Assignment 2: Adding and testing a new system call to Linux kernel

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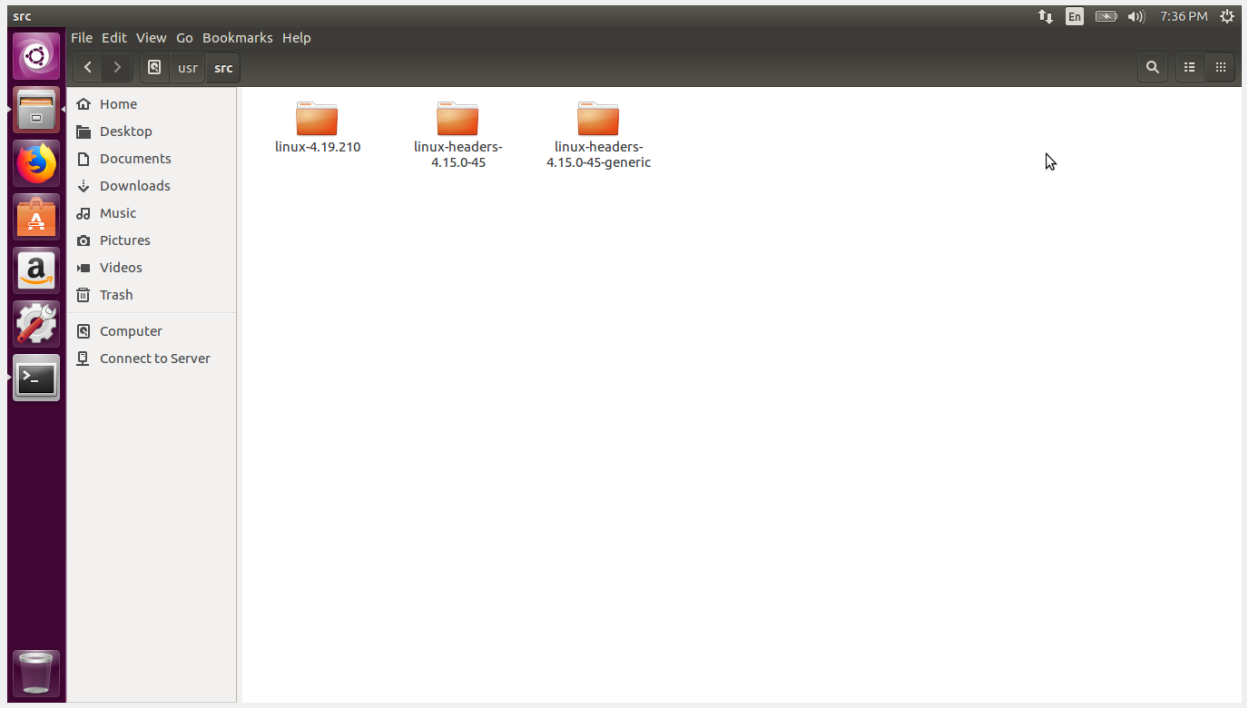
In this assignment, our task was to implement the system calls in the Linux kernel and test then out by compiling the kernel.

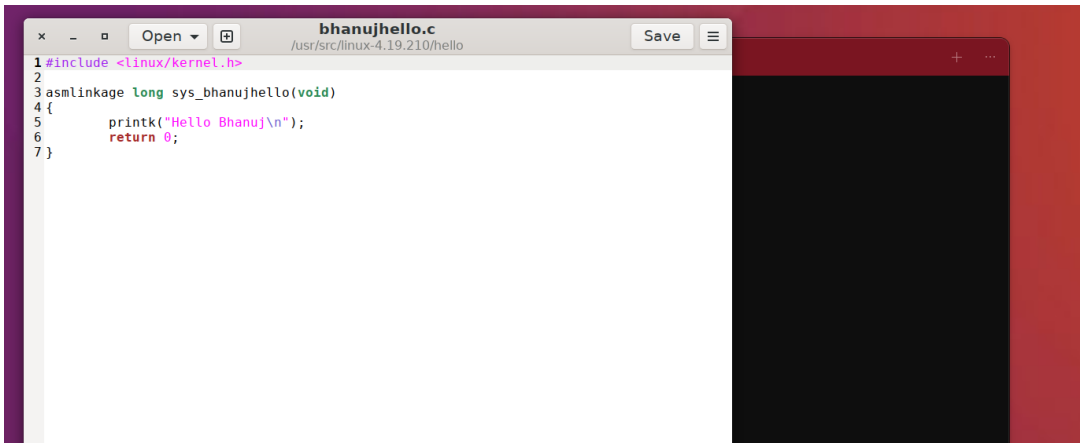
Steps Followed

1. Download the compressed file of *Linux Kernel version 4.19.210*.
2. Extract the downloaded kernel file in */usr/src*.

```
$ sudo tar -xvf linux-4.19.210.tar.xz -C/usr/src
```



1. Go to the extracted folder
2. Implement System Calls
    a. **Question 1. : Write syscall to print a welcome message to Linux logs**
        i. Create a Folder for a new system-call `hello`
        ii. Create a C file inside it. `hello.c`
        iii. Implement the system call as shown in `bhanujhello.c`



iv. Create a make file in the `hello` folder named `Makefile` and include the following line in it.

```
obj-y := hello.o
```

v. Add function call definition in `./include/syscall.h` header file.

```
asmlinkage long sys_bhanujhello(void);
```

vi. Add the system call entry in `syscalls_32.tbl`

vii. Add folder name to `Makefile` of kernel

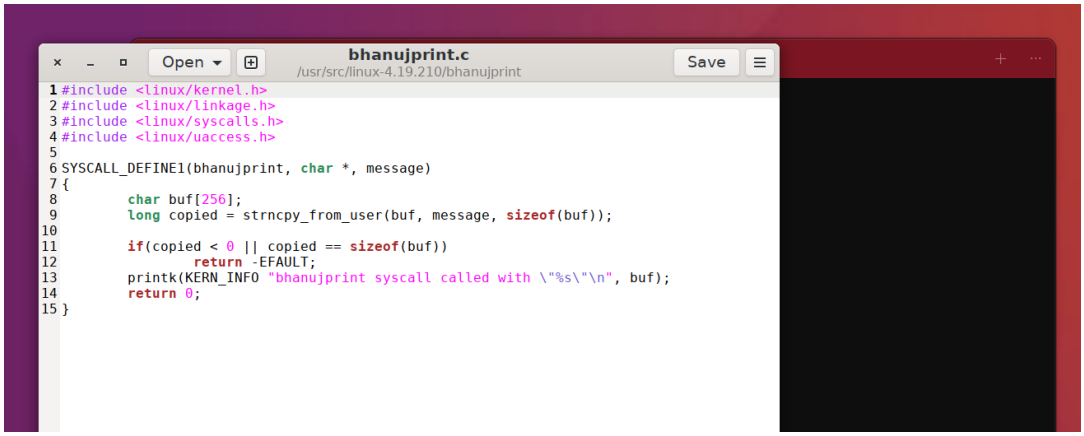
```
core-y += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/
```

