Operating Systems Lab
Assignment 9

Name: Aditya Kangune
Roll number: 33323
Batch: K11

Aim:

Implement a new system call, add this new system call in the Linux kernel (any kernel source, any architecture and any Linux kernel distribution) and demonstrate the use of same.

Objective:

Add a new system call, swipe(), to the Linux kernel that transfers the remaining time slice of each process in a specified set to a target process. You will also demonstrate various uses of the system call (both advantageous and detrimental)

Theory:

Adding a simple system call:

1. Download the kernel source:

In your terminal type the following command:

```
wget https://www.kernel.org/pub/linux/kernel/v4.x/linux-4.17.4.tar.xz
```

Else go to kernel.org and download the latest version.

2. Extract the kernel source code:

```
sudo tar -xvf linux-4.17.4.tar.xz -C/usr/src/
```

tar — Tar stores and extracts files from a tape or disk archive.

-x — extract files from an archive

-v — requested using the –verbose option, when extracting archives

-f — file archive; use archive file or device archive

-C — extract to the directory specified after it.(in this case /usr/src/) Now, we'll change the directory to where the files are extracted:

3. Define a new system call sys_hello( ):

Create a directory named hello/ and change the directory to hello/:

mkdir

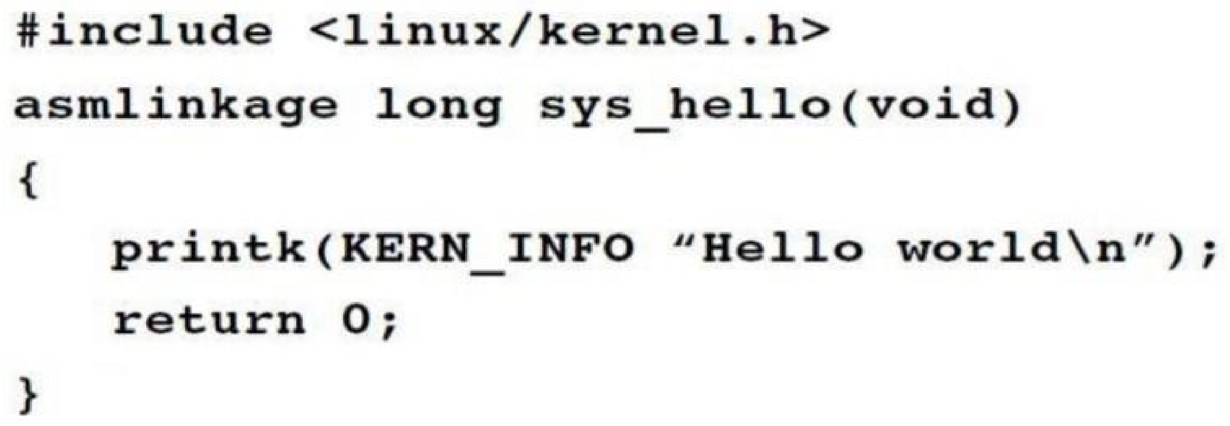
hello cd

Hello

Create a file **hello.c** using text editor:

gedit hello.c

Write the following code in the editor:



```
#include <linux/kernel.h>
asmlinkage long sys_hello(void)
{
   printk(KERN_INFO “Hello world\n”);
   return 0;
}
```

printk prints to the kernel's log file.

Create a “Makefile” in the hello directory:

gedit Makefile

and add the following line to it:

obj-y := hello.o

This is to ensure that the hello.c file is compiled and included in the kernel source code.

Note: There is no space in between“obj-y”.

4. Adding hello/ to the kernel’s Makefile:

Go back to the parent dir i.e. cd ../ and open “Makefile”

gedit Makefile

search for core-y in the document, you’ll find this line as the second instance of your search:

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

Add ‘hello/’ to the end of this line:

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

Note: There is a space between “block/” and “hello/”. (Doing such a mistake may cause errors in further steps)

This is to tell the compiler that the source files of our new system call (sys_hello()) are in present in the hello directory.

5. Add the new system call to the system call table:

If you are on a 32-bit system you’ll need to change ‘syscall_32.tbl’.

