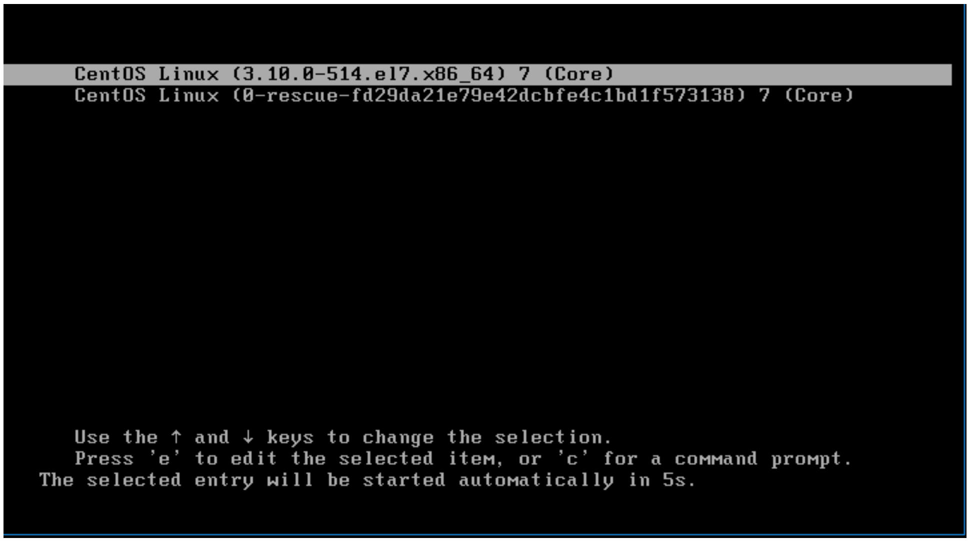
Debugging

Objective: In this lab you will debug a kernel module using gdb post mortem (not live since this would require kgdb and multiple machines).

File(s) for this lab:

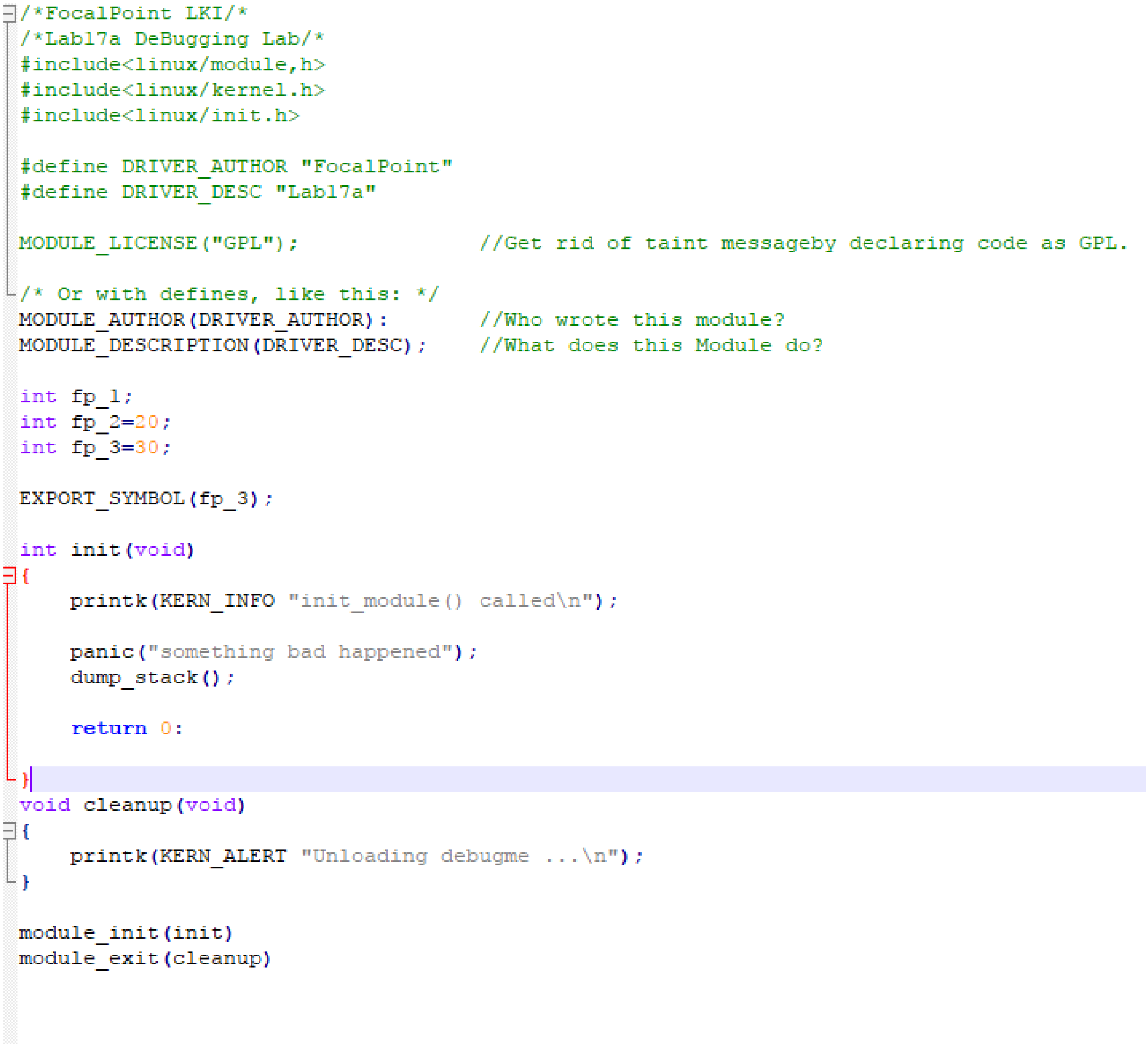
1. Reboot the computer and choose the debug kernel.



```
      CentOS Linux (3.10.0-514.el7.x86_64) 7 (Core)
      CentOS Linux (0-rescue-fd29da21e79e42dcbfe4c1bd1f573138) 7 (Core)




      Use the ↑ and ↓ keys to change the selection.
      Press 'e' to edit the selected item, or 'c' for a command prompt.
   The selected entry will be started automatically in 5s.
```