b. **Question 2.: Write syscall which will receive string parameter and print it along with some message to kernel logs**

i. Create a Folder for a new system-call `bhanujprint`

ii. Create a C file inside it. `bhanujprint.c`

iii. Implement the system call as shown in `bhanujprint.c`



iv. Create a make file in the `bhanujprint` folder named `Makefile` and include the following line in it.

```
obj-y := bhanujprint.o
```

v. Add the system call entry in `syscalls_32.tbl`

vi. Add folder name to `Makefile` of kernel

```
core-y += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/ bhanujprint/
```

c. **Question 3.: Write system call to print the parent process id and current process id upon calling it**

i. Create a Folder for a new system-call `bhanujprocess`

ii. Create a C file inside it. `bhanujprocess.c`

iii. Implement the system call as shown in `bhanujprocess.c`

iv. Create a make file in the `bhanujprocess` folder named `Makefile` and include the following line in it.

```
obj-y := bhanujprocess.o
```

v. Add function call definition in `./include/syscall.h` header file.

```
asmlinkage long sys_bhanujprocess(void);
```

vi. Add the system call entry in *`syscalls_32.tbl`*

vii. Add folder name to `Makefile` of kernel

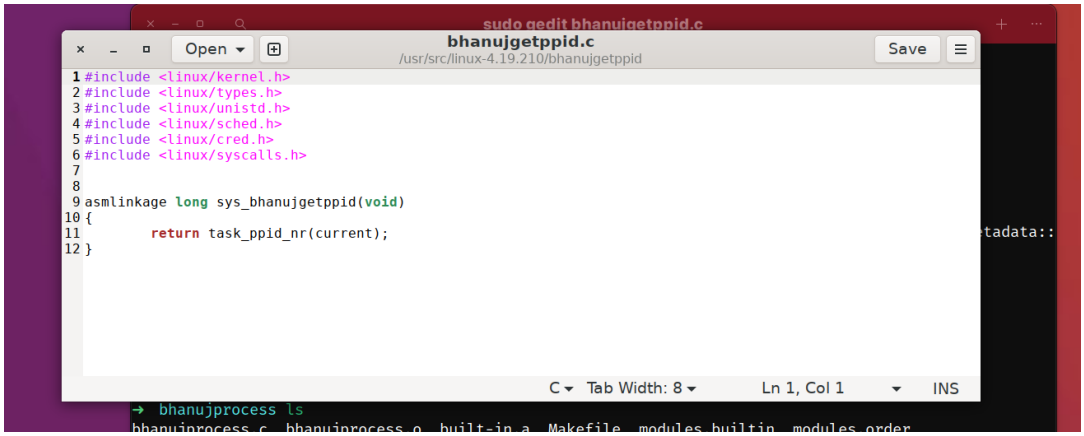
```
core-y += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/
bhanujprint/ bhanujprocess/
```

d. **Question 4: Write system call to execute some predefined system call from your written system call**

In this question, I have implemented `getppid()` function call which is named as `bhanujgetppid()` which will return parent process' process id(pid).

1. Create a Folder for a new system-call *`bhanujgetppid`*
2. Create a C file inside it. *`bhanujgetppid.c`*

3. Implement the system call as shown in `bhanujgetppid.c`



4. Create a make file in the `bhanujgetppid` folder named `Makefile` and include the following line in it.

   `obj-y := bhanujgetppid.o`

5. Add function call definition in `./include/syscall.h` header file.

   `asmlinkage long sys_bhanujgetppid(void);`

6. Add the system call entry in *`syscalls_32.tbl`*

7. Add folder name to `Makefile` of kernel

   `core-y += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/ bhanujprint/ bhanujprocess/ bhanujgetppid/`

Final `syscalls_32.tbl` file will look like:

Last 4 entries have my implemented system calls for question 1, question 2, question 3, question 4, respectively

