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ФАКУЛЬТЕТ

«Информатика и системы управления»

КАФЕДРА

«Программное обеспечение ЭВМ и информационные технологии»

ОТЧЁТ

По лабораторной работе №3

По курсу: «Операционные системы»

Тема: «Загружаемые модули ядра»

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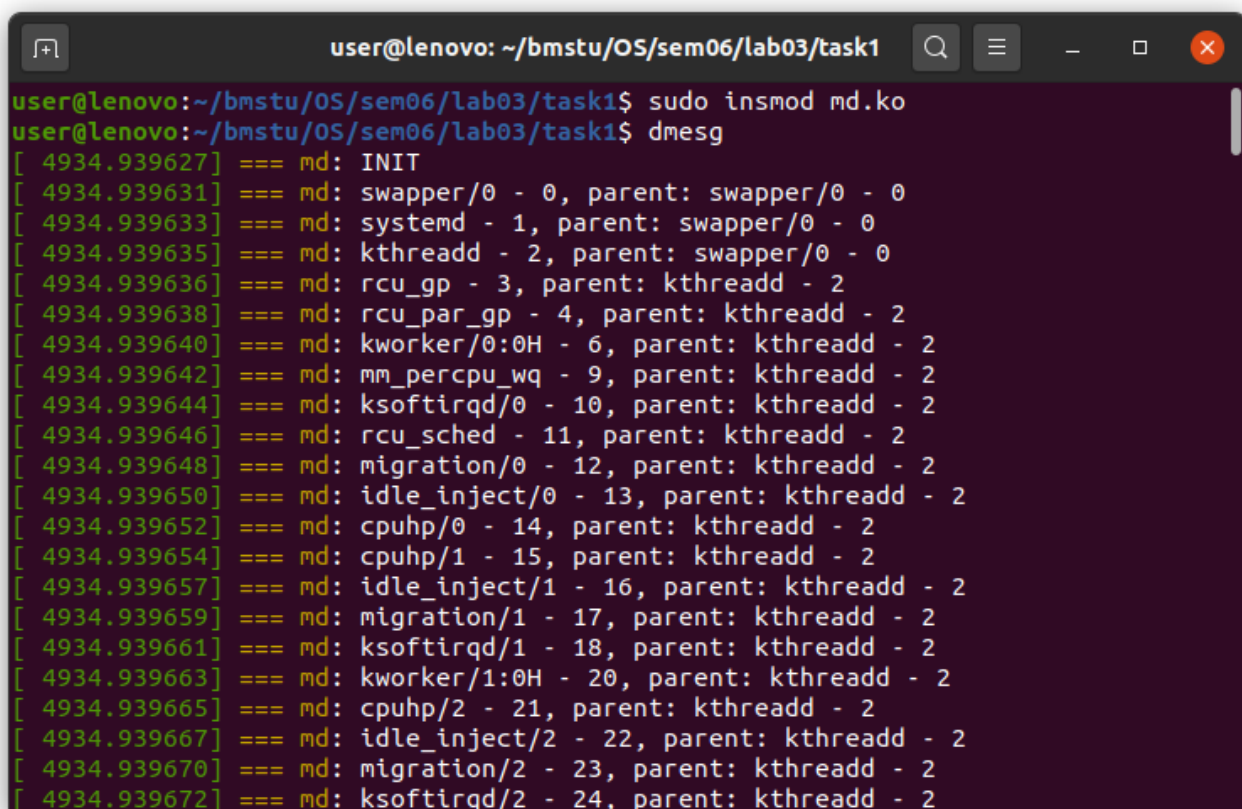
Москва

