

Writing the system call code in a file and creating a Makefile for the system call:

```
bilal@ubuntu: ~/Desktop/linux-4.19.237
bilal@ubuntu:~/Desktop/linux-4.19.237/hello$ gedit hello.c
bilal@ubuntu:~/Desktop/linux-4.19.237/hello$ gedit Makefile
bilal@ubuntu:~/Desktop/linux-4.19.237/hello$ cd..
cd..: command not found
bilal@ubuntu:~/Desktop/linux-4.19.237/hello$ cd ..
bilal@ubuntu:~/Desktop/linux-4.19.237$ cd arch/x86/entry/syscalls/syscall_64.tbl
bash: cd: arch/x86/entry/syscalls/syscall_64.tbl: Not a directory
bilal@ubuntu:~/Desktop/linux-4.19.237$ cd arch/x86/entry/syscalls
bilal@ubuntu:~/Desktop/linux-4.19.237/arch/x86/entry/syscalls$ cd ..
bilal@ubuntu:~/Desktop/linux-4.19.237/arch/x86/entry$ cd ..
bilal@ubuntu:~/Desktop/linux-4.19.237/arch/x86$ cd ..
bilal@ubuntu:~/Desktop/linux-4.19.237/arch$ cd ..
bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit arch/x86/entry/syscalls/syscall_64.tbl
bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit include/linux/syscalls.h
bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit include/linux/syscalls.h
bilal@ubuntu:~/Desktop/linux-4.19.237$
```

1. Adding my Roll number in place of the kernel version

```
# SPDX-License-Identifier: GPL-2.0
VERSION = 4
PATCHLEVEL = 19
SUBLEVEL = 237
EXTRAVERSION =-200183
NAME = "People's Front"
```

2. Adding hello folder in the kernel's MakeFile

```
ifeq ($(KBUILD_EXTMOD),)
core-y += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/
```

3. Confirming the presence of the config file using ls

```

bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit arch/x86/entry/syscalls/syscall_64.tbl
bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit include/linux/syscalls.h
bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit include/linux/syscalls.h
bilal@ubuntu:~/Desktop/linux-4.19.237$ gedit Makefile
bilal@ubuntu:~/Desktop/linux-4.19.237$ ls /boot | grep config
config-4.15.0-112-generic
bilal@ubuntu:~/Desktop/linux-4.19.237$ cp /boot/config-4.15.0-112-generic
cp: missing destination file operand after '/boot/config-4.15.0-112-generic'
Try 'cp --help' for more information.
bilal@ubuntu:~/Desktop/linux-4.19.237$ pwd
/home/bilal/Desktop/linux-4.19.237
bilal@ubuntu:~/Desktop/linux-4.19.237$ ^C
bilal@ubuntu:~/Desktop/linux-4.19.237$ /home/bilal/Desktop/linux-4.19.237
bash: /home/bilal/Desktop/linux-4.19.237: Is a directory
bilal@ubuntu:~/Desktop/linux-4.19.237$ cp /boot/config-4.15.0-112-generic /home/bilal/Desktop/linux-4.19.237
bilal@ubuntu:~/Desktop/linux-4.19.237$ ls
arch          crypto        include       lib           README       usr
block         Documentation init          LICENSES     samples      virt
certs         drivers       ipc           MAINTAINERS  scripts
config-4.15.0-112-generic firmware      Kbuild       Makefile     security
COPYING       fs            Kconfig      mm           sound
CREDITS       hello        kernel       net          tools
bilal@ubuntu:~/Desktop/linux-4.19.237$

```

4. Checking the number of cores available using lscpu

```

bilal@ubuntu:~/Desktop/linux-4.19.237$ lscpu
Architecture: x86_64
CPU op-mode(s): 32-bit, 64-bit
Byte Order: Little Endian
CPU(s): 12
On-line CPU(s) list: 0-11
Thread(s) per core: 1
Core(s) per socket: 3
Socket(s): 4
NUMA node(s): 1
Vendor ID: AuthenticAMD
CPU family: 23
Model: 8
Model name: AMD Ryzen 5 2600 Six-Core Processor
Stepping: 2
CPU MHz: 3400.001
BogoMIPS: 6800.00
Hypervisor vendor: VMware
Virtualization type: full
L1d cache: 32K
L1i cache: 64K
L2 cache: 512K
L3 cache: 8192K
NUMA node0 CPU(s): 0-11
Flags: fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 ht syscall nx mmxext fxsr_opt pdpe1gb rdtscp lm constant_tsc rep_good nopl xtopology tsc_reliable nonstop_tsc cpuid extd_apicid pni pclmulqdq ssse3 fma cx16 sse4_1 sse4_2 x2apic movbe popcnt aes xsave avx f16c rdrand hypervisor lahf_lm cmp_legacy extapic cr8_legacy abm sse4a misalignsse 3dnowprefetch osvw topoext perfctr_core ssbd lbrb vmcall fsgsbase bti avx2 smep bmt2 rdseed adx snap clflushopt sha_ni xsaveopt xsavec xgetbv1 xsaves clzero arat overflow_recov succor
bilal@ubuntu:~/Desktop/linux-4.19.237$ yes "" | oldconfig -j12
No command 'oldconfig' found, did you mean:
  Command 'ldconfig' from package 'libc-bin' (main)
oldconfig: command not found
bilal@ubuntu:~/Desktop/linux-4.19.237$ yes "" | make oldconfig -j12
HOSTCC scripts/basic/fixdep
HOSTCC scripts/kconfig/conf.o
YACC scripts/kconfig/zconf.tab.c
LEX scripts/kconfig/zconf.lex.c
HOSTCC scripts/kconfig/zconf.tab.o
HOSTLD scripts/kconfig/conf
scripts/kconfig/conf --oldconfig Kconfig
#
# using defaults found in /boot/config-4.15.0-112-generic
#
/boot/config-4.15.0-112-generic:897:warning: symbol value 'm' invalid for HOTPLUG_PCI_SHPC
/boot/config-4.15.0-112-generic:1151:warning: symbol value 'm' invalid for NF_NAT_REDIRECT
/boot/config-4.15.0-112-generic:1154:warning: symbol value 'm' invalid for NF_TABLES_INET
/boot/config-4.15.0-112-generic:1155:warning: symbol value 'm' invalid for NF_TABLES_NETDEV
/boot/config-4.15.0-112-generic:1338:warning: symbol value 'm' invalid for NF_TABLES_IPV4