syscall_32.tbl
/usr/src/linux-4.19.210/arch/x86/entry/syscalls

```
354 340     i386    prlimit64               sys_prlimit64               __ia32_sys_prlimit64
355 341     i386    name_to_handle_at       sys_name_to_handle_at       __ia32_sys_name_to_handle_at
356 342     i386    open_by_handle_at       sys_open_by_handle_at       __ia32_compat_sys_open_by_handle_at
357 343     i386    clock_adjtime           sys_clock_adjtime           __ia32_compat_sys_clock_adjtime
358 344     i386    syncfs                  sys_syncfs                  __ia32_sys_syncfs
359 345     i386    sendmmsg                sys_sendmmsg                __ia32_compat_sys_sendmmsg
360 346     i386    setns                   sys_setns                   __ia32_sys_setns
361 347     i386    process_vm_readv        sys_process_vm_readv        __ia32_compat_sys_process_vm_readv
362 348     i386    process_vm_writev       sys_process_vm_writev       __ia32_compat_sys_process_vm_writev
363 349     i386    kcmp                    sys_kcmp                    __ia32_sys_kcmp
364 350     i386    finit_module            sys_finit_module            __ia32_sys_finit_module
365 351     i386    sched_setattr           sys_sched_setattr           __ia32_sys_sched_setattr
366 352     i386    sched_getattr           sys_sched_getattr           __ia32_sys_sched_getattr
367 353     i386    renameat2               sys_renameat2               __ia32_sys_renameat2
368 354     i386    seccomp                 sys_seccomp                 __ia32_sys_seccomp
369 355     i386    getrandom               sys_getrandom               __ia32_sys_getrandom
370 356     i386    memfd_create            sys_memfd_create            __ia32_sys_memfd_create
371 357     i386    bpf                     sys_bpf                     __ia32_sys_bpf
372 358     i386    execveat                sys_execveat                __ia32_compat_sys_execveat
373 359     i386    socket                  sys_socket                  __ia32_sys_socket
374 360     i386    socketpair              sys_socketpair              __ia32_sys_socketpair
375 361     i386    bind                    sys_bind                    __ia32_sys_bind
376 362     i386    connect                 sys_connect                 __ia32_sys_connect
377 363     i386    listen                  sys_listen                  __ia32_sys_listen
378 364     i386    accept4                 sys_accept4                 __ia32_sys_accept4
379 365     i386    getsockopt              sys_getsockopt              __ia32_compat_sys_getsockopt
380 366     i386    setsockopt              sys_setsockopt              __ia32_compat_sys_setsockopt
381 367     i386    getsockname             sys_getsockname             __ia32_sys_getsockname
382 368     i386    getpeername             sys_getpeername             __ia32_sys_getpeername
383 369     i386    sendto                  sys_sendto                  __ia32_sys_sendto
384 370     i386    sendmsg                 sys_sendmsg                 __ia32_compat_sys_sendmsg
385 371     i386    recvfrom                sys_recvfrom                __ia32_compat_sys_recvfrom
386 372     i386    recvmsg                 sys_recvmsg                 __ia32_compat_sys_recvmsg
387 373     i386    shutdown                sys_shutdown                __ia32_sys_shutdown
388 374     i386    userfaultfd             sys_userfaultfd             __ia32_sys_userfaultfd
389 375     i386    membarrier              sys_membarrier              __ia32_sys_membarrier
390 376     i386    mlock2                  sys_mlock2                  __ia32_sys_mlock2
391 377     i386    copy_file_range         sys_copy_file_range         __ia32_sys_copy_file_range
392 378     i386    preadv2                 sys_preadv2                 __ia32_compat_sys_preadv2
393 379     i386    pwritev2                sys_pwritev2                __ia32_compat_sys_pwritev2
394 380     i386    pkey_mprotect           sys_pkey_mprotect           __ia32_sys_pkey_mprotect
395 381     i386    pkey_alloc              sys_pkey_alloc              __ia32_sys_pkey_alloc
396 382     i386    pkey_free               sys_pkey_free               __ia32_sys_pkey_free
397 383     i386    statx                   sys_statx                   __ia32_sys_statx
398 384     i386    arch_prctl              sys_arch_prctl              __ia32_compat_sys_arch_prctl
399 385     i386    io_pgetevents           sys_io_pgetevents           __ia32_compat_sys_io_pgetevents
400 386     i386    rseq                    sys_rseq                    __ia32_sys_rseq
401 387     i386    hello                   sys_bhanujhello
402 388     i386    bhanujprint             sys_bhanujprint             __ia32_sys_bhanujprint
403 389     i386    bhanujprocess           sys_bhanujprocess
404 390     i386    bhanujgetppid           sys_bhanujgetppid
```

syscalls_32.tbl file snapshot

Final `Makefile` in root directory of kernel will look like:

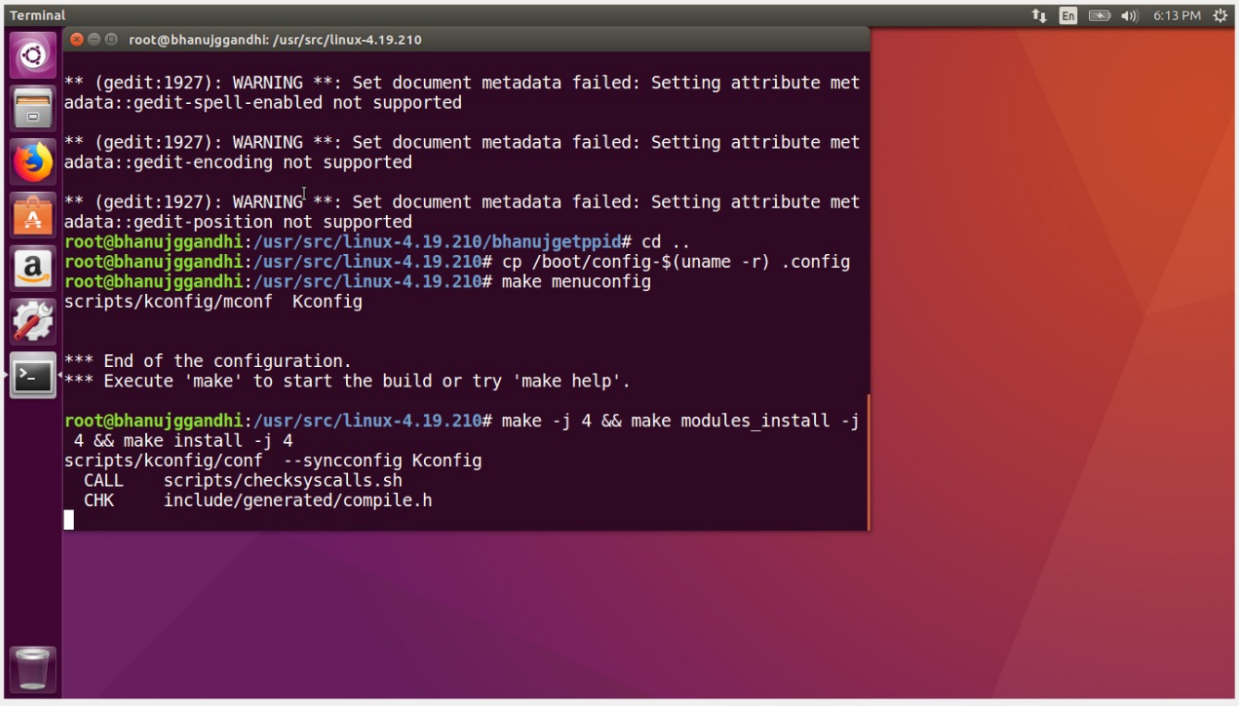
Makefile
/usr/src/linux-4.19.210

```
975             echo "int main() {}" | $(HOSTCC) -xc -o /dev/null $(HOST_LIBELF_LIBS) -,1,0)
976   ifeq ($(has_libelf),1)
977     objtool_target := tools/objtool FORCE
978   else
979     SKIP_STACK_VALIDATION := 1
980     export SKIP_STACK_VALIDATION
981   endif
982 endif
983
984 PHONY += prepare0
985
986 ifeq ($(KBUILD_EXTMOD),)
987 core-y          += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/ bhanujprint/ bhanujprocess/ bhanujgetppid/
988
989 vmlinux-dirs    := $(patsubst %/,%,$(filter %/, $(init-y) $(init-m) \
990                      $(core-y) $(core-m) $(drivers-y) $(drivers-m) \
991                      $(net-y) $(net-m) $(libs-y) $(libs-m) $(virt-y)))
992
993 vmlinux-alldirs := $(sort $(vmlinux-dirs) $(patsubst %/,%,$(filter %/, \
994                      $(init-) $(core-) $(drivers-) $(net-) $(libs-) $(virt-))))
995
996 init-y          := $(patsubst %/, %/built-in.a, $(init-y))
997 core-y          := $(patsubst %/, %/built-in.a, $(core-y))
998 drivers-y       := $(patsubst %/, %/built-in.a, $(drivers-y))
999 net-y           := $(patsubst %/, %/built-in.a, $(net-y))
1000 libs-y1         := $(patsubst %/, %/lib.a, $(libs-y))
1001 libs-y2         := $(patsubst %/, %/built-in.a, $(filter-out %.a, $(libs-y)))
```

