

# Advanced Linux

## Lab 5: USB-Protected Kernel Stack Implementation

Repository: <https://github.com/Friedox/Advanced-Linux/tree/main/Lab5>

### Project Overview

Lab 5 extends previous kernel stack implementation from Lab 4 by adding USB device detection capabilities. This enhancement creates a "hardware key" mechanism where the stack operations are only available when a specific USB device is connected to the system.

### Implementation Details

#### Identifying the USB Device

First, I identified the USB device using `lsusb` command:

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ lsusb
Bus 002 Device 003: ID 13fe:4300 Kingston Technology Company Inc. USB DISK 2.0
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 001 Device 002: ID 80ee:0021 virtualBox USB Tablet
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
```

The Kingston USB flash drive (ID `13fe:4300`) was selected as the hardware key for this project.

#### Kernel Module Modifications

Modified the `int_stack.c` module to implement USB device detection by adding:

```
static struct usb_device_id electronic_key_table[] = {
    { USB_DEVICE(0x13FE, 0x4300) },
    { }
};

MODULE_DEVICE_TABLE(usb, electronic_key_table);

static struct usb_driver electronic_key_driver = {
    .name = "electronic_key",
    .id_table = electronic_key_table,
    .probe = electronic_key_probe,
    .disconnect = electronic_key_disconnect,
};

static int __init int_stack_init(void)
{
    result = usb_register(&electronic_key_driver);
    return result < 0 ? result : 0;
}
```

# Testing Process

The testing process involved:

1. Load module: Initially, no device node is present

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo insmod  
int_stack.ko  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ ls -l /dev/int_stack  
ls: cannot access '/dev/int_stack': No such file or directory
```

2. Connect USB device: Device node appears automatically

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo dmesg | tail  
[11576.181894] USB key (13FE:4300) plugged  
[11576.182623] Int Stack: device has been registered  
[11576.182661] usbcore: registered new interface driver electronic_key  
[11576.182663] Int Stack: Registered USB driver  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ ls -l /dev/int_stack  
crw----- 1 root root 240, 0 мая  9 23:44 /dev/int_stack
```

3. Set permissions and use stack operations

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo chmod 666  
/dev/int_stack  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack  
set-size 3  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack  
push 1  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack  
push 2  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack  
push 3  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack  
push 4  
ERROR: stack is full
```

4. Disconnect USB: Device node disappears

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ls -l  
/dev/int_stack  
ls: cannot access '/dev/int_stack': No such file or directory  
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack  
push 5  
ERROR: USB key not inserted
```

5. Reconnect USB: Device node reappears and stack data is preserved

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ls -l
/dev/int_stack
crw----- 1 root root 240, 0 мая 9 23:46 /dev/int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ sudo chmod 666
/dev/int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack pop
2
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack pop
1
```

Screenshot:

```
dm@Ubuntu: ~/AdvancedLinux/Lab5/kernel_stack... x dm@Ubuntu: ~/AdvancedLinux/Lab4/kernel_stack... x
[11484.704780] sd 3:0:0:0: [sdb] Attached SCSI removable disk
[11486.204965] FAT-fs (sdb1): Volume was not properly unmounted. Some data may be corrupt. Please run fsck.
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ ls -l /dev/int_stack
ls: cannot access '/dev/int_stack': No such file or directory
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo umount /dev/sdb1
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo rmod uas 2>/dev/null
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo rmod usb_storage 2>/dev/null
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo rmod int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo insmod int_stack.ko
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo dmesg | tail
[11484.704780] sd 3:0:0:0: [sdb] Attached SCSI removable disk
[11486.204965] FAT-fs (sdb1): Volume was not properly unmounted. Some data may be corrupt. Please run fsck.
[11550.522685] usbcore: deregistering interface driver uas
[11556.614104] usbcore: deregistering interface driver usb-storage
[11571.280489] usbcore: deregistering interface driver electronic_key
[11571.280548] Int Stack: module unloaded
[11576.181894] USB Key (13FE:4300) plugged
[11576.182623] Int Stack: device has been registered
[11576.182661] usbcore: registered new interface driver electronic_key
[11576.182663] Int Stack: Registered USB driver
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ ls -l /dev/int_stack
crw----- 1 root root 240, 0 мая 9 23:44 /dev/int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo chmod 666 /dev/int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ cd ../userspace
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack set-size 3
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack push 1
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack push 2
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack push 3
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack push 4
ERROR: stack is full
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack pop
3
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ls -l /dev/int_stack
ls: cannot access '/dev/int_stack': No such file or directory
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack push 5
ERROR: USB key not inserted
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ls -l /dev/int_stack
crw----- 1 root root 240, 0 мая 9 23:46 /dev/int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ sudo chmod 666 /dev/int_stack
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack pop
2
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ ./kernel_stack pop
1
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/userspace$ sudo rmod int_stack
```

## Challenges and Solutions

### Conflict with Default Kernel USB Storage Driver

The primary challenge was handling conflicts with the default kernel USB storage drivers (`usb-storage` and `uas`). When connecting the USB flash drive, these drivers would automatically claim the device before our custom driver could handle it.

Solution:

1. Unload the conflicting drivers before testing:

```
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo umount /dev/sdb1
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo rmmod uas
2>/dev/null
dm@Ubuntu:~/AdvancedLinux/Lab5/kernel_stack_project/module$ sudo rmmod
usb_storage 2>/dev/null
```

This allowed our custom USB driver to claim the device without interference from the standard storage drivers.

## Conclusion

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In Lab 5, I integrated USB detection with kernel module:

- Modified kernel module to register USB driver
- Added functions to detect USB insertion/removal
- Created/removed device node based on USB presence
- Solved conflict with standard usb-storage driver
- Preserved stack data between USB reconnections