2. Open a terminal and verify that the kdump service is operational using the command “sudo service kdump status”.

3. Navigate to the “~/LKI/labs/Lab17” folder and view the debugme.c file.

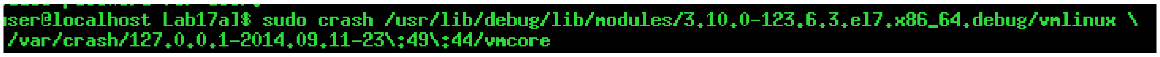


```
/*FocalPoint LKI/*
/*Lab17a DeBugging Lab/*
#include<linux/module,h>
#include<linux/kernel.h>
#include<linux/init.h>

#define DRIVER_AUTHOR "FocalPoint"
#define DRIVER_DESC "Lab17a"

MODULE_LICENSE("GPL");                //Get rid of taint messageby declaring code as GPL.

/* Or with defines, like this: */
MODULE_AUTHOR(DRIVER_AUTHOR):         //Who wrote this module?
MODULE_DESCRIPTION(DRIVER_DESC);      //What does this Module do?

int fp_1;
int fp_2=20;
int fp_3=30;

EXPORT_SYMBOL(fp_3);

int init(void)
{
    printk(KERN_INFO "init_module() called\n");

    panic("something bad happened");
    dump_stack();

    return 0:

}
void cleanup(void)
{
    printk(KERN_ALERT "Unloading debugme ...\n");
}

module_init(init)
module_exit(cleanup)
```

