

Lab 5: USB Key Gating for Character Device

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Course: Advanced Linux

Lab: 5 — USB Device Trigger

Topic: Gating access to a chardev using USB detection

Objective Summary

The goal of this lab is to enhance the kernel module from Lab 4 by gating access to the character device `/dev/int_stack` based on the presence of a specific USB device. The idea is to treat the USB device (keyboard, mouse, flash drive, etc.) as an "electronic key."

Requirements

- The character device should **only appear** when the USB key is connected.
 - On USB removal, the device should **disappear from `/dev`**, but the internal stack must **persist**.
 - The userspace wrapper `kernel_stack` must print `ERROR: USB key not inserted` if the device is not present.
 - USB matching should be based on `VID:PID`.
 - Bonus points for properly handling driver conflicts (e.g., with `usb_storage`, `hid`, etc.).
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Implementation Overview

1. Modifying `int_stack.c`

The original `int_stack.c` from Lab 4 contained this line inside `int_stack_init()`:

```
if (device_create(stack_class, NULL, dev_number, NULL, DEVICE_NAME) ==
    NULL) {
    class_destroy(stack_class);
    cdev_del(&stack_cdev);
    unregister_chrdev_region(dev_number, 1);
    return -1;
}
```

In Lab 5, we **removed** that section:

```
// Removed to defer device creation to USB key insertion
```

And replaced it with:

```
pr_info("int_stack: core initialized, waiting for USB key\n");
```

This ensures the stack is initialized but **the device node is only created** by the USB gating module.

2. Creating `usb_gate.c`

We added a new file `usb_gate.c` which:

- Declares a matching `VID:PID` for a USB device (in my case, a Logitech keyboard).
- Registers a USB driver with `probe()` and `disconnect()` callbacks.
- Calls `device_create()` and `device_destroy()` for `/dev/int_stack`.

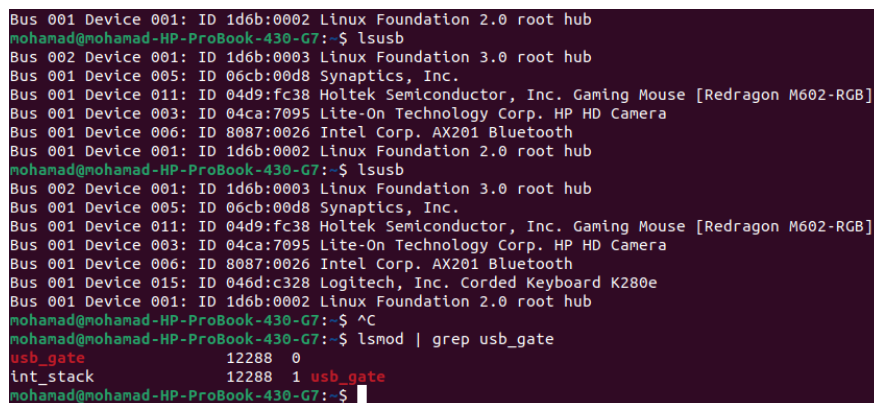
Example

```
{ USB_DEVICE(0x046D, 0xC328) } // Logitech keyboard
```

To get the device information:

```
lsusb
```

Screenshot:



```
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
mohamad@mohamad-HP-ProBook-430-G7:~$ lsusb
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 005: ID 06cb:00d8 Synaptics, Inc.
Bus 001 Device 011: ID 04d9:fc38 Holtek Semiconductor, Inc. Gaming Mouse [Redragon M602-RGB]
Bus 001 Device 003: ID 04ca:7095 Lite-On Technology Corp. HP HD Camera
Bus 001 Device 006: ID 8087:0026 Intel Corp. AX201 Bluetooth
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
mohamad@mohamad-HP-ProBook-430-G7:~$ lsusb
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 005: ID 06cb:00d8 Synaptics, Inc.
Bus 001 Device 011: ID 04d9:fc38 Holtek Semiconductor, Inc. Gaming Mouse [Redragon M602-RGB]
Bus 001 Device 003: ID 04ca:7095 Lite-On Technology Corp. HP HD Camera
Bus 001 Device 006: ID 8087:0026 Intel Corp. AX201 Bluetooth
Bus 001 Device 015: ID 046d:c328 Logitech, Inc. Corded Keyboard K280e
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
mohamad@mohamad-HP-ProBook-430-G7:~$ ^C
mohamad@mohamad-HP-ProBook-430-G7:~$ lsmod | grep usb_gate
usb_gate      12288  0
int_stack     12288  1 usb_gate
mohamad@mohamad-HP-ProBook-430-G7:~$
```

3. Resolving Conflicts with Built-in Drivers

Initially, my USB device was being claimed by other kernel drivers (`usb_storage`, `hid_generic`, `usbhid`), so `probe()` was never triggered.

