

1. Решил писать на C (победил проблему сборки модуля на rust, но проиграл при написании чего-то более сложного, чем простой модуль на rust :))
2. Код модуля и утилиты можно найти в репо
3. Собрал модуль `int_stack.ko` :

```
ildar@ildar-VM:~/labs/lab5/int_stack$ make
make -C /lib/modules/6.14.0-37-generic/build M=/home/ildar/labs/lab5/int_stack
modules
make[1]: Entering directory '/usr/src/linux-headers-6.14.0-37-generic'
make[2]: Entering directory '/home/ildar/labs/lab5/int_stack'
warning: the compiler differs from the one used to build the kernel
The kernel was built by: x86_64-linux-gnu-gcc-14 (Ubuntu 14.2.0-19ubuntu2) 14
2.0
You are using:          gcc-14 (Ubuntu 14.2.0-19ubuntu2) 14.2.0
CC [M]  int_stack.o
MODPOST Module.symvers
CC [M]  int_stack.mod.o
LD [M]  int_stack.ko
BTF [M] int_stack.ko
Skipping BTF generation for int_stack.ko due to unavailability of vmlinux
make[2]: Leaving directory '/home/ildar/labs/lab5/int_stack'
make[1]: Leaving directory '/usr/src/linux-headers-6.14.0-37-generic'
```

4. Зарегистрировал модуль:

```
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo insmod int_stack.ko
ildar@ildar-VM:~/labs/lab5/int_stack$ ls /dev/int_stack
ls: cannot access '/dev/int_stack': No such file or directory
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n
10
[ 1450.247303] usbcore: registered new interface driver int_stack_usb
[ 1450.247327] int_stack_dev: USB driver registered. Waiting for key (18D1:
4EE8)
[ 1466.146883] int_stack_dev: pen drive unplugged
[ 1466.147855] int_stack_dev: /dev/int_stack removed
[ 1475.251890] int_stack_dev: unloading USB driver...
[ 1475.251913] usbcore: deregistering interface driver int_stack_usb
[ 1475.252039] int_stack_dev: unloaded USB driver
[ 1488.388233] int_stack_dev: loading
[ 1488.388363] usbcore: registered new interface driver int_stack_usb
[ 1488.388384] int_stack_dev: USB driver registered. Waiting for key (18D1:
4EE8)
ildar@ildar-VM:~/labs/lab5/int_stack$
```

5. Чтобы драйвер заработал, добавил в blacklist драйвер snd-usb-audio:

```
ildar@ildar-VM:~/labs/lab5/kernel_stack$ sudo cat /etc/modprobe.d/blacklist.conf | tail -n 10
# nice pulseaudio bing (Ubuntu: #77010)
blacklist pcspkr

# EDAC driver for amd76x clashes with the agp driver preventing the aperture
# from being initialised (Ubuntu: #297750). Blacklist so that the driver
# continues to build and is installable for the few cases where its
# really needed.
blacklist amd76x_edac

blacklist snd-usb-audio
ildar@ildar-VM:~/labs/lab5/kernel_stack$
```

6. В качестве usb устройства использовал телефон:

```
ildar@ildar-VM:~/labs/lab5/kernel_stack$ lsusb
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
Bus 001 Device 002: ID 0e0f:0003 VMware, Inc. Virtual Mouse
Bus 001 Device 003: ID 0e0f:0002 VMware, Inc. Virtual USB Hub
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 006: ID 18d1:4ee8 Google Inc. Nexus/Pixel Device (MIDI)
ildar@ildar-VM:~/labs/lab5/kernel_stack$
```

```

Bus 002 Device 006: ID 18d1:4ee8 Google Inc. Nexus/Pixel Device (MIDI)
Couldn't open device, some information will be missing
Negotiated speed: High Speed (480Mbps)
Device Descriptor:
  bLength                18
  bDescriptorType         1
  bcdUSB                  2.00
  bDeviceClass             0 [unknown]
  bDeviceSubClass          0 [unknown]
  bDeviceProtocol          0
  bMaxPacketSize0         64
  idVendor                0x18d1 Google Inc.
  idProduct               0x4ee8 Nexus/Pixel Device (MIDI)
  bcdDevice               5.04
  iManufacturer           1 OnePlus
  iProduct                2 SM8350-MTP _SN:FC004EDA
  iSerial                 3 fc004eda
  bNumConfigurations      1
Configuration Descriptor:
  bLength                9
  bDescriptorType         2
  wTotalLength           0x0065

```

7. `idVendor` и `idProduct` имеют значения `0x18d1` и `0x4ee8` соответственно.