4. The program debugme simply causes a kernel panic during LKM initialization.

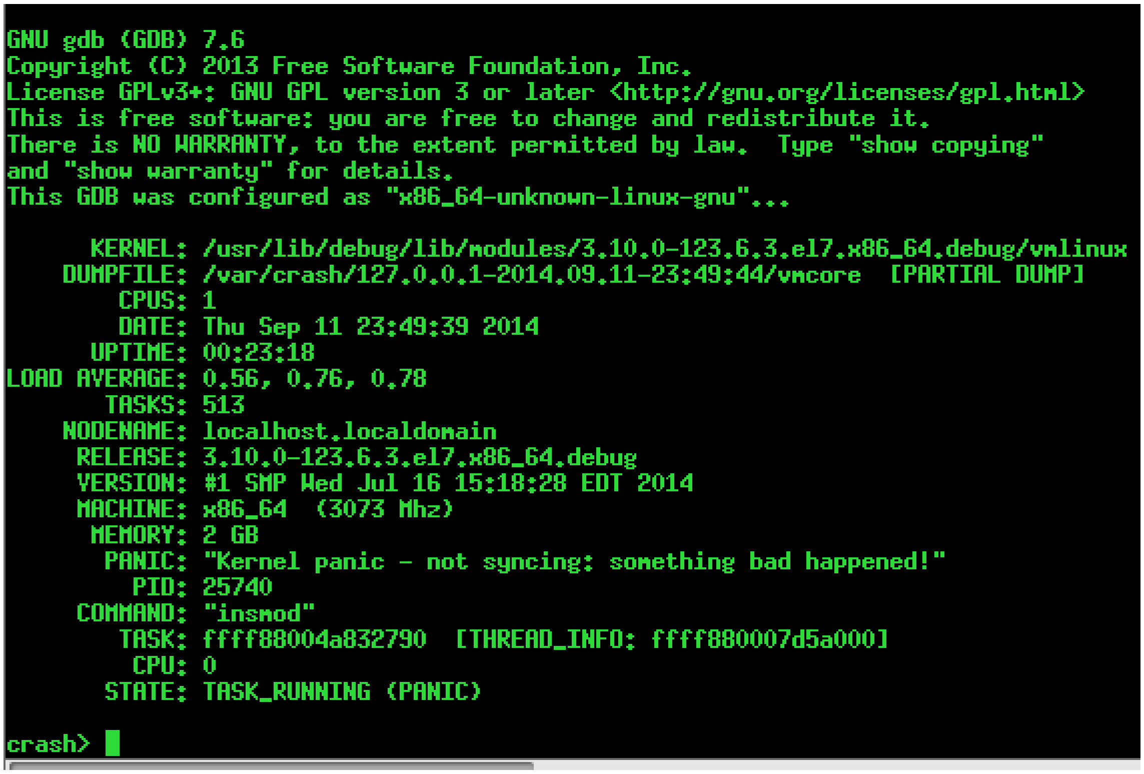
5. Load the module via “sudo /sbin/insmod debugme.ko”. Observe what happens. (Make sure you do not interfere with the system until it boots for the second time and choose the debug kernel again).

6. When the system resumes open a terminal and view the crash dump file using the “crash” command.



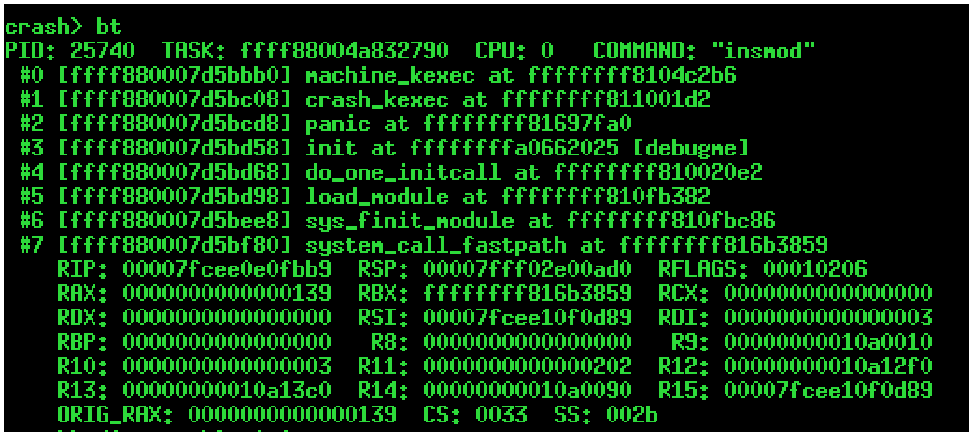
```
ser@localhost Lab17a]$ sudo crash /usr/lib/debug/lib/modules/3.10.0-123.6.3.el7.x86_64.debug/vmlinux \
/var/crash/127.0.0.1-2014.09.11-23\:49\:44/vmcore
```