```

5. Cleaning the kernel

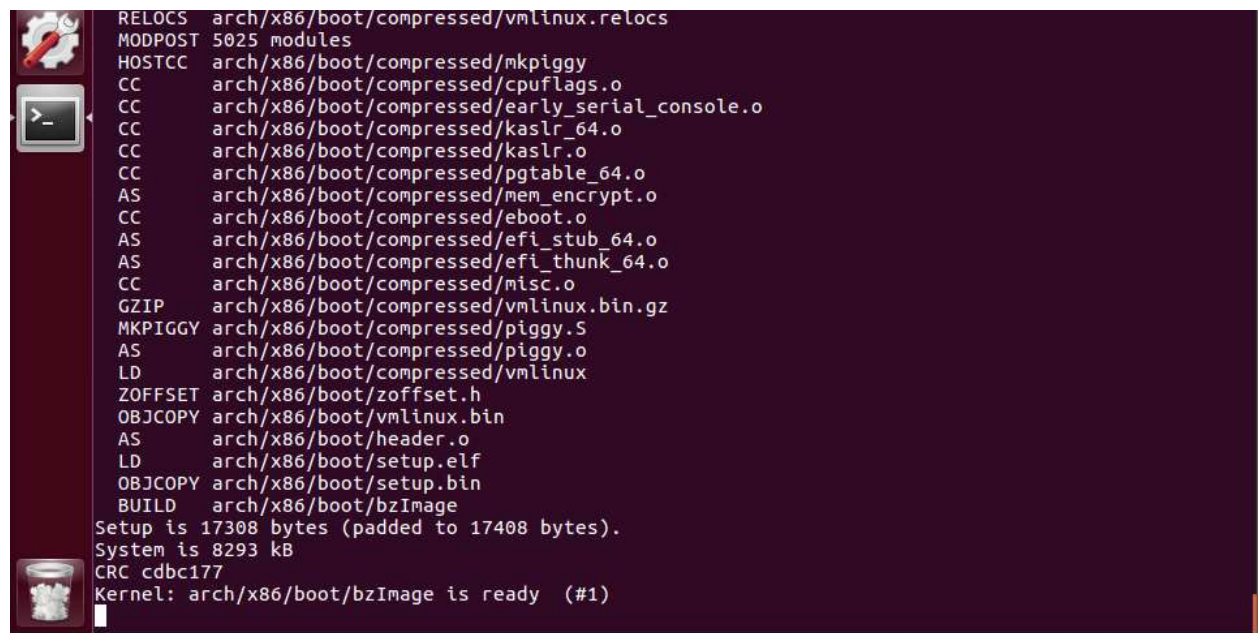

```

Kprobes sanity tests (KPROBES_SANITY_TEST) [N/y/?] n
Self test for the backtrace code (BACKTRACE_SELF_TEST) [N/m/y/?] n
Red-Black tree test (RBTREE_TEST) [N/m/y/?] n
Interval tree test (INTERVAL_TREE_TEST) [N/m/y/?] n
Per cpu operations test (PERCPU_TEST) [N/m/?] n
Perform an atomic64_t self-test (ATOMIC64_SELFTEST) [N/m/y/?] n
Self test for hardware accelerated raid6 recovery (ASYNC_RAID6_TEST) [N/m/?] n
Test functions located in the hexdump module at runtime (TEST_HEXDUMP) [N/m/y/?] n
Test functions located in the string_helpers module at runtime (TEST_STRING_HELPERS) [N/m/y/?] n
n
Test kstrt*() family of functions at runtime (TEST_KSTRTX) [N/m/y/?] n
Test printf() family of functions at runtime (TEST_PRINTF) [N/m/y/?] n
Test bitmap_*() family of functions at runtime (TEST_BITMAP) [N/m/y/?] n
Test bitfield functions at runtime (TEST_BITFIELD) [N/m/y/?] (NEW)
Test functions located in the uuid module at runtime (TEST_UUID) [N/m/y/?] n
Test check_*_overflow() functions at runtime (TEST_OVERFLOW) [N/m/y/?] (NEW)
Perform selftest on resizable hash table (TEST_RHASHTABLE) [N/m/y/?] n
Perform selftest on hash functions (TEST_HASH) [N/m/y/?] n
Perform selftest on IDA functions (TEST_IDA) [N/m/y/?] (NEW)
Perform selftest on priority array manager (TEST_PARMAN) [N/m/?] n
Test module loading with 'hello world' module (TEST_LKM) [M/n/?] m
Test user/kernel boundary protections (TEST_USER_COPY) [M/n/?] m
Test BPF filter functionality (TEST_BPF) [M/n/?] m
Test find_bit functions (FIND_BIT_BENCHMARK) [N/m/y/?] (NEW)
Test firmware loading via userspace interface (TEST_FIRMWARE) [M/n/y/?] m
sysctl test driver (TEST_SYSCTL) [N/m/y/?] n
udelay test driver (TEST_UDELAY) [M/n/y/?] m
Test static keys (TEST_STATIC_KEYS) [M/n/?] m
kmod stress tester (TEST_KMOD) [N/m/?] n
#
# configuration written to .config
#
bilal@ubuntu:~/Desktop/linux-4.19.237$ make -j12

```

6. Compiling the kernel

After the wait of 21 mins and 15 secs....



```

RELOCS arch/x86/boot/compressed/vmlinux.relocs
MODPOST 5025 modules
HOSTCC arch/x86/boot/compressed/mkpiggy
CC arch/x86/boot/compressed/cpuflags.o
CC arch/x86/boot/compressed/early_serial_console.o
CC arch/x86/boot/compressed/kaslr_64.o
CC arch/x86/boot/compressed/kaslr.o
CC arch/x86/boot/compressed/pgtable_64.o
AS arch/x86/boot/compressed/mem_encrypt.o
CC arch/x86/boot/compressed/eboot.o
AS arch/x86/boot/compressed/efi_stub_64.o
AS arch/x86/boot/compressed/efi_thunk_64.o
CC arch/x86/boot/compressed/misc.o
GZIP arch/x86/boot/compressed/vmlinux.bin.gz
MKPIGGY arch/x86/boot/compressed/piggy.S
AS arch/x86/boot/compressed/piggy.o
LD arch/x86/boot/compressed/vmlinux
ZOFFSET arch/x86/boot/zoffset.h
OBJCOPY arch/x86/boot/vmlinux.bin
AS arch/x86/boot/header.o
LD arch/x86/boot/setup.elf
OBJCOPY arch/x86/boot/setup.bin
BUILD arch/x86/boot/bzImage
Setup is 17308 bytes (padded to 17408 bytes).
System is 8293 kB
CRC cdbc177
Kernel: arch/x86/boot/bzImage is ready (#1)

