Hacking Blind

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Stanford University

Hacking buffer overflows

Exploit

GET /0xDEAD HTTP/1.0

shell

NGINX

```
$ cat /etc/passwd
  root:x:0:0:::/bin/sh
  sorbo:x:6:9:pac:/bin/sh
```

Crash or no Crash?
Enough to build exploit

GET /blabla HTTP/1.0

HTTP/1.0 404 Not Found

GET /AAAAAAAAAAAAAAAAAA

connection closed

Don't even need to know what application is running!

Exploit scenarios:

1. Open source

2. Open binary

3. Closed-binary (and source)

Attack effectiveness

- Works on 64-bit Linux with ASLR, NX and canaries

Server	Requests	Time (mins)
nginx	2,401	1
MySQL	3,851	20
Toy proprietary service (unknown binary and source)	1,950	5

Attack requirements

1. Stack vulnerability, and knowledge of how to trigger it.
2. Server process that respawns after crash
   - E.g., nginx, MySQL, Apache, OpenSSH, Samba.

Outline

- Introduction.
- Background on exploits.
- Blind ROP (BROP).
- Optimizations.

Stack vulnerabilities

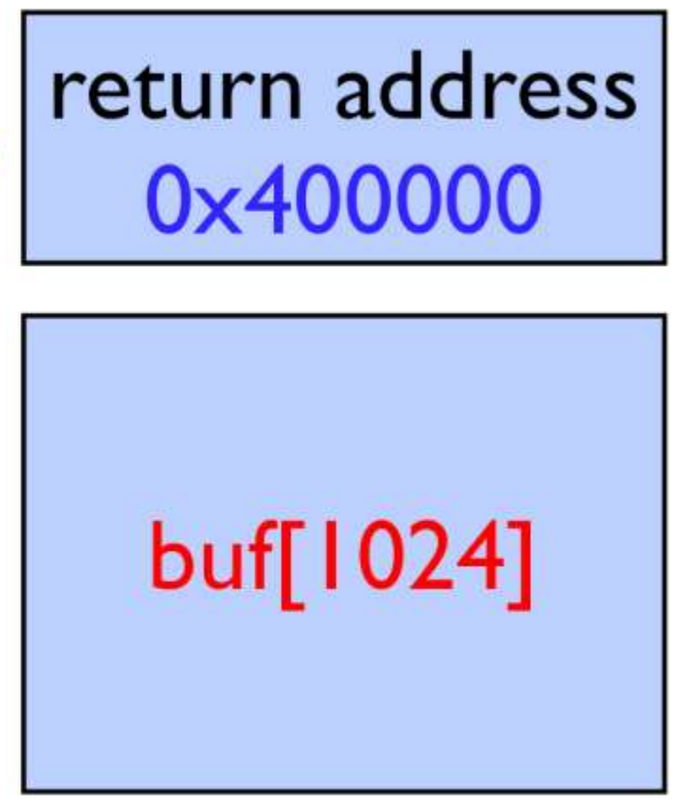
```
void process_packet(int s) {
    char buf[1024];
    int len;

    read(s, &len, sizeof(len));
    read(s, buf, len);

    return;
}
```

handle_client()

Stack:



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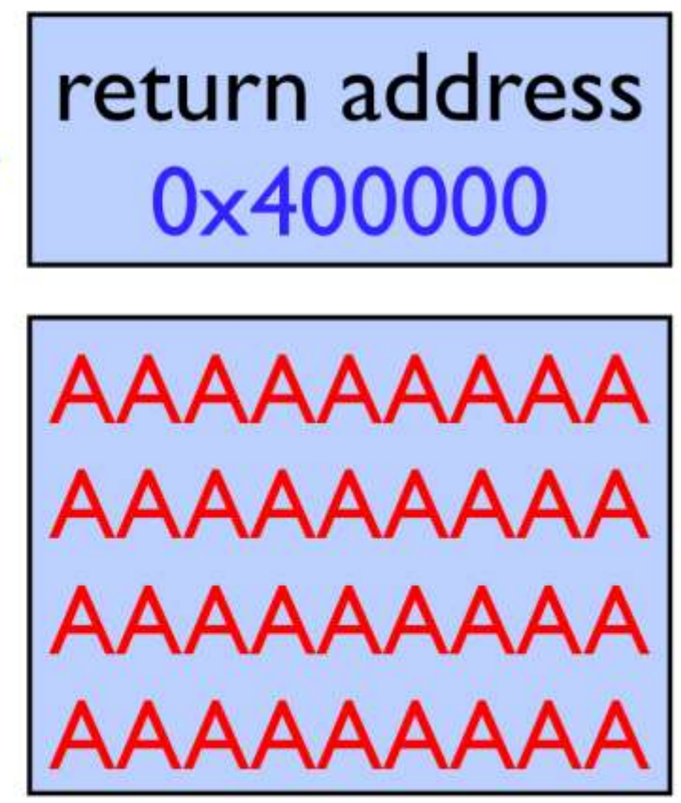

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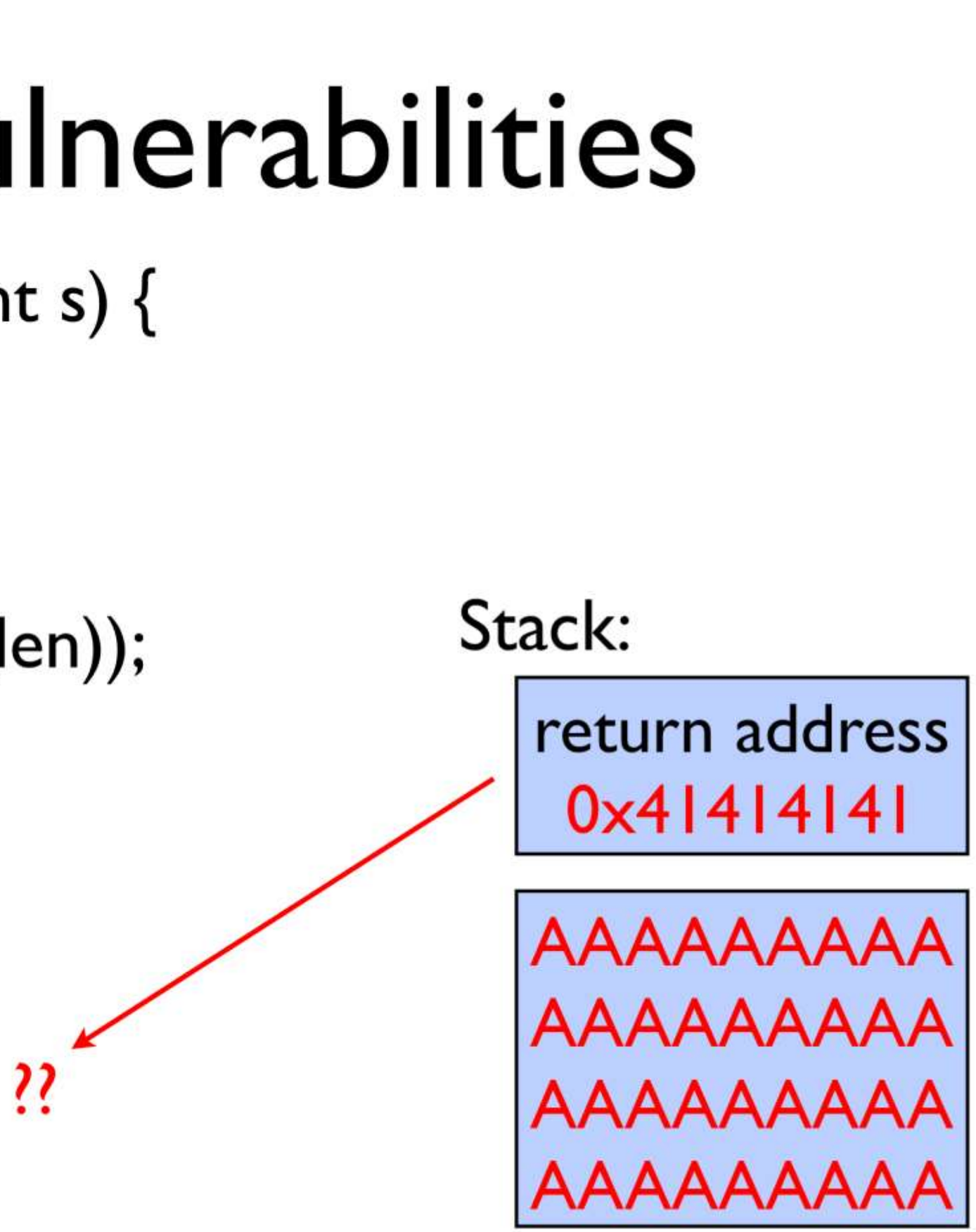

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Shellcode:

```
dup2(sock, 0);
dup2(sock, 1);
execve("/bin/sh", 0, 0);
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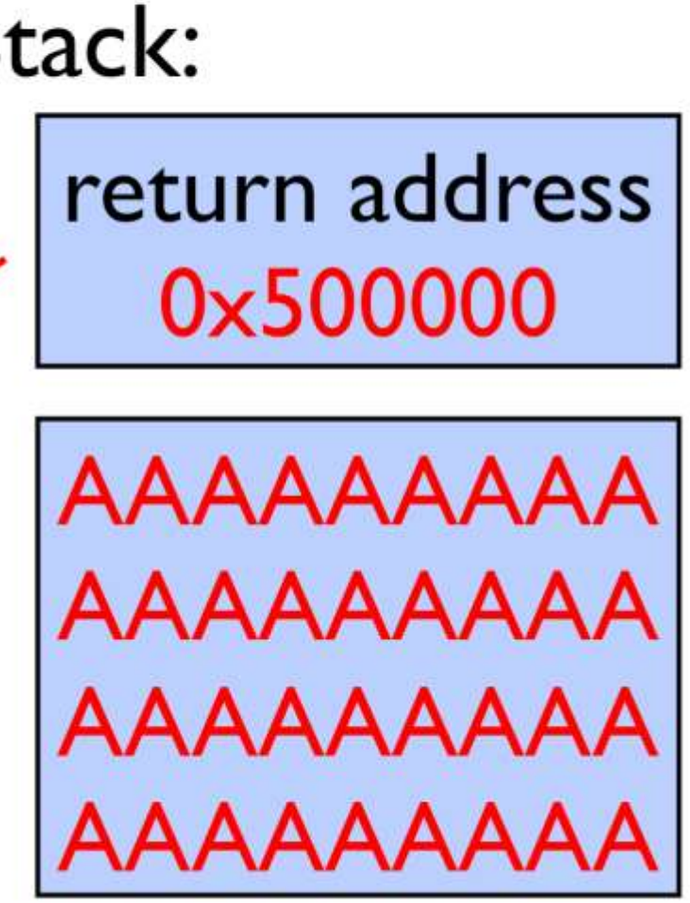

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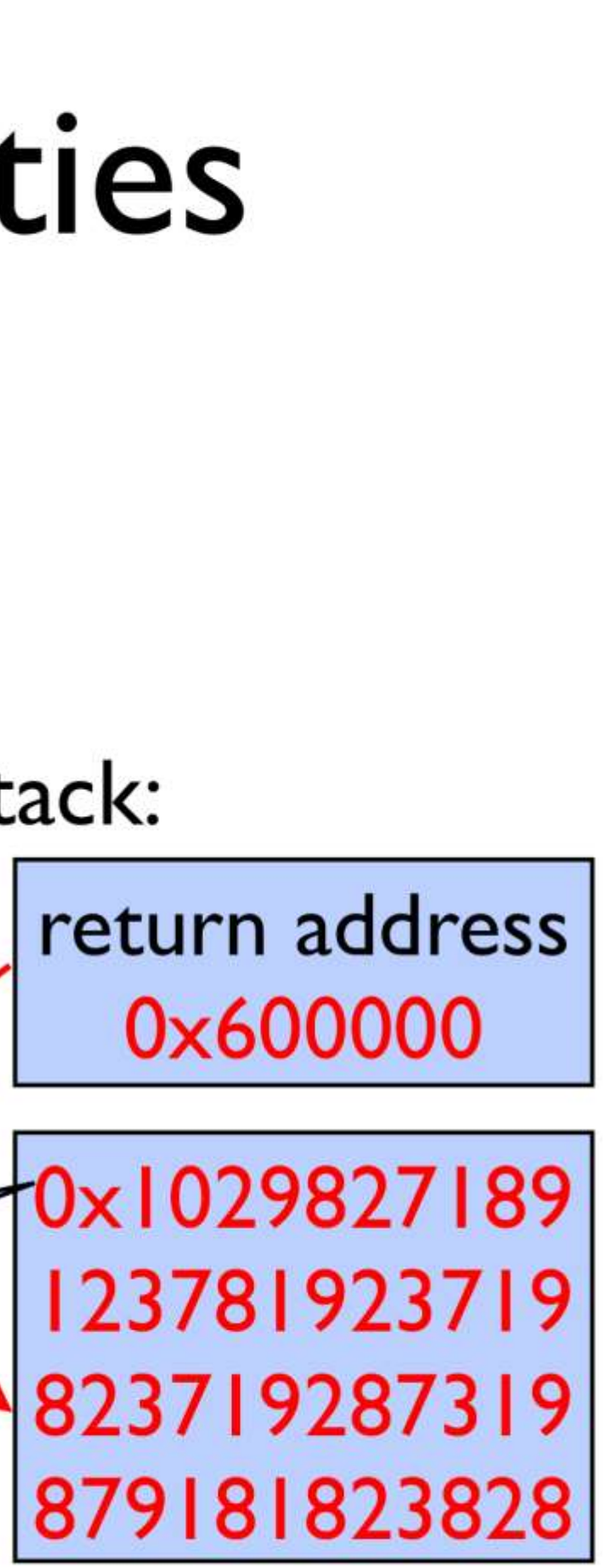


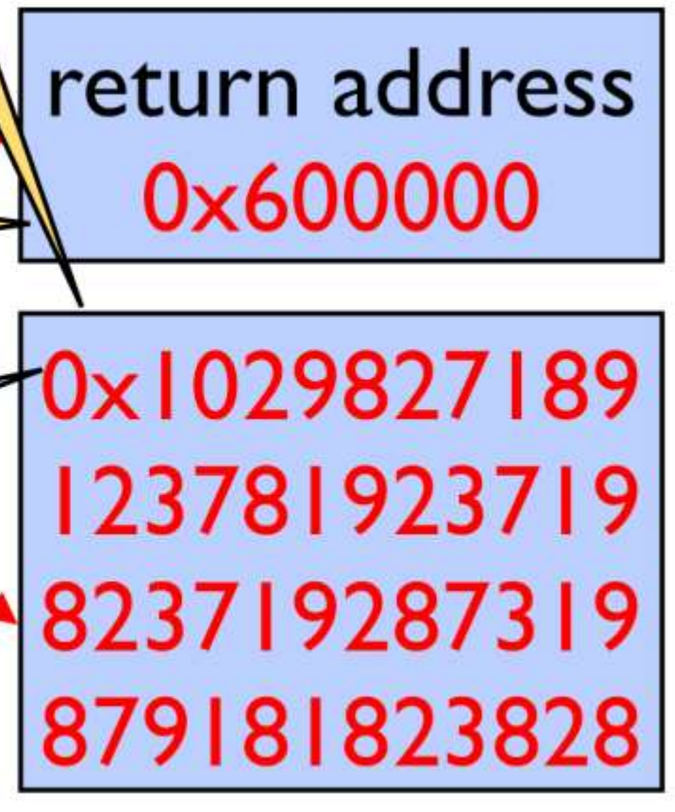
Exploit protections

