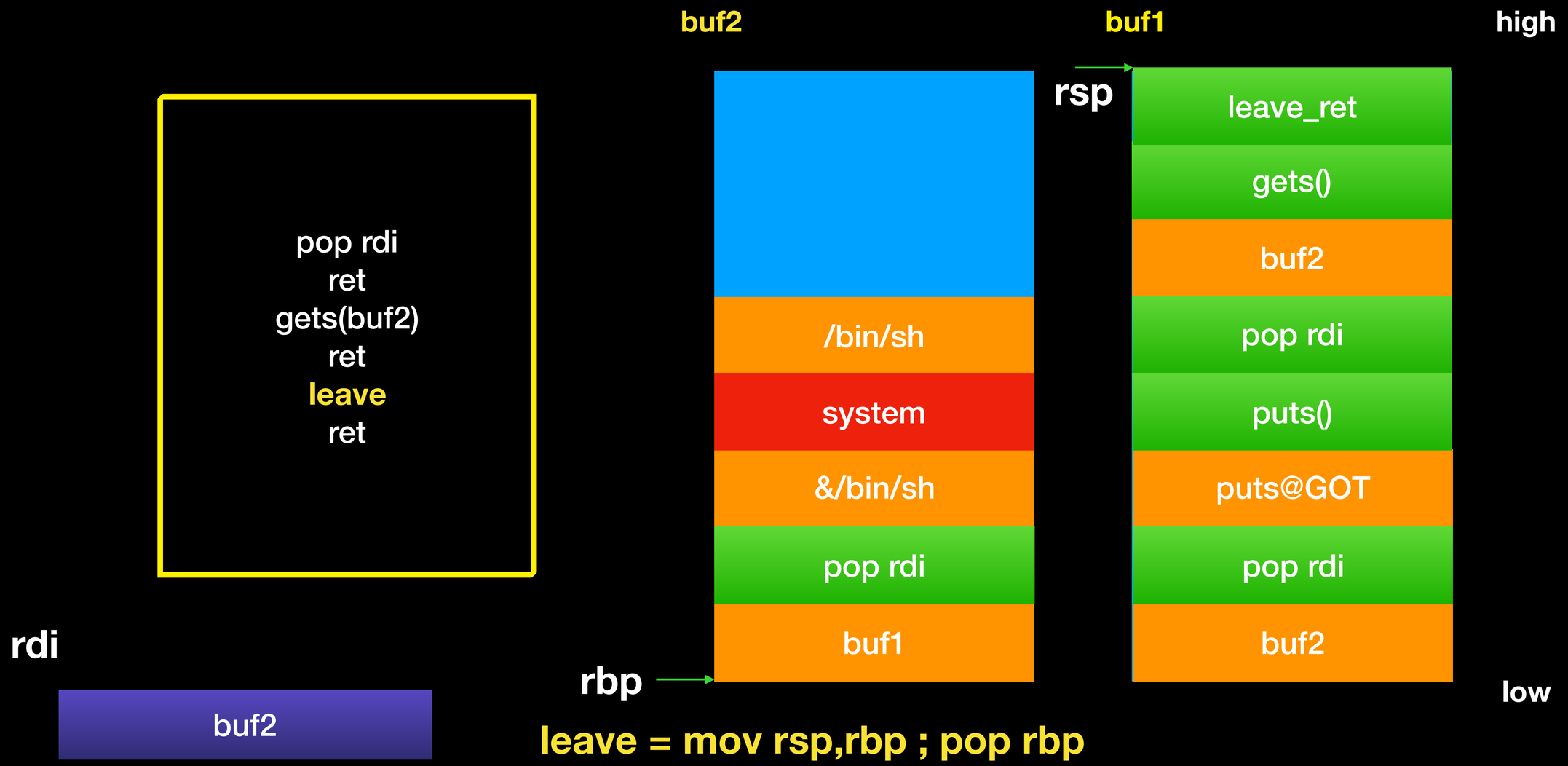