7. The crash program gives us a wealth of information about what happened.



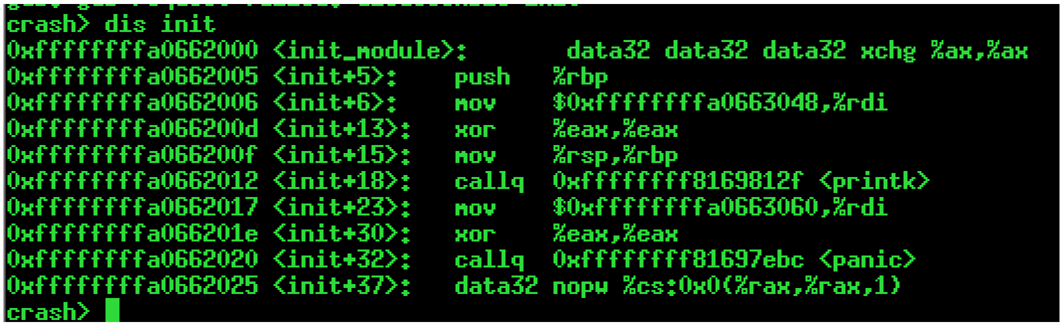
```
GNU gdb (GDB) 7.6
Copyright (C) 2013 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-unknown-linux-gnu"...

      KERNEL: /usr/lib/debug/lib/modules/3.10.0-123.6.3.el7.x86_64.debug/vmlinux
    DUMPFILE: /var/crash/127.0.0.1-2014.09.11-23:49:44/vmcore  [PARTIAL DUMP]
        CPUS: 1
        DATE: Thu Sep 11 23:49:39 2014
      UPTIME: 00:23:18
LOAD AVERAGE: 0.56, 0.76, 0.78
       TASKS: 513
    NODENAME: localhost.localdomain
     RELEASE: 3.10.0-123.6.3.el7.x86_64.debug
     VERSION: #1 SMP Wed Jul 16 15:18:28 EDT 2014
     MACHINE: x86_64  (3073 Mhz)
      MEMORY: 2 GB
       PANIC: "Kernel panic - not syncing: something bad happened!"
         PID: 25740
     COMMAND: "insmod"
        TASK: ffff88004a832790  [THREAD_INFO: ffff880007d5a000]
         CPU: 0
       STATE: TASK_RUNNING (PANIC)

crash> 
```

8. Where is the result of our panic() call?
9. Finally you can issue normal gdb commands to get to the bottom of what may have gone wrong. Example “bt” or backtrace.