```
void pro
    char
    int le
re
re
return;
}
```

1. Make stack non-executable (NX)

2. Randomize memory addresses (ASLR)

Stack:



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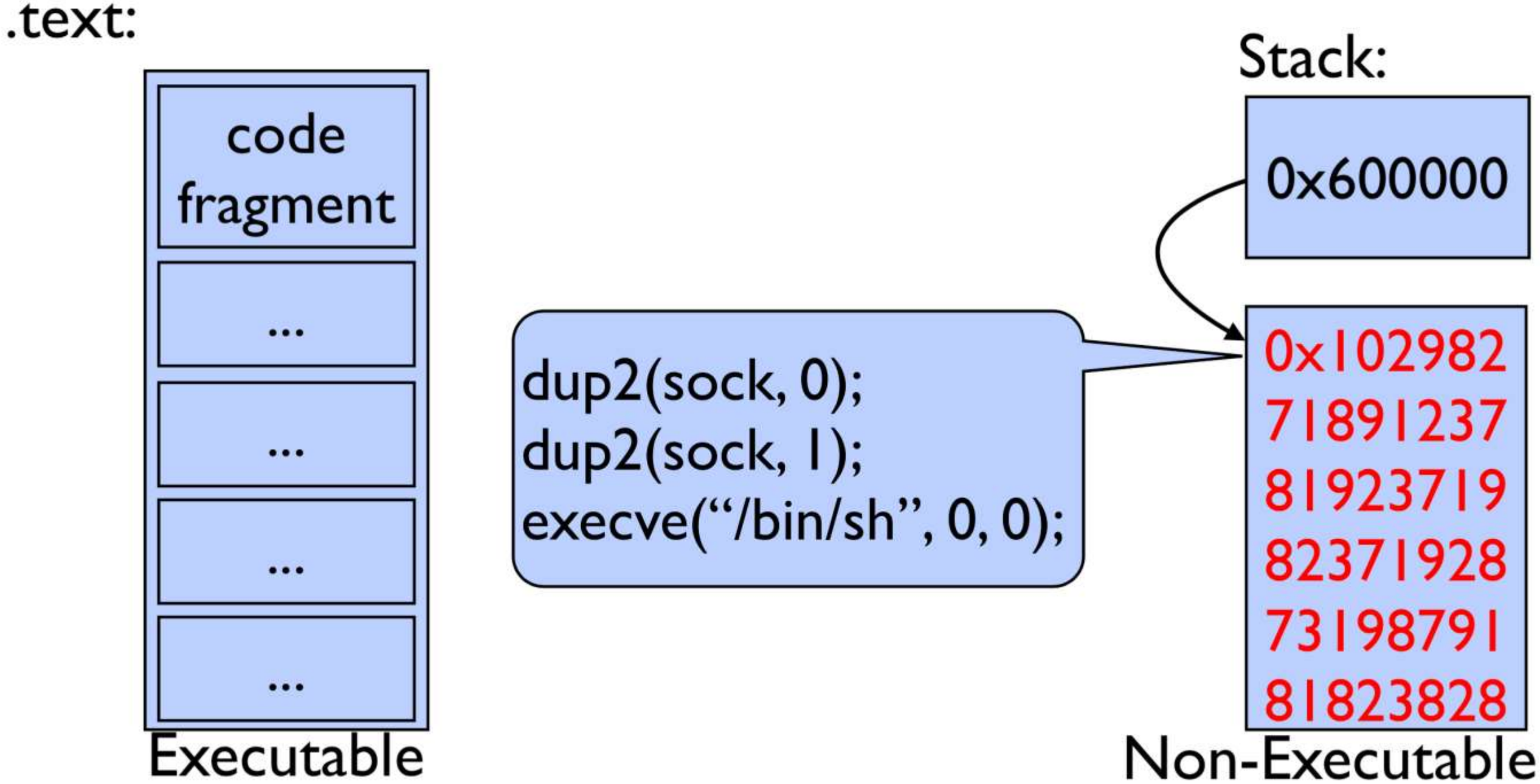
Return-Oriented Programming (ROP)



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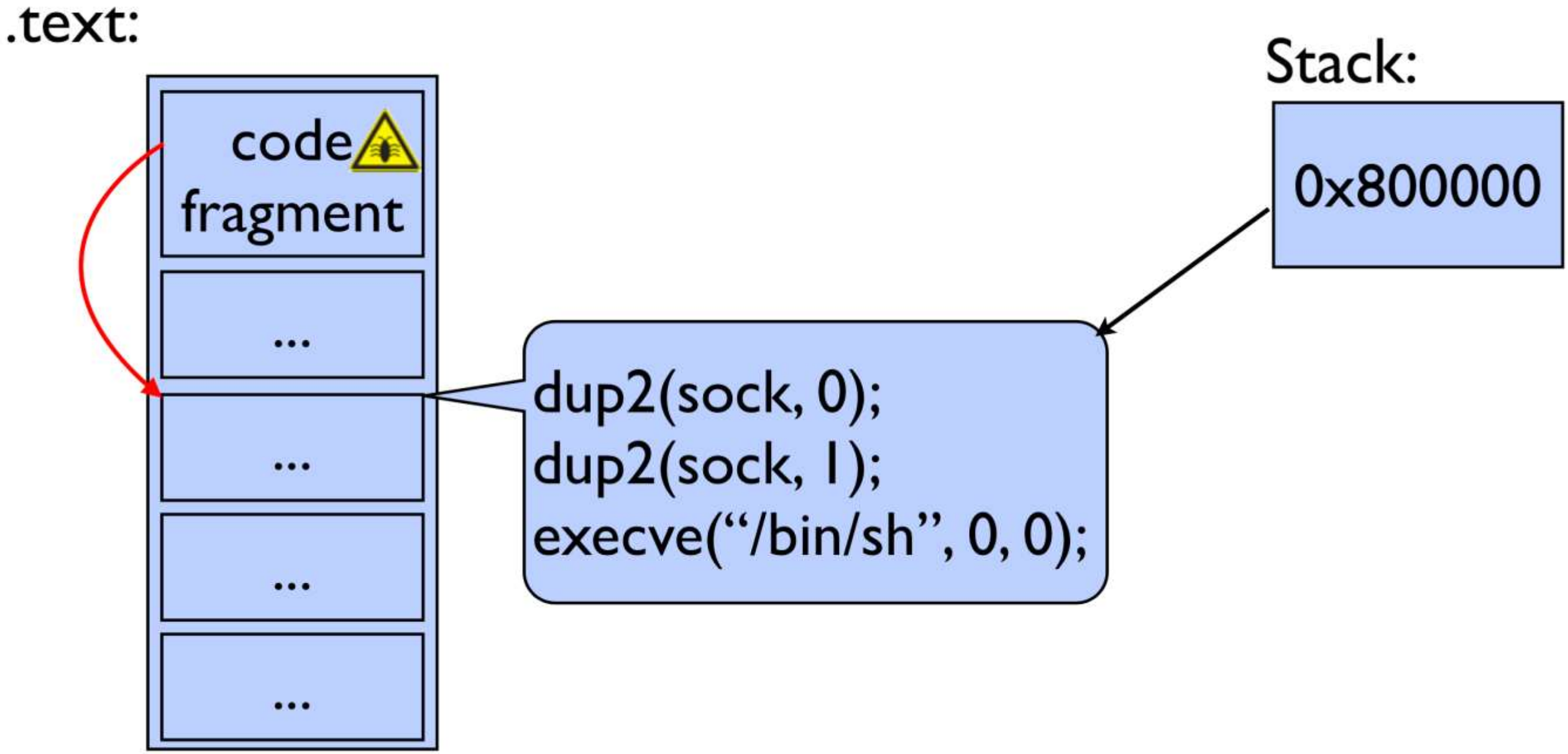

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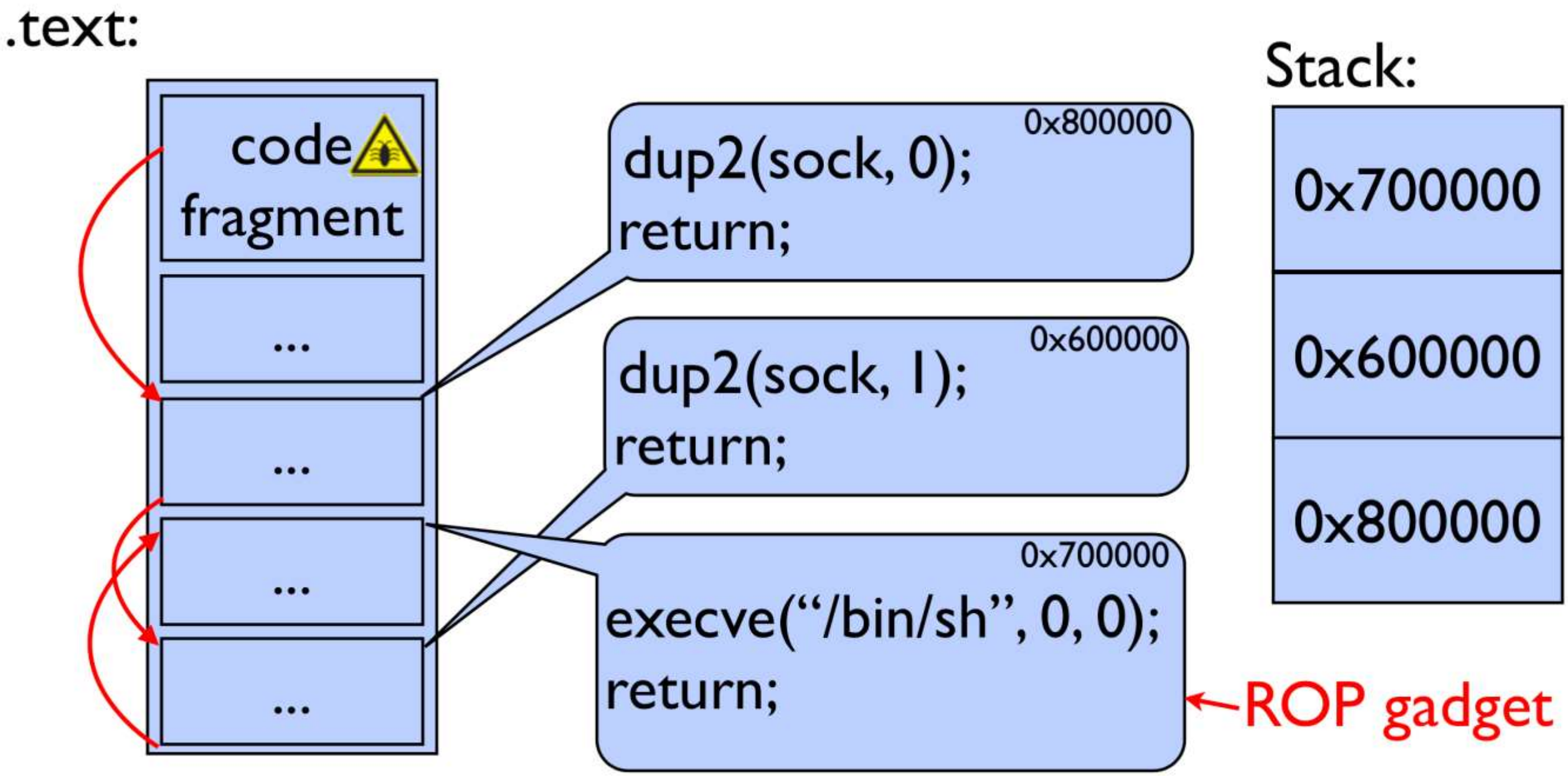
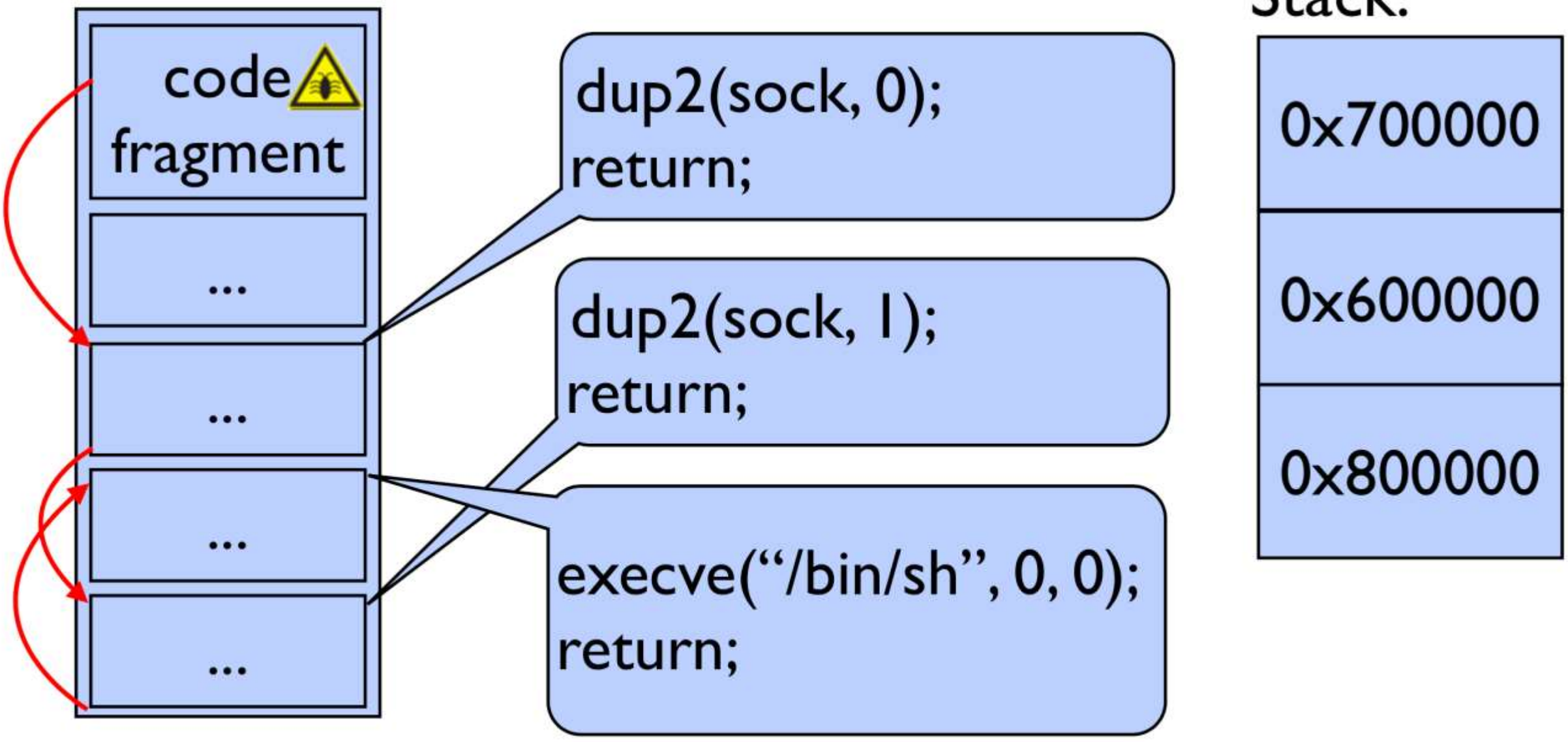


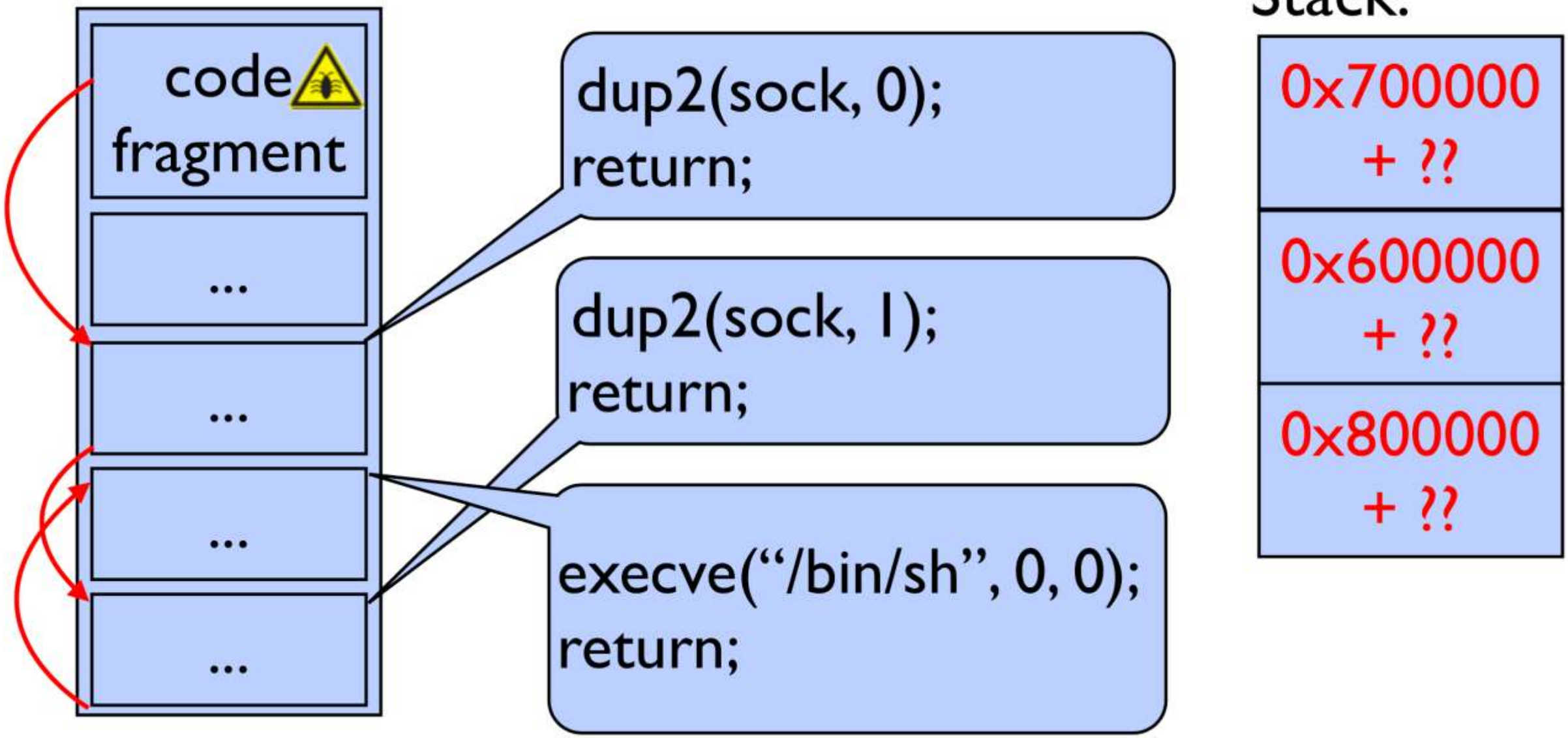
Address Space Layout Randomization (ASLR)

.text: 0x400000



Address Space Layout Randomization (ASLR)

.text: 0x400000 + ??



Exploit requirements today

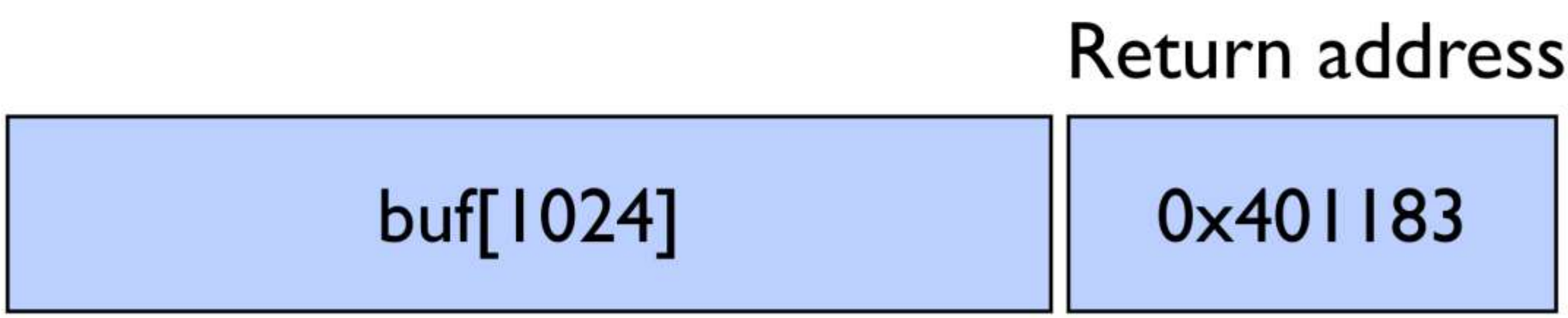