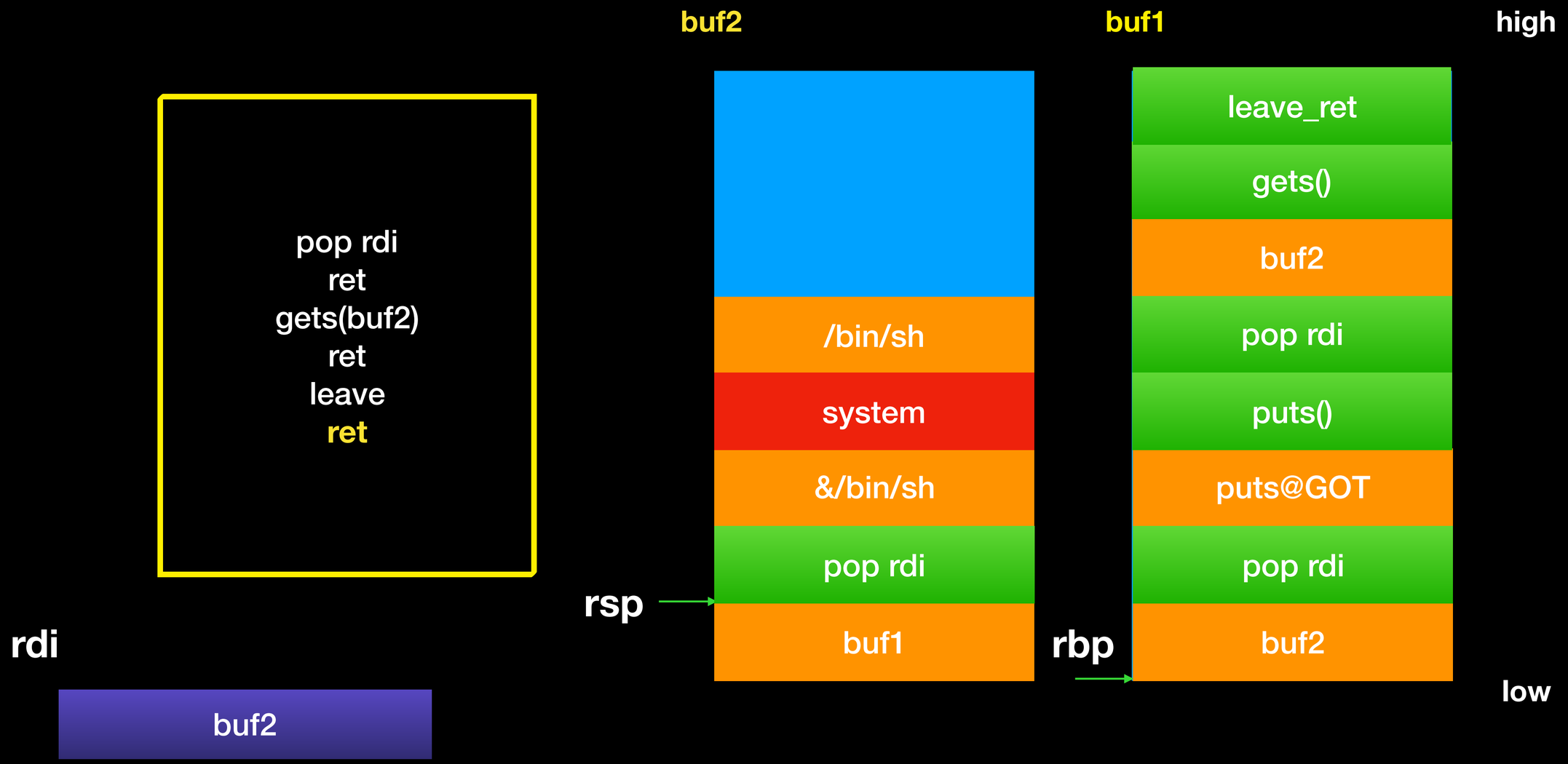