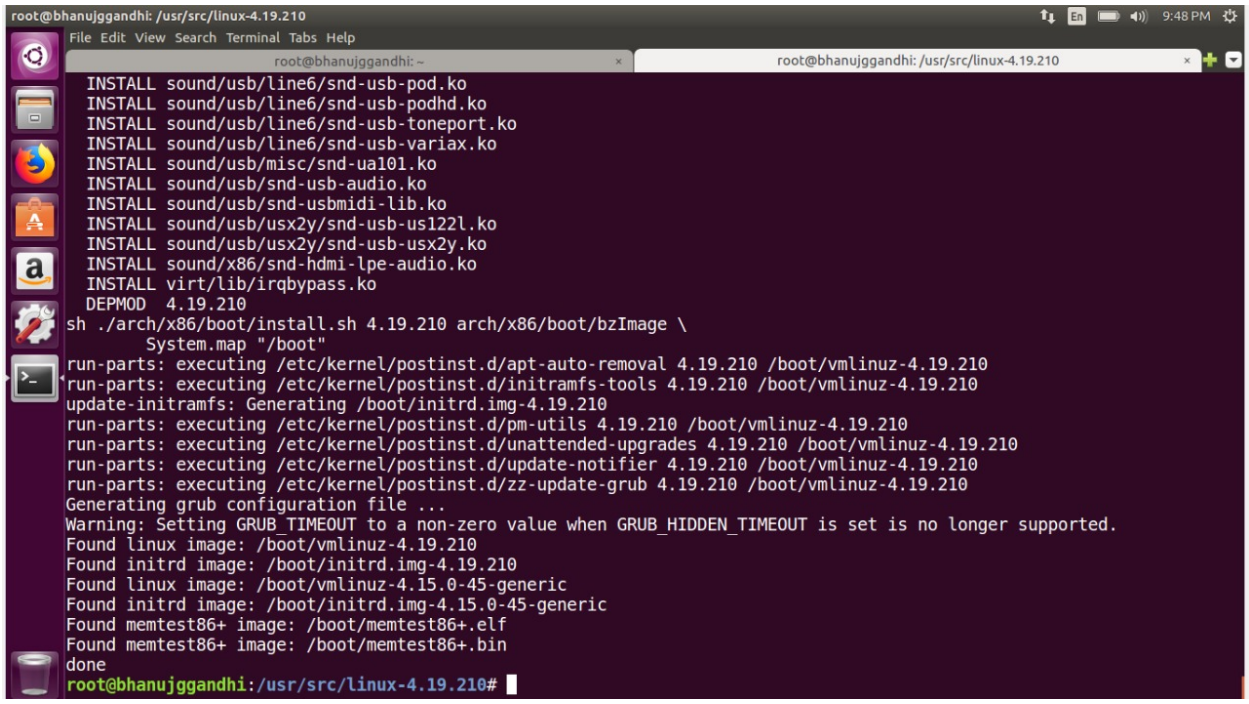
Makefile snapshot

3. Compile the Kernel

```
# Makefile for menuconfig
$ sudo make menuconfig

# Compiling kernel and kernel modules
$ sudo make -j 4 && sudo make modules_install -j 4

# Installing kernel
$ sudo make install -j 4

# Where -j n defines the number of cores to be give to the process
# that will run this command



# This is to update the kernel entries in the grub
$ sudo update-grub
$ sudo shutdown now -r
```



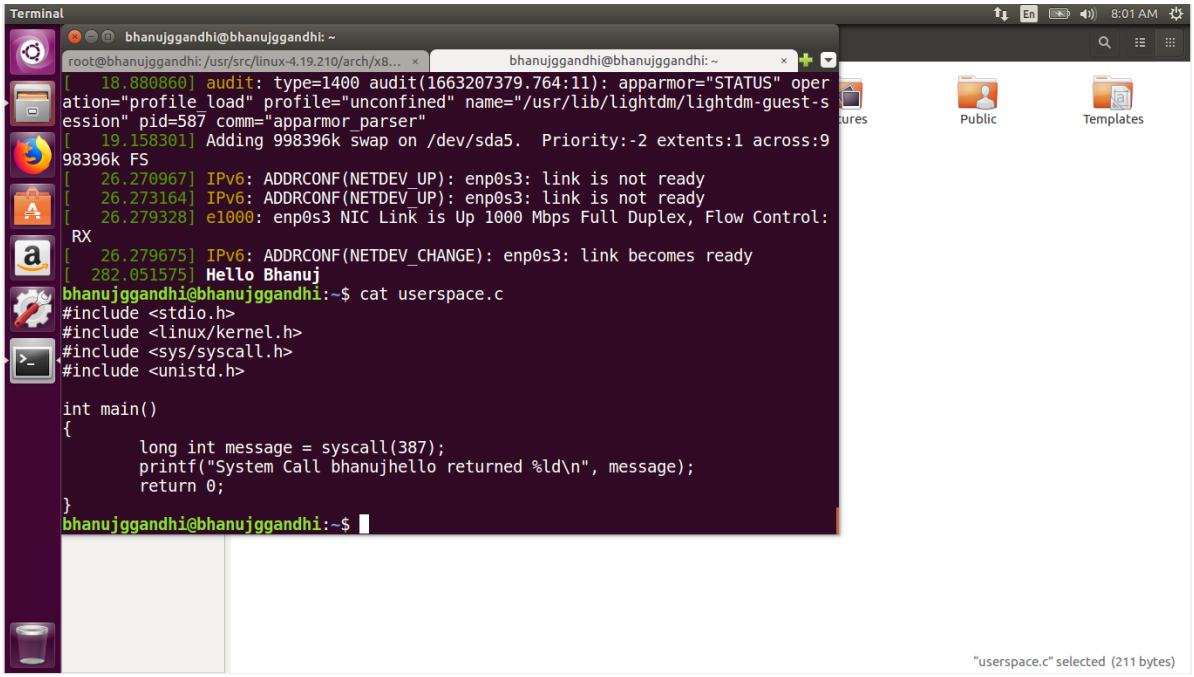
Execution snapshot of *menuconfig and make command*



