
Final Project

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0 实验配置

- Linux Kernel: 5.4.126
- OS: Ubuntu 18.04.5 LTS
- Architecture: x86_64

1 实验过程

本次实验修改系统调用表（`sys_call_table`）中的 `__NR_clone` 系统调用。其中难点主要分为 3 个部分，定位系统调用表、修改内存权限为可读以及对系统调用表进行替换。

1.1 定位系统调用表

在 x86 系统中可以使用 `linux/kallsyms.h` 中定义的 `kallsyms_lookup_name("sys_call_table")` 直接找出系统调用表的内存位置。

```
static unsigned long *syscall_table;

syscall_table = (void *) kallsyms_lookup_name("sys_call_table");
if (!syscall_table) {
    printk(KERN_ERR "Syscall_table not found");
    return -1;
}
```

系统调用表中通过 `__NR_clone` 访问原先的系统调用处理函数。为事后复原系统调用表，这里用一个自定义指针储存一下。

```
typedef long(sys_clone) (unsigned long, unsigned long, int __user *, int __user *, unsigned long);
static sys_clone *old_clone;

old_clone = (sys_clone *)syscall_table[__NR_clone];
```

1.2 修改内存权限

系统调用表所在内存是只读内存，因此我们需要将该块内存改为可读写内存。除此之外，x86 系统还对该块区域内存做出了保护，需要对 `WP flag` 进行修改。这个 `flag` 用于阻止 CPU 写入只读内存页。

```
inline void mywrite_cr0(unsigned long cr0) {
    asm volatile("mov %0,%%cr0" : "+r"(cr0));
}

#define unprotect_memory() \
({ \
    orig_cr0 = read_cr0(); \
    mywrite_cr0(orig_cr0 & (~ 0x10000)); /* Set WP flag to 0 */ \
});

#define protect_memory() \
({ \
    mywrite_cr0(orig_cr0); /* Set WP flag to 1 */ \
});
```

1.3 替换系统调用表

在修改过内存权限后，就可以对系统调用表进行替换了。首先调用在第一部中存着的原来的系统调用，然后向内核输出替换掉用成功的信息，并返回原来调用的返回值。

```
asmlinkage long sys_clone_hook(unsigned long x1, unsigned long x2, int __user *x3, int __user *x4, unsigned
long x5) {
    long ret_val = old_clone(x1, x2, x3, x4, x5);
    printk(KERN_INFO "hello, I have hacked this syscall");
    return ret_val;
}
unprotect_memory();
syscall_table[_NR_clone] = (unsigned long)sys_clone_hook;
protect_memory();
```

在退出模块的时候，将系统调用表恢复成原来的程序即可。

```
unprotect_memory();
syscall_table[_NR_clone] = (unsigned long)old_clone;
protect_memory();
```