1. Break ASLR.
2. Copy of binary (find ROP gadgets / break NX).
    - Is it even possible to hack unknown applications?

Blind Return-Oriented Programming (BROP)

1. Break ASLR.
2. Leak binary:
    - Remotely find enough gadgets to call write().
    - write() binary from memory to network to disassemble and find more gadgets to finish off exploit.

Defeating ASLR: stack reading

- Overwrite a single byte with value X:
  - No crash: stack had value X.
  - Crash: guess X was incorrect.
- Known technique for leaking canaries.



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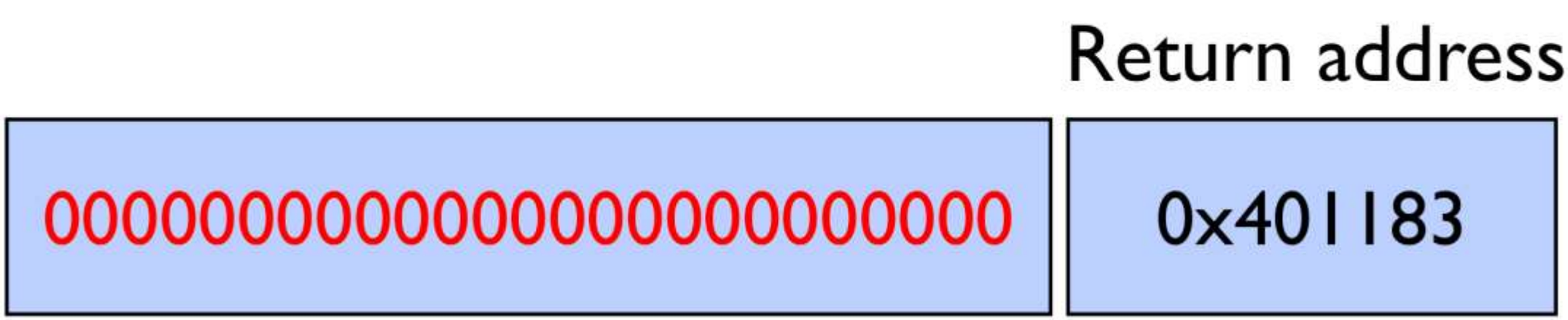

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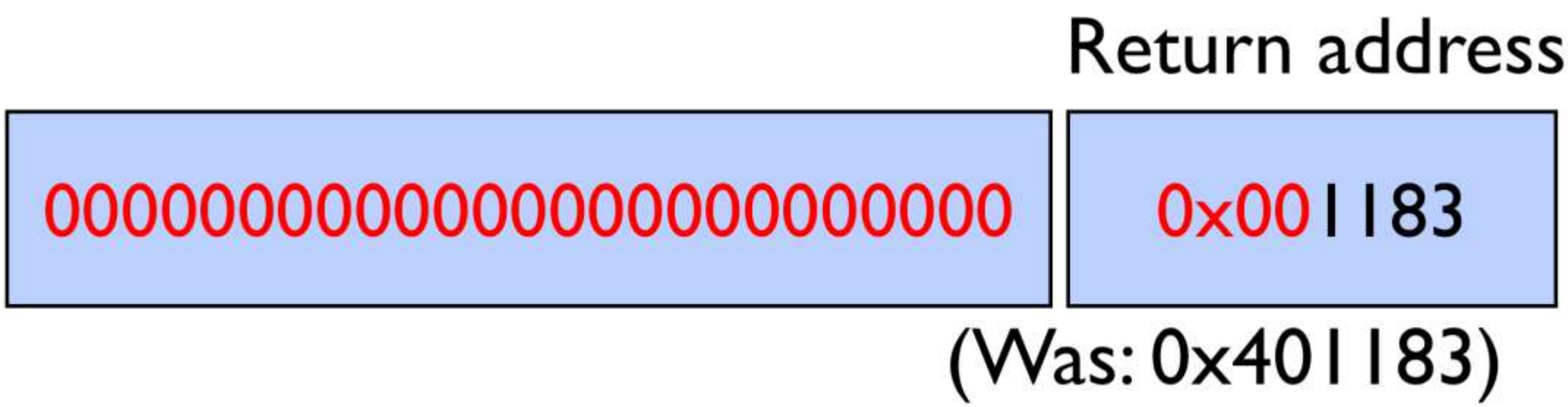

