

Міністерство освіти та науки України
Національний технічний університет України
«Київський політехнічний інститут ім. Ігоря Сікорського»
Факультет інформатики і обчислювальної техніки
Кафедра обчислювальної техніки

ЛАБОРАТОРНА РОБОТА №7
з дисципліни «Архітектура комп'ютерів 2»

Виконав:
студент III курсу ФІОТ
групи ІВ-81 :
Бухтій О. В.
Перевірив:
Каплунов А. В.

Київ-2020

ЛАБОРАТОРНА РОБОТА №7

-----hello.c-----

```
#include <linux/init.h>
#include <linux/module.h>
#include <linux/printk.h>
#include <asm-generic/bug.h>
#include <linux/ktime.h>
#include <linux/slab.h>

struct head_list {
    struct head_list *next;
    ktime_t time;
};

MODULE_AUTHOR("Buhtiy Oleksandr <sasha007.h@gmail.com>");
MODULE_DESCRIPTION("Hello, world in Linux Kernel Training");
MODULE_LICENSE("Dual BSD/GPL");

static uint repeats = 1;
module_param(repeats, uint, 0);

MODULE_PARM_DESC(repeats, "Repeat printing n times");

static struct head_list *head;

static int __init initter(void)
{
    int i = 0;
    struct head_list *previous, *curr, *node;

    pr_info("Number of repeats : %d\n", repeats);
    if (repeats == 0) {
        pr_warn("repeats == 0");
    } else if (repeats >= 5 && repeats <= 10) {
        pr_warn("5 <= repeats <= 10");
    } else if (repeats > 10) {
        BUG_ON(1);
        //pr_err("The numberOfRepeats is greater than 10");
        //return -EINVAL;
    }

    head = kmalloc(sizeof(struct head_list *), GFP_KERNEL);
    curr = head;

    for (i = 0; i < repeats; i++) {
        if (i == 3) {
            curr->next = kmalloc(0, GFP_KERNEL);
        } else {
            curr->next = kmalloc(sizeof(struct head_list *), GFP_KERNEL);
        }
        if (curr->next == NULL) {
            while (head != NULL && repeats != 0) {
                node = head;
                head = node->next;
                kfree(node);
            }
            return -ENOMEM;
        }
        curr->time = ktime_get();
        previous = curr;
        curr = curr->next;
    }
}
```

```

        pr_info("Hello, world!\n");
    }
    if (repeats != 0) {
        kfree(previous->next);
        previous->next = NULL;
    }
    return 0;
}

static void __exit exitter(void)
{
    struct head_list *node;

    while (head != NULL && repeats != 0) {
        node = head;
        pr_debug("Current time: %lld", node->time);
        head = node->next;
        kfree(node);
    }
}

module_init(initter);
module_exit(exitter);