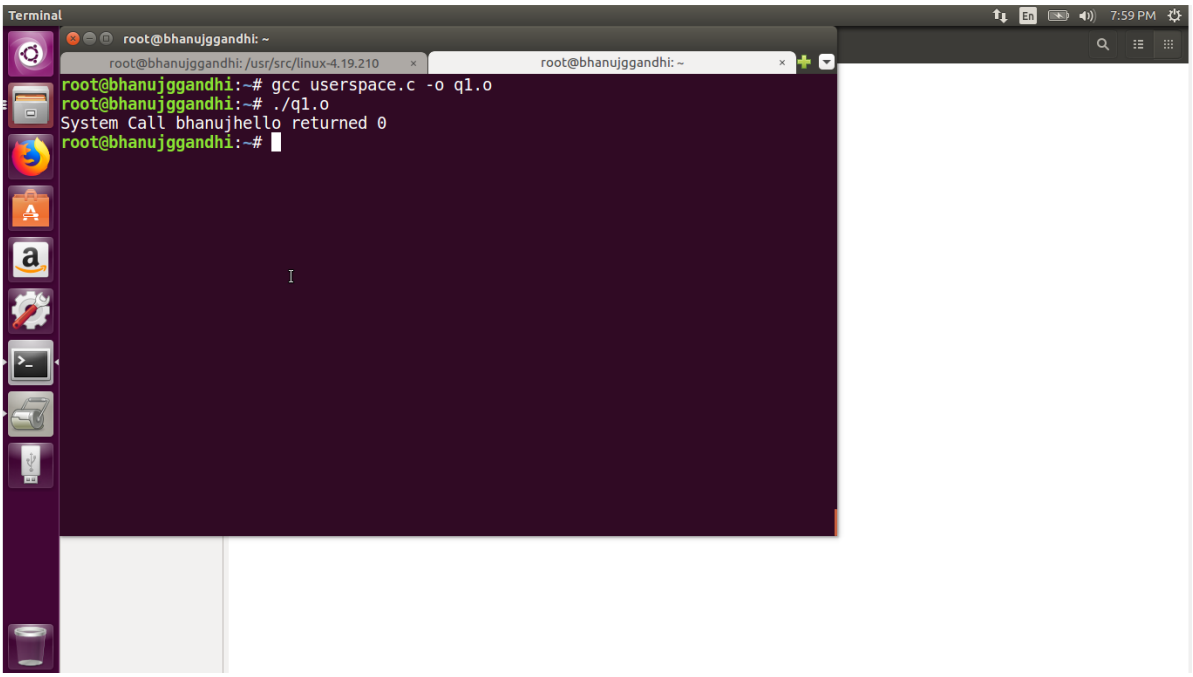
Completion of make install command

4. Test the system calls

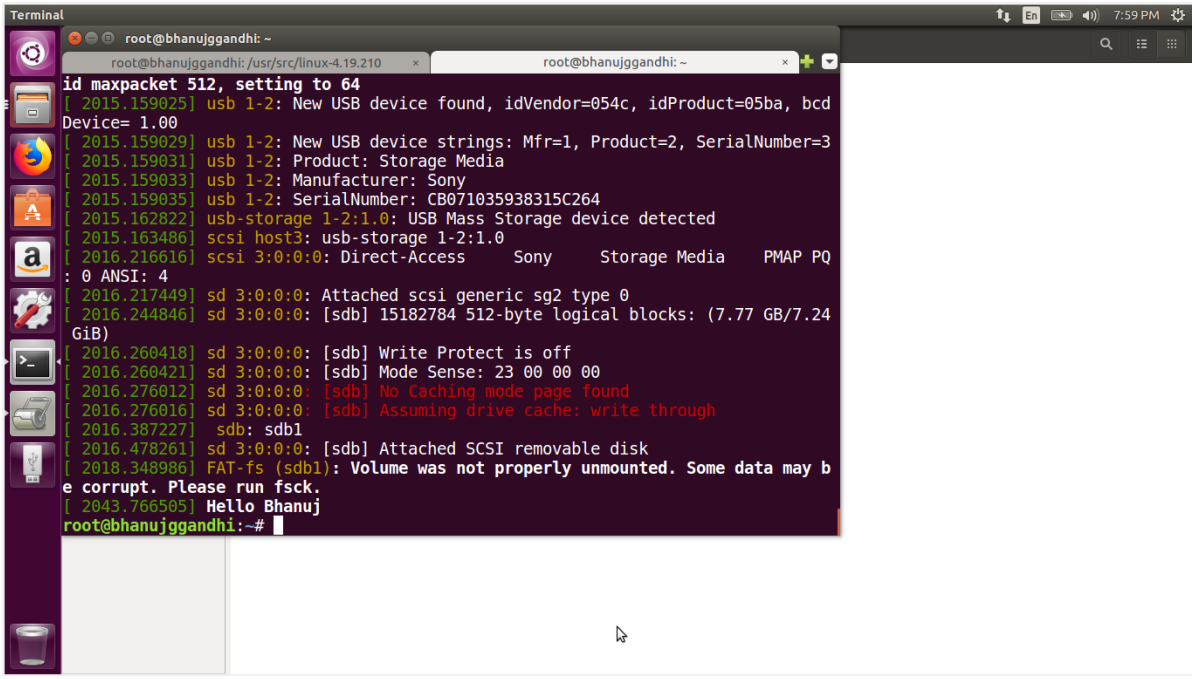
   a. **Question 1:**



Driver Code to Test question 1 sys_bhanujhello system call

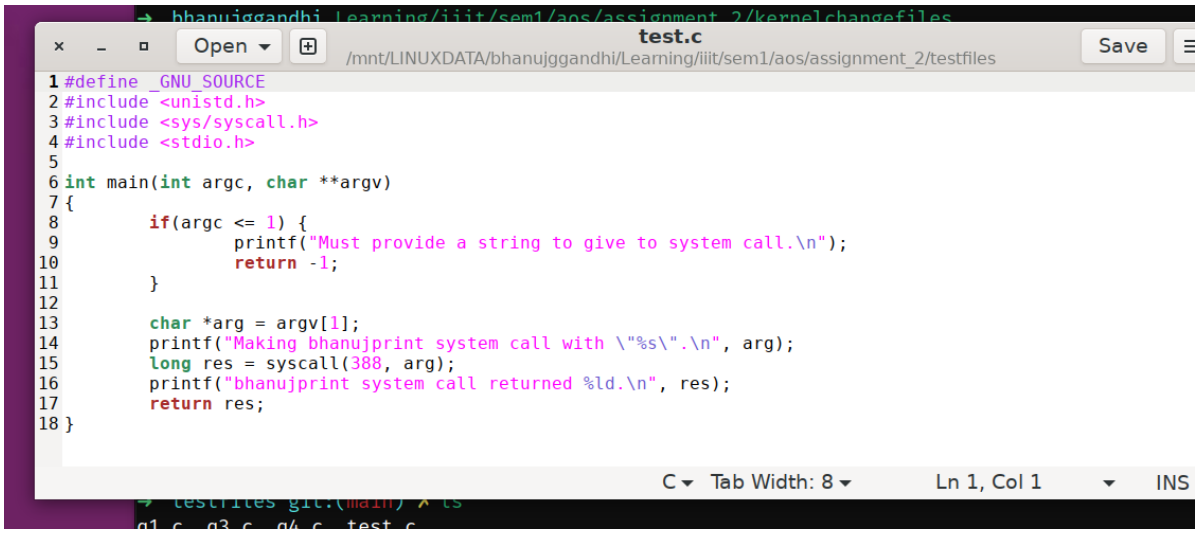