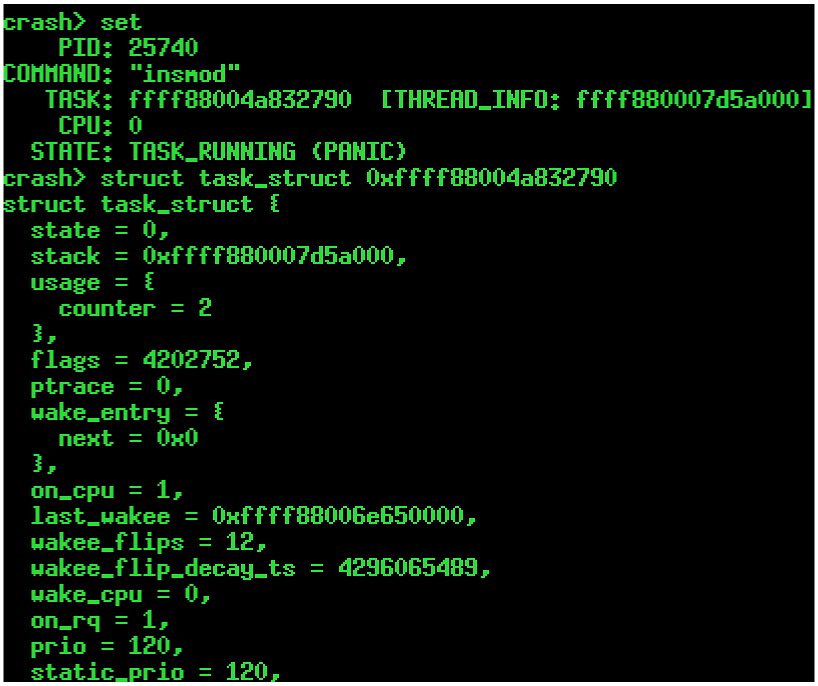
```
crash> bt
PID: 25740  TASK: ffff88004a832790  CPU: 0   COMMAND: "insmod"
 #0 [ffff880007d5bbb0] machine_kexec at ffffffff8104c2b6
 #1 [ffff880007d5bc08] crash_kexec at ffffffff811001d2
 #2 [ffff880007d5bcd8] panic at ffffffff81697fa0
 #3 [ffff880007d5bd58] init at ffffffffa0662025 [debugme]
 #4 [ffff880007d5bd68] do_one_initcall at ffffffff810020e2
 #5 [ffff880007d5bd98] load_module at ffffffff810fb382
 #6 [ffff880007d5bee8] sys_finit_module at ffffffff810fbc86
 #7 [ffff880007d5bf80] system_call_fastpath at ffffffff816b3859
    RIP: 00007fcee0e0fbb9  RSP: 00007fff02e00ad0  RFLAGS: 00010206
    RAX: 0000000000000139  RBX: ffffffff816b3859  RCX: 0000000000000000
    RDX: 0000000000000000  RSI: 00007fcee10f0d89  RDI: 0000000000000003
    RBP: 0000000000000000   R8: 0000000000000000   R9: 00000000010a0010
    R10: 0000000000000003  R11: 0000000000000202  R12: 00000000010a12f0
    R13: 00000000010a13c0  R14: 00000000010a0090  R15: 00007fcee10f0d89
    ORIG_RAX: 0000000000000139  CS: 0033  SS: 002b
```

10. If you are familiar with gdb, disassemble (**dis**) the **init** function and locate the call to panic.



```
crash> dis init
0xffffffffa0662000 <init_module>:       data32 data32 data32 xchg %ax,%ax
0xffffffffa0662005 <init+5>:    push   %rbp
0xffffffffa0662006 <init+6>:    mov    $0xffffffffa0663048,%rdi
0xffffffffa066200d <init+13>:   xor    %eax,%eax
0xffffffffa066200f <init+15>:   mov    %rsp,%rbp
0xffffffffa0662012 <init+18>:   callq  0xffffffff8169812f <printk>
0xffffffffa0662017 <init+23>:   mov    $0xffffffffa0663060,%rdi
0xffffffffa066201e <init+30>:   xor    %eax,%eax
0xffffffffa0662020 <init+32>:   callq  0xffffffff81697ebc <panic>
0xffffffffa0662025 <init+37>:   data32 nopw %cs:0x0(%rax,%rax,1)
crash>
```

11. Other helpful commands include: **set** (provides information on current process context, can be changed to other process, ex. *set 1*, change to init), **dmesg** (system log, page down to see any important information), **ps** (view process information, note insmod was last active process), **task** (dump active task_struct, likely the culprit which brought down the system, this works because the crash utility operates in the *current context*), **kmem –i** (was crash memory consumption related?), **files** (provide information on active file handles), **sig** (signal information), **net** (network device info), **vm** (memory map status of active task), use **struct** (to dereference memory as structures, ex. struct task_struct 0xdeadc0de)



```
crash> set
    PID: 25740
COMMAND: "insmod"
   TASK: ffff88004a832790  [THREAD_INFO: ffff880007d5a000]
    CPU: 0
  STATE: TASK_RUNNING (PANIC)
crash> struct task_struct 0xffff88004a832790
struct task_struct {
  state = 0,
  stack = 0xffff880007d5a000,
  usage = {
    counter = 2
  },
  flags = 4202752,
  ptrace = 0,
  wake_entry = {
    next = 0x0
  },
  on_cpu = 1,
  last_wakee = 0xffff88006e650000,
  wakee_flips = 12,
  wakee_flip_decay_ts = 4296065489,
  wake_cpu = 0,
  on_rq = 1,
  prio = 120,
  static_prio = 120,
```

12. Type quit to **exit** crash. Continue to Lab 17b.