8. Тесты:

1. С отключенным устройством из вывода видно, что `int_stack` не зарегистрирован:

The image shows two terminal windows. The left window, titled 'ildar@ildar-VM: ~/labs/lab5/int_stack', shows the process of loading and unloading the 'int_stack' driver. It starts with 'sudo insmod int_stack.ko', followed by 'ls /dev/int_stack' which fails. Then 'sudo dmesg | grep int_stack | tail -n 10' shows logs of the driver being registered, unplugged, and reloaded. The right window, titled 'ildar@ildar-VM: ~/labs/lab5/kernel_stack', shows the output of 'lsusb', listing several USB devices including root hubs, a virtual mouse, a virtual USB hub, and a Linux Foundation 2.0 root hub.

```

ildar@ildar-VM: ~/labs/lab5/int_stack
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo insmod int_stack.ko
ildar@ildar-VM:~/labs/lab5/int_stack$ ls /dev/int_stack
ls: cannot access '/dev/int_stack': No such file or directory
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 10
[ 1450.247303] usbcore: registered new interface driver int_stack_usb
[ 1450.247327] int_stack_dev: USB driver registered. Waiting for key (18D1:4EE8)
[ 1466.146883] int_stack_dev: pen drive unplugged
[ 1466.147855] int_stack_dev: /dev/int_stack removed
[ 1475.251890] int_stack_dev: unloading USB driver...
[ 1475.251913] usbcore: deregistering interface driver int_stack_usb
[ 1475.252039] int_stack_dev: unloaded USB driver
[ 1488.388233] int_stack_dev: loading
[ 1488.388363] usbcore: registered new interface driver int_stack_usb
[ 1488.388384] int_stack_dev: USB driver registered. Waiting for key (18D1:4EE8)
ildar@ildar-VM:~/labs/lab5/int_stack$

ildar@ildar-VM:~/labs/lab5/kernel_stack$ lsusb
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
Bus 001 Device 002: ID 0e0f:0003 VMware, Inc. Virtual Mouse
Bus 001 Device 003: ID 0e0f:0002 VMware, Inc. Virtual USB Hub
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
ildar@ildar-VM:~/labs/lab5/kernel_stack$

```

Вывод утилиты:

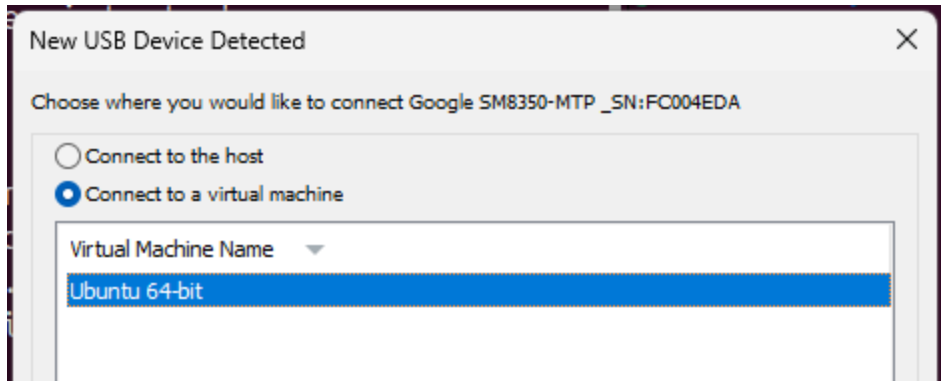
The image shows a terminal window titled 'ildar@ildar-VM: ~/labs/lab5/kernel_stack'. It shows the command './kernel_stack set-size 10' being executed, which results in the error message 'error: USB key is not inserted'.

```

ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack set-size 10
error: USB key is not inserted
ildar@ildar-VM:~/labs/lab5/kernel_stack$