```

Повідомлення на "помилку" з виділенням пам'яті :

```
Terminal - kekemon@kekemon:~/repos/busybox/_install
File Edit View Terminal Tabs Help

/ # cd lib/modules/
/lib/modules # insmod hello.ko repeats=5
[ 32.584827] hello: loading out-of-tree module taints kernel.
[ 32.598203] Number of repeats : 5
[ 32.598500] 5 <= repeats <= 10
[ 32.598639] Hello, world!
[ 32.599054] Hello, world!
[ 32.599236] Hello, world!
[ 32.599413] Hello, world!
[ 32.599713] Unhandled fault: page domain fault (0x81b) at 0x00000010
[ 32.600308] pgd = (ptrval)
[ 32.600532] [00000010] *pgd=5768a835, *pte=00000000, *ppte=00000000
[ 32.601886] Internal error: : 81b [#1] SMP ARM
[ 32.602518] Modules linked in: hello(0+)
[ 32.603599] CPU: 0 PID: 62 Comm: insmod Tainted: G          O      4.19.155 #1
[ 32.604158] Hardware name: Generic DT based system
[ 32.605473] PC is at initter+0xdc/0x1000 [hello]
[ 32.605945] LR is at 0xd7697640
[ 32.606231] pc : [<bf0050dc>]   lr : [<d7697640>]   psr: a00e0013
[ 32.606623] sp : d76e7db0   ip : a00e0013   fp : 006000c0
[ 32.607034] r10: bf001080   r9 : bf002240   r8 : c136134c
[ 32.607428] r7 : bf002000   r6 : d76975c0   r5 : 00000004   r4 : 00000010
[ 32.607889] r3 : c188a638   r2 : 00000000   r1 : d76e7d88   r0 : d7697600
[ 32.608425] Flags: NzCv IRQs on FIQs on Mode SVC_32 ISA ARM Segment none
[ 32.608939] Control: 10c5387d Table: 576e806a DAC: 00000051
[ 32.609394] Process insmod (pid: 62, stack limit = 0x(ptrval))
[ 32.609916] Stack: (0xd76e7db0 to 0xd76e8000)
[ 32.610705] 7da0: d76e7dac 00000010 c1899d30 c1889940
[ 32.611813] 7dc0: bf005000 ffff0000 00000000 00000002 d76973c0 00000000 00000028 c0302d90
[ 32.612697] 7de0: 00000000 00210d00 d76a900c d7684600 8040003f d76e7df4 d76e7df4 c1704c48
[ 32.613610] 7e00: 00000000 dbec6080 8040003e c0466504 dbec6080 c1704c48 c0466504 dbec6080
[ 32.614525] 7e20: d7684600 c03d6c90 bf002040 c1704c48 00000002 bf002040 d7697380 d7697480
[ 32.615416] 7e40: bf002040 c03d4aa0 d76973c0 d76e7f38 d7697380 d76e7f38 d7697380 00000002
[ 32.616258] 7e60: bf002040 c03d6cac bf00204c 00007fff bf002040 c03d3cdc bf002088 006000c0
[ 32.617090] 7e80: bf00222c c0f089ec bf002170 c135f450 bf002154 c121d9e0 c121da38 ffe00000
[ 32.618012] 7ea0: c1708ec4 d7684800 ffff0000 00000001 c0466cb8 d7684600 00000000 00000000
[ 32.618822] 7ec0: 00000000 00000000 00000000 00000000 6e72656b 00006c65 00000000 00000000
[ 32.619752] 7ee0: 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
[ 32.620696] 7f00: 00000000 00000000 00000000 c1704c48 00000080 00001500 e0969500 000d9798
[ 32.621693] 7f20: 00000000 000d8238 d76e6000 00000051 000b0972 c03d7224 e096838e e0968400
[ 32.622460] 7f40: e0968000 00001500 e0968fb0 e0968e58 e0968b6c 00003000 00003040 00000000
[ 32.623240] 7f60: 00000000 00000000 00000000 0000001f 00000020 00000017 00000000 00000011
[ 32.623934] 7f80: 00000000 c1704c48 00001500 0963cf85 b6e54aa0 00000080 c0301204 d76e6000