```

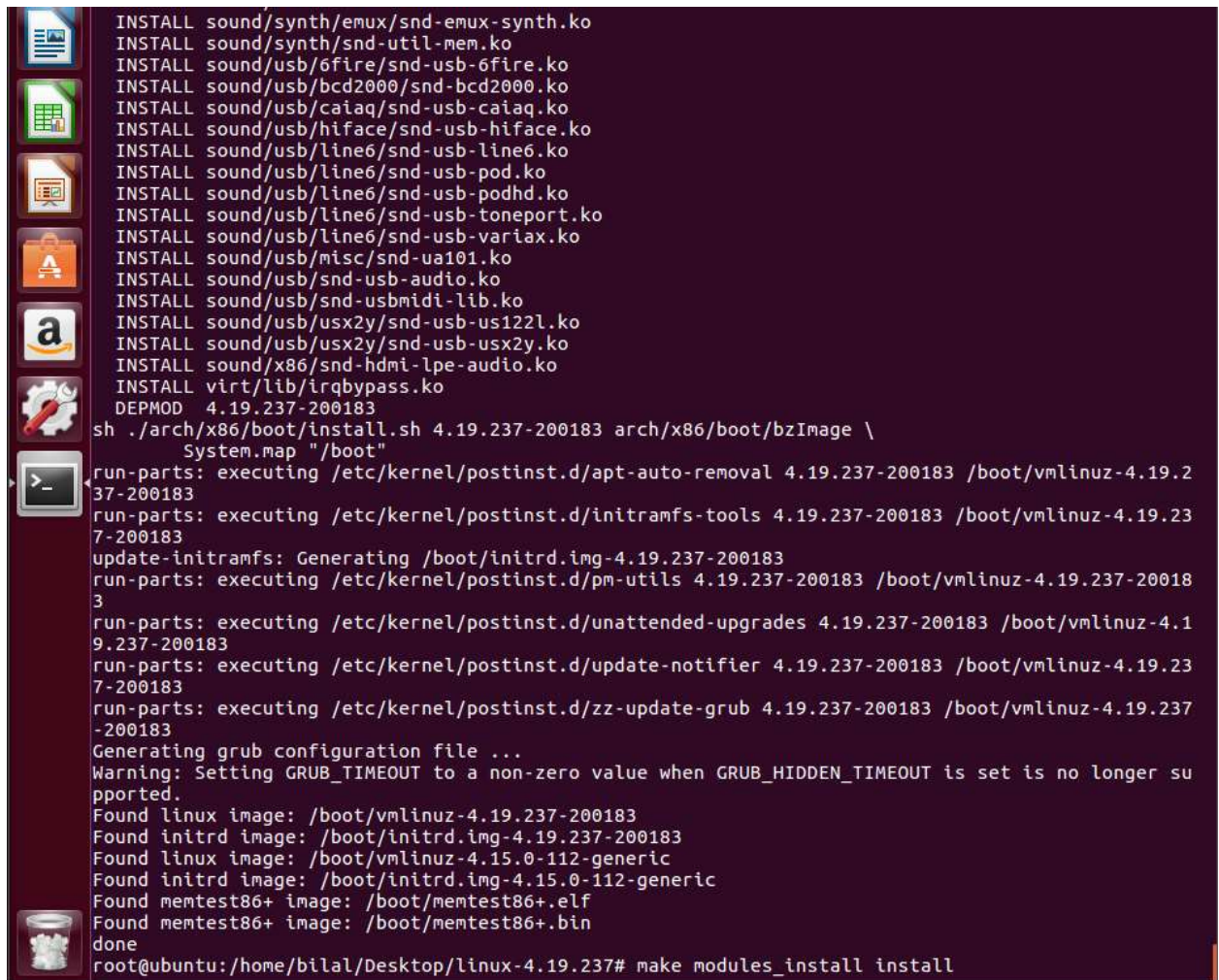
And 5 more mins...

```
LD [M] sound/soc/snd-soc-dept.ko
LD [M] sound/soc/intel/skylake/snd-soc-skl.ko
LD [M] sound/soc/snd-soc-core.ko
LD [M] sound/soc/xtensa/snd-soc-xtfpga-i2s.ko
LD [M] sound/soc/zte/zx-tdm.ko
LD [M] sound/synth/emux/snd-emux-synth.ko
LD [M] sound/soundcore.ko
LD [M] sound/synth/snd-util-mem.ko
LD [M] sound/usb/6fire/snd-usb-6fire.ko
LD [M] sound/usb/bcd2000/snd-bcd2000.ko
LD [M] sound/usb/caiaq/snd-usb-caiaq.ko
LD [M] sound/usb/hiface/snd-usb-hiface.ko
LD [M] sound/usb/line6/snd-usb-line6.ko
LD [M] sound/usb/line6/snd-usb-pod.ko
LD [M] sound/usb/line6/snd-usb-podhd.ko
LD [M] sound/usb/line6/snd-usb-toneport.ko
LD [M] sound/usb/line6/snd-usb-variak.ko
LD [M] sound/usb/misc/snd-ua101.ko
LD [M] sound/usb/snd-usb-audio.ko
LD [M] sound/usb/snd-usbmidi-lib.ko
LD [M] sound/usb/usx2y/snd-usb-us122l.ko
LD [M] sound/usb/usx2y/snd-usb-usx2y.ko
LD [M] sound/x86/snd-hdmi-lpe-audio.ko
LD [M] virt/lib/irqbypass.ko
bilal@ubuntu:~/Desktop/linux-4.19.237$
```