leave = mov rsp,rbp ; pop rbp

Stack Migration



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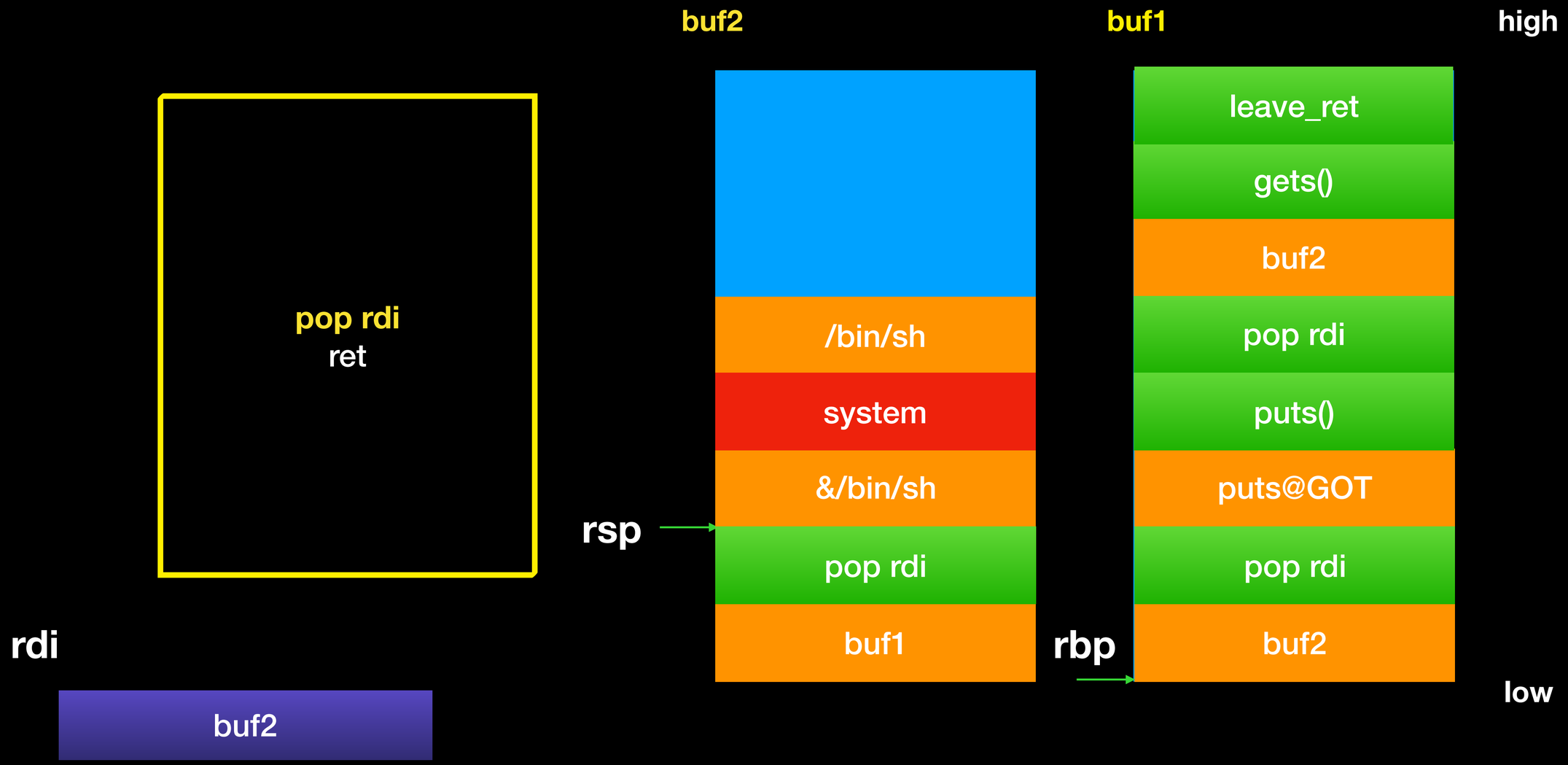