2020

Часть 1

Листинг 1: task1/md.c

```
1 #include <linux/init.h>
2 #include <linux/module.h>
3 #include <linux/init_task.h>
4
5 MODULE_LICENSE("GPL");
6 MODULE_AUTHOR("Kerimov A.");
7 MODULE_DESCRIPTION("sem03/lab03/task1");
8
9 static int __init md_init(void)
10 {
11     printk(KERN_INFO "=== md: INIT\n");
12
13     struct task_struct *task = &init_task;
14     do {
15         printk(KERN_INFO "=== md: %s - %d, parent: %s - %d\n",
16             task->comm, task->pid, task->parent->comm, task->parent->pid);
17     } while ((task = next_task(task)) != &init_task);
18
19     printk(KERN_INFO "=== md: current: %s - %d, parent: %s - %d\n",
20         current->comm, current->pid, current->parent->comm, current->parent->pid);
21
22     return 0;
23 }
24
25 static void __exit md_exit(void)
26 {
27     printk(KERN_INFO "=== md: EXIT\n");
28 }
29
30 module_init(md_init);
31 module_exit(md_exit);
```



```
user@lenovo: ~/bmstu/OS/sem06/lab03/task1
user@lenovo:~/bmstu/OS/sem06/lab03/task1$ sudo insmod md.ko
user@lenovo:~/bmstu/OS/sem06/lab03/task1$ dmesg
[ 4934.939627] === md: INIT
[ 4934.939631] === md: swapper/0 - 0, parent: swapper/0 - 0
[ 4934.939633] === md: systemd - 1, parent: swapper/0 - 0
[ 4934.939635] === md: kthreadd - 2, parent: swapper/0 - 0
[ 4934.939636] === md: rcu_gp - 3, parent: kthreadd - 2
[ 4934.939638] === md: rcu_par_gp - 4, parent: kthreadd - 2
[ 4934.939640] === md: kworker/0:0H - 6, parent: kthreadd - 2
[ 4934.939642] === md: mm_percpu_wq - 9, parent: kthreadd - 2
[ 4934.939644] === md: ksoftirqd/0 - 10, parent: kthreadd - 2
[ 4934.939646] === md: rcu_sched - 11, parent: kthreadd - 2
[ 4934.939648] === md: migration/0 - 12, parent: kthreadd - 2
[ 4934.939650] === md: idle_inject/0 - 13, parent: kthreadd - 2
[ 4934.939652] === md: cpuhp/0 - 14, parent: kthreadd - 2
[ 4934.939654] === md: cpuhp/1 - 15, parent: kthreadd - 2
[ 4934.939657] === md: idle_inject/1 - 16, parent: kthreadd - 2
[ 4934.939659] === md: migration/1 - 17, parent: kthreadd - 2
[ 4934.939661] === md: ksoftirqd/1 - 18, parent: kthreadd - 2
[ 4934.939663] === md: kworker/1:0H - 20, parent: kthreadd - 2
[ 4934.939665] === md: cpuhp/2 - 21, parent: kthreadd - 2
[ 4934.939667] === md: idle_inject/2 - 22, parent: kthreadd - 2
[ 4934.939670] === md: migration/2 - 23, parent: kthreadd - 2
[ 4934.939672] === md: ksoftirqd/2 - 24, parent: kthreadd - 2
```

Рис. 1: Демонстрация работы программы (начало)

```
user@lenovo: ~/bmstu/OS/sem06/lab03/task1
[ 4934.940475] === md: kworker/1:0 - 6356, parent: kthreadd - 2
[ 4934.940477] === md: kworker/3:1 - 6412, parent: kthreadd - 2
[ 4934.940480] === md: kworker/u8:1 - 6437, parent: kthreadd - 2
[ 4934.940482] === md: kworker/0:2 - 6474, parent: kthreadd - 2
[ 4934.940485] === md: kworker/1:2 - 6672, parent: kthreadd - 2
[ 4934.940488] === md: kworker/u8:4 - 6690, parent: kthreadd - 2
[ 4934.940490] === md: nautilus - 6697, parent: systemd - 1441
[ 4934.940492] === md: Web Content - 6891, parent: IPC Launch - 4369
[ 4934.940495] === md: kworker/0:1 - 6980, parent: kthreadd - 2
[ 4934.940498] === md: kworker/2:2 - 6981, parent: kthreadd - 2
[ 4934.940500] === md: gnome-terminal- - 7016, parent: systemd - 1441
[ 4934.940503] === md: bash - 7027, parent: gnome-terminal- - 7016
[ 4934.940506] === md: kworker/3:0 - 7033, parent: kthreadd - 2
[ 4934.940510] === md: kworker/1:1 - 7034, parent: kthreadd - 2
[ 4934.940513] === md: texstudio - 8360, parent: gnome-shell - 1778
[ 4934.940515] === md: kworker/1:3 - 8478, parent: kthreadd - 2
[ 4934.940518] === md: sudo - 8496, parent: bash - 7027
[ 4934.940520] === md: insmod - 8497, parent: sudo - 8496
[ 4934.940522] === md: systemd-udevd - 8498, parent: systemd-udevd - 335
[ 4934.940525] === md: current: insmod - 8497, parent: sudo - 8496
user@lenovo:~/bmstu/OS/sem06/lab03/task1$ sudo rmmod md
user@lenovo:~/bmstu/OS/sem06/lab03/task1$ dmesg | tail -1
[ 4965.823765] === md: EXIT
user@lenovo:~/bmstu/OS/sem06/lab03/task1$
```