7. Installing the modules

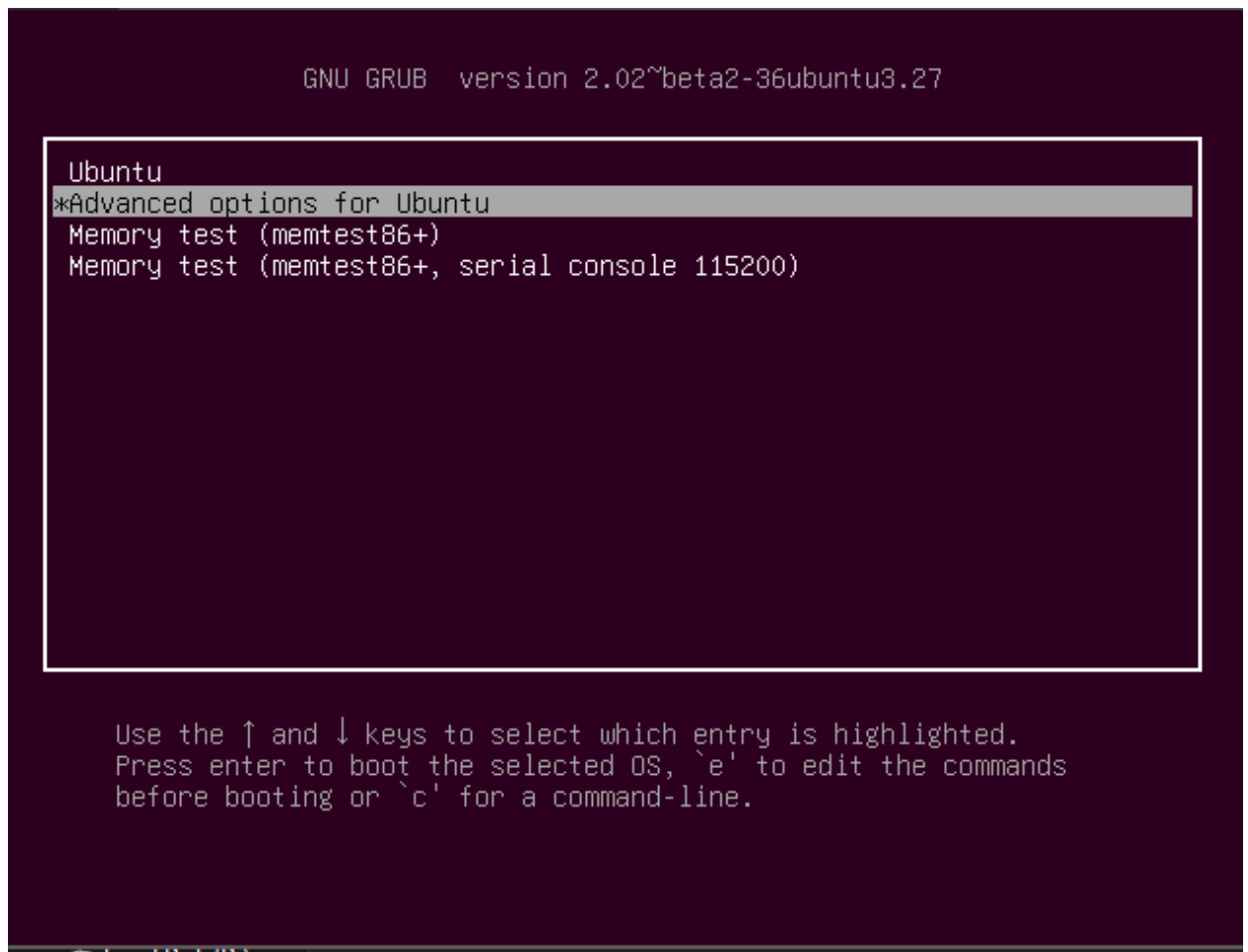
```
root@ubuntu:~/hane/bilal/Desktop/linux-4.19.237# make modules_install install
INSTALL arch/x86/crypto/aes-x86_64.ko
INSTALL arch/x86/crypto/aesni-intel.ko
INSTALL arch/x86/crypto/blowfish-x86_64.ko
INSTALL arch/x86/crypto/camellia-aesni-avx-x86_64.ko
INSTALL arch/x86/crypto/camellia-aesni-avx2.ko
INSTALL arch/x86/crypto/camellia-x86_64.ko
INSTALL arch/x86/crypto/cast5-avx-x86_64.ko
INSTALL arch/x86/crypto/cast6-avx-x86_64.ko
INSTALL arch/x86/crypto/chacha20-x86_64.ko
INSTALL arch/x86/crypto/crc32-pclmul.ko
INSTALL arch/x86/crypto/crc10dif-pclmul.ko
INSTALL arch/x86/crypto/des3_ede-x86_64.ko
INSTALL arch/x86/crypto/ghash-clmulni-intel.ko
INSTALL arch/x86/crypto/glue_helper.ko
INSTALL arch/x86/crypto/poly1305-x86_64.ko
INSTALL arch/x86/crypto/serpent-avx-x86_64.ko
INSTALL arch/x86/crypto/serpent-avx2.ko
INSTALL arch/x86/crypto/serpent-sse2-x86_64.ko
INSTALL arch/x86/crypto/sha1-mb/sha1-mb.ko
INSTALL arch/x86/crypto/sha1-ssse3.ko
INSTALL arch/x86/crypto/sha256-mb/sha256-mb.ko
INSTALL arch/x86/crypto/sha256-ssse3.ko
INSTALL arch/x86/crypto/sha512-mb/sha512-mb.ko
INSTALL arch/x86/crypto/sha512-ssse3.ko
INSTALL arch/x86/crypto/twofish-avx-x86_64.ko
INSTALL arch/x86/crypto/twofish-x86_64-3way.ko
INSTALL arch/x86/crypto/twofish-x86_64.ko
INSTALL arch/x86/events/intel/intel-cstate.ko
INSTALL arch/x86/events/intel/intel-rapl-perf.ko
INSTALL arch/x86/kernel/cpu/mcheck/mce-inject.ko
INSTALL arch/x86/kernel/cpuid.ko
INSTALL arch/x86/kernel/msr.ko
INSTALL arch/x86/kvm/kvm-amd.ko
INSTALL arch/x86/kvm/kvm-intel.ko
INSTALL arch/x86/kvm/kvm.ko
INSTALL arch/x86/oprofile/oprofile.ko
INSTALL arch/x86/platform/atom/punit_atom_debug.ko
INSTALL block/bfq.ko
INSTALL block/kyber-iosched.ko
INSTALL block/nq-deadline.ko
INSTALL crypto/842.ko
INSTALL crypto/aes-tt.ko
INSTALL crypto/af_alg.ko
INSTALL crypto/algif_aead.ko
INSTALL crypto/algif_hash.ko
INSTALL crypto/algif_rng.ko
INSTALL crypto/ast256-llnt.ko
```