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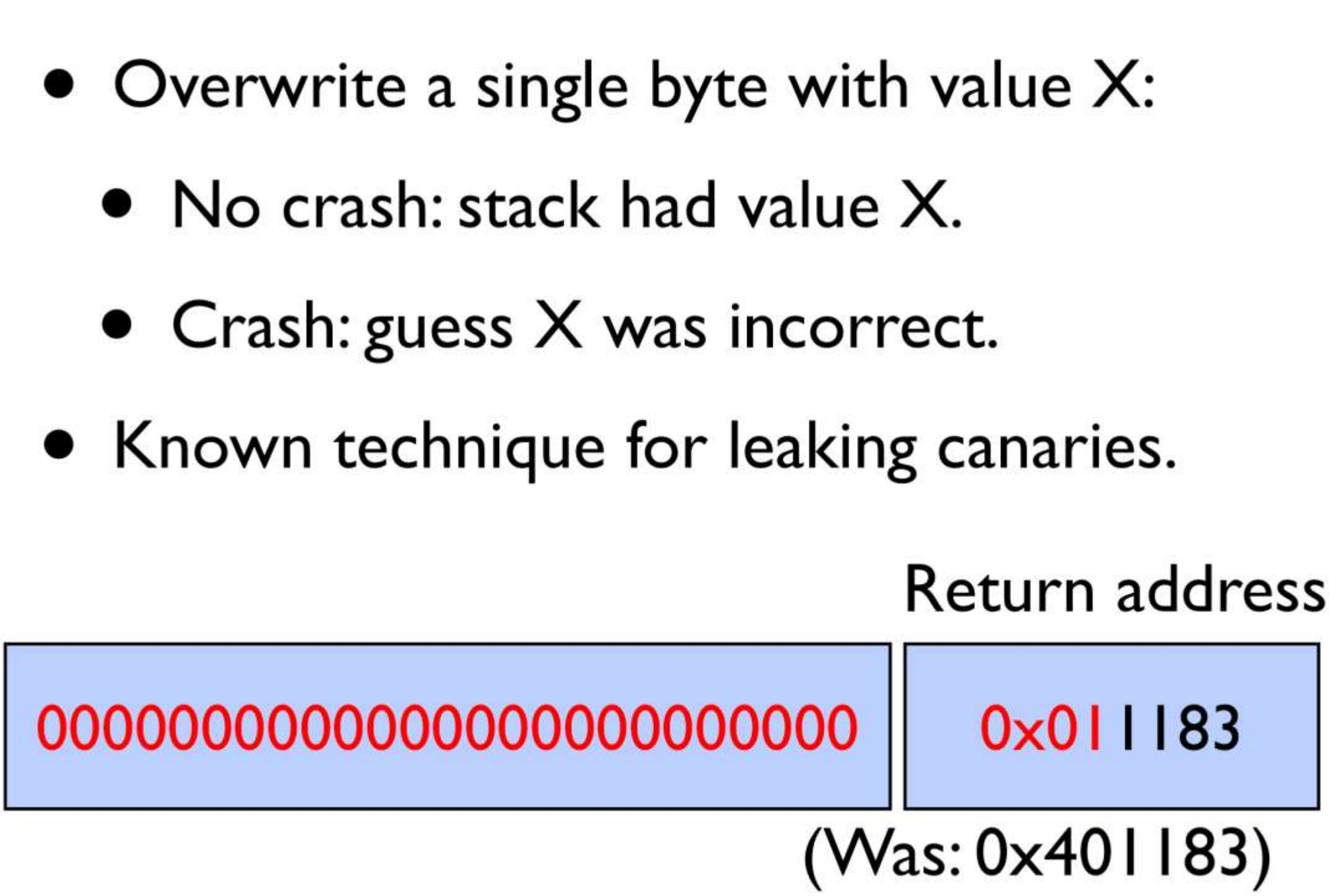

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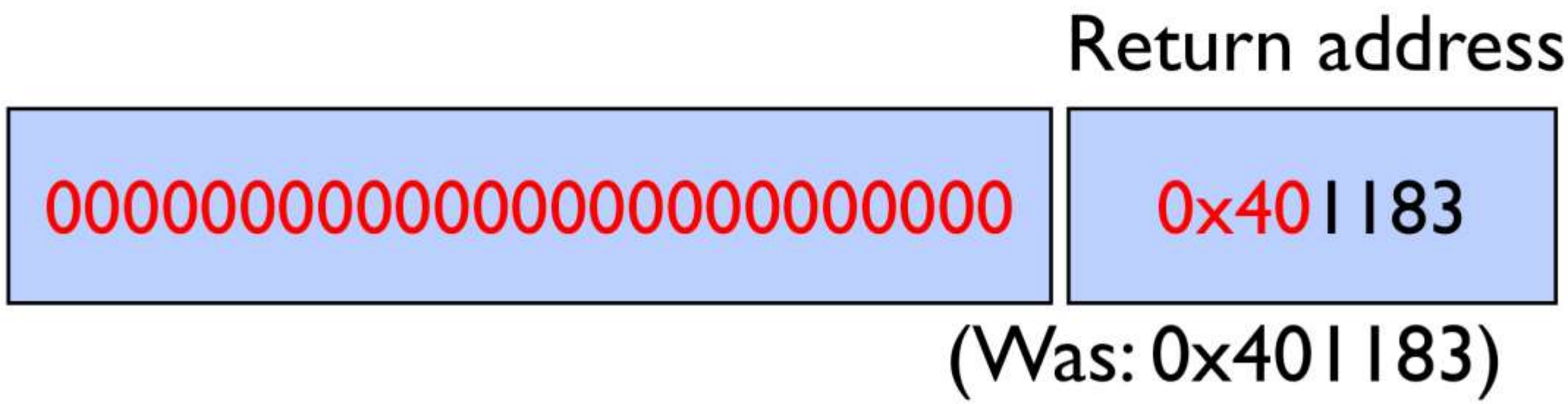
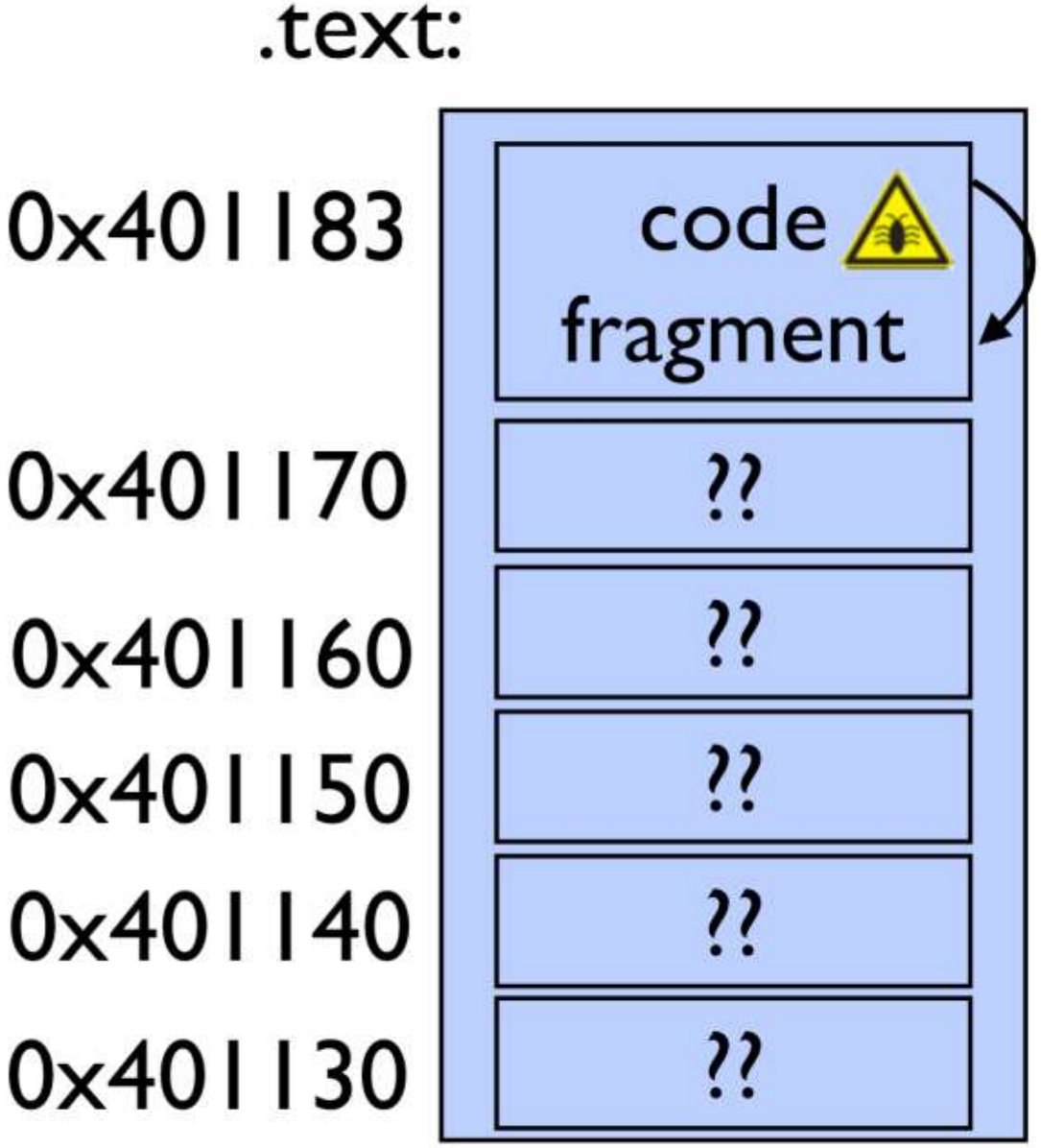


How to find gadgets?



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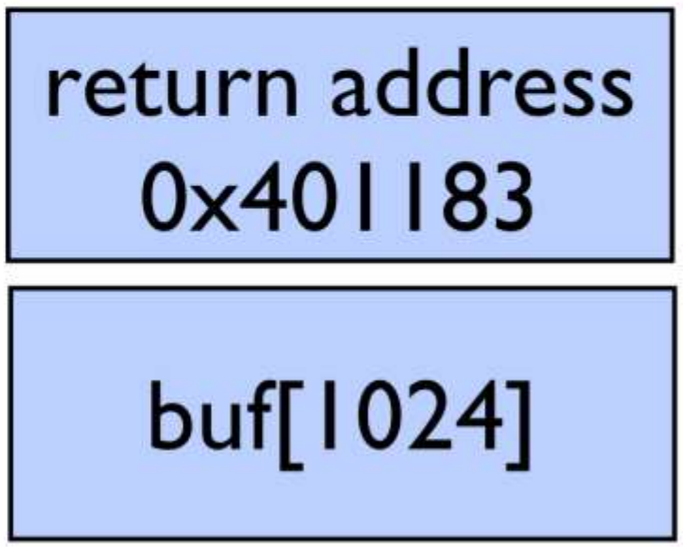

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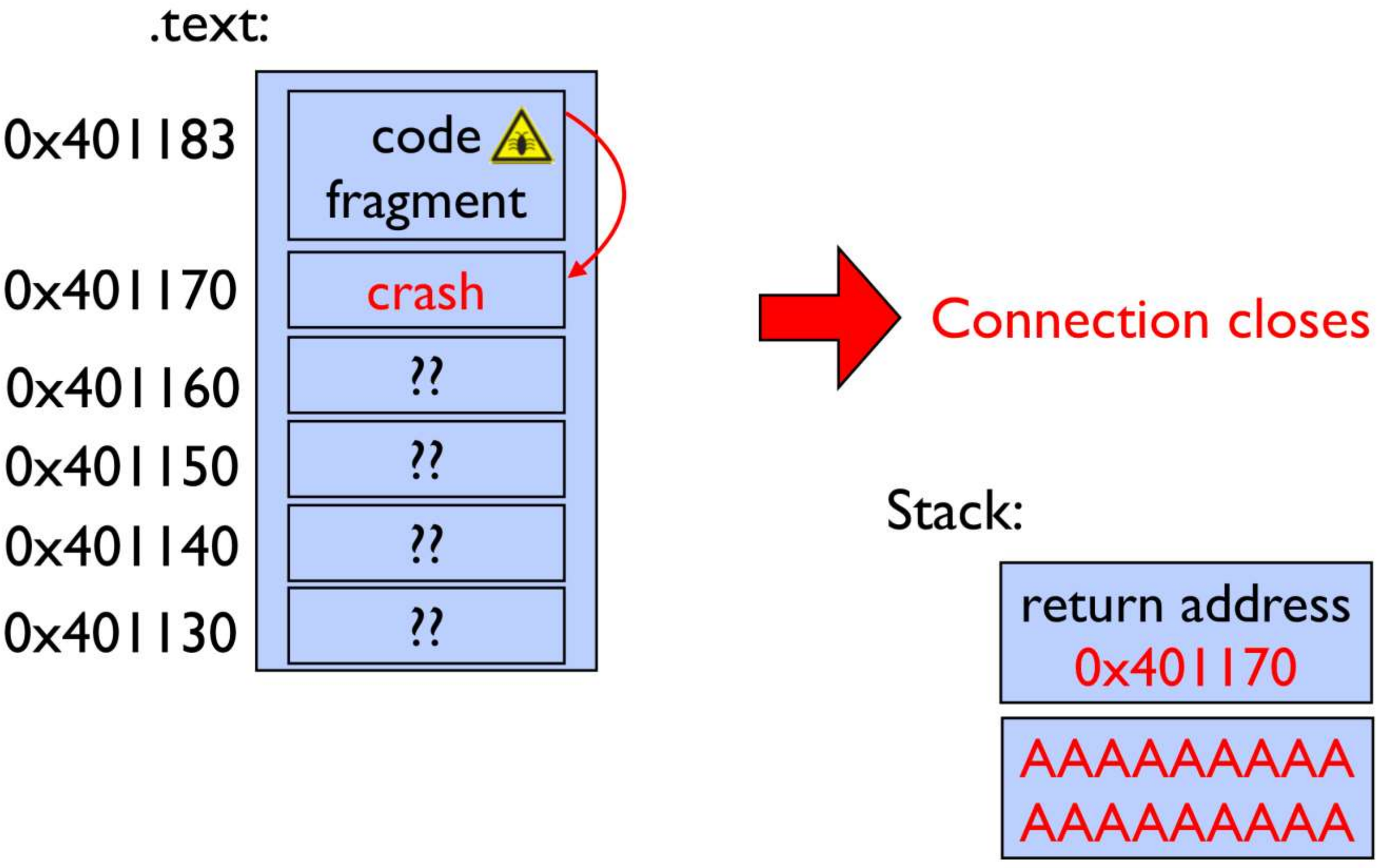

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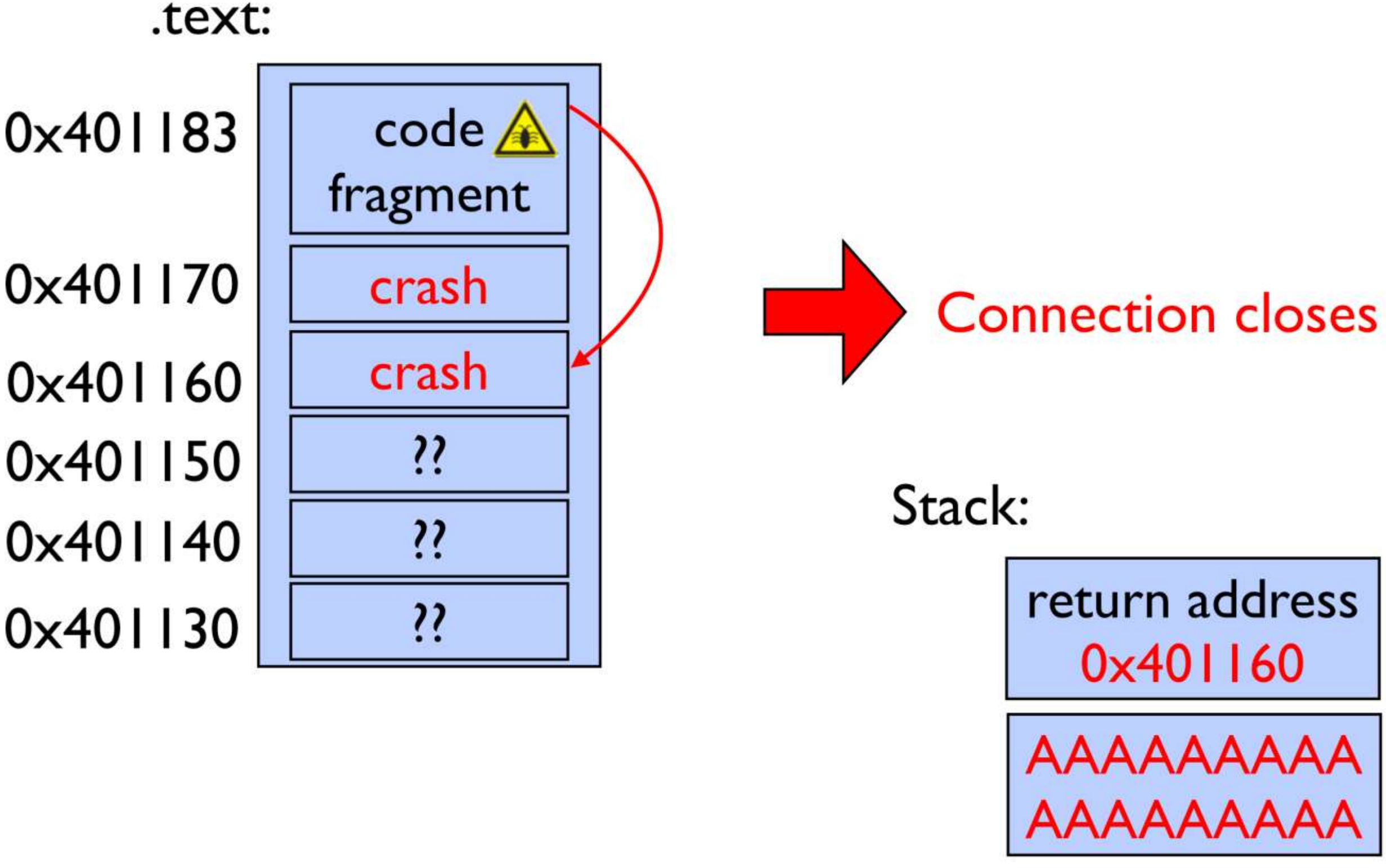

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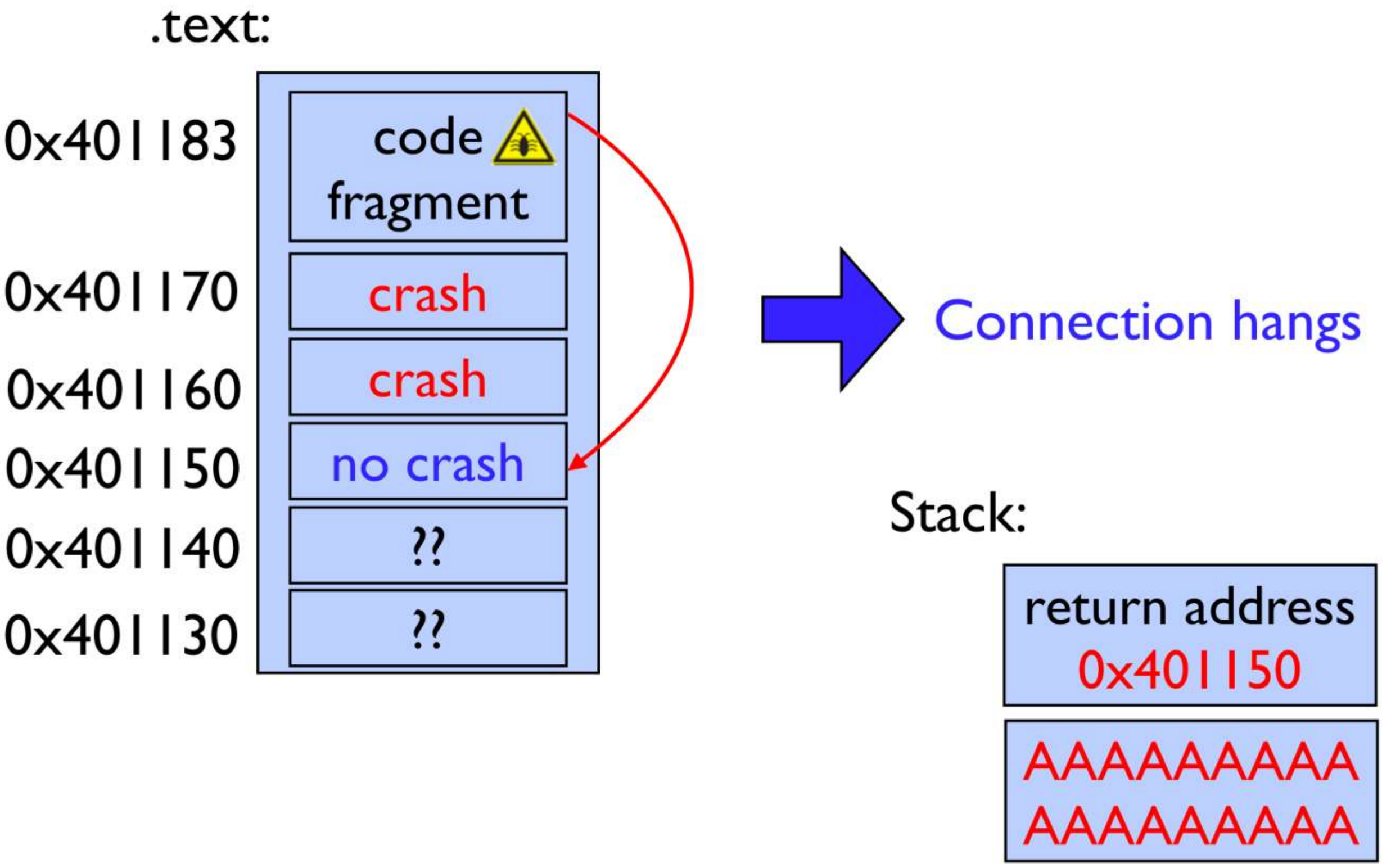

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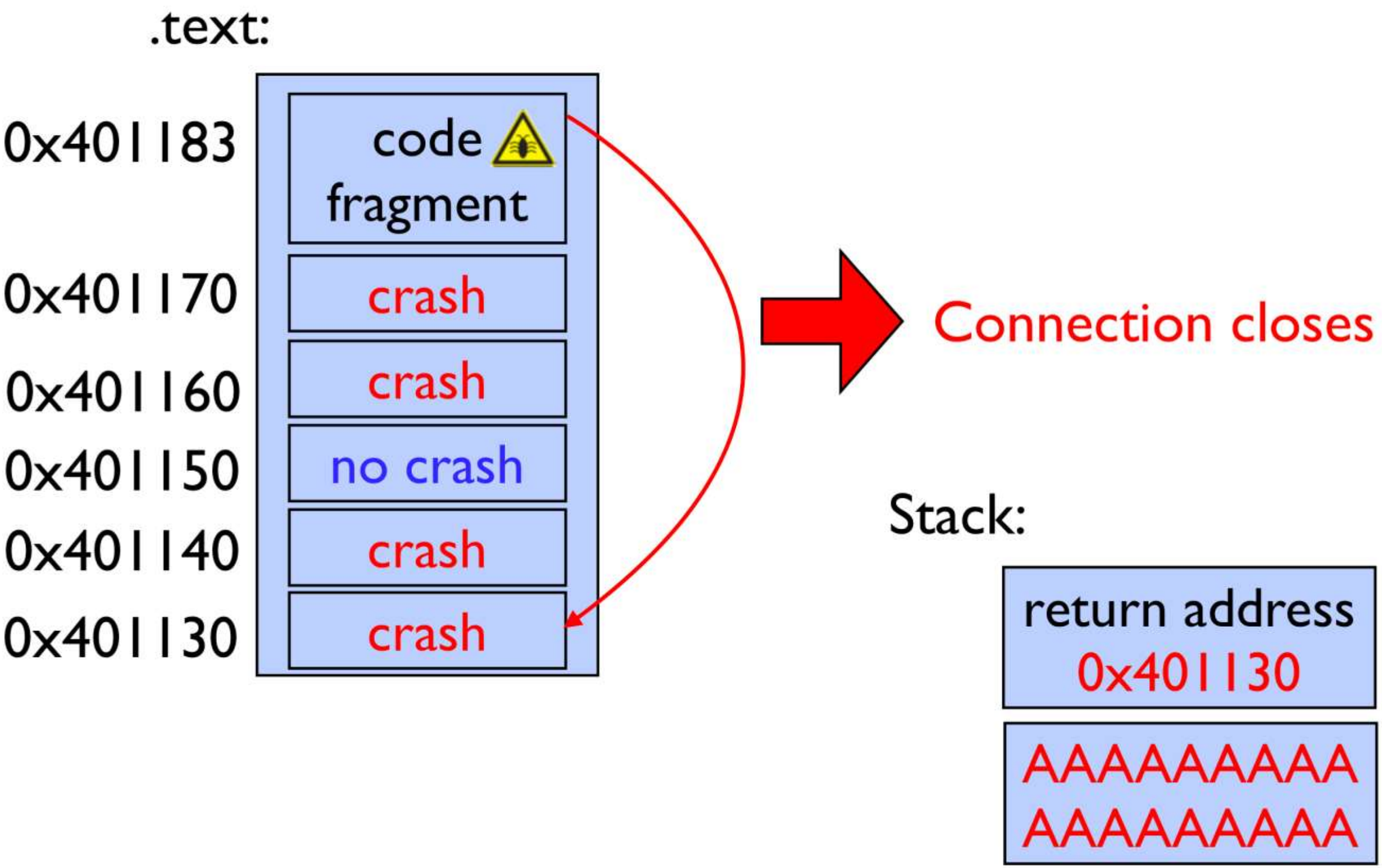

Three types of gadgets

Stop gadget