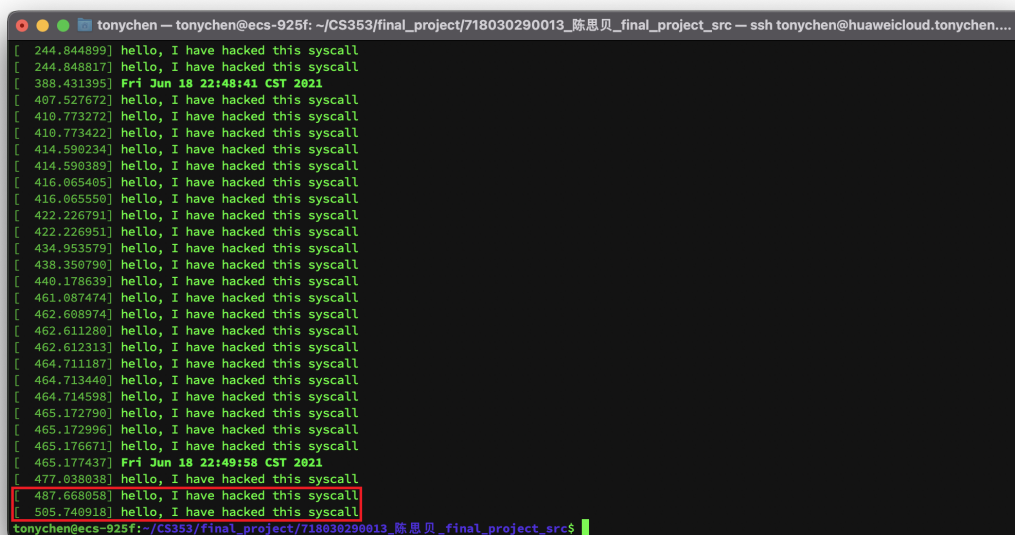
2 实验效果截图

1. 第一次测试（图1）仅运行 dmesg 指令，新增 1 条输出（dmesg）。

```
tonychen — tonychen@ecs-925f: ~/CS353/final_project/718030290013_陈思贝_final_project_src — ssh tonychen@huaweicloud.tonychen....
[ 244.499015] hello, I have hacked this syscall
[ 244.499218] hello, I have hacked this syscall
[ 244.844899] hello, I have hacked this syscall
[ 244.848817] hello, I have hacked this syscall
[ 388.431395] Fri Jun 18 22:48:41 CST 2021
[ 407.527672] hello, I have hacked this syscall
[ 410.773272] hello, I have hacked this syscall
[ 410.773422] hello, I have hacked this syscall
[ 414.590234] hello, I have hacked this syscall
[ 414.590389] hello, I have hacked this syscall
[ 416.065405] hello, I have hacked this syscall
[ 416.065550] hello, I have hacked this syscall
[ 422.226791] hello, I have hacked this syscall
[ 422.226951] hello, I have hacked this syscall
[ 434.953570] hello, I have hacked this syscall
[ 438.350790] hello, I have hacked this syscall
[ 440.178639] hello, I have hacked this syscall
[ 461.087474] hello, I have hacked this syscall
[ 462.608974] hello, I have hacked this syscall
[ 462.611280] hello, I have hacked this syscall
[ 462.612313] hello, I have hacked this syscall
[ 464.711187] hello, I have hacked this syscall
[ 464.713440] hello, I have hacked this syscall
[ 464.714598] hello, I have hacked this syscall
[ 465.172790] hello, I have hacked this syscall
[ 465.172996] hello, I have hacked this syscall
[ 465.176671] hello, I have hacked this syscall
[ 465.177437] Fri Jun 18 22:49:58 CST 2021
[ 477.038038] hello, I have hacked this syscall
tonychen@ecs-925f:~/CS353/final_project/718030290013_陈思贝_final_project_src$
```

图 1: 第一次测试

2. 第二次测试 (图2) 运行 test.o 后通过 dmesg 查看, 新增 2 条输出 (test.o * 1 和 dmesg * 1)。



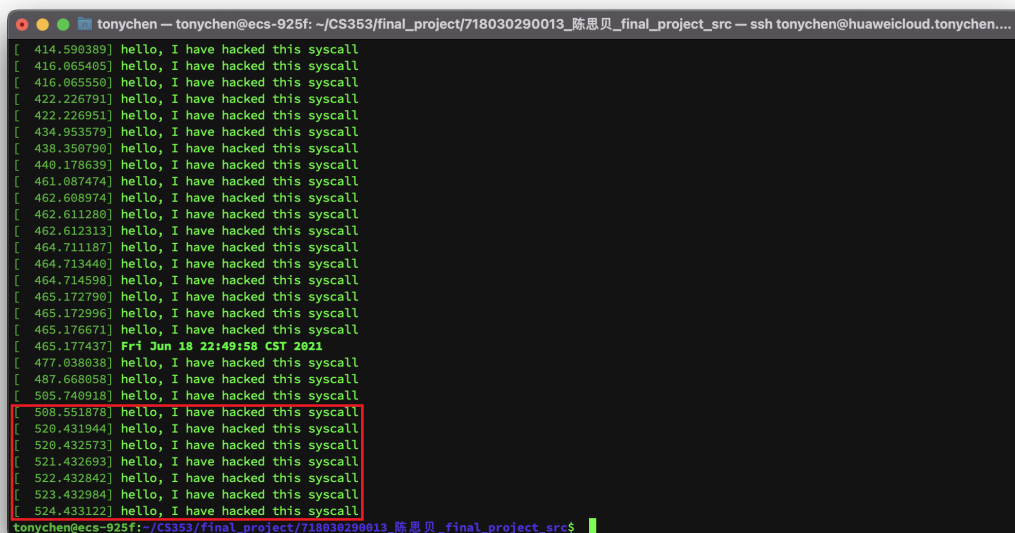
```

tonychen@ecs-925f: ~/CS353/final_project/718030290013_陈思贝_final_project_src -- ssh tonychen@huaweicloud.tonychen....
[ 244.844899] hello, I have hacked this syscall
[ 244.848817] hello, I have hacked this syscall
[ 388.431395] Fri Jun 18 22:48:41 CST 2021
[ 497.527672] hello, I have hacked this syscall
[ 419.773272] hello, I have hacked this syscall
[ 419.773422] hello, I have hacked this syscall
[ 414.590234] hello, I have hacked this syscall
[ 414.590389] hello, I have hacked this syscall
[ 416.065405] hello, I have hacked this syscall
[ 416.065550] hello, I have hacked this syscall
[ 422.226791] hello, I have hacked this syscall
[ 422.226951] hello, I have hacked this syscall
[ 434.953579] hello, I have hacked this syscall
[ 438.350790] hello, I have hacked this syscall
[ 440.178639] hello, I have hacked this syscall
[ 461.087474] hello, I have hacked this syscall
[ 462.608974] hello, I have hacked this syscall
[ 462.611280] hello, I have hacked this syscall
[ 462.612313] hello, I have hacked this syscall
[ 464.711187] hello, I have hacked this syscall
[ 464.713440] hello, I have hacked this syscall
[ 464.714598] hello, I have hacked this syscall
[ 465.172790] hello, I have hacked this syscall
[ 465.172996] hello, I have hacked this syscall
[ 465.176671] hello, I have hacked this syscall
[ 465.177437] Fri Jun 18 22:49:58 CST 2021
[ 477.038038] hello, I have hacked this syscall
[ 487.668058] hello, I have hacked this syscall
[ 505.740918] hello, I have hacked this syscall
tonychen@ecs-925f:~/CS353/final_project/718030290013_陈思贝_final_project_src$