```

2. С подключенным устройством:



Вывод dmesg :

```
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 10
[ 163.752561] int_stack: loading out-of-tree module taints kernel.
[ 163.752587] int_stack: module verification failed: signature and/or required key missing - tainting kernel
[ 163.756792] int_stack_usb: loading
[ 163.756955] usbcore: registered new interface driver int_stack_usb
[ 163.756981] int_stack_usb: USB driver registered. Waiting for key (18D1:4EE8)
[ 371.246223] int_stack: Pen drive (18D1:4EE8) plugged
[ 371.247053] int_stack: registered /dev/int_stack
[ 371.247192] int_stack: skipping interface 1
```

```
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 10
[ 1475.251913] usbcore: deregistering interface driver int_stack_usb
[ 1475.252039] int_stack_dev: unloaded USB driver
[ 1488.388233] int_stack_dev: loading
[ 1488.388363] usbcore: registered new interface driver int_stack_usb
[ 1488.388384] int_stack_dev: USB driver registered. Waiting for key (18D1:4EE8)
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 10
[ 1466.147855] int_stack_dev: /dev/int_stack removed
[ 1475.251890] int_stack_dev: unloading USB driver...
[ 1475.251913] usbcore: deregistering interface driver int_stack_usb
[ 1475.252039] int_stack_dev: unloaded USB driver
[ 1488.388233] int_stack_dev: loading
[ 1488.388363] usbcore: registered new interface driver int_stack_usb
[ 1488.388384] int_stack_dev: USB driver registered. Waiting for key (18D1:4EE8)
[ 1630.152205] int_stack_dev: Pen drive (18D1:4EE8) plugged
[ 1630.153479] int_stack_dev: registered /dev/int_stack
[ 1630.153863] int_stack_dev: skipping interface 1
ildar@ildar-VM:~/labs/lab5/int_stack$
```

Отключаем устройство:

```
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 10
[ 1708.012862] int_stack: open(USB key presented)
[ 1708.012989] int_stack: release
[ 1711.502699] int_stack: open(USB key presented)
[ 1711.502862] int_stack: release
[ 1713.449279] int_stack: open(USB key presented)
[ 1713.450170] int_stack: release
[ 1720.394931] int_stack: open(USB key presented)
[ 1720.397563] int_stack: release
[ 1724.664603] int_stack_dev: pen drive unplugged
[ 1724.665848] int_stack_dev: /dev/int_stack removed
ildar@ildar-VM:~/labs/lab5/int_stack$
```

Снова подключили:

```
ildar@ildar-VM: ~/labs/lab5/int_stack
[ 1711.502862] int_stack: release
[ 1713.449279] int_stack: open(USB key presented)
[ 1713.450170] int_stack: release
[ 1720.394931] int_stack: open(USB key presented)
[ 1720.397563] int_stack: release
[ 1724.664603] int_stack_dev: pen drive unplugged
[ 1724.665848] int_stack_dev: /dev/int_stack removed
ildar@ildar-VM: ~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 10
[ 1720.397563] int_stack: release
[ 1724.664603] int_stack_dev: pen drive unplugged
[ 1724.665848] int_stack_dev: /dev/int_stack removed
[ 1785.702676] int_stack_dev: Pen drive (18D1:4EE8) plugged
[ 1785.702915] int_stack_dev: registered /dev/int_stack
[ 1785.703075] int_stack_dev: skipping interface 1
[ 1788.469189] int_stack: open(USB key presented)
[ 1788.469716] int_stack: release
[ 1790.971800] int_stack: open(USB key presented)
[ 1790.973232] int_stack: release
ildar@ildar-VM: ~/labs/lab5/int_stack$

ildar@ildar-VM: ~/labs/lab5/kernel_stack
v = Bus 001 Device 002: ID 0e0f:0003 VMware, Inc. Virtual Mouse
Bus 001 Device 003: ID 0e0f:0002 VMware, Inc. Virtual USB Hub
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack set-size 2
OK
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 2
+inildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 1
o_usildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 3
ERROR: stack is full
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack pop
Inte1
inte-
->deildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack pop
error: USB key is not inserted
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack pop
error: USB key is not inserted
4X:4ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack pop
2
d->iildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack pop
NULL
ildar@ildar-VM: ~/labs/lab5/kernel_stack$
```