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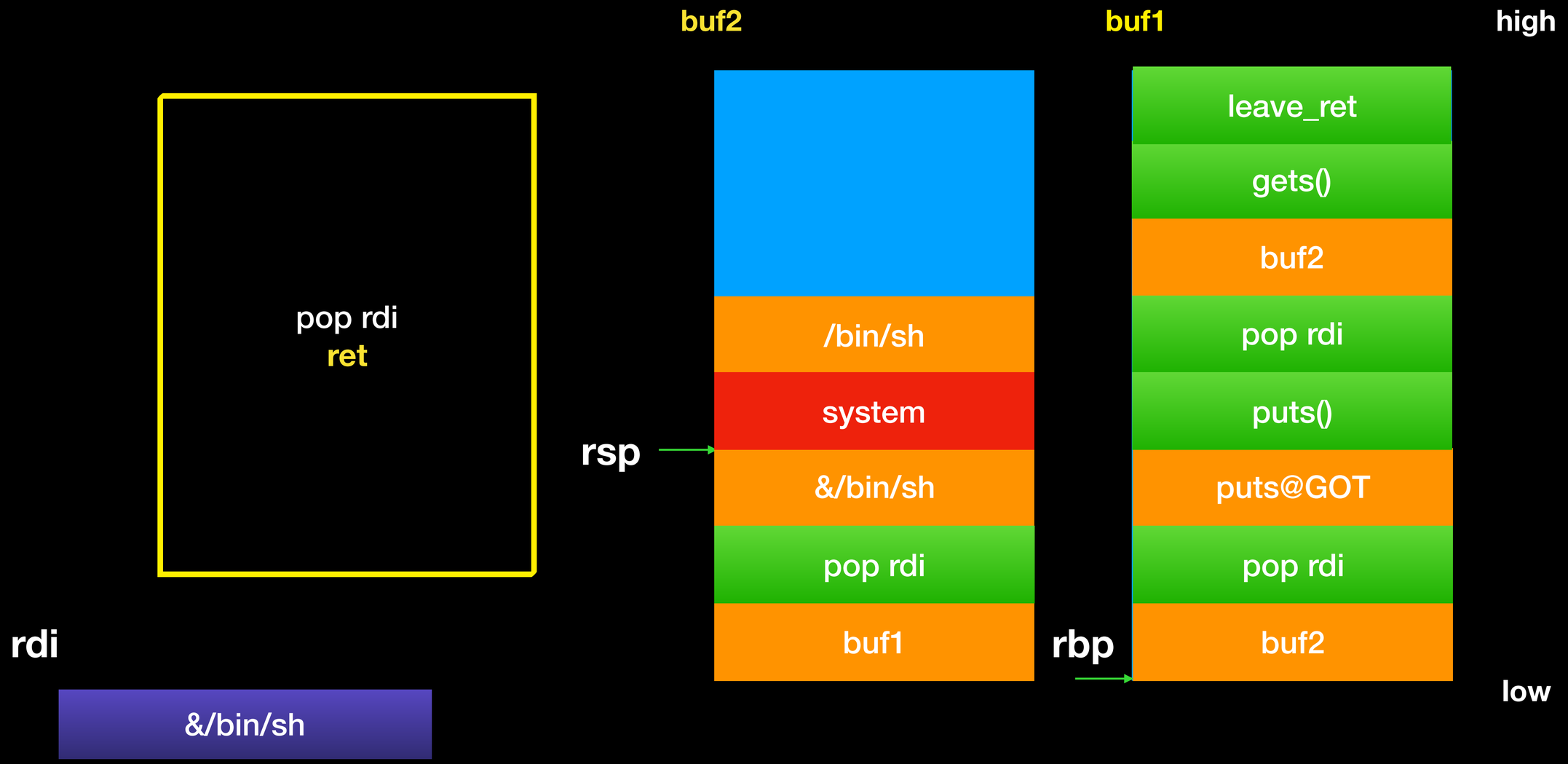