```
sleep(10);
return;
```

- Never crashes

Crash gadget

```
abort();
return;
```

- Always crashes

Useful gadget

```
dup2(sock, 0);
return;
```

- Crash depends on return

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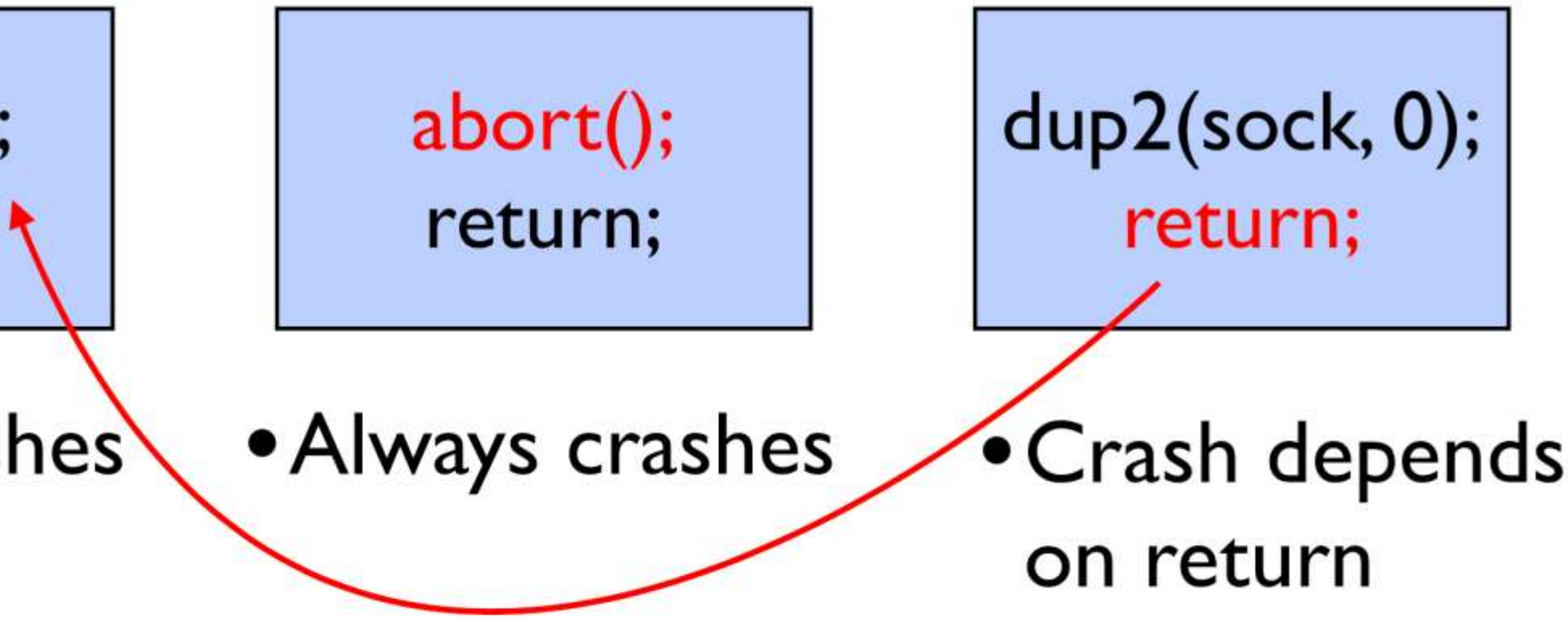
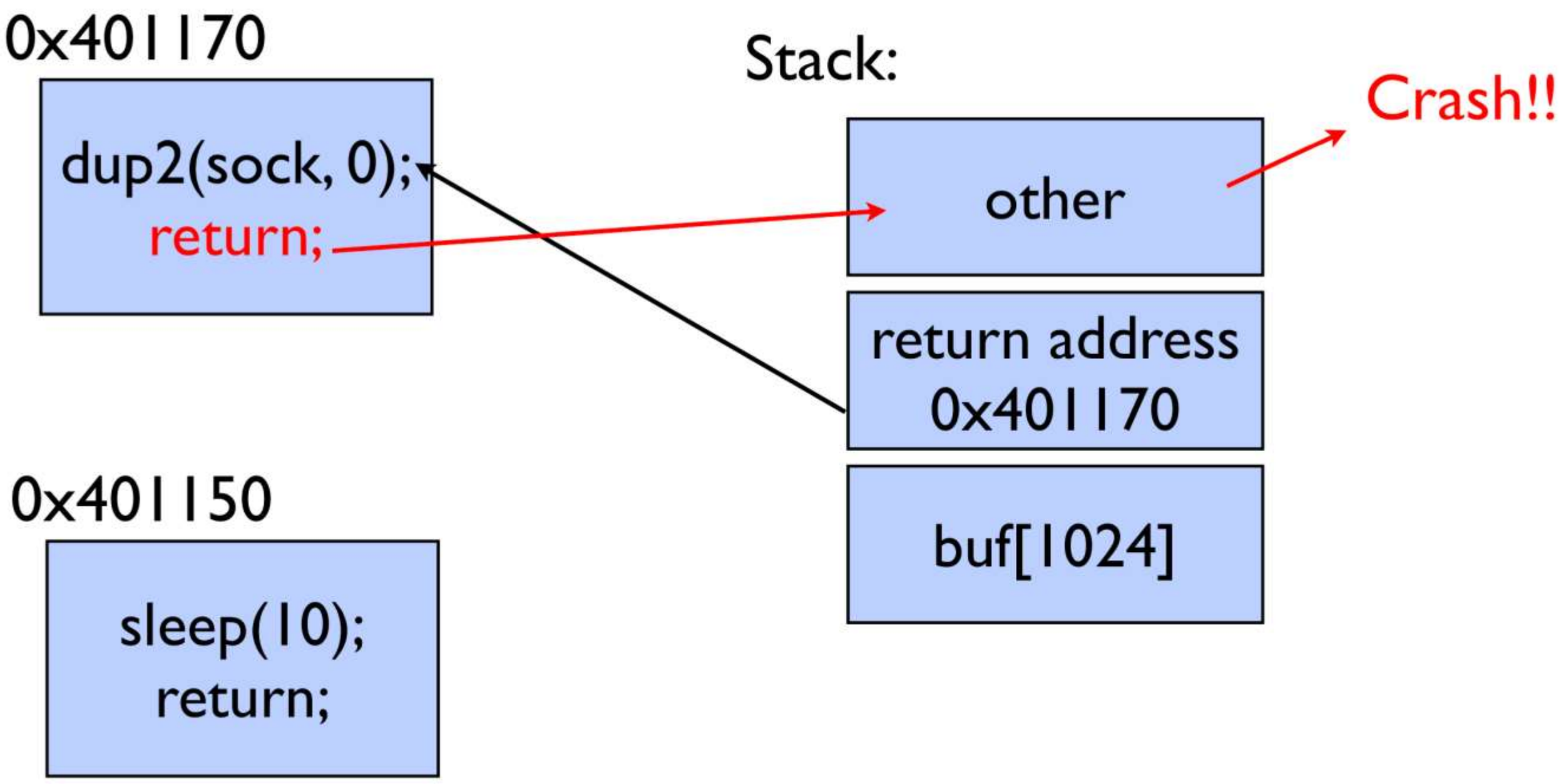


Finding useful gadgets



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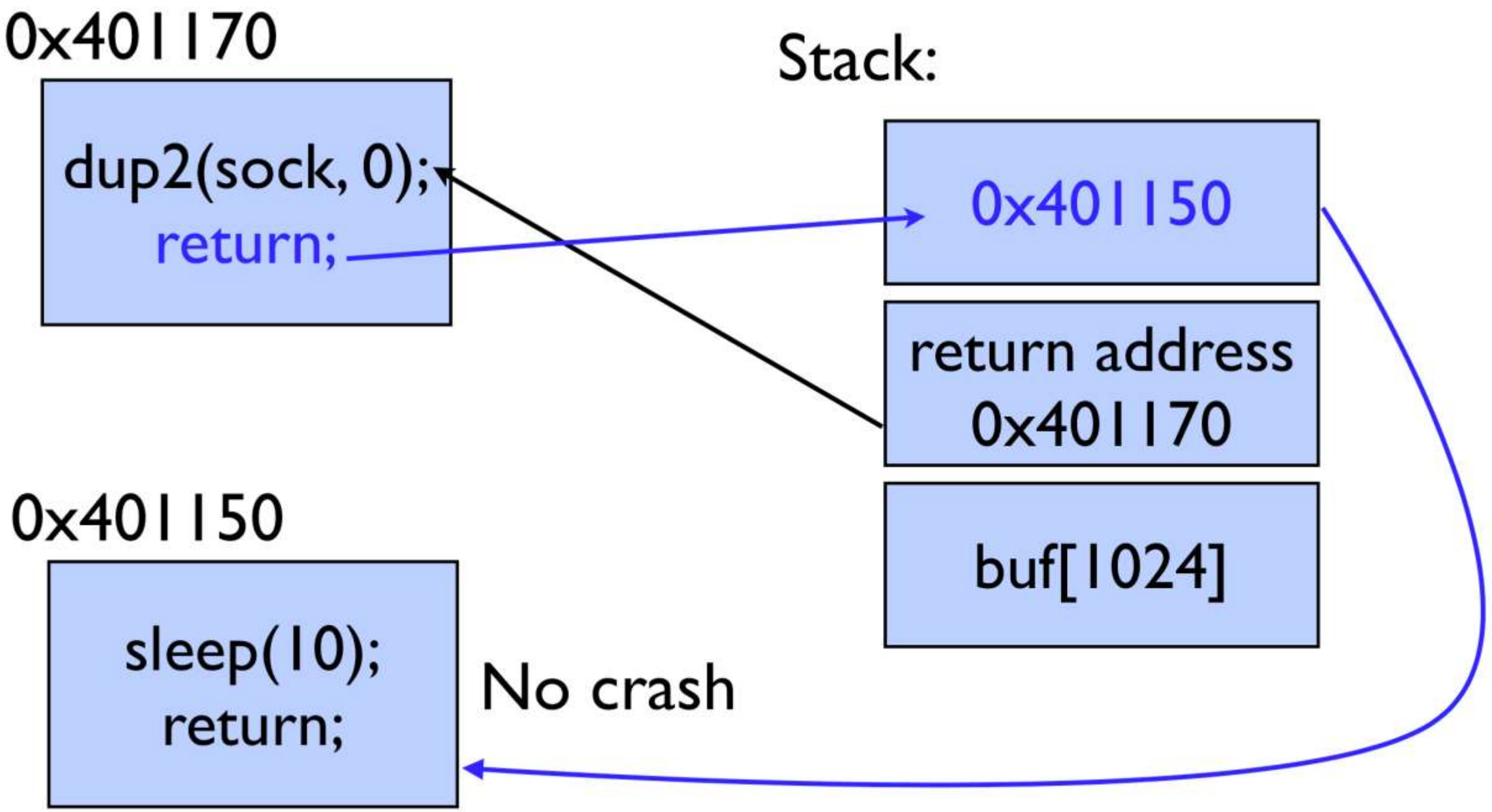

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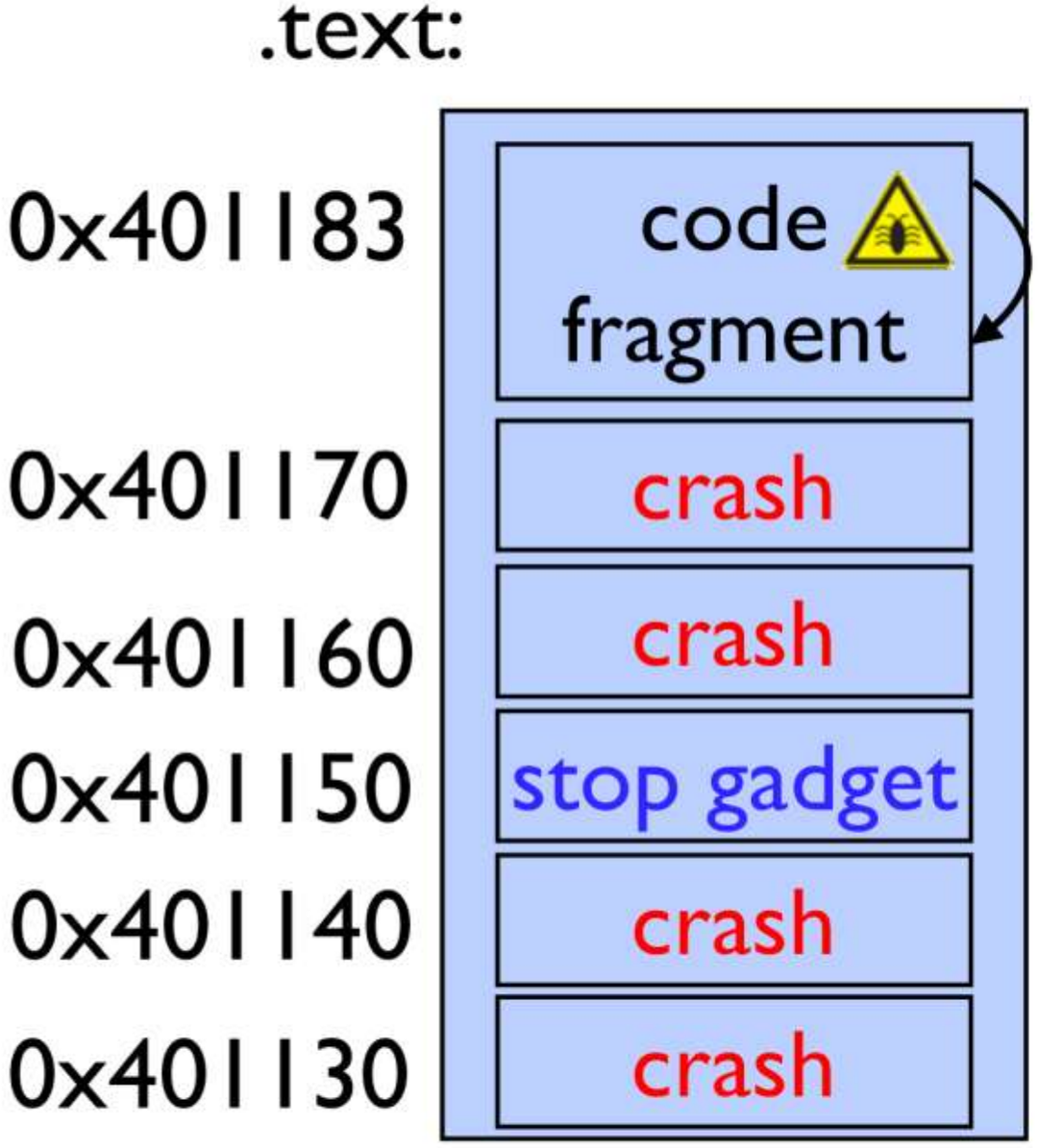
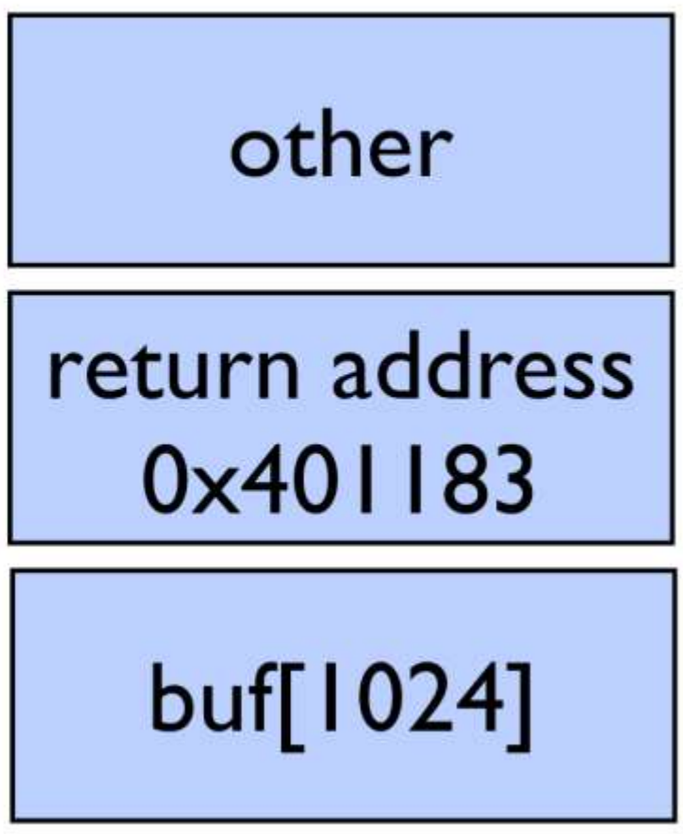
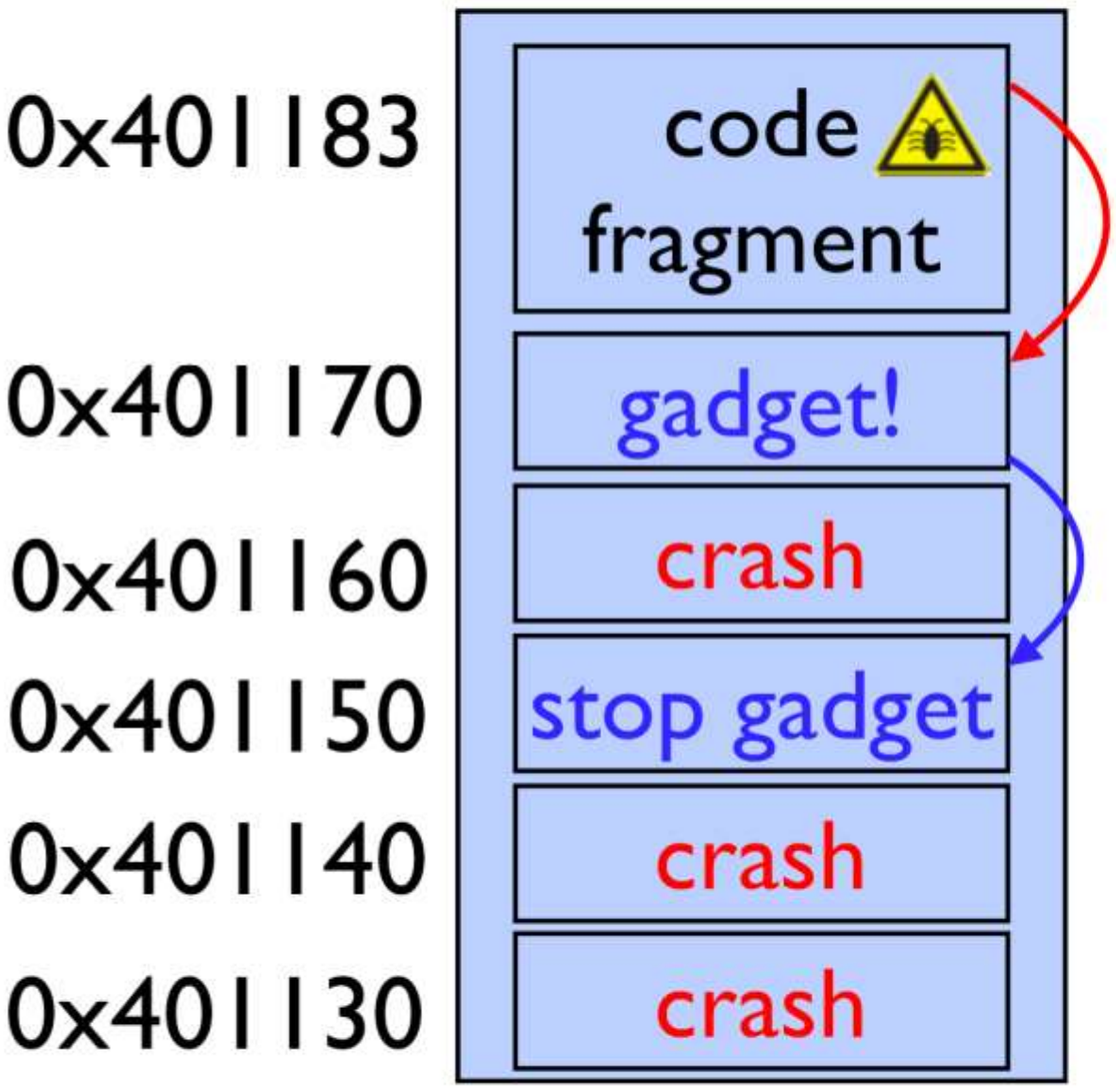
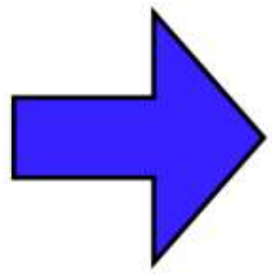




How to find gadgets?

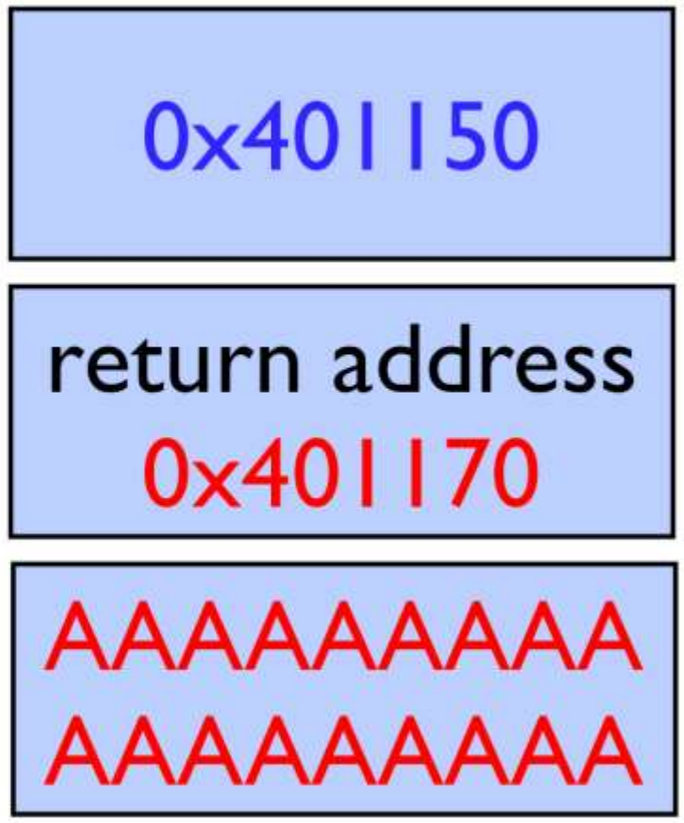