Рис. 2: Демонстрация работы программы (продолжение)

Часть 2

Листинг 2: task2/md1.c

```
1 #include <linux/init.h>
2 #include <linux/module.h>
3 #include "md.h"
4
5 MODULE_LICENSE("GPL");
6 MODULE_AUTHOR("Kerimov A.");
7 MODULE_DESCRIPTION("sem03/lab03/task2/md1");
8
9 static int __init md1_init(void)
10 {
11     printk(KERN_INFO "=== md1: INIT\n");
12     return 0;
13 }
14
15 static void __exit md1_exit(void)
16 {
17     printk(KERN_INFO "=== md1: EXIT\n");
18 }
19
20 module_init(md1_init);
21 module_exit(md1_exit);
22
23
24 char *md1_string = "Hello, World!";
25 int md1_number = 1024;
26
27 EXPORT_SYMBOL(md1_string);
28 EXPORT_SYMBOL(md1_number);
29
30 extern char *md1_palindrome(int n)
31 {
32     printk(KERN_INFO "=== md1: PALINDROME");
```

```

33
34     return n == md1_reverse(n) ? "palindrome" : "not palindrome";
35 }
36
37 extern int md1_reverse(int n)
38 {
39     int r, t;
40     printk(KERN_INFO "=== md1: REVERSE");
41
42     r = 0;
43     for (t = n; t; t /= 10) {
44         r = 10 * r + t % 10;
45     }
46
47     return r;
48 }
49
50 EXPORT_SYMBOL(md1_palindrome);
51 EXPORT_SYMBOL(md1_reverse);