[ 32.624539] 7fa0: 00000080 c0301000 00001500 0963cf85 000d8298 00001500 000d8238 00000001
[ 32.625204] 7fc0: 00001500 0963cf85 b6e54aa0 00000080 bed83e78 bed83e80 000d8238 000b0972
[ 32.625881] 7fe0: bed83b40 bed83b30 0002f01d b6edfc22 800e0030 000d8298 00000000 00000000
[ 32.627634] [<bf0050dc>] (initter [hello]) from [<c0302d90>] (do_one_initcall+0x58/0x214)
[ 32.628206] [<c0302d90>] (do_one_initcall) from [<c03d4aa0>] (do_init_module+0x64/0x208)
[ 32.628534] [<c03d4aa0>] (do_init_module) from [<c03d6cac>] (load_module+0x2004/0x2424)
[ 32.628912] [<c03d6cac>] (load_module) from [<c03d7224>] (sys_init_module+0x158/0x194)
[ 32.629271] [<c03d7224>] (sys_init_module) from [<c0301000>] (ret_fast_syscall+0x0/0x54)
[ 32.629645] Exception stack(0xd76e7fa8 to 0xd76e7ff0)
[ 32.630142] 7fa0: 00001500 0963cf85 000d8298 00001500 000d8238 00000001
[ 32.630921] 7fc0: 00001500 0963cf85 b6e54aa0 00000080 bed83e78 bed83e80 000d8238 000b0972
[ 32.631566] 7fe0: bed83b40 bed83b30 0002f01d b6edfc22
[ 32.632395] Code: e3a02004 e1a0100b eb51c086 e3500000 (e5840000)
[ 32.633201] ---[ end trace 9fd19ee62c68fc79 ]---
Segmentation fault
/lib/modules #
```

```
Terminal - kekemon@kekemon:~/Desktop/LAB/3_plw/1_семестр/AK-2/LAB_7
File Edit View Terminal Tabs Help

for (i = 0; i < repeats; i++) {
ac: e5970000   ldr    r0, [r7]
b0: e1500005   cmp    r0, r5
b4: 9a00001f   bls    138 <init_module+0x138>
      if (i == 3) {
b8: e3550003   cmp    r5, #3
      curr->next = kmalloc(0, GFP_KERNEL);
bc: 03a03010   moveq  r3, #16
c0: 05843000   streq  r3, [r4]
      if (i == 3) {
c4: 0a000010   beq    10c <init_module+0x10c>
c8: e5980018   ldr    r0, [r8, #24]
cc: e3a02004   mov    r2, #4
d0: e1a0100b   mov    r1, fp
d4: ebfffffe   bl     0 <kmem_cache_alloc_trace>
      if (curr->next == NULL) {
d8: e3500000   cmp    r0, #0
      curr->next = kmalloc(sizeof(struct head_list *), GFP_KERNEL);
dc: e5840000   str    r0, [r4]
      if (curr->next == NULL) {
e0: 1a000009   bne    10c <init_module+0x10c>
      while (head != NULL && repeats != 0) {
```

```
Terminal - kekemon@kekemon:~/Desktop/LAB/3_plw/1_семестр/AK-2/LAB_7
File Edit View Terminal Tabs Help

0x000000ac <+76>: movw    r0, #0
0x000000b0 <+80>: movt    r0, #0
0x000000b4 <+84>: bl      0xb4 <initter+84>
0x000000b8 <+88>: b       0xc8 <initter+104>
0x000000bc <+92>: cmp     r3, #10
0x000000c0 <+96>: bls     0xc8 <initter+104>
0x000000c4 <+100>: udf     #18
0x000000c8 <+104>: movw    r8, #0
0x000000cc <+108>: movt    r8, #0
0x000000d0 <+112>: mov     r1, #192      ; 0xc0
0x000000d4 <+116>: mov     r2, #4
0x000000d8 <+120>: ldr     r0, [r8, #24]
0x000000dc <+124>: movt    r1, #96 ; 0x60
0x000000e0 <+128>: bl      0xe0 <initter+128>
0x000000e4 <+132>: movw    r3, #0
0x000000e8 <+136>: movt    r3, #0
0x000000ec <+140>: mov     r11, #192     ; 0xc0
0x000000f0 <+144>: movw    r10, #0
0x000000f4 <+148>: movt    r11, #96      ; 0x60
0x000000f8 <+152>: movt    r10, #0
```