unwind:

```
ildar@ildar-VM: ~/labs/lab5/kernel_stack
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack set-size 3
OK
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 1
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 2
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 3
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack unwind
3
2
1
ildar@ildar-VM: ~/labs/lab5/kernel_stack$
```

Во время проверки снова отключаю устройство, чтобы проверить, что стек и данные сохранились:

```
ildar@ildar-VM: ~/labs/lab5/int_stack
ildar@ildar-VM: ~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 15
[ 1980.771358] int_stack: auto-pop 0 -> 2
[ 1980.772478] int_stack: release
[ 1988.328754] int_stack: open(USB key presented)
[ 1988.329454] int_stack: release
[ 1989.718570] int_stack: open(USB key presented)
[ 1989.718696] int_stack: release
[ 1991.077500] int_stack: open(USB key presented)
[ 1991.078375] int_stack: release
[ 2000.164372] int_stack_dev: pen drive unplugged
[ 2000.165266] int_stack_dev: /dev/int_stack removed
[ 2012.039228] int_stack_dev: Pen drive (18D1:4EE8) plugged
[ 2012.039490] int_stack_dev: registered /dev/int_stack
[ 2012.040009] int_stack_dev: skipping interface 1
[ 2045.173552] int_stack: open(USB key presented)
[ 2045.174427] int_stack: release
ildar@ildar-VM: ~/labs/lab5/int_stack$

ildar@ildar-VM: ~/labs/lab5/kernel_stack
v = ERROR: size should be > 0
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack set-size -1
ERROR: size should be > 0
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack set-size 2
OK
+inildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 1
o_usildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 2
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 3
ERROR: stack is full
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack push 3
error: USB key is not inserted
ildar@ildar-VM: ~/labs/lab5/kernel_stack$ ./kernel_stack unwind
2
4X:4ildar@ildar-VM: ~/labs/lab5/kernel_stack$
```

echo \$? :

```
ildar@ildar-VM: ~/labs/lab5/int_stack
2045.173552] int_stack: open(USB key presented)
2045.174427] int_stack: release
ildar@ildar-VM:~/labs/lab5/int_stack$ sudo dmesg | grep int_stack | tail -n 15
1991.077500] int_stack: open(USB key presented)
1991.078375] int_stack: release
2000.164372] int_stack_dev: pen drive unplugged
2000.165266] int_stack_dev: /dev/int_stack removed
2012.039228] int_stack_dev: Pen drive (18D1:4EE8) plugged
2012.039490] int_stack_dev: registered /dev/int_stack
2012.040009] int_stack_dev: skipping interface 1
2045.173552] int_stack: open(USB key presented)
2045.174427] int_stack: release
2099.207975] int_stack: open(USB key presented)
2099.208108] int_stack: release
2101.250308] int_stack: open(USB key presented)
2101.250464] int_stack: release
2103.711166] int_stack: open(USB key presented)
2103.711511] int_stack: release
ildar@ildar-VM:~/labs/lab5/int_stack$

ildar@ildar-VM:~/labs/lab5/kernel_stack
v = ERROR: size should be > 0
ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack set-size 2
OK
ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack push 1
ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack push 2
ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack push 3
ERROR: stack is full
ildar@ildar-VM:~/labs/lab5/kernel_stack$
ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack push 3
error: USB key is not inserted
ildar@ildar-VM:~/labs/lab5/kernel_stack$ ./kernel_stack unwind
ERROR: stack is full
ildar@ildar-VM:~/labs/lab5/kernel_stack$ echo $?
222
ildar@ildar-VM:~/labs/lab5/kernel_stack$
```