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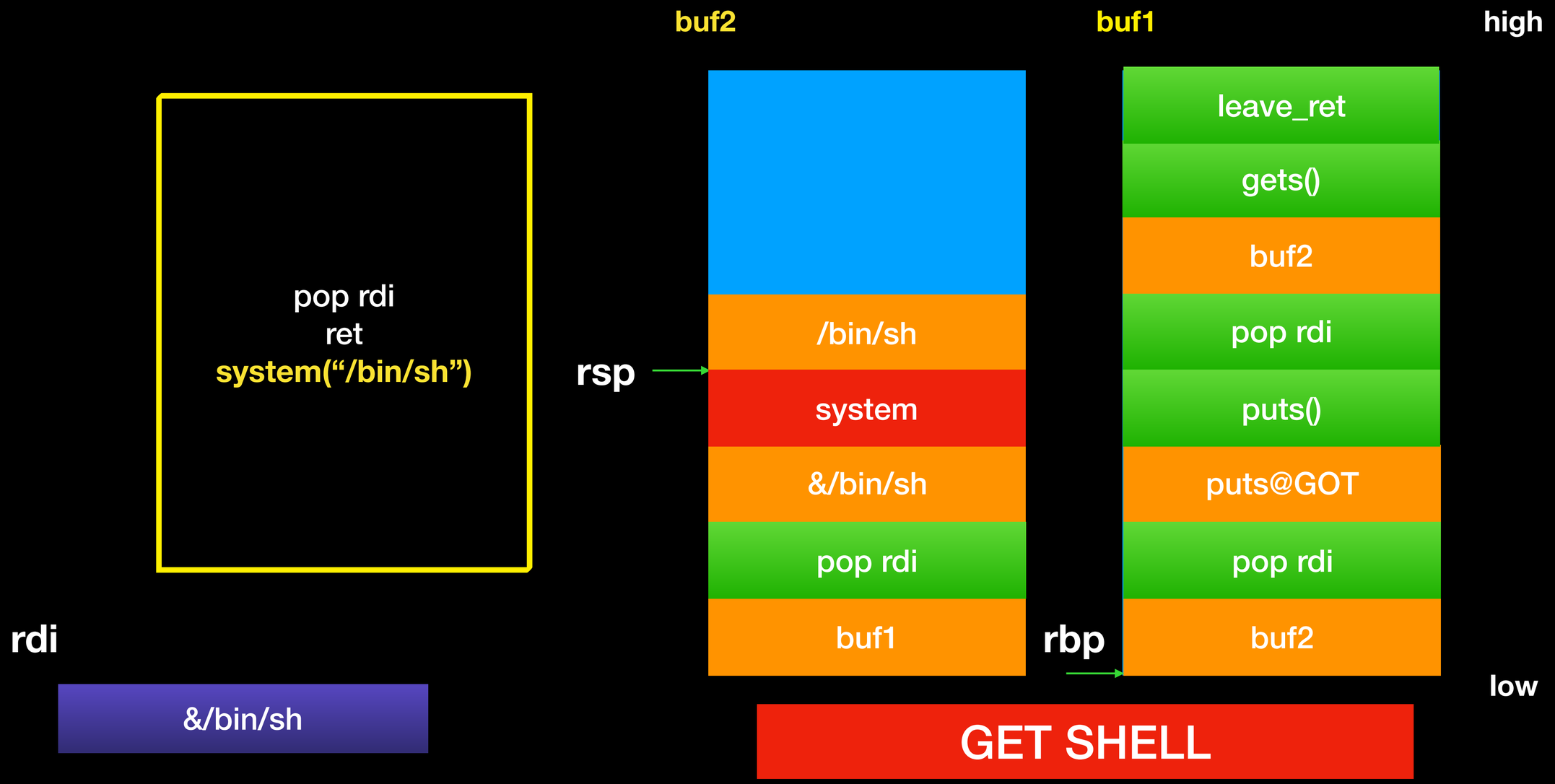