.text:





Connection hangs

Stack:



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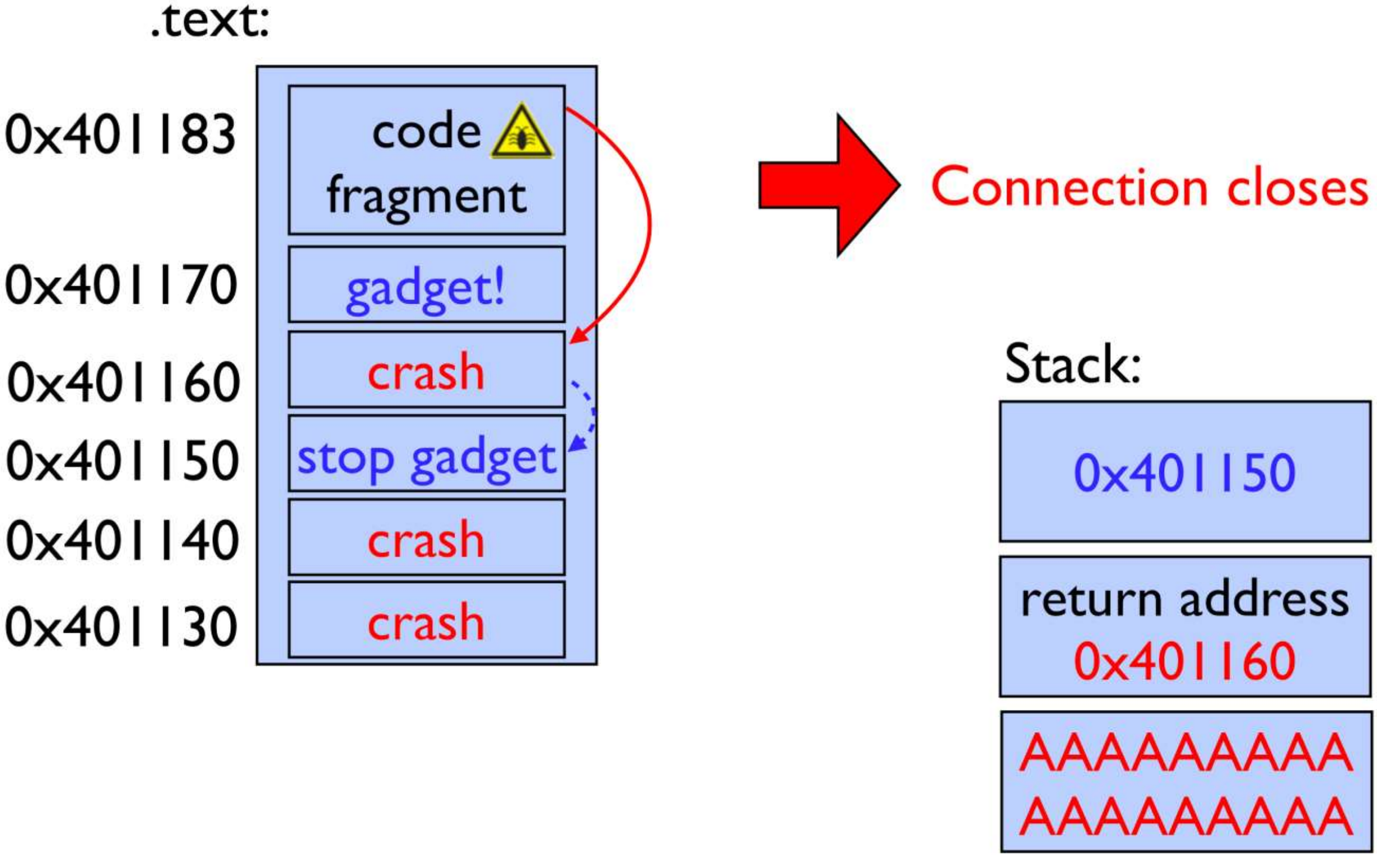
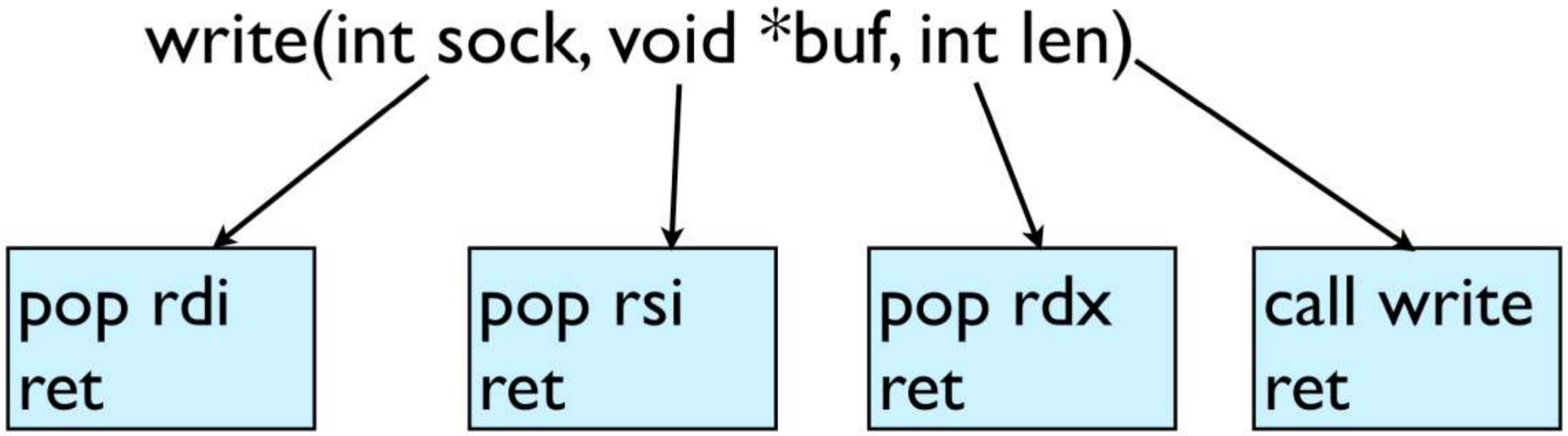


What are we looking for?



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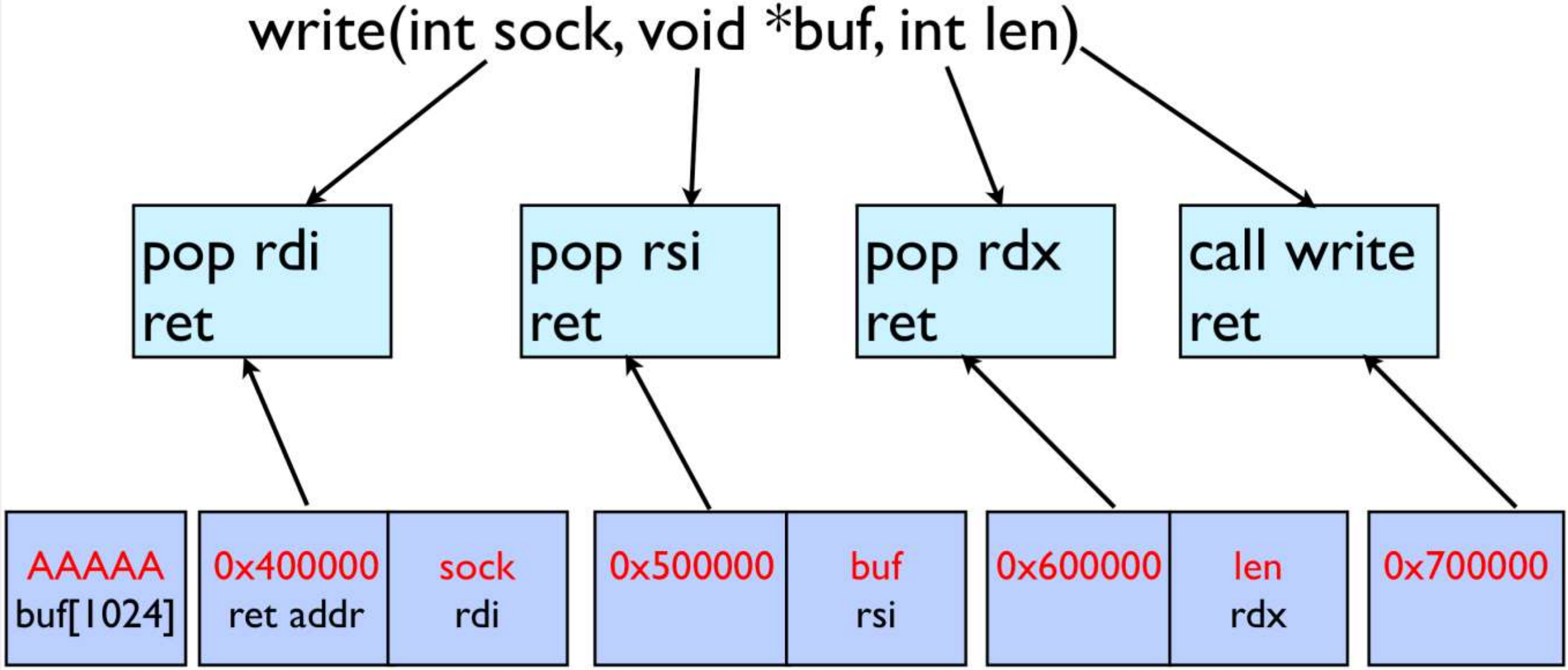


Pieces of the puzzle

pop rsi
ret

pop rdi
ret

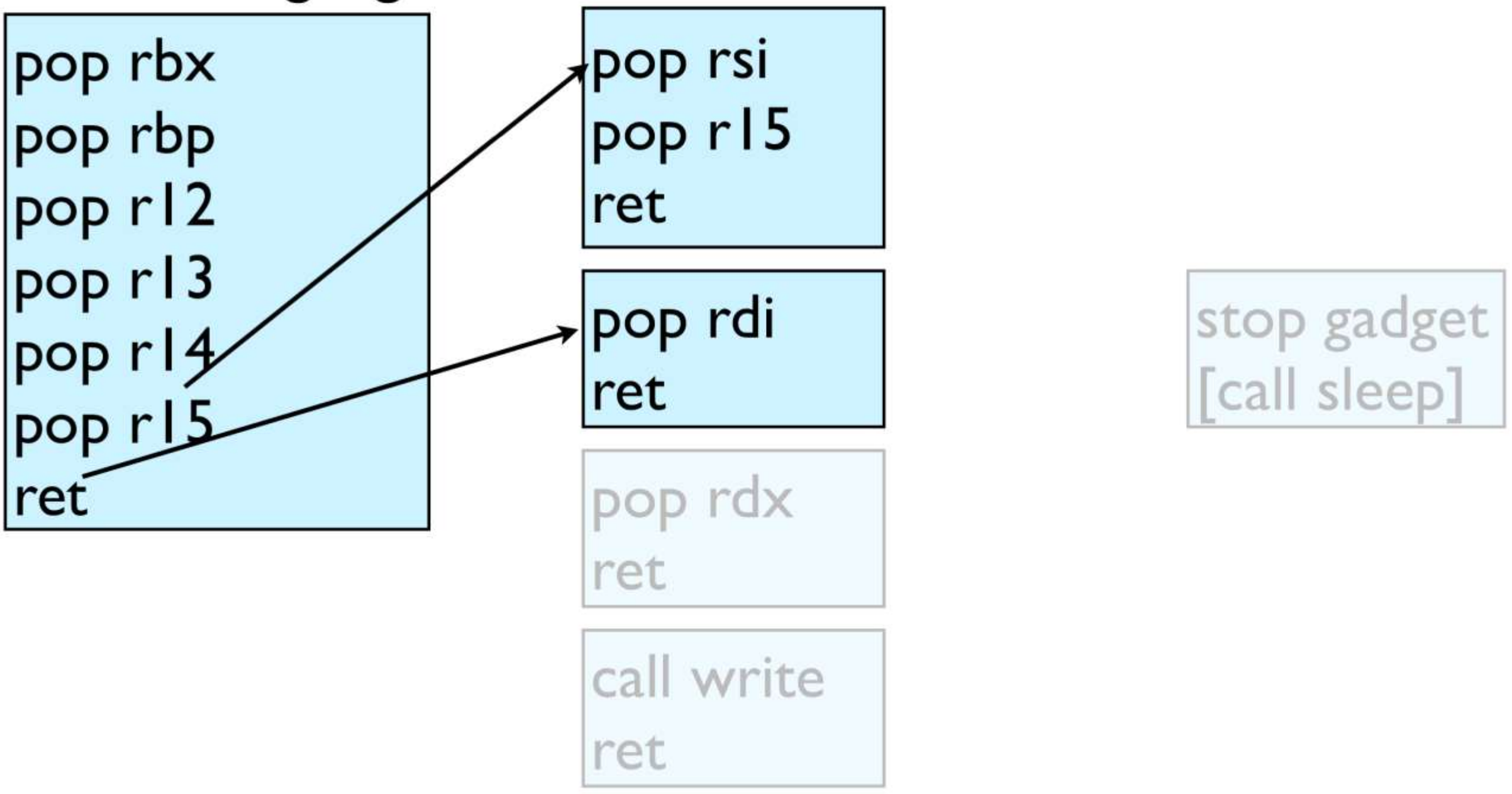
pop rdx
ret

call write
ret

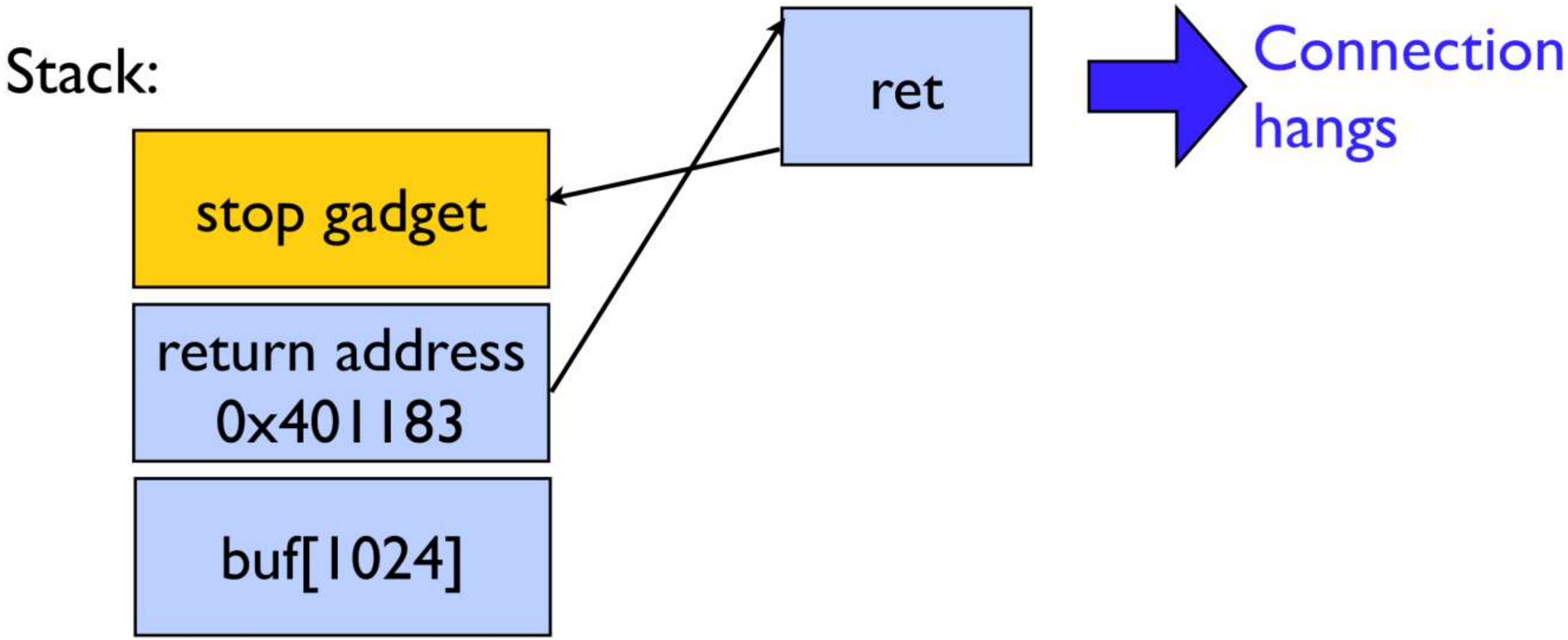
stop gadget
[call sleep]

Pieces of the puzzle

The BROP gadget



Finding the BROP gadget



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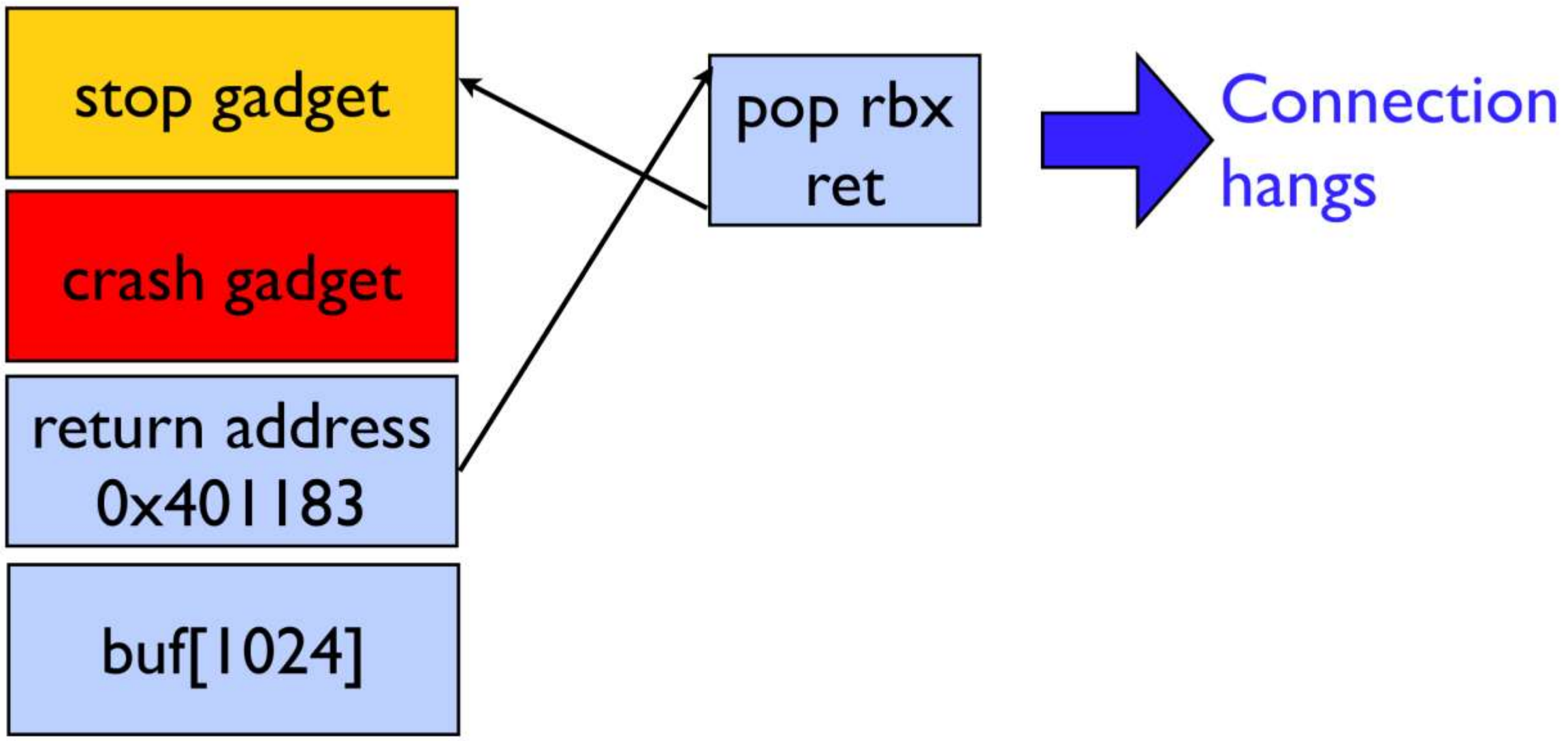

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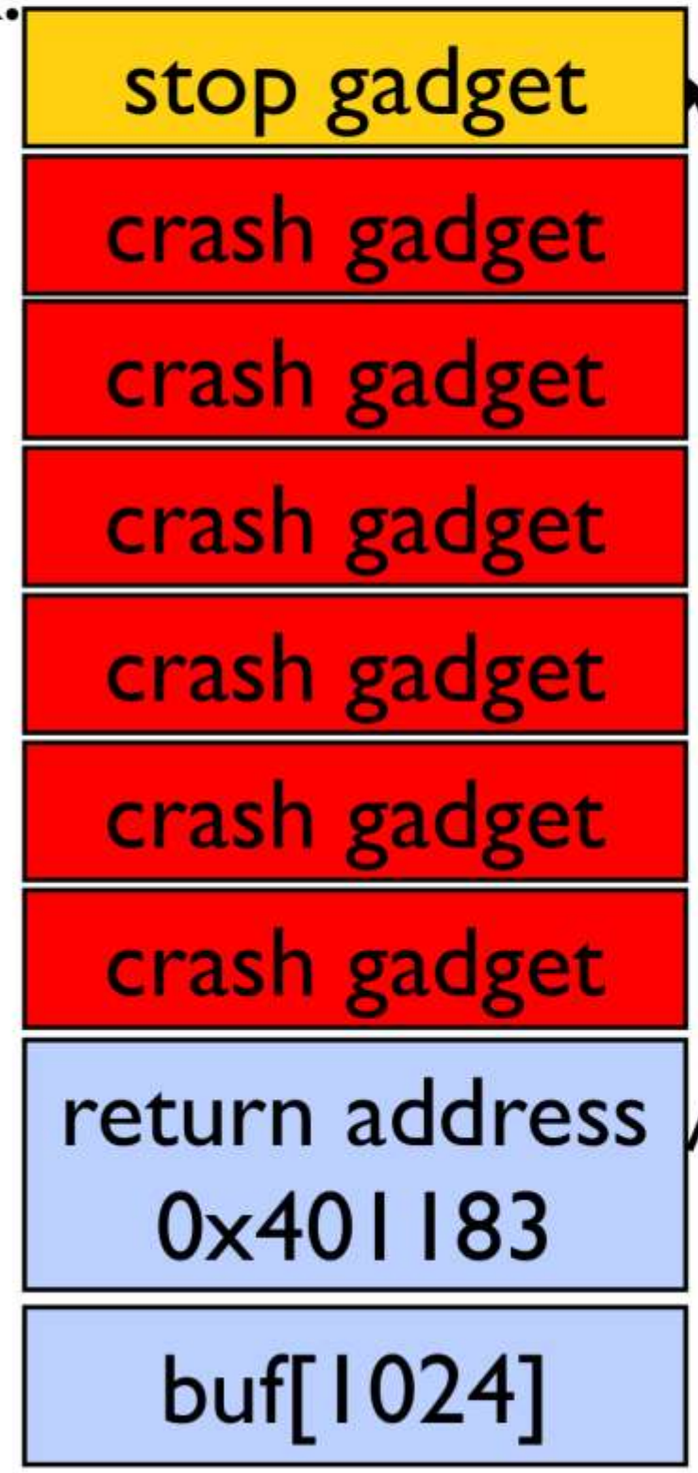
