

Lab Exercise 5 - Write a C program. Compile. Insert the compiled program as a Kernel Module in Kernel. Remove the module from Kernel. Verify whether the insertion and deletion happened properly.

Code:

```
#include<linux/kernel.h>
#include<linux/module.h>

MODULE_LICENSE("GPL");

int init(void)
{
    printk("hello world\n");
    return(0);
}

void cleanup(void)
{
    printk("GoodBye!\n");
    return;
}

module_init(init);      // Registers the __init function for the module.
module_exit(cleanup);   // Registers the __exit function for the module.
```

Makefile:

```
obj-m := hello.o
KDIR := /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)

default:
    $(MAKE) -C $(KDIR) M=$(PWD) modules

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

Output screenshot:

```
[ 140.530762] rtkill: input handler disabled
[ 143.026984] audit: type=1400 audit(1643027358.008:54): apparmor="DENIED" operation="capable" profile="/snap/snapd/14295/usr/lib/snapd/snap-confine" pid=2132 comm="snap-confine" capability=4 capname="fsetid"
[ 148.206008] logitech-hidpp-device 0003:046D:4054.0004: HID++ 4.5 device connected.
[ 157.377925] audit: type=1326 audit(1643027372.361:55): auid=1000 uid=1000 gid=1000 ses=3 subj=snap.snap-store.ubuntu-software pid=2132 comm="snap-store" exe="/snap/snap-store/558/usr/bin/snap-store" sig=0 arch=c000003e syscall=314 compat=0 ip=0x7f512d06989d code=0x50000
[ 169.331236] audit: type=1107 audit(1643027384.318:56): pid=824 uid=103 auid=4294967295 ses=4294967295 subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Authority" interface="org.freedesktop.DBus.Properties" member="GetAll" mask="send" name=":1.9" pid=2132 label="snap.snap-store.ubuntu-software" peer_pid=850 peer_label="unconfined" exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 169.331737] audit: type=1107 audit(1643027384.318:57): pid=824 uid=103 auid=4294967295 ses=4294967295 subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Authority" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send" name=":1.9" pid=2132 label="snap.snap-store.ubuntu-software" peer_pid=850 peer_label="unconfined" exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 169.708334] audit: type=1107 audit(1643027384.694:58): pid=824 uid=103 auid=4294967295 ses=4294967295 subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Authority" interface="org.freedesktop.DBus.Properties" member="GetAll" mask="send" name=":1.9" pid=2132 label="snap.snap-store.ubuntu-software" peer_pid=850 peer_label="unconfined" exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 169.709517] audit: type=1107 audit(1643027384.694:59): pid=824 uid=103 auid=4294967295 ses=4294967295 subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Authority" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send" name=":1.9" pid=2132 label="snap.snap-store.ubuntu-software" peer_pid=850 peer_label="unconfined" exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 171.219567] audit: type=1400 audit(1643027386.206:60): apparmor="DENIED" operation="open" profile="snap.snap-store.ubuntu-software" name="/etc/PackageKit/Vendor.conf" pid=2132 comm="snap-store" requested_mask="r" denied_mask="r" fsuid=1000 ouid=0
[ 183.657996] hello: loading out-of-tree module taints kernel.
[ 183.658000] hello: module verification failed: signature and/or required key missing - tainting kernel
[ 183.658627] hello world
[ 203.496955] GoodBye!
[ 221.117506] clocksource: timekeeping watchdog on CPU1: hpet retried 2 times before success
[ 246.520640] hello world
[ 256.610284] clocksource: timekeeping watchdog on CPU0: hpet retried 2 times before success
[ 257.249459] GoodBye!
paleti@paleti-Lenovo-ideapad-330-15ICH: ~/Documents/SEM_8/DD/Labs/code_files/kernels
```

- make
- sudo insmod hello.ko
- sudo rmmod hello
- sudo dmesg

References:

- <https://askubuntu.com/questions/762254/why-do-i-get-required-key-not-available-when-i-install-3rd-party-kernel-modules>
- <https://stackoverflow.com/questions/58546126/insmod-error-could-not-insert-module-hello-world-ko-operation-not-permitted>
- Had to disable secure boot to allow insertion.