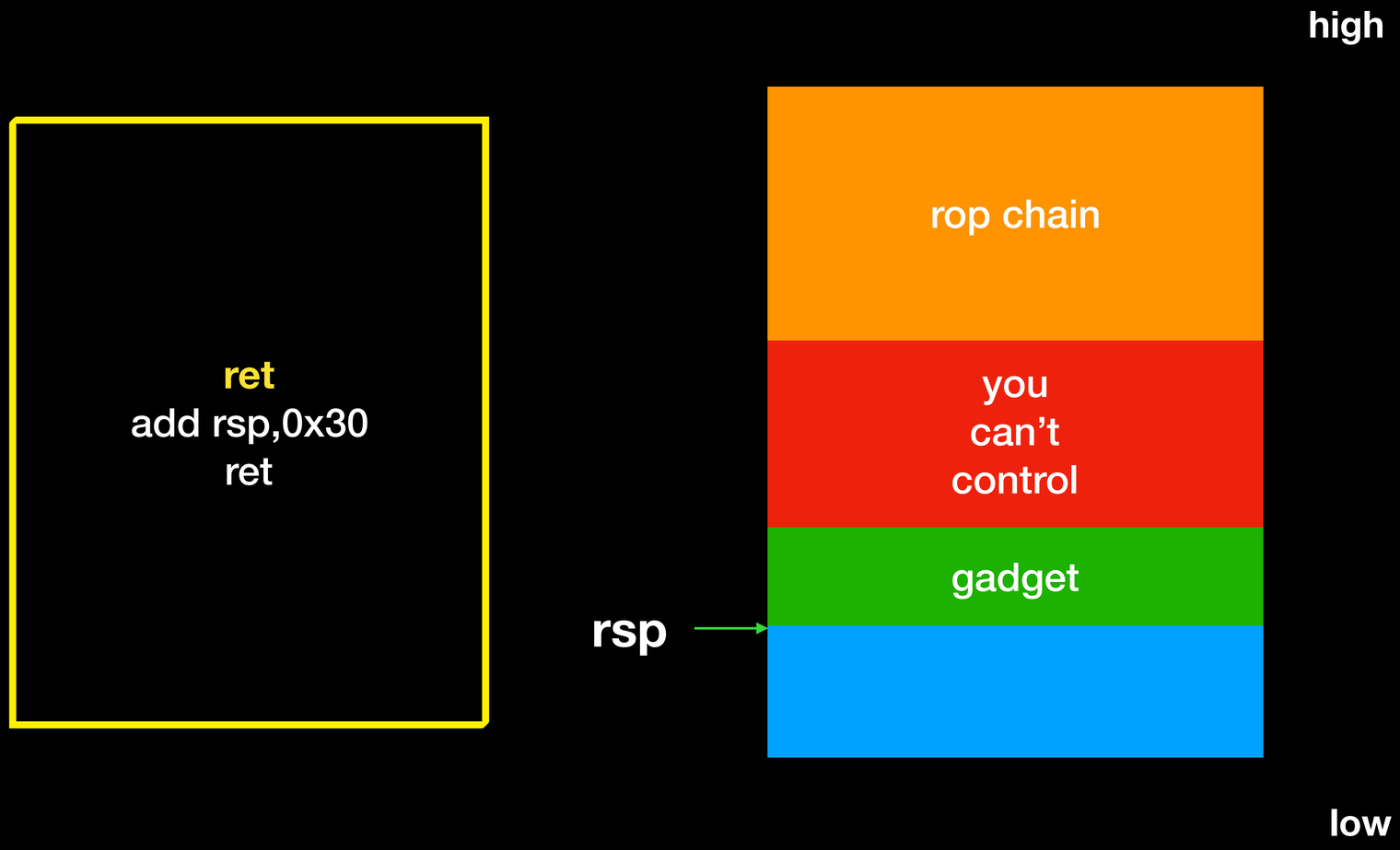
Stack Migration

- 若能妥善利用，在沒有 libc 的情況下，有機會將整個 libc 給 dump 出來，更有機會直接找出 system 的位置
- 無限 ROP ，幾乎可以做出所有事情，但唯一要注意的是 buf 大小要控制好，盡量選 bss 後半段位置，否則可能因為 stack 不夠大而 segfault