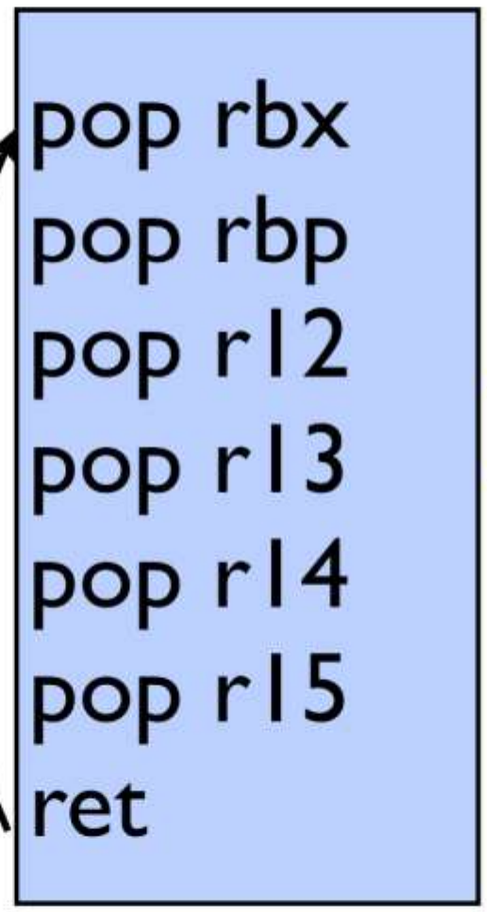
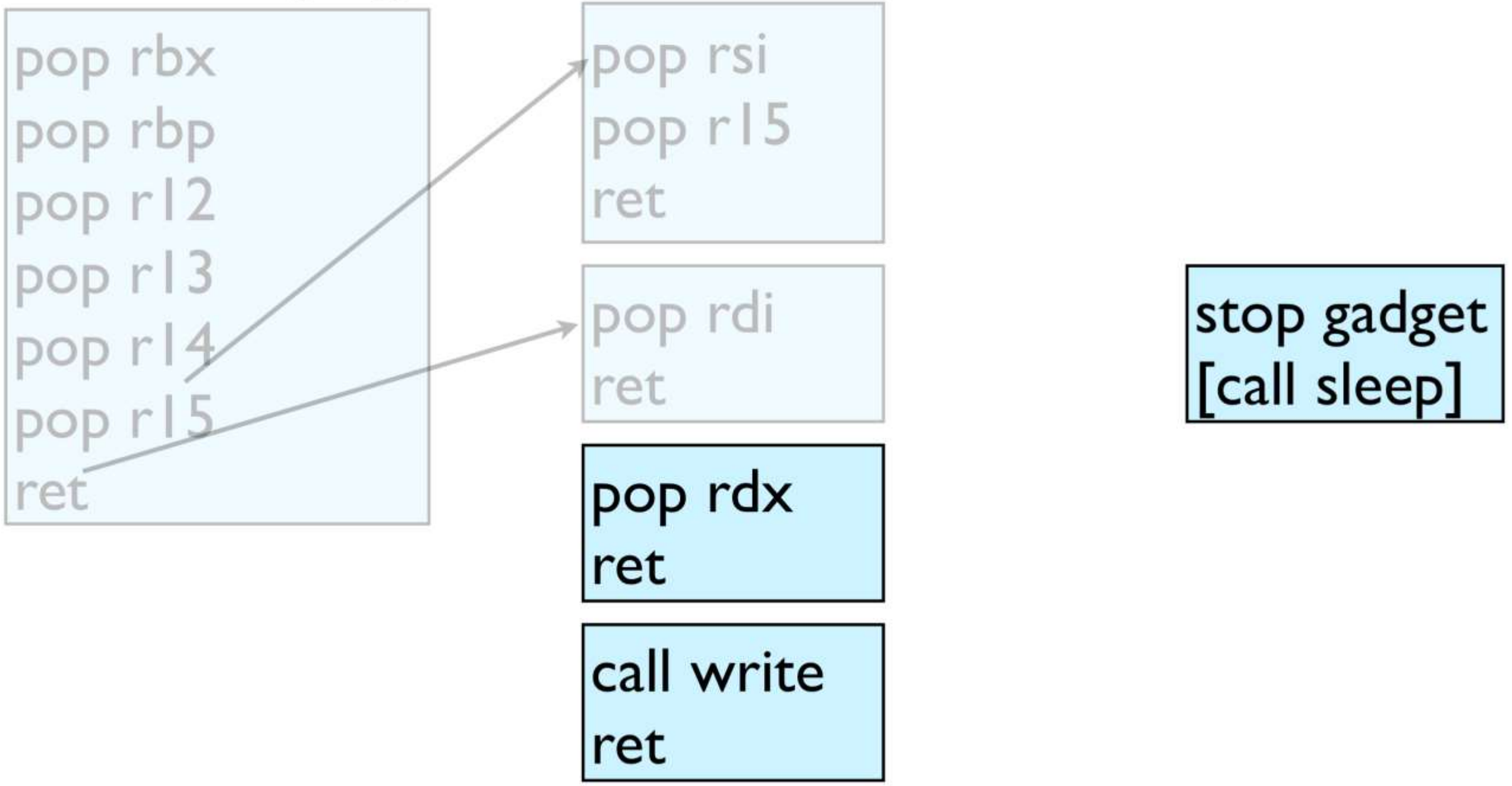




BROP gadget

Pieces of the puzzle

The BROP gadget



Pieces of the puzzle

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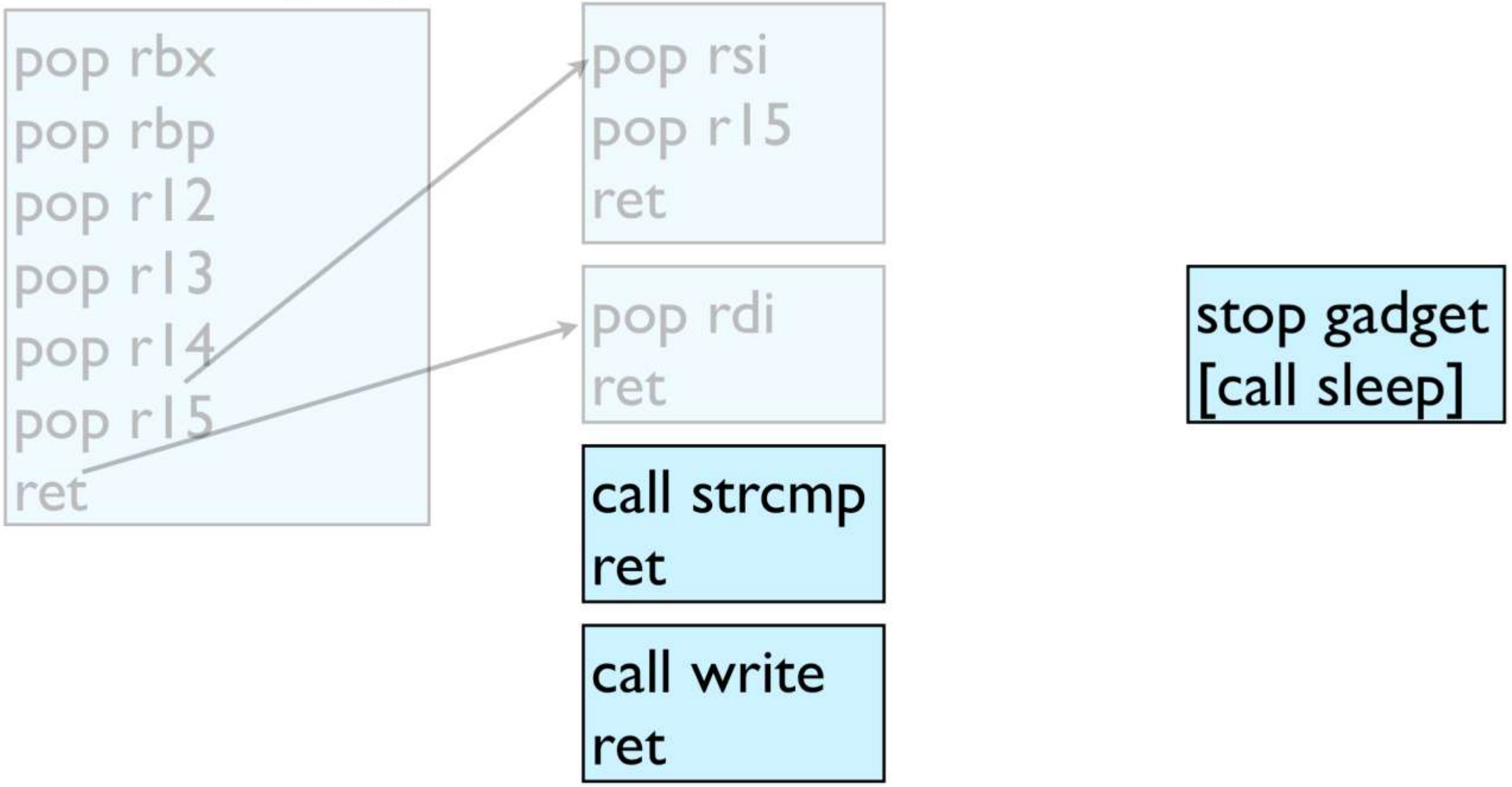

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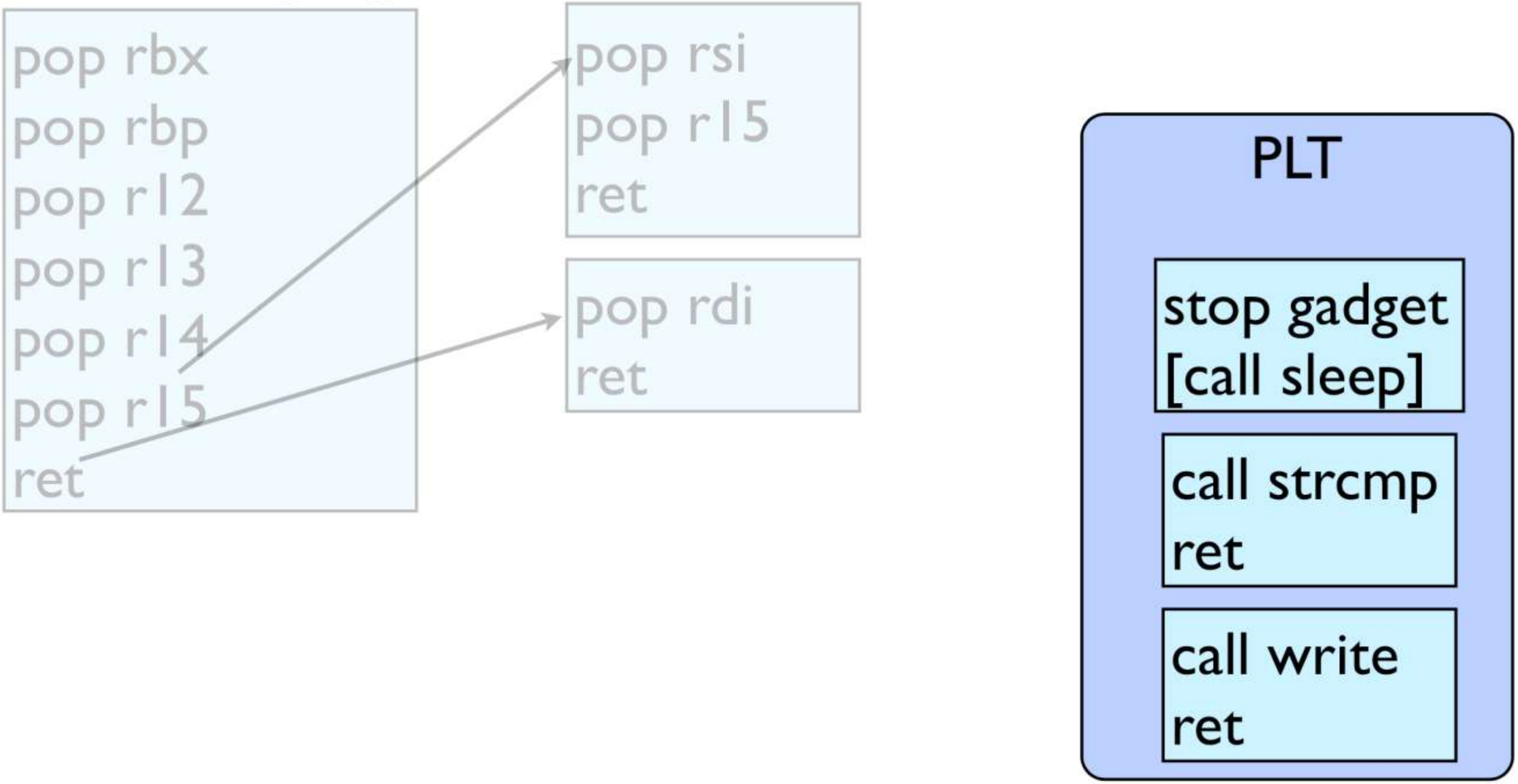
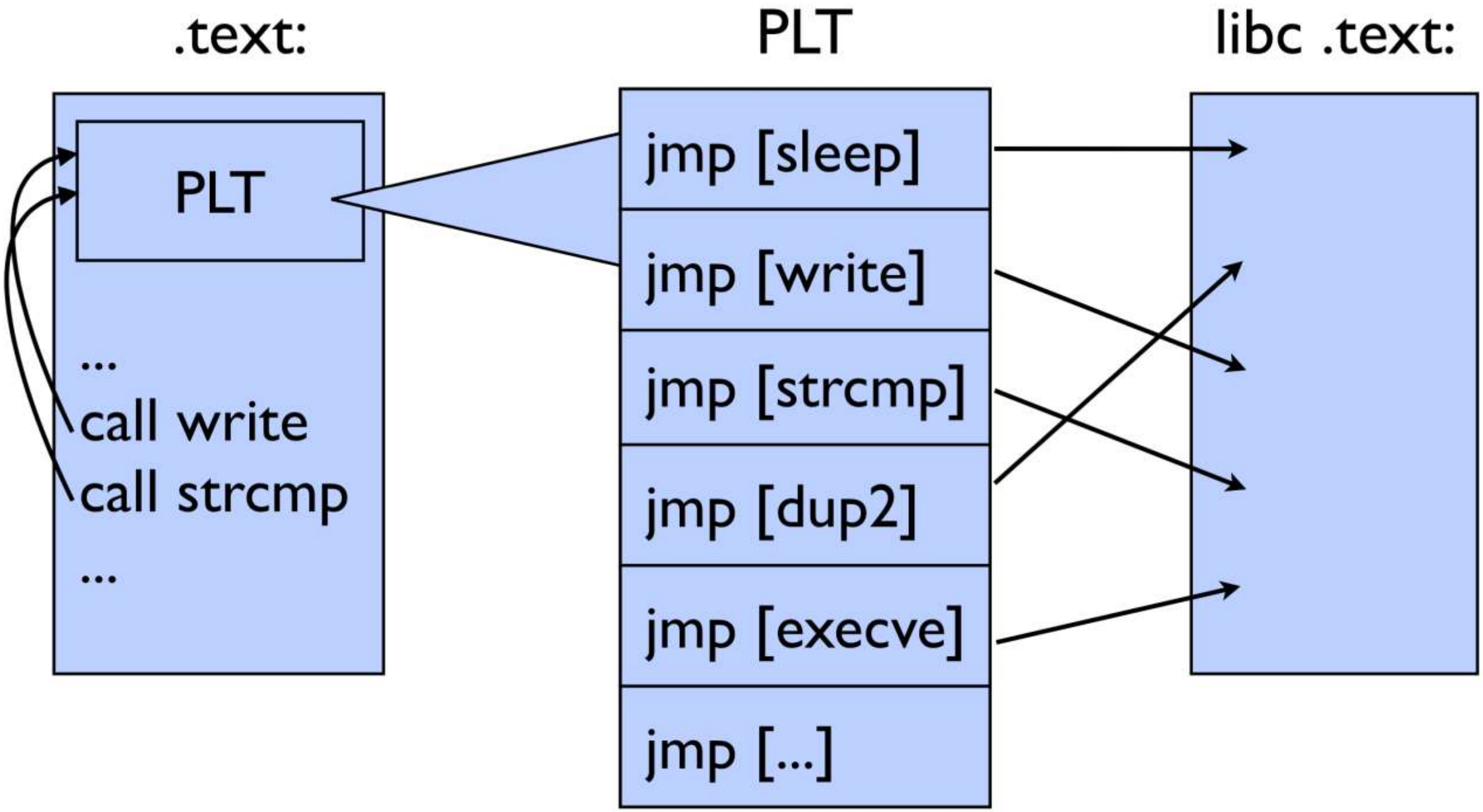


Procedure Linking Table (PLT)



Fingerprinting strcmp

arg1	arg2	result
readable	0x0	crash
0x0	readable	crash
readable	readable	nocrash

Can now control three arguments:
strcmp sets RDX to length of string

Finding write

- Try sending data to socket by calling candidate PLT function.