```

Листинг 3: task2/md2.c

```

1  #include <linux/init.h>
2  #include <linux/module.h>
3  #include "md.h"
4
5  MODULE_LICENSE("GPL");
6  MODULE_AUTHOR("Kerimov A.");
7  MODULE_DESCRIPTION("sem03/lab03/task2/md2");
8
9  static int __init md2_init(void)
10 {
11     printk(KERN_INFO "=== md2: INIT\n");
12
13     printk(KERN_INFO "=== md2: md1_string is \"%s\"\n", md1_string);
14     printk(KERN_INFO "=== md2: md1_number is %d\n", md1_number);
15
16     printk(KERN_INFO "=== md2: 12321 is %s\n", md1_palindrome(12321));
17     printk(KERN_INFO "=== md2: 12345 is %s\n", md1_palindrome(12345));
18     printk(KERN_INFO "=== md2: reverse of 12321 is %d\n", md1_reverse(12321));
19     printk(KERN_INFO "=== md2: reverse of 12345 is %d\n", md1_reverse(12345));
20
21     return 0;
22 }
23
24 static void __exit md2_exit(void)
25 {
26     printk(KERN_INFO "=== md2: EXIT\n");
27 }
28
29 module_init(md2_init);
30 module_exit(md2_exit);

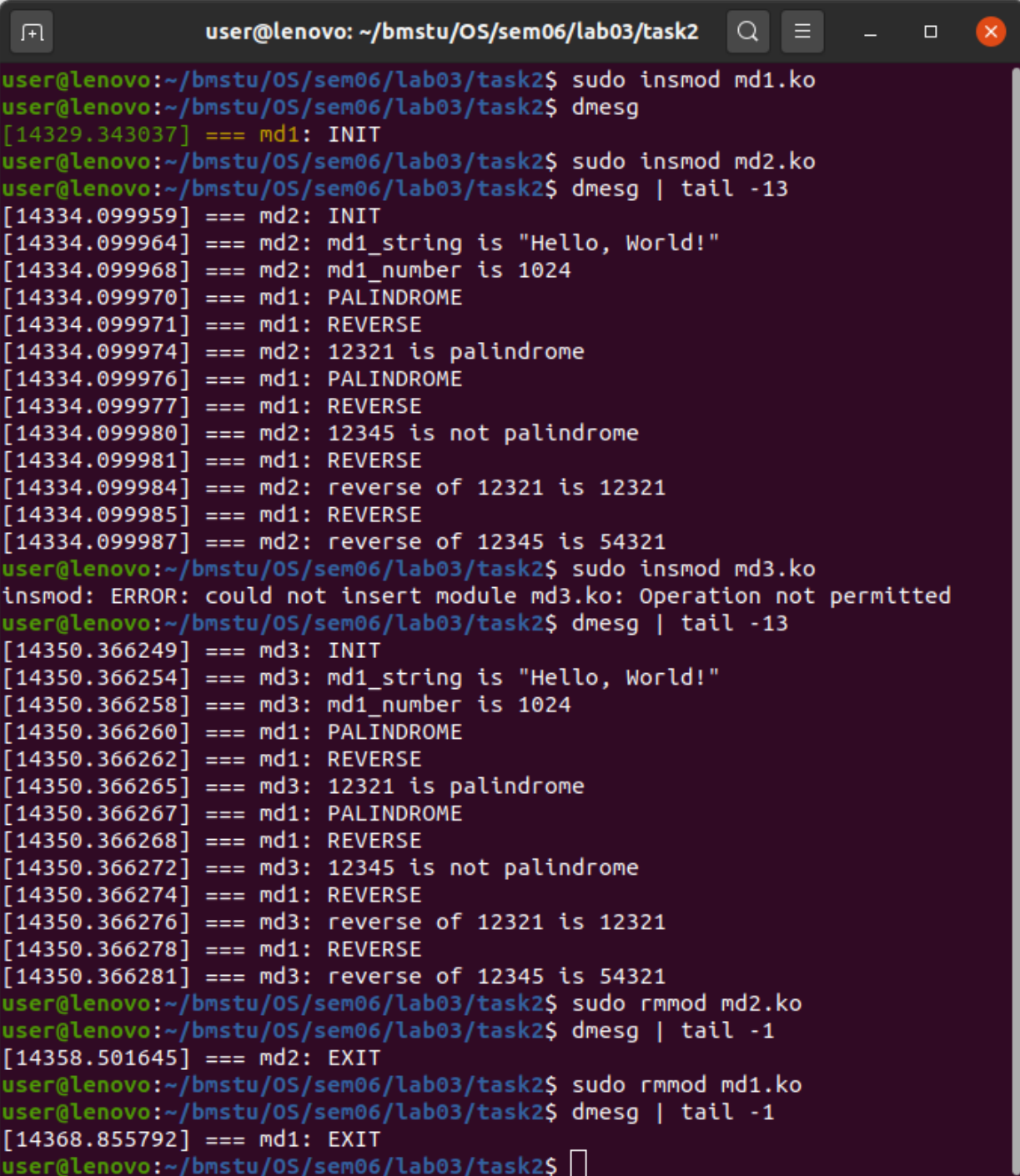
```