```

图 2: 第二次测试

3. 第三次测试 (图3) 运行 bench.o 后通过 dmesg 查看, 新增 7 条输出 (bench.o * 6 和 dmesg * 1)。



```

tonychen@ecs-925f: ~/CS353/final_project/718030290013_陈思贝_final_project_src -- ssh tonychen@huaweicloud.tonychen....
[ 414.590389] hello, I have hacked this syscall
[ 416.065405] hello, I have hacked this syscall
[ 416.065550] hello, I have hacked this syscall
[ 422.226791] hello, I have hacked this syscall
[ 422.226951] hello, I have hacked this syscall
[ 434.953579] hello, I have hacked this syscall
[ 438.350790] hello, I have hacked this syscall
[ 440.178639] hello, I have hacked this syscall
[ 461.087474] hello, I have hacked this syscall
[ 462.608974] hello, I have hacked this syscall
[ 462.611280] hello, I have hacked this syscall
[ 462.612313] hello, I have hacked this syscall
[ 464.711187] hello, I have hacked this syscall
[ 464.713440] hello, I have hacked this syscall
[ 464.714598] hello, I have hacked this syscall
[ 465.172790] hello, I have hacked this syscall
[ 465.172996] hello, I have hacked this syscall
[ 465.176671] hello, I have hacked this syscall
[ 465.177437] Fri Jun 18 22:49:58 CST 2021
[ 477.038038] hello, I have hacked this syscall
[ 487.668058] hello, I have hacked this syscall
[ 505.740918] hello, I have hacked this syscall
[ 508.551878] hello, I have hacked this syscall
[ 520.431944] hello, I have hacked this syscall
[ 520.432573] hello, I have hacked this syscall
[ 521.432693] hello, I have hacked this syscall
[ 522.432842] hello, I have hacked this syscall
[ 523.432984] hello, I have hacked this syscall
[ 524.433122] hello, I have hacked this syscall
tonychen@ecs-925f:~/CS353/final_project/718030290013_陈思贝_final_project_src$

```

图 3: 第三次测试

3 实验心得

通过本次的实验，对 Linux 中系统调用表有了更深入的理解。对于该文件和其他辅助头文件的阅读，对系统调用操作有了更深入的理解。通过对网上公开的代码示例的分析，成功完成了这次实验。

4 参考资料

1. [How to write to protected pages in the Linux kernel? - StackOverflow](#)
2. [Linux Kernel Module Rootkit —Syscall Table Hijacking](#)
3. [Linux Kernel: System call hooking example - StackOverflow](#)
4. [Adding a New System Call](#)