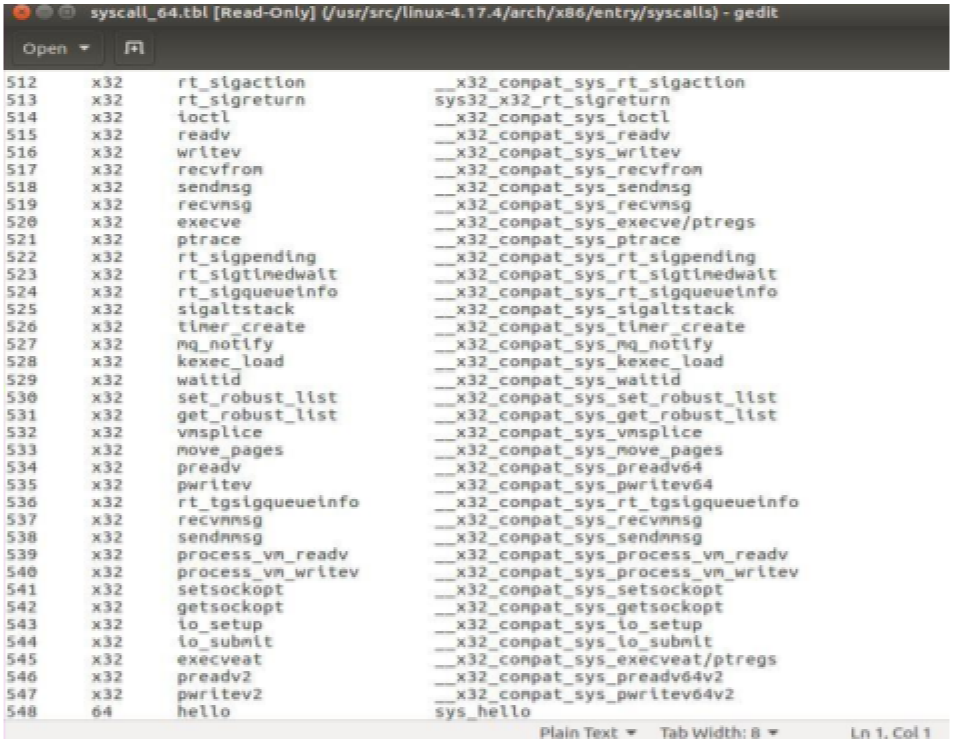
For 64-bit, change ‘syscall_64.tbl’.

Run the following commands in your terminal from linux-4.17.4/ directory:

cd arch/x86/entry/syscalls

/ gedit syscall_64.tbl

You’ll get a file like the following in your editor:



syscall_64.tbl [Read-Only] (/usr/src/linux-4.17.4/arch/x86/entry/syscalls) - gedit
Open
Plain Text
Tab Width: 8
Ln 1, Col 1