8. Kernel compilation done (Finally....)

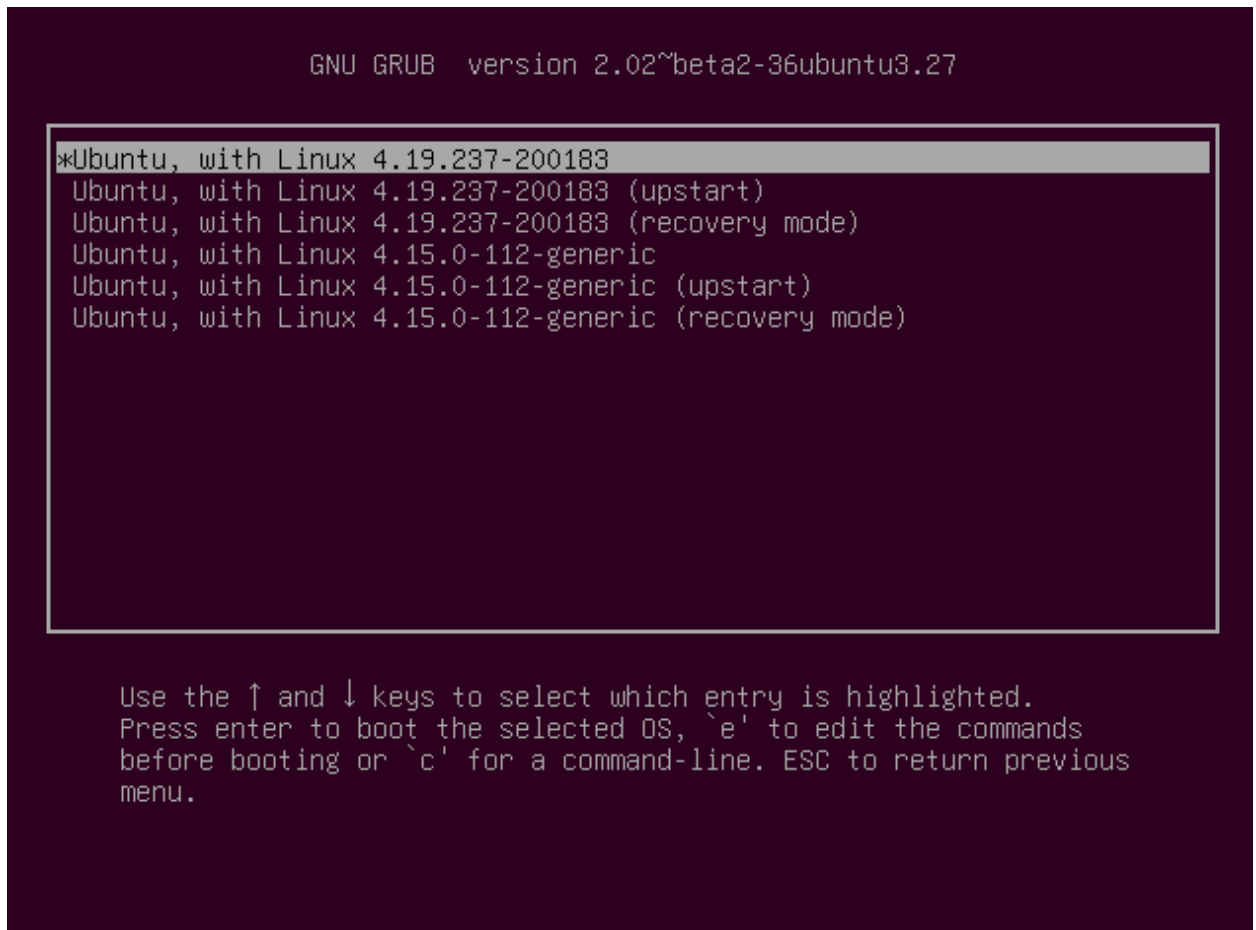
A terminal window with a dark purple background and white text. On the left side, there is a vertical toolbar with several icons: a document, a spreadsheet, a presentation, a folder, a shopping bag, a logo with the letter 'a', a gear, and a terminal icon. The terminal text shows the installation of various sound modules, the generation of boot images, and the execution of post-installation tasks. The prompt at the bottom is 'root@ubuntu:/home/bilal/Desktop/linux-4.19.237#'.

```
INSTALL sound/synth/emux/snd-emux-synth.ko
INSTALL sound/synth/snd-util-mem.ko
INSTALL sound/usb/6fire/snd-usb-6fire.ko
INSTALL sound/usb/bcd2000/snd-bcd2000.ko
INSTALL sound/usb/caiaq/snd-usb-caiaq.ko
INSTALL sound/usb/hiface/snd-usb-hiface.ko
INSTALL sound/usb/line6/snd-usb-line6.ko
INSTALL sound/usb/line6/snd-usb-pod.ko
INSTALL sound/usb/line6/snd-usb-podhd.ko
INSTALL sound/usb/line6/snd-usb-toneport.ko
INSTALL sound/usb/line6/snd-usb-variax.ko
INSTALL sound/usb/misc/snd-ua101.ko
INSTALL sound/usb/snd-usb-audio.ko
INSTALL sound/usb/snd-usbmidi-lib.ko
INSTALL sound/usb/usx2y/snd-usb-us122l.ko
INSTALL sound/usb/usx2y/snd-usb-usx2y.ko
INSTALL sound/x86/snd-hdmi-lpe-audio.ko
INSTALL virt/lib/irqbypass.ko
DEPMOD 4.19.237-200183
sh ./arch/x86/boot/install.sh 4.19.237-200183 arch/x86/boot/bzImage \
    System.map "/boot"
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 4.19.237-200183 /boot/vmlinuz-4.19.237-200183
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 4.19.237-200183 /boot/vmlinuz-4.19.237-200183
update-initramfs: Generating /boot/initrd.img-4.19.237-200183
run-parts: executing /etc/kernel/postinst.d/pm-utils 4.19.237-200183 /boot/vmlinuz-4.19.237-200183
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 4.19.237-200183 /boot/vmlinuz-4.19.237-200183
run-parts: executing /etc/kernel/postinst.d/update-notifier 4.19.237-200183 /boot/vmlinuz-4.19.237-200183
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 4.19.237-200183 /boot/vmlinuz-4.19.237-200183
Generating grub configuration file ...
Warning: Setting GRUB_TIMEOUT to a non-zero value when GRUB_HIDDEN_TIMEOUT is set is no longer supported.
Found linux image: /boot/vmlinuz-4.19.237-200183
Found initrd image: /boot/initrd.img-4.19.237-200183
Found linux image: /boot/vmlinuz-4.15.0-112-generic
Found initrd image: /boot/initrd.img-4.15.0-112-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
root@ubuntu:/home/bilal/Desktop/linux-4.19.237# make modules_install install
```