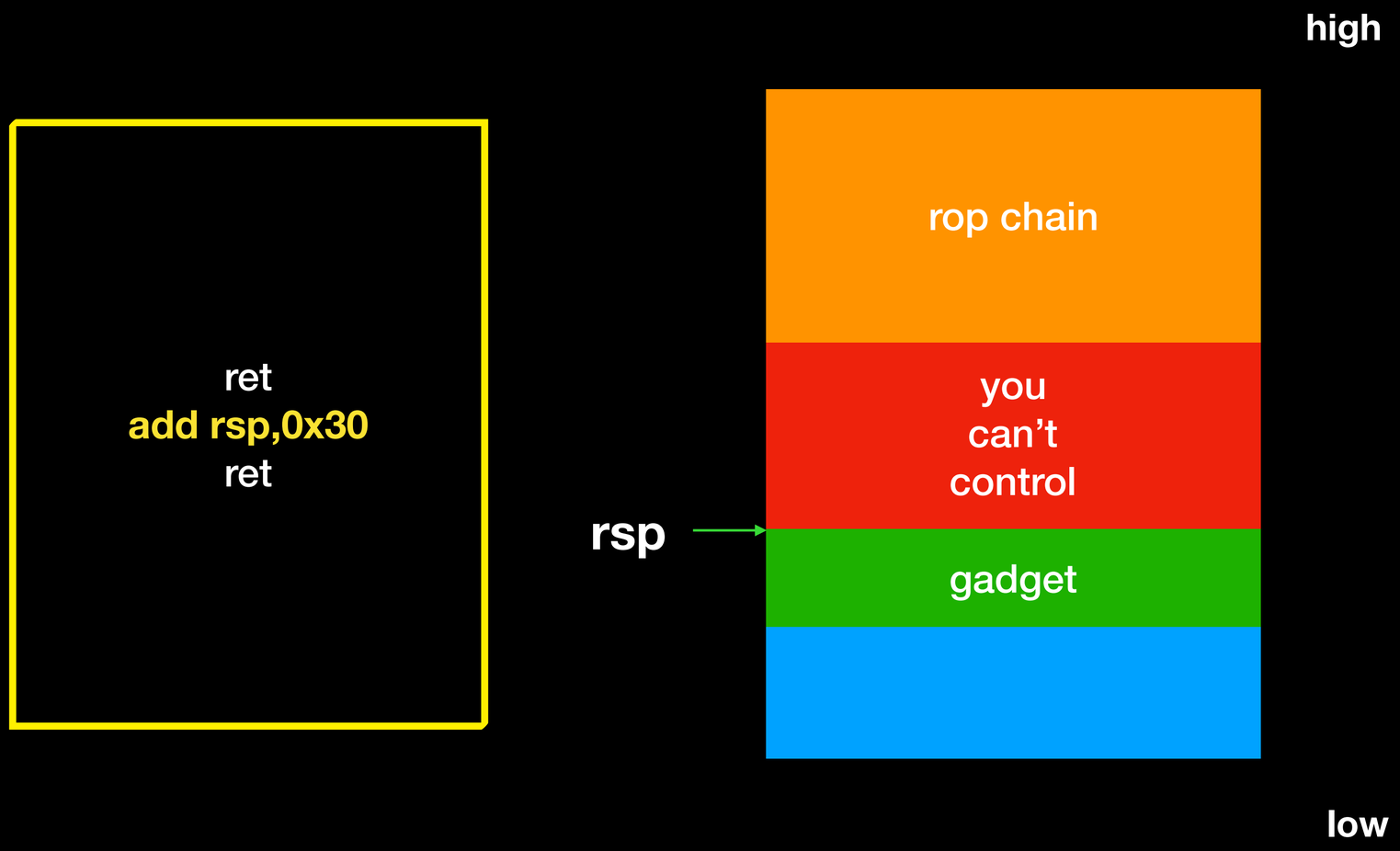
Stack Migration

- Other migration gadget
  - add rsp,0xNN ; ret
  - sub rsp,0xNN ; ret
  - ret 0xNN
  - xchg rsp,exx ; ret
  - partial overwrite rbp