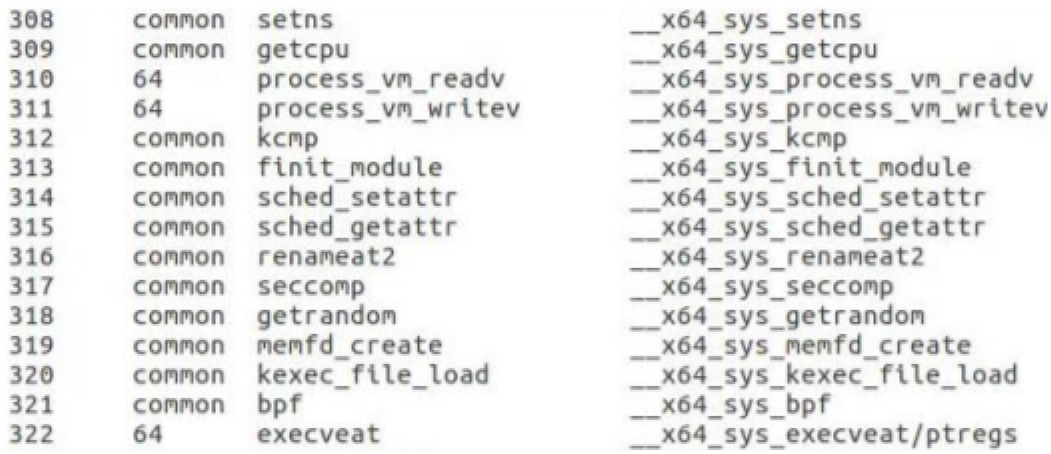
```
512     x32     rt_sigaction            __x32_compat_sys_rt_sigaction
513     x32     rt_sigreturn            sys32_x32_rt_sigreturn
514     x32     ioctl                   __x32_compat_sys_ioctl
515     x32     readv                   __x32_compat_sys_readv
516     x32     writev                  __x32_compat_sys_writev
517     x32     recvfrom                __x32_compat_sys_recvfrom
518     x32     sendmsg                 __x32_compat_sys_sendmsg
519     x32     recvmsg                 __x32_compat_sys_recvmsg
520     x32     execve                  __x32_compat_sys_execve/ptregs
521     x32     ptrace                  __x32_compat_sys_ptrace
522     x32     rt_sigpending           __x32_compat_sys_rt_sigpending
523     x32     rt_sigtimedwait         __x32_compat_sys_rt_sigtimedwait
524     x32     rt_sigqueueinfo         __x32_compat_sys_rt_sigqueueinfo
525     x32     sigaltstack             __x32_compat_sys_sigaltstack
526     x32     timer_create            __x32_compat_sys_timer_create
527     x32     mq_notify               __x32_compat_sys_mq_notify
528     x32     kexec_load              __x32_compat_sys_kexec_load
529     x32     waitid                  __x32_compat_sys_waitid
530     x32     set_robust_list         __x32_compat_sys_set_robust_list
531     x32     get_robust_list         __x32_compat_sys_get_robust_list
532     x32     vmsplice                __x32_compat_sys_vmsplice
533     x32     move_pages              __x32_compat_sys_move_pages
534     x32     preadv                  __x32_compat_sys_preadv64
535     x32     pwritev                 __x32_compat_sys_pwritev64
536     x32     rt_tgsigqueueinfo       __x32_compat_sys_rt_tgsigqueueinfo
537     x32     recvmmsg                __x32_compat_sys_recvmmsg
538     x32     sendmmsg                __x32_compat_sys_sendmmsg
539     x32     process_vm_readv        __x32_compat_sys_process_vm_readv
540     x32     process_vm_writev       __x32_compat_sys_process_vm_writev
541     x32     setsockopt              __x32_compat_sys_setsockopt
542     x32     getsockopt              __x32_compat_sys_getsockopt
543     x32     io_setup                __x32_compat_sys_io_setup
544     x32     io_submit               __x32_compat_sys_io_submit
545     x32     execveat                __x32_compat_sys_execveat/ptregs
546     x32     preadv2                 __x32_compat_sys_preadv64v2
547     x32     pwritev2                __x32_compat_sys_pwritev64v2
548     64      hello                   sys_hello
```

Go to the last of the document and add a new line like so:

548 64 hello sys_hello

Note: Here 548 is written because in the previous line the number entry was 547. Remember this number it will be used in the later steps.

Also, note that I’ve written 64 in my system because it is 64 bit. You may have to write i586 or x32. For knowing what is to be written check in this file itself in many of the lines you may find entries like so:



```
308     common  setns                   __x64_sys_setns
309     common  getcpu                  __x64_sys_getcpu
310     64      process_vm_readv        __x64_sys_process_vm_readv
311     64      process_vm_writev       __x64_sys_process_vm_writev
312     common  kcmp                    __x64_sys_kcmp
313     common  finit_module            __x64_sys_finit_module
314     common  sched_setattr           __x64_sys_sched_setattr
315     common  sched_getattr           __x64_sys_sched_getattr
316     common  renameat2               __x64_sys_renameat2
317     common  seccomp                 __x64_sys_seccomp
318     common  getrandom               __x64_sys_getrandom
319     common  memfd_create            __x64_sys_memfd_create
320     common  kexec_file_load         __x64_sys_kexec_file_load
321     common  bpf                     __x64_sys_bpf
322     64      execveat                __x64_sys_execveat/ptregs
```

64 written at 310, 311 and 322 line numbers.

This will tell you whether to write i586 or something else.

Save and exit.

6. Add new system call to the system call header file:

Go to the linux-4.17.4/ directory and type the following commands:

cd include/linux/

gedit syscalls.h

Add the following line to the end of the document before the #endif statement:

asmlinkage long sys_hello(void);

Save and exit. This defines the prototype of the function of our system call. “asmlinkage” is a key word used to indicate that all parameters of the function would be available on the stack.

7. Compile the kernel:

Before starting to compile you need to install a few packages. Type the following commands in your terminal:

sudo apt-get install gcc

```
sudo apt-get install

libncurses5-dev sudo apt-get

ev sudo apt-get

install bison

sudo apt-get install flex

sudo apt-get install

libssl-dev sudo apt-get

install libelf-dev sudo

apt-get update

sudo apt-get upgrade
```

to configure your kernel use the following command in your **linux-4.17.4/** directory:

```
sudo make menuconfig
```

Once the above command is used to configure the Linux kernel, you will get a pop up window with the list of menus and you can select the items for the new configuration. If your unfamiliar with the configuration just check for the file systems menu and check whether “ext4” is chosen or not, if not select it and save the configuration.