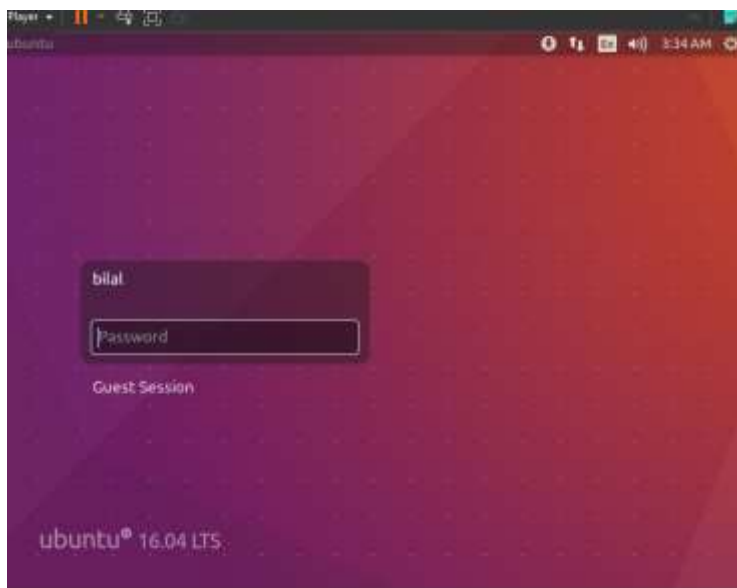
9. Booting from the compiled kernel (Opening the Advanced options)



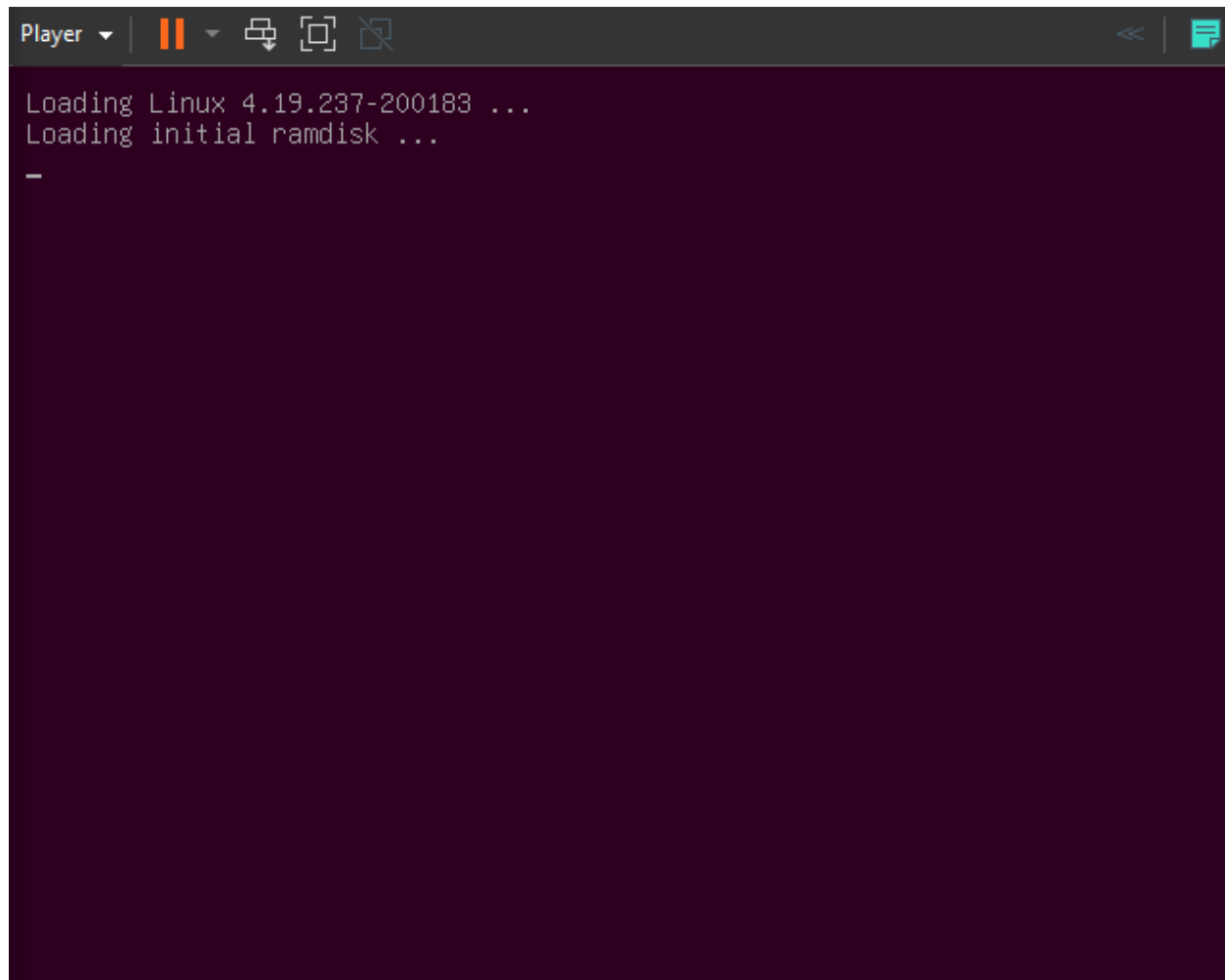
10. Selecting the kernel with my Roll No.