Аналогічно зі створеною помилкою з неправильним аргументом :

```
Terminal - kekemon@kekemon:~/repos/busybox/_install
File Edit View Terminal Tabs Help
[ 6.178857] rtc-pl031 9010000.pl031: setting system clock to 2020-12-22 19:36:23 UTC (1608665783)
[ 6.191329] uart-pl011 9000000.pl011: no DMA platform data
[ 6.383892] Freeing unused kernel memory: 2048K
[ 6.399055] Run /init as init process

Please press Enter to activate this console.
/# cd lib/modules/
/lib/modules # insmod hello.ko repeats=45
40.474842] hello: loading out-of-tree module taints kernel.
40.487808] Number of repeats : 45
40.489323] -----[ cut here ]-----
40.489722] kernel BUG at /home/kekemon/Desktop/LAB/3_pix/1_цементрп/AK-2/LAB_7/hello.c:35!
40.490390] Internal error: Oops - BUG: 0 [#1] SMP ARM
40.490968] Modules linked in: hello(O+)
40.491814] CPU: 0 PID: 62 Comm: insmod Tainted: G          O      4.19.155 #1
40.492300] Hardware name: Generic DT based system
40.493607] PC is at initter+0x64/0x1000 [hello]
40.493962] LR is at initter+0x24/0x1000 [hello]
40.494281] pc : [<bf005064>] lr : [<bf005024>] psr: 200e0013
40.494670] sp : d7665db0 ip : 000001ea fp : 00000028
40.495025] r10: 00000000 r9 : d76d63c0 r8 : 00000002
40.495389] r7 : bf002000 r6 : fffffe00 r5 : bf005000 r4 : bf002000
40.495826] r3 : 0000002d r2 : 00000028 r1 : 1a567000 r0 : 00000016
40.496337] Flags: nzCv IRQs on FIQs on Mode SVC_32 ISA ARM Segment none
40.496834] Control: 10c5387d Table: 576f406a DAC: 00000051
40.497379] Process insmod (pid: 62, stack limit = 0x(ptrval))
40.497923] Stack: (0xd7665db0 to 0xd7666000)
40.498657] 5da0: d7665dac c1704c48 c1899d30 c1899940
40.499669] 5dc0: bf005000 fffffe00 00000000 00000002 d76d63c0 00000000 00000028 c0302d90
40.500635] 5de0: 00000000 00210d00 d768800c d7691600 8040003f d7665df4 d7665df4 c1704c48
40.501611] 5e00: 00000000 dbec6220 8040003e c0466504 dbec6220 c1704c48 c0466504 dbec6220
40.502268] 5e20: d7691600 c03d6c90 bf002040 c1704c48 00000002 bf002040 d76d6380 d76d6480
40.502910] 5e40: bf002040 c03d4aa0 d76d63c0 d7665f38 d76d6380 d7665f38 d76d6380 00000002
40.503584] 5e60: bf002040 c03d6cac bf00204c 00007fff bf002040 c03d3cdc bf002088 006000c0
40.504171] 5e80: bf00222c c0f089ac bf002170 c135f450 bf002154 c121d9a0 c121da38 ffe00000
40.504775] 5ea0: c1708ac4 d7691800 fffffe00 00000001 c0466cb8 d7691600 00000000 00000000
40.505388] 5ec0: 00000000 00000000 00000000 00000000 00000000 6e72656b 00006e55 00000000
40.505991] 5ee0: 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
40.506720] 5f00: 00000000 00000000 00000000 c1704c48 00000080 00001500 a0969500 a0d49798
40.507579] 5f20: 00000000 000d8238 d7664000 00000051 000b0972 c03d7224 a096838e a0968400
40.508181] 5f40: a0968000 00001500 a0968fb0 a0968e58 a0968b6c 00003000 00003040 00000000
40.510004] 5f60: 00000000 00000000 0000162c 0000001f 00000020 00000017 00000000 00000011
40.510871] 5f80: 00000000 c1704c48 00001500 0963cf85 b6e52aa0 00000080 c0301204 d7664000
40.511749] 5fa0: 00000080 c0301000 00001500 0963cf85 000d8298 00001500 000d8238 00000001
40.512486] 5fc0: 00001500 0963cf85 b6e52aa0 00000080 beb11e78 beb11e80 000d8238 000b0972
40.513191] 5fe0: beb11b40 beb11b30 0002f01d b6eddc22 800e0030 000d8298 00000000 00000000
40.515137] [<bf005064>] (initter [hello]) from [<c0302d90>] (do_one_initcall+0x58/0x214)
40.515684] [<c0302d90>] (do_one_initcall) from [<c03d4aa0>] (do_init_module+0x64/0x208)
40.516094] [<c03d4aa0>] (do_init_module) from [<c03d6cac>] (load_module+0x2004/0x2424)
40.516567] [<c03d6cac>] (load_module) from [<c03d7224>] (sys_init_module+0x158/0x194)
40.516935] [<c03d7224>] (sys_init_module) from [<c0301000>] (ret_fast_syscall+0x0/0x54)
40.517365] Exception stack(0xd7665fa8 to 0xd7665ff0)
40.517918] 5fa0: 00001500 0963cf85 00001500 0963cf85 000d8298 00001500 000d8238 00000001
40.518898] 5fc0: 00001500 0963cf85 b6e52aa0 00000080 beb11e78 beb11e80 000d8238 000b0972
40.519695] 5fe0: beb11b40 beb11b30 0002f01d b6eddc22
40.520630] Code: eb4e52b4 ea000002 e353000a 9a000000 (e7f001f2)
40.521458] ---[ end trace d7d3469036627d2e ]---
Segmentation fault
/lib/modules #
```

```
Terminal - kekemon@kekemon:~/Desktop/LAB/3_pix/1_цементрп/AK-2/LAB_7
File Edit View Terminal Tabs Help
44: e3520005 cmp r2, #5
48: 8a000003 bhi 5c <init_module+0x5c>
pr_warn("S <= repeats <= 10");
4c: e3000000 movw r0, #0
50: e3400000 movt r0, #0
54: ebfffffe bl 0 <printk>
58: ea000002 b 68 <init_module+0x68>
} else if (repeats > 10) {
5c: e353000a cmp r3, #10
60: 9a000000 bls 68 <init_module+0x68>
BUG ON(1);
64: e7f001f2 .word 0xe7f001f2
unsigned int index = kmalloc_index(size);
if (!index)
return ZERO_SIZE_PTR;
return kmem_cache_alloc_trace(kmalloc_caches[index],
68: e3008000 movw r8, #0
6c: e3408000 movt r8, #0
```

```
Terminal - kekemon@kekemon:~/Desktop/LAB/3_pix/1_цементрп/AK-2/LAB_7
File Edit View Terminal Tabs Help
Dump of assembler code for function initter:
0x00000060 <+0>: push {r4, r5, r6, r7, r8, r9, r10, r11, lr}
0x00000064 <+4>: movw r4, #0
0x00000068 <+8>: movt r4, #0
0x0000006c <+12>: sub sp, sp, #12
0x00000070 <+16>: movw r0, #0
0x00000074 <+20>: movt r0, #0
0x00000078 <+24>: ldr r1, [r4]
0x0000007c <+28>: mov r7, r4
0x00000080 <+32>: bl 0x80 <initter+32>
0x00000084 <+36>: ldr r3, [r4]
0x00000088 <+40>: cmp r3, #0
0x0000008c <+44>: bne 0xa0 <initter+64>
0x00000090 <+48>: movw r0, #0
0x00000094 <+52>: movt r0, #0
0x00000098 <+56>: bl 0x98 <initter+56>
0x0000009c <+60>: b 0xc8 <initter+104>
0x000000a0 <+64>: sub r2, r3, #5
0x000000a4 <+68>: cmp r2, #5
```