Листинг 4: task2/md3.c

```

1  #include <linux/init.h>
2  #include <linux/module.h>
3  #include "md.h"
4
5  MODULE_LICENSE("GPL");
6  MODULE_AUTHOR("Kerimov A.");
7  MODULE_DESCRIPTION("sem03/lab03/task2/md3");
8
9  static int __init md3_init(void)
10 {
11     printk(KERN_INFO "=== md3: INIT\n");
12
13     printk(KERN_INFO "=== md3: md1_string is \"%s\"\n", md1_string);
14     printk(KERN_INFO "=== md3: md1_number is %d\n", md1_number);
15
16     printk(KERN_INFO "=== md3: 12321 is %s\n", md1_palindrome(12321));
17     printk(KERN_INFO "=== md3: 12345 is %s\n", md1_palindrome(12345));
18     printk(KERN_INFO "=== md3: reverse of 12321 is %d\n", md1_reverse(12321));
19     printk(KERN_INFO "=== md3: reverse of 12345 is %d\n", md1_reverse(12345));
20
21     return -1;
22 }
23

```

A terminal window titled 'user@lenovo: ~/bmstu/OS/sem06/lab03/task2' with standard window controls. It displays a series of commands and their outputs related to loading and unloading kernel modules md1.ko, md2.ko, and md3.ko. The output includes timestamps, module names, and specific data like 'Hello, World!', '1024', and palindrome checks for '12321' and '12345'. An error is shown when trying to load md3.ko without root permissions.

```
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ sudo insmod md1.ko
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ dmesg
[14329.343037] === md1: INIT
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ sudo insmod md2.ko
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ dmesg | tail -13
[14334.099959] === md2: INIT
[14334.099964] === md2: md1_string is "Hello, World!"
[14334.099968] === md2: md1_number is 1024
[14334.099970] === md1: PALINDROME
[14334.099971] === md1: REVERSE
[14334.099974] === md2: 12321 is palindrome
[14334.099976] === md1: PALINDROME
[14334.099977] === md1: REVERSE
[14334.099980] === md2: 12345 is not palindrome
[14334.099981] === md1: REVERSE
[14334.099984] === md2: reverse of 12321 is 12321
[14334.099985] === md1: REVERSE
[14334.099987] === md2: reverse of 12345 is 54321
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ sudo insmod md3.ko
insmod: ERROR: could not insert module md3.ko: Operation not permitted
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ dmesg | tail -13
[14350.366249] === md3: INIT
[14350.366254] === md3: md1_string is "Hello, World!"
[14350.366258] === md3: md1_number is 1024
[14350.366260] === md1: PALINDROME
[14350.366262] === md1: REVERSE
[14350.366265] === md3: 12321 is palindrome
[14350.366267] === md1: PALINDROME
[14350.366268] === md1: REVERSE
[14350.366272] === md3: 12345 is not palindrome
[14350.366274] === md1: REVERSE
[14350.366276] === md3: reverse of 12321 is 12321
[14350.366278] === md1: REVERSE
[14350.366281] === md3: reverse of 12345 is 54321
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ sudo rmmod md2.ko
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ dmesg | tail -1
[14358.501645] === md2: EXIT
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ sudo rmmod md1.ko
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ dmesg | tail -1
[14368.855792] === md1: EXIT
user@lenovo:~/bmstu/OS/sem06/lab03/task2$
```

Рис. 3: Демонстрация работы программ

```
user@lenovo: ~/bmstu/OS/sem06/lab03/task2
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ lsmod | grep md
crypto_simd      16384  1 aesni_intel
cryptd           24576  3 crypto_simd,ghash_clmulni_intel
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ sudo insmod md2.ko
insmod: ERROR: could not insert module md2.ko: Unknown symbol in module
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ dmesg
[ 5155.906927] md2: Unknown symbol md1_reverse (err -2)
[ 5155.906955] md2: Unknown symbol md1_palindrome (err -2)
[ 5155.906981] md2: Unknown symbol md1_number (err -2)
[ 5155.907006] md2: Unknown symbol md1_string (err -2)
user@lenovo:~/bmstu/OS/sem06/lab03/task2$ lsmod | grep md
crypto_simd      16384  1 aesni_intel
cryptd           24576  3 crypto_simd,ghash_clmulni_intel
user@lenovo:~/bmstu/OS/sem06/lab03/task2$
```

Рис. 4: Ошибка при невозможности обратиться к данным из другого модуля