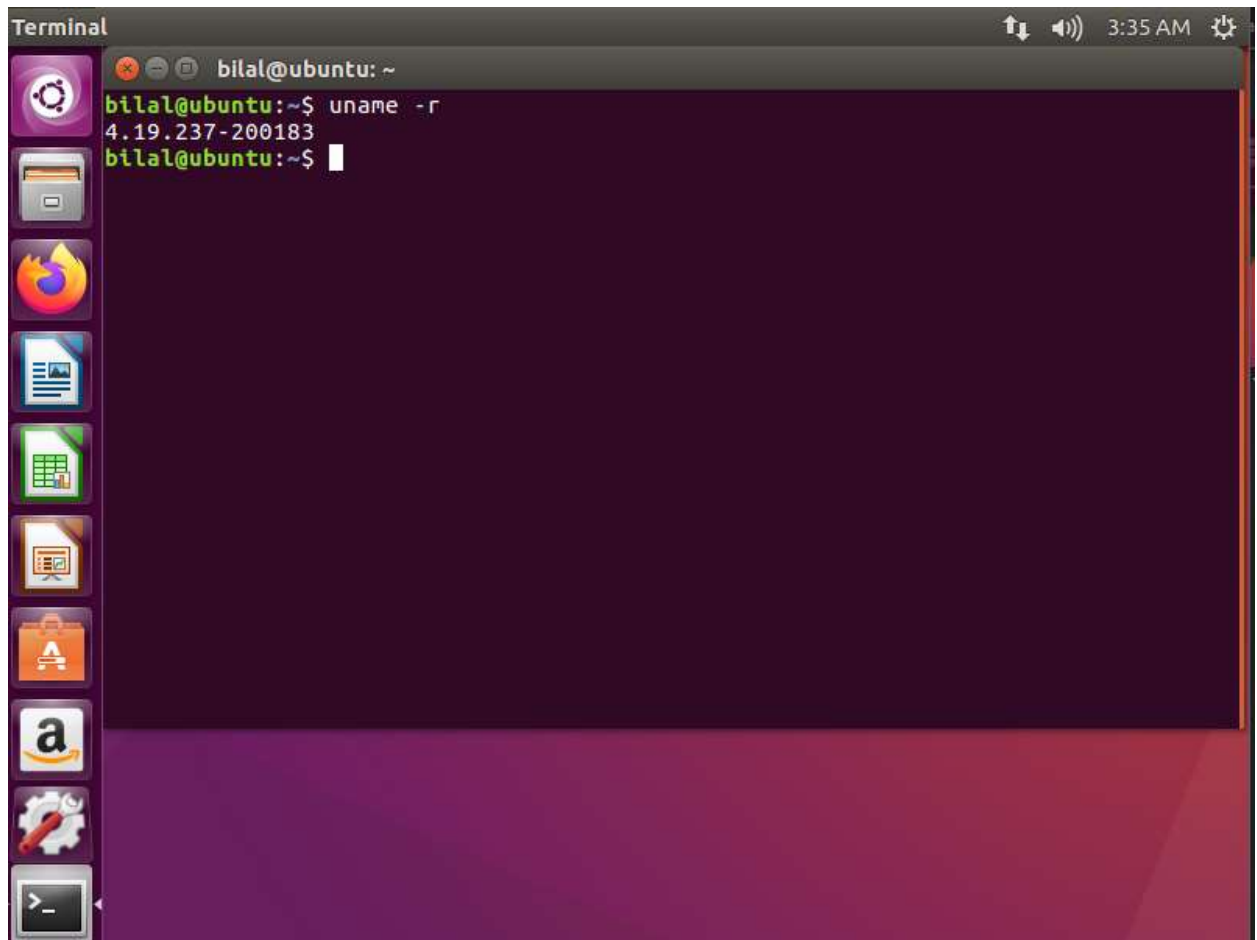
11. Logged In!