Upon running the out file after compiling

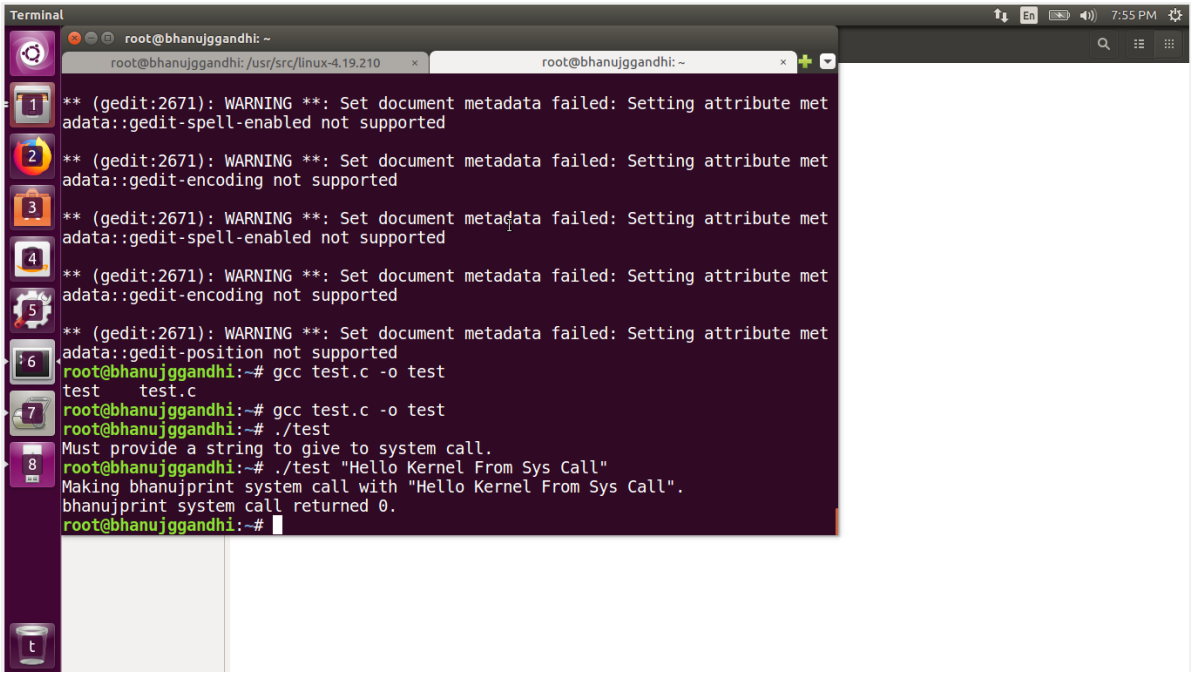


Output in dmesg by sys_bhanujhello system call

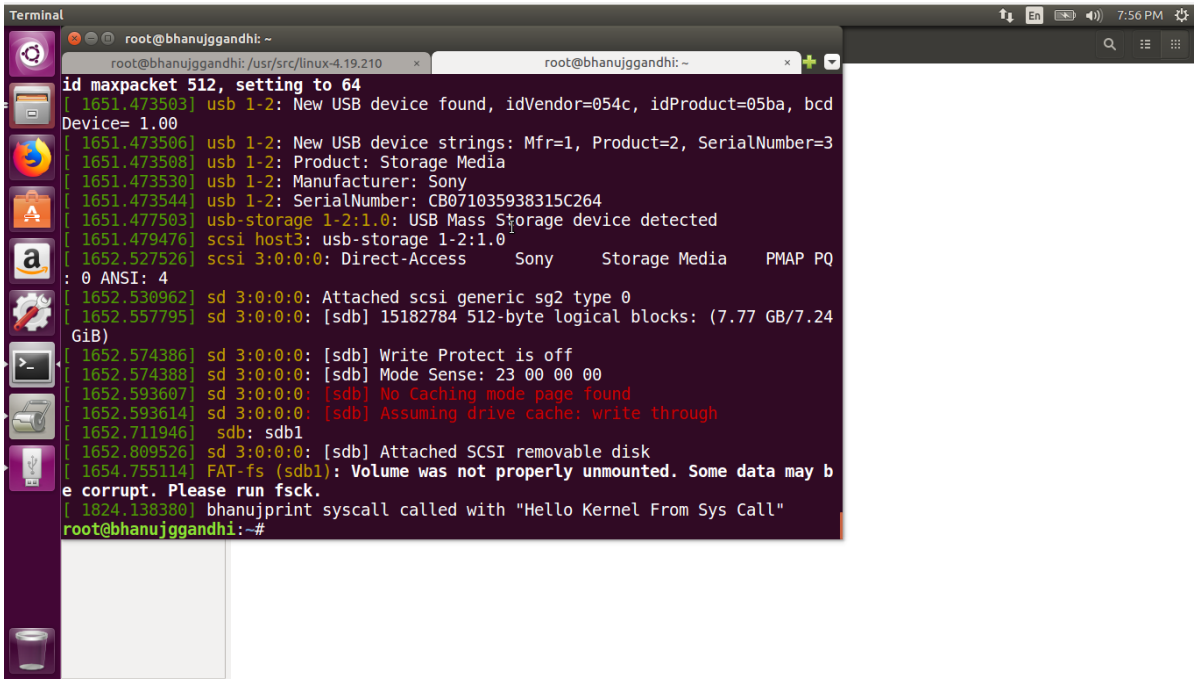
b. **Question 2:**



Driver code for bhanujprint system call

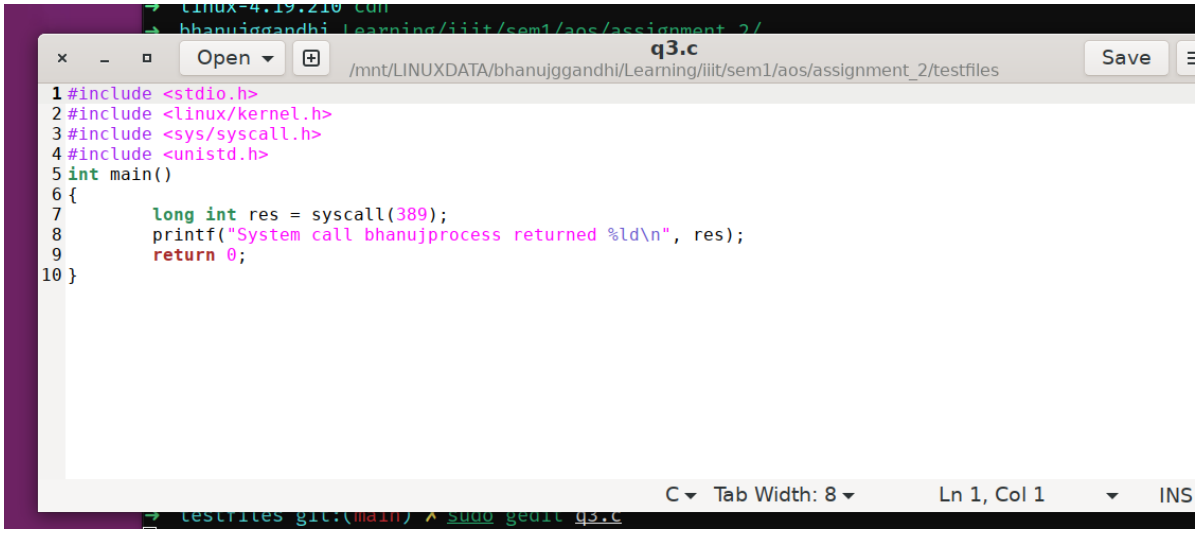