Now to compile the kernel you can use the make command:

```
sudo make
```

Pro Tip:

The make command can take a lot of time in compiling, to speed up the process you can take advantage of the multiple cores that our systems have these days.

Simply type,

```
sudo make -jn
```

where n is the number of cores that you have in your linux system.

For example if you have a Quad core(4) processor, you can write:

```
sudo make -j4
```

this will speed up my make process 4x times.

This might take an hours or more depending on your system.

8. Install / update Kernel:

Run the following command in your terminal:

```
sudo make modules_install install
```

It will create some files under /boot/ directory and it will automatically make a entry in your grub.cfg.

To check whether it made correct entry, check the files under /boot/ directory .

If you have followed the steps without any error you will find the following files in it in addition to others.

1. System.map-4.17.4

2. vmlinuz-4.17.4

3. initrd.img-4.17.4

4. config-4.17.4

Now to update the kernel in your system reboot the system. You can use the following command:

```
shutdown -r now
```

After rebooting you can verify the kernel version using the following command:

```
uname -r
```

It will display the kernel version like so:

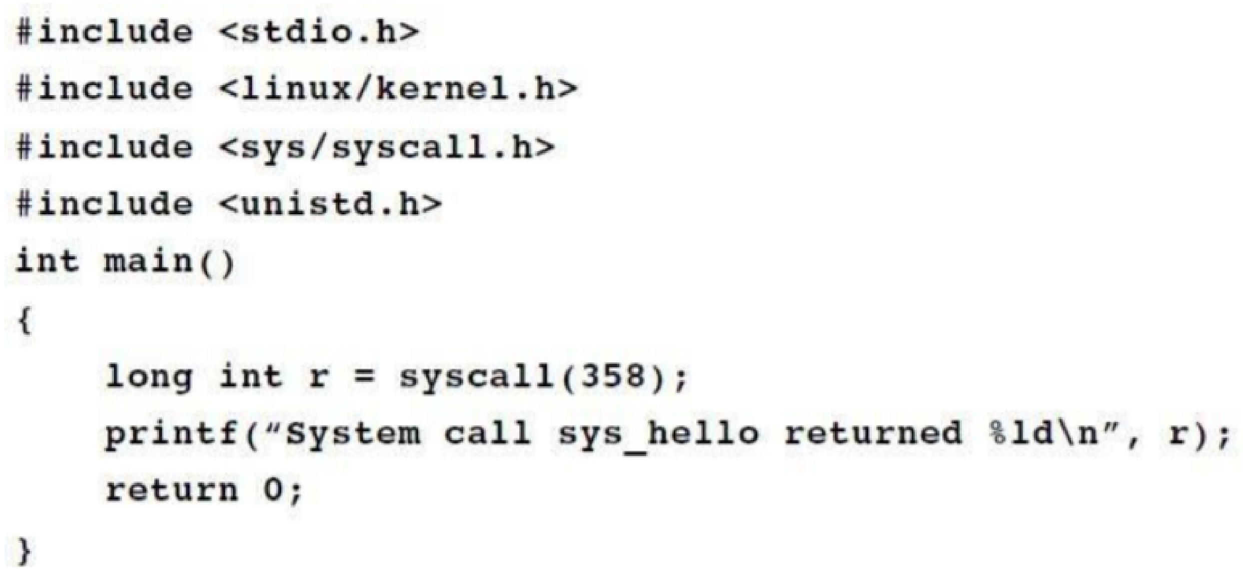
```
4.17.4
```

9. Test system call:

Go to your home(~) directory using the following commands and create a userspace.c file.

cd ~

gedit userspace.c



```
#include <stdio.h>
#include <linux/kernel.h>
#include <sys/syscall.h>
#include <unistd.h>
int main()
{
    long int r = syscall(358);
    printf("System call sys_hello returned %ld\n", r);
    return 0;
}
```

Note: Remember to keep in mind the number of system call that is added in syscalls_64.tbl? In my case the number was 548. Write that same number in your userspace.c file as an argument in syscall() function.

Now, compile and run the program:

gcc userspace.c

./a.out

If all the steps are done correctly you'll get an output like below:

System call sys_hello returned 0

Now, to check the message of your kernel run the following command:

dmesg

This will display Hello world at the end of the kernel's message.

Write the following code in this file:

Conclusion:

A new system call, add this new system call in the Linux kernel (any kernel source, any architecture, and any Linux kernel distribution) was studied.