12. Loading

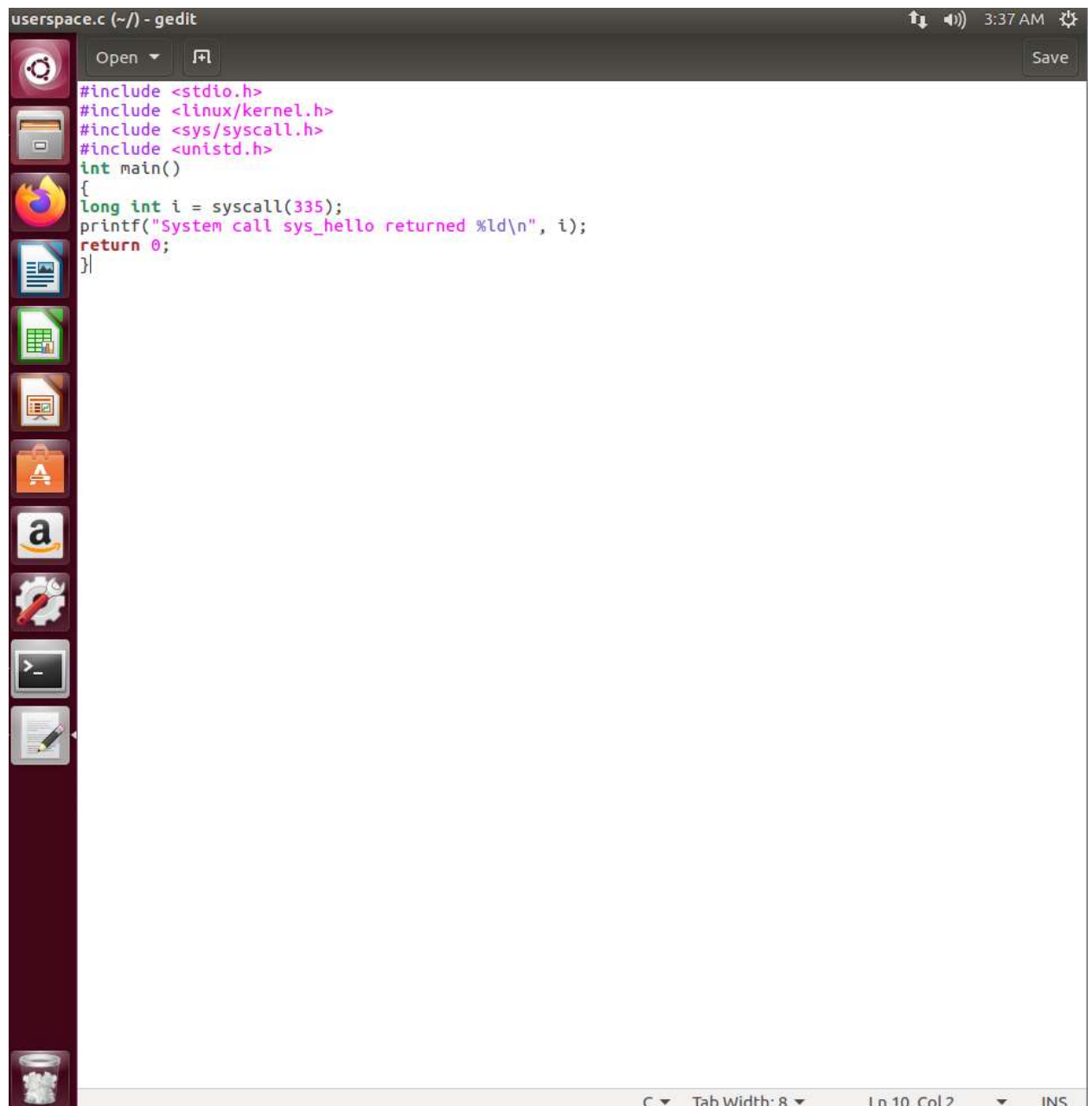


13. Checking kernel version with my own Roll No.

A screenshot of a Linux terminal window titled "Terminal". The window has a dark purple background. On the left side, there is a vertical dock with several application icons: a gear (Settings), a folder (Files), a Firefox browser, a document (LibreOffice Writer), a spreadsheet (LibreOffice Calc), a presentation (LibreOffice Impress), a shopping bag (Ubuntu Software Center), an Amazon logo, a gear with a wrench (System Settings), and a terminal icon. The terminal window itself shows the prompt "bilal@ubuntu: ~". The user has entered the command "uname -r", and the output is "4.19.237-200183". The prompt is now "bilal@ubuntu:~\$" with a cursor. The top of the window shows system status icons (up/down arrows, speaker, battery) and the time "3:35 AM".

```
Terminal 3:35 AM
bilal@ubuntu: ~
bilal@ubuntu:~$ uname -r
4.19.237-200183
bilal@ubuntu:~$
```

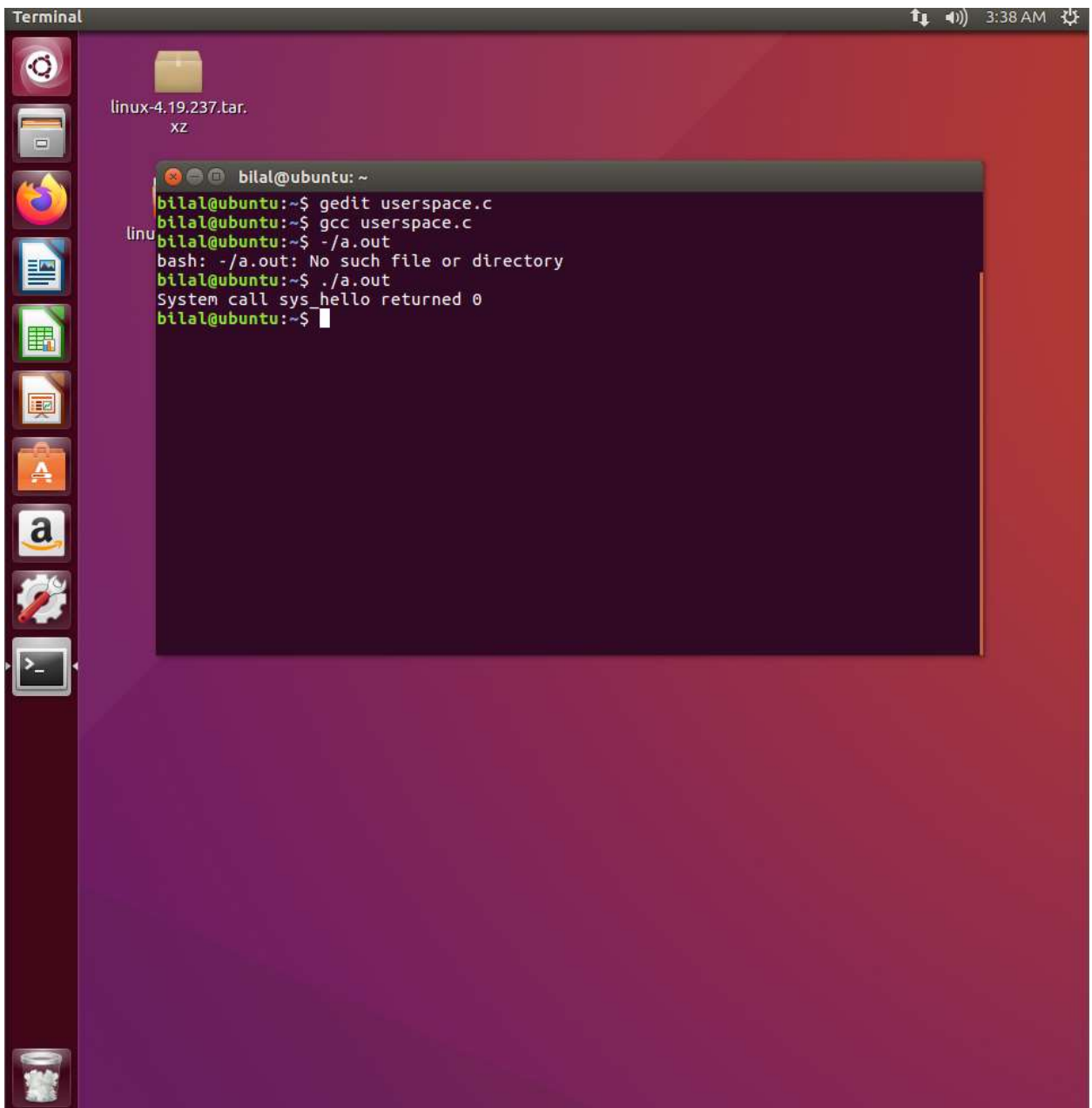
14. Code to test System Call



```
userspace.c (~/) - gedit
#include <stdio.h>
#include <linux/kernel.h>
#include <sys/syscall.h>
#include <unistd.h>
int main()
{
    long int i = syscall(335);
    printf("System call sys_hello returned %ld\n", i);
    return 0;
}
```

C Tab Width: 8 Ln 10, Col 2 INS

15. System Call implemented Successfully



```
[ 11.383984] Decoding supported only on Scalable MCA processors.
[ 11.389897] random: crng init done
[ 11.389899] random: 7 urandom warning(s) missed due to ratelimiting
[ 11.393375] Adding 998396k swap on /dev/sda5. Priority:-2 extents:1 across:9
98396k FS
[ 11.442229] Decoding supported only on Scalable MCA processors.
[ 11.481442] Decoding supported only on Scalable MCA processors.
[ 13.553328] IPv6: ADDRCONF(NETDEV_UP): ens33: link is not ready
[ 13.559273] IPv6: ADDRCONF(NETDEV_UP): ens33: link is not ready
[ 13.563484] e1000: ens33 NIC Link is Up 1000 Mbps Full Duplex, Flow Control:
None
[ 13.564415] IPv6: ADDRCONF(NETDEV_CHANGE): ens33: link becomes ready
[ 259.847898] Hello world
bilal@ubuntu:~$
```