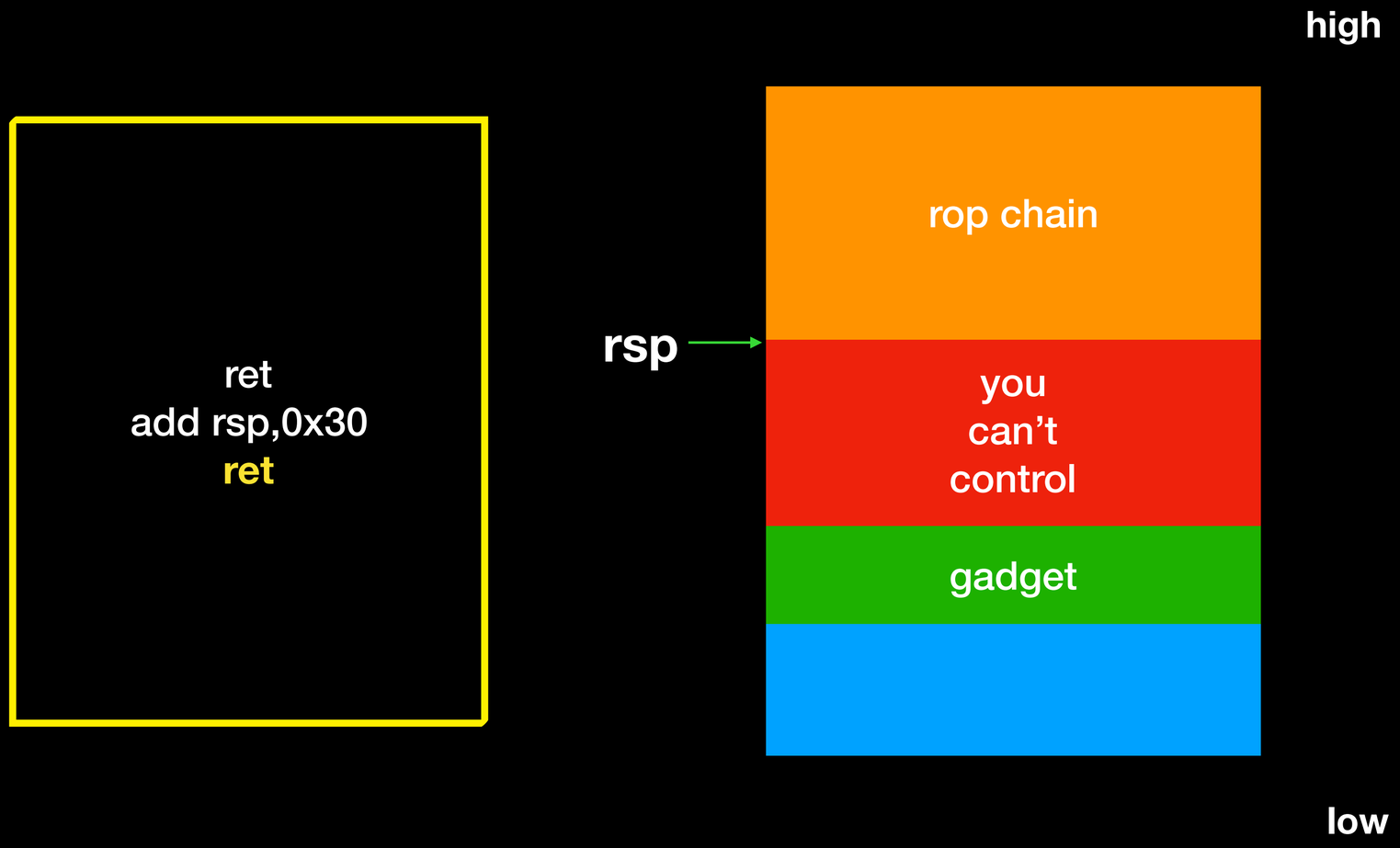
Stack Migration



Stack Migration



Stack Migration



Reference

- http://www.slideshare.net/hackstuff/rop-40525248

Q & A