To fix this, I unloaded the conflicting drivers:

```
sudo modprobe -r usb_storage
sudo modprobe -r usbhid
sudo modprobe -r hid_generic
```

Explanation:

- These modules auto-bind to devices like flash drives, mice, and keyboards.
- By removing them temporarily, our custom USB driver (`usb_gate.ko`) is allowed to bind and trigger `probe()`.

Screenshot:

```
modprobe: FATAL: Module usb_storage is in use.
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo modprobe -r usbhid
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo modprobe -r hid_generic
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo modprobe -r usb_storage
modprobe: FATAL: Module usb_storage is in use.
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo modprobe -r usb_storage
modprobe: FATAL: Module usb_storage is in use.
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo modprobe -r usb_storage
modprobe: FATAL: Module usb_storage is in use.
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ make clean
```

4. Updating the Makefile

To compile both modules (`int_stack.ko` and `usb_gate.ko`), I updated the `Makefile`:

```
obj-m += int_stack.o
obj-m += usb_gate.o

KDIR := /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)

all:
    make -C $(KDIR) M=$(PWD) modules

clean:
    make -C $(KDIR) M=$(PWD) clean
```

5. Build & Run

```
make clean
make

sudo rmmod usb_gate
sudo rmmod int_stack

sudo insmod int_stack.ko
sudo insmod usb_gate.ko
```

6. Test the USB Key Behavior

When plugged in

```
ls /dev/int_stack  
sudo chmod 666 /dev/int_stack
```

Then test the kernel stack:

```
./kernel_stack set-size 3  
./kernel_stack push 1  
./kernel_stack push 2  
./kernel_stack push 3  
./kernel_stack unwind
```

When USB key is removed

```
ls /dev/int_stack
```

Then try:

```
./kernel_stack set-size 2
```

Screenshot:

```
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ make clean
make
sudo rmmod usb_gate
sudo rmmod int_stack
sudo insmod int_stack.ko
sudo insmod usb_gate.ko
make -C /lib/modules/6.8.0-57-generic/build M=/home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05 clean
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-57-generic'
CLEAN /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/Module.symvers
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-57-generic'
make -C /lib/modules/6.8.0-57-generic/build M=/home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05 modules
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-57-generic'
warning: the compiler differs from the one used to build the kernel
The kernel was built by: x86_64-linux-gnu-gcc-12 (Ubuntu 12.3.0-1ubuntu1-22.04) 12.3.0
You are using: gcc-12 (Ubuntu 12.3.0-1ubuntu1-22.04) 12.3.0
CC [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/int_stack.o
CC [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/usb_gate.o
MODPOST /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/Module.symvers
LD [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/int_stack.mod.o
LD [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/int_stack.ko
BTF [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/int_stack.ko
Skipping BTF generation for /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/int_stack.ko due to unavailability of vmlinux
CC [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/usb_gate.mod.o
LD [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/usb_gate.ko
BTF [M] /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/usb_gate.ko
Skipping BTF generation for /home/mohamad/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05/usb_gate.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-57-generic'
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo rmmod usb_gate
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo rmmod int_stack
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo insmod int_stack.ko
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo insmod usb_gate.ko
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ls /dev/int_stack
/dev/int_stack
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack set-size 2
Failed to open device: Permission denied
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo chmod 666 /dev/int_stack
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack set-size 2
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack push 1\
>
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack push 2
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack push 3
ERROR: stack is full
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack unwind
2
1
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ls /dev/int_stack
ls: cannot access '/dev/int_stack': No such file or directory
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ls /dev/int_stack
/dev/int_stack
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack set-size 2
Failed to open device: Permission denied
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack set-size 2
Failed to open device: Permission denied
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ sudo chmod 666 /dev/int_stack
[sudo] password for mohamad:
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack set-size 2
mohamad@mohamad-HP-ProBook-430-G7:~/Desktop/thirdYear/second-semester/advanced-linux/advanced-linux/Lab05$ ./kernel_stack set-size 2
```

[Github Link](#)