- check if data received on socket.
- chain writes with different FD numbers to find socket. Use multiple connections.

Launching a shell

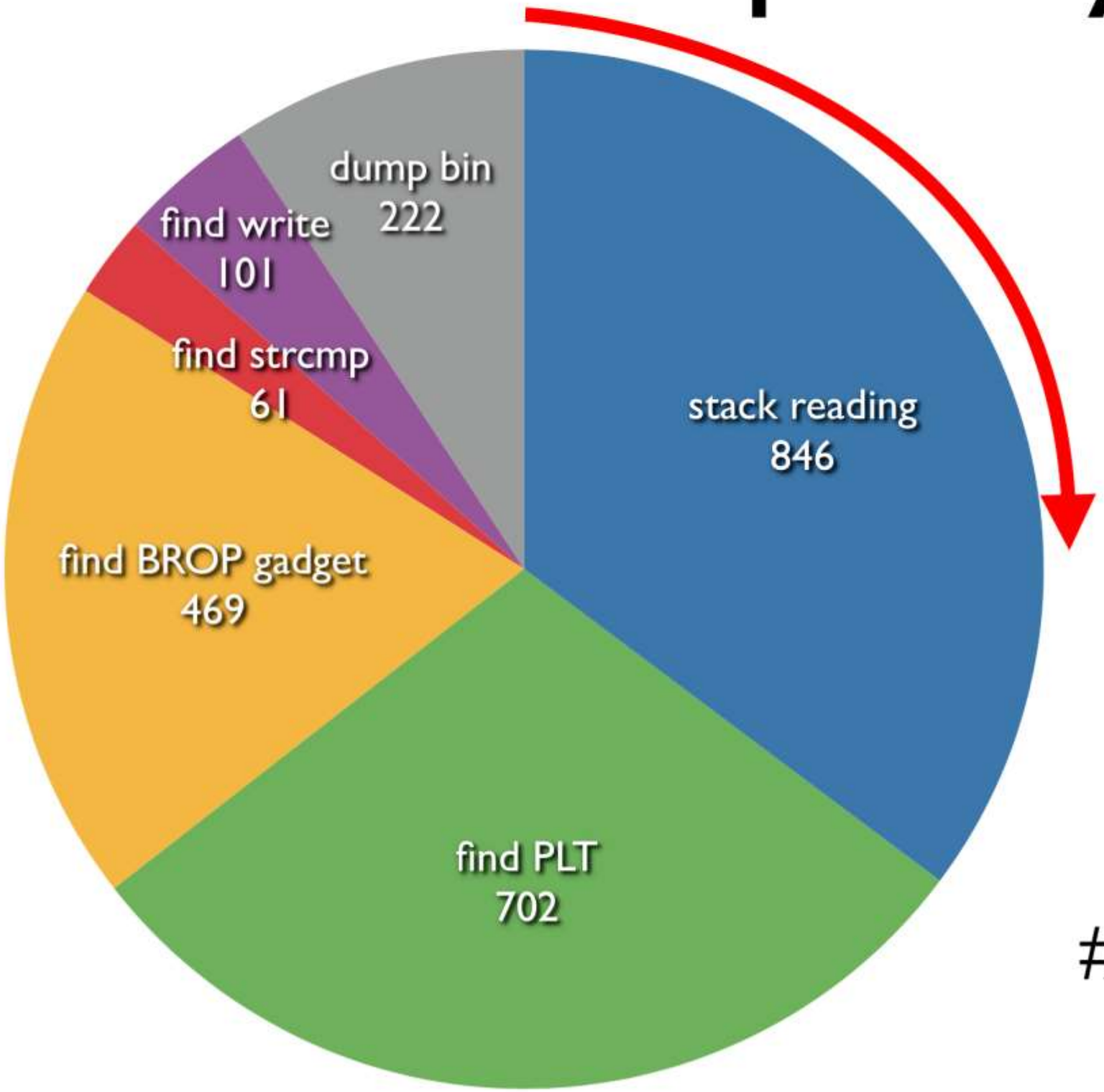
1. dump binary from memory to network.
   Not blind anymore!
2. dump symbol table to find PLT calls.
3. redirect stdin/out to socket:
   - dup2(sock, 0); dup2(sock, 1);
4. read() “/bin/sh” from socket to memory
5. execve(“/bin/sh”, 0, 0)

Braille

- Fully automated: from first crash to shell.
- 2,000 lines of Ruby.
- Needs function that will trigger overflow:
  - nginx: 68 lines.
  - MySQL: 121 lines.
  - toy proprietary service: 35 lines.

```
try_exp(data) → true  crash
                false no crash
```

Attack complexity



# of requests
for nginx