Upon compiling and running out file

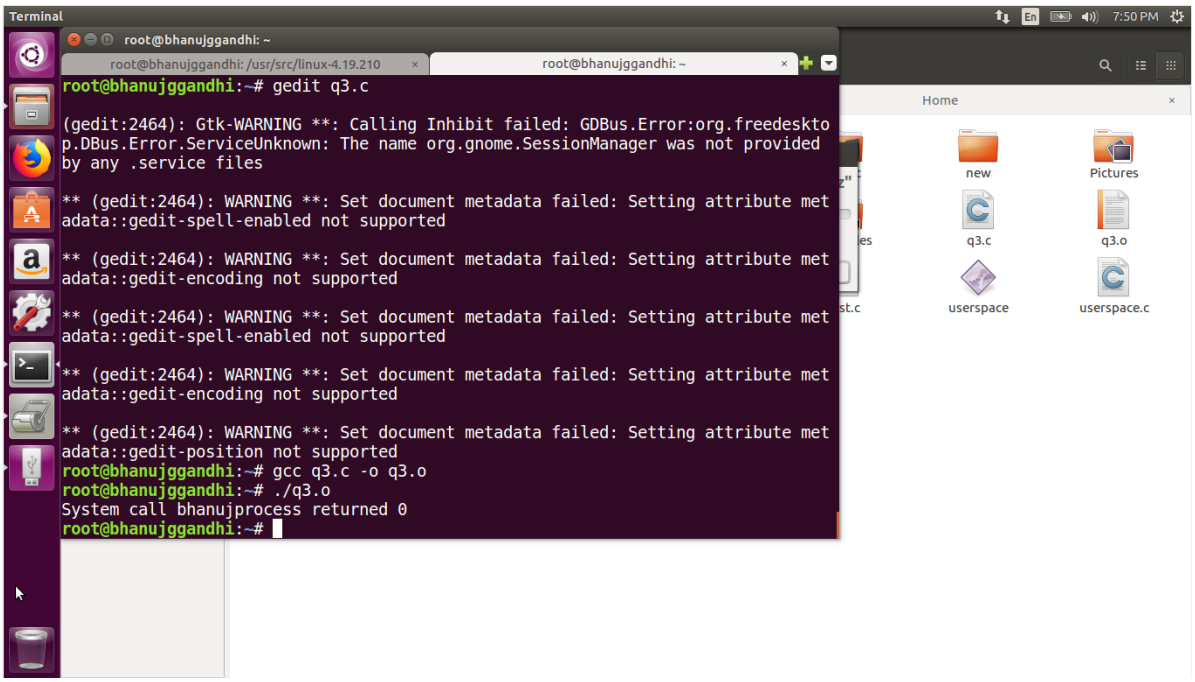


Output in dmesg by sys_bhanujprint system call

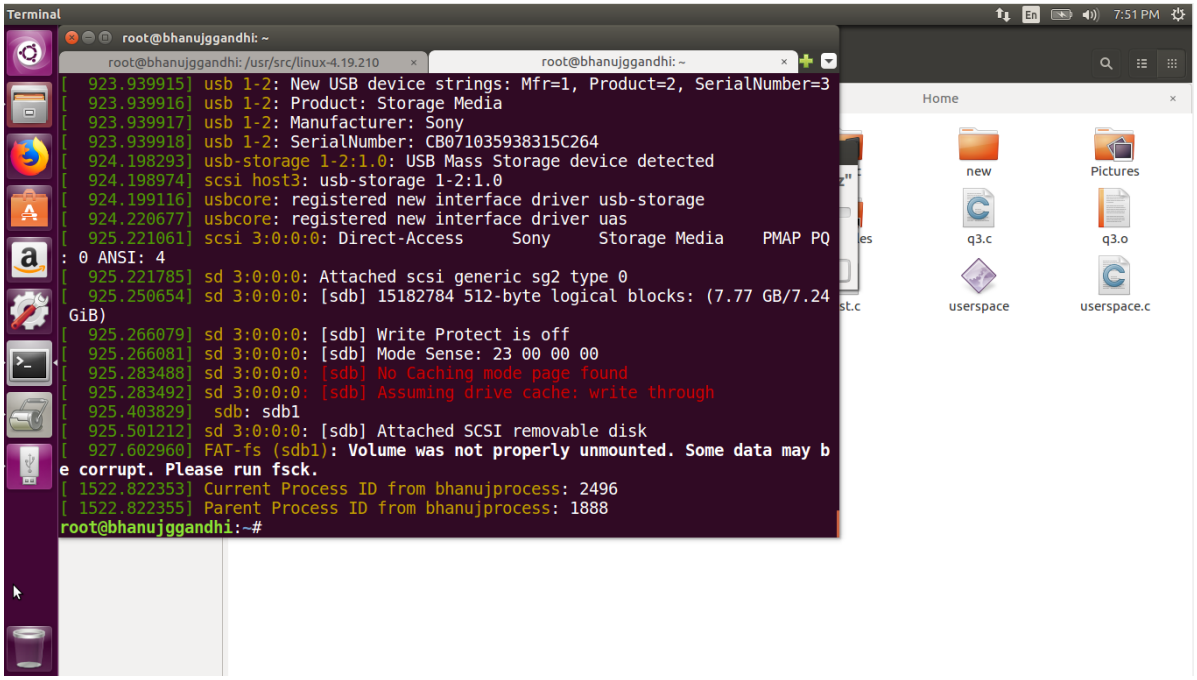
c. **Question 3:**



Driver code for sys_bhanujprocess system call



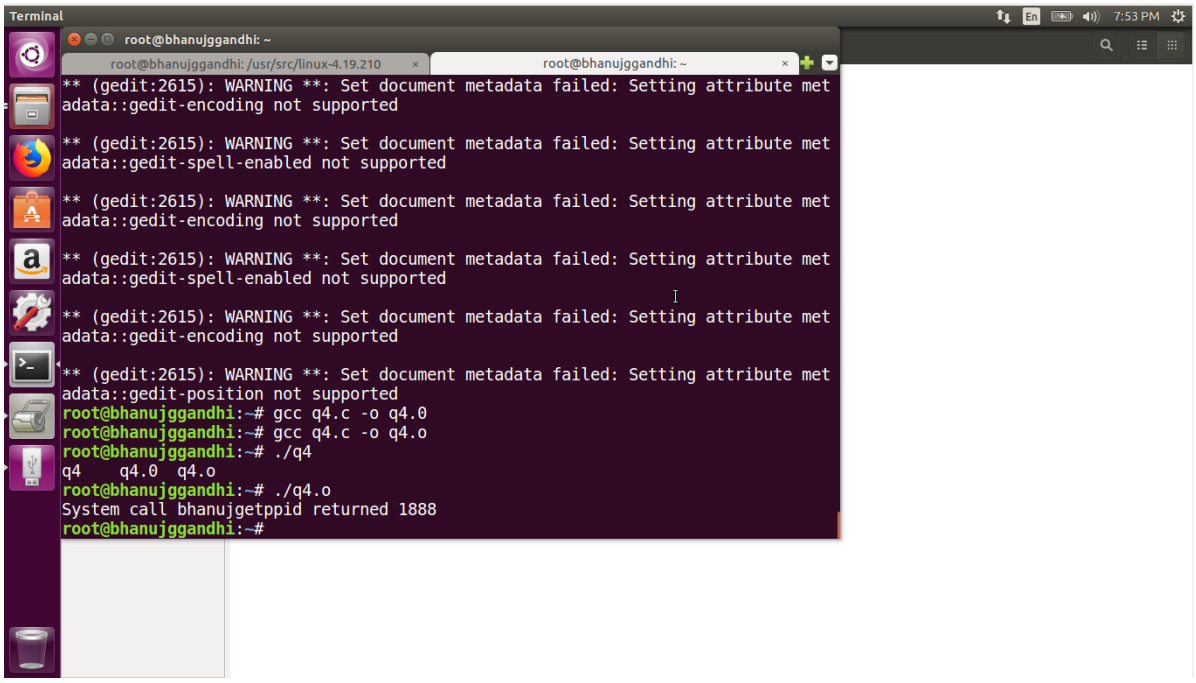
Upon compiling and running out file for question 3 system call



Output in dmesg by sys_bhanujprocess system call

d. **Question 4:**

Driver code for sys_bhanujgetppid system call



Upon compiling and running the out file, the process outputs the pid of parent